Collembola Diversity in Agricultural Environments (Lajta Project, Western Hungary)

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Abstract – The actual paper presents the results of a comparative study of Collembola communities in different agricultural habitats including intensively managed plant cultures, shelterbelts and grassy embankments in the area of the Lajta Project. A total of 62 species were collected during the eleven-year study period (2002-2012). Collembola species richness, abundance and diversity were the highest in shelterbelts, which shows their ecological role in agricultural environments. Grassy embankments are further important ecotone habitats that play significant role in soil fauna diversity and abundance. Intensively managed monocultures (maize, summer rape and winter wheat) were characterized by Collembola communities with low species richness and abundance.

Keywords: soil fauna diversity / agro-environment /monocultures /edge ecotones

1. INTRODUCTION

Springtails (Collembola) are the most abundant arthropods in terrestrial ecosystems, colonising all soil habitats that provide enough humidity and food, such as organic matter or microorganisms. They are regarded as key indicators of soil fertility and health. Several papers have reported that agricultural intensification tends to reduce collembolan diversity (e.g. GILLER et al. 1997, PETERSEN 2002, SOUSA et al. 2006). The main goal of our research was to investigate Collembola community species composition, abundance and diversity in different agricultural habitats including intensively managed monocultures, shelterbelts and grassy ecotones.

2. MATERIALS AND METHODS

2.1. Study sites

The study was conducted in a predominantly agricultural area, in the LAJTA Project, Győr-Moson-Sopron county, 47°47'33"–47°52'18"N, 17°03'37"–17°09'50"E. Lowland (120m above sea level), underlain by alluvial deposits silty loess, which results in thin, poor quality soils. The climate is continental with annual precipitation of 504 mm and mean annual temperature of 9.6 °C. Large scale and small scale farming are also practiced with different management intensity. Sampling was conducted in three different plant cultures (summer rape, maize and winter wheat) as well as in grassy embankments and shelterbelts.

2.2. Sampling, extraction and taxonomic identification

Samplings were carried out during the eleven-year study period from 2002-2012. A total of 200 soil samples were taken. In each habitat, soil cores of 100 cm^3 were collected. Collembola were extracted from the soil cores for 14 days using a Berlese-Tullgren apparatus. Specimens were collected in 70% ethanol and separated under a binocular microscope. Springtails were identified at the species level according to GISIN (1960), STACH (1960, 1963), MASSOUD (1967), DEHARVENG (1982), FJELLBERG (1980, 1998), BABENKO et al. (1994), ZIMDARS & DUNGER (1994), WEINER (1996), JORDANA et al. (1997), POMORSKI (1998), BRETFELD (1999), POTAPOW (2001) and THIBAUD et al. (2004). Taxonomic classification is based on the annotated checklist of the Hungarian Collembola fauna (DÁNYI & TRASER 2008).

2.3. Data analysis

The characteristics of Collembola community structures were analyzed by using different diversity indices (Shannon-Wiener index, Simpson's diversity index, Fisher α, Pielou's equitability index). Collembola community structure comparison between the different habitats was estimated using single linkage cluster analysis based on the Bray-Curtis similarity index.

3. RESULTS

A total of 9259 specimens representing 14 families (*Figure 1*) and belonging to 62 species (*Table 1*) were collected. Hypogastruridae was the most abundant springtail group (2603 individuals – 28.11%) followed by Tullbergiidae (2332 individuals – 25.19%) and Isotomidae (2042 individuals – 22.05%). The most important Collembola community structural properties of the sampled habitats are presented in *Table 2*.

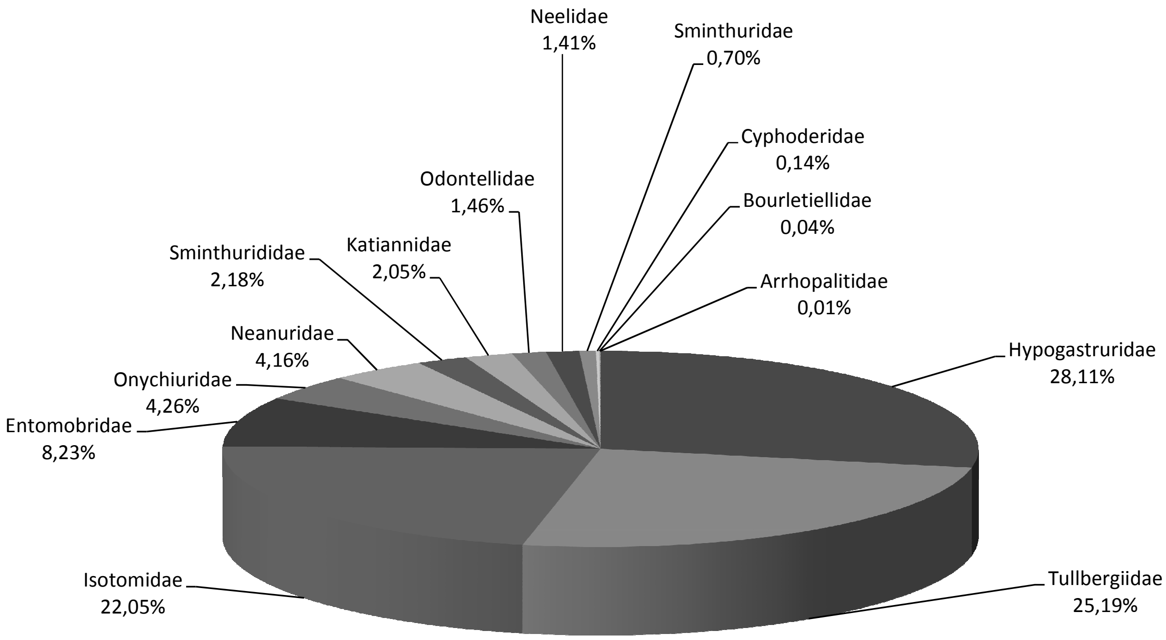

Figure 1. Proportional distribution of Collembola families

Table 1. Collembola species spectrum and abundance in the sampled habitats

Species	shelterbelt	summer rape	maize	winter wheat	embankments	Σ
Hypogastrura manubrialis	28	0	0	0	0	28
Hypogastrura socialis	0	0	0	44	577	621
Hypogastrura vernalis	0	74	17	17	0	108
Ceratophysella denticulata	8	1	98	1	0	108
Ceratophysella succinea	0	992	0	126	0	1118
Schoettella ununguiculata	374	0	0	0	0	374
Willemia intermedia	9	3	0	5	0	17
Willemia virae	130	34	28	7	28	227
Xenylla grisea	2	0	0	0	0	2
Axenyllodes bayeri	13	0	0	0	122	135
Friesea afurcata	0	0	9	19	0	28
Micranurida pygmaea	98	0	0	0	2	100
Pseudachorutes dubius	5	0	0	0	0	5
Pseudachorutes parvulus	160	0	0	0	13	173
Pseudachorutes pratensis	76	0	0	0	3	79
Protaphorura armata	357	18	2	7	3	387
Protaphorura tricampata	7	0	0	0	0	7
Doutnacia xerophyla	133	3	0	0	11	147
Mesaphorura critica	4	8	6	8	35	61
Mesaphorura hilophila	2	0	0	4	0	6
Mesaphorura italica	6	7	0	9	0	22
Mesaphorura krausbaueri	44	0	0	0	78	122
Mesaphorura macrochaeta	0	0	0	11	0	11
Mesaphorura sylvatica	1	0	0	0	0	1
Mesaphorura yosii	0	7	2	0	0	9
Metaphorura affinis	660	0	0	0	0	660
Metaphorura denisi	9	0	0	10	1274	1293
Cryptopygus thermophilus	0	0	0	0	54	54
Folsomides parvulus	63	21	0	2	54	140
Isotomodes productus	0	0	0	0	70	70
Proisotoma minuta	1	0	0	0	0	1
Isotoma anglicana	0	0	0	4	0	4
Isotoma viridis	15	0	0	0	31	46
Parisotoma notabilis	777	577	27	27	71	1479
Isotomiella minor	220	0	0	1	20	241
Isotomurus palustris	7	0	0	0	0	7
Entomobrya lanuginosa	3	35	2	6	5	51
Entomobrya multifasciata	119	2	1	0	9	131
Orchesella albofasciata	16	0	0	0	0	16
Orchesella cincta	64	10	0	0	7	81
Lepidocyrtus lignorum	10	0	0	0	0	10
Lepidocyrtus paradoxus	0	0	0	0	1	1
Heteromurus major	4	0	0	1	12	17
Willowsia buski	13	0	0	0	14	27
Willowsia nigromaculata	1	0	0	0	0	1
Pseudosinella aelleni	8	0	0	0	5	13
Pseudosinella alba	135	52	11	15	46	259
Pseudosinella octopunctata	9	26	0	14	38	87
Pseudosinella petterseni	1	6	2	0	18	27
Pseudosinella sexoculata	0	3	0	0	0	3
Pseudosinella zygophora	16	0	6	0	16	38
Cyphoderus albinus	6	0	0	0	5	11
Cxphoderus bidenticulatus	2	0	0	0	0	2
Megalothorax minimus	115	3	1	3	9	131
Sphaeridia pumilis	93	0	0	43	66	202
Sminthurinus aureus	0	172	0	1	1	174
Sminthurinus elegans	0	0	0	0	16	16
Sminthurus nigromaculatus	0	0	0	0	3	3
Sminthurus viridis	22	1	0	2	37	62
Deuterosminthurus bicinctus	0	0	0	0	1	1
Heterosminthurus bilineatus	3	0	0	0	0	3
Arrhopalites sp.	0	0	0	0	1	1
Σ	**3849**	**2055**	**212**	**387**	**2756**	**9259**

Table 2. Ecological structural properties of Collembola communities of the sampled agro-habitats

	Species richness (S)	Number of individuals (N)	Simpson's diversity (D)	Shannon diversity (H')	Equitability (J)
shelterbelt	46	3849	0.899	2.728	0.713
summer rape	22	2055	0.678	1.565	0.506
maize	14	212	0.740	1.805	0.684
winter wheat	25	387	0.853	2.451	0.762
grassy embankment	37	2756	0.736	2.044	0.566

Species richness, abundance and values of the different diversity measures were the highest in shelterbelts, which shows the great importance of tree line ecotones in agricultural environments. Grassy embankments, ditches are further ecotones that play a significant role in Collembola diversity and abundance reflected in the relative high values of ecological structural properties. Collembola species richness in intensively managed habitats (maize, summer rape and winter wheat) was lower compared with the species richness of ecotones.

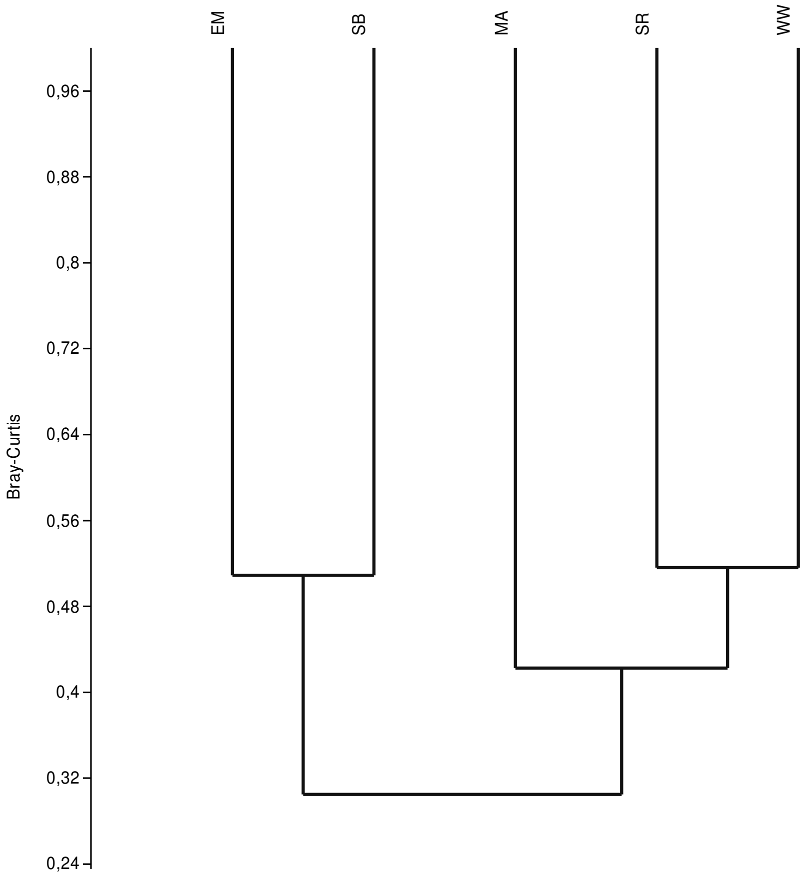

Figure 2. Dendrogram based on cluster analysis using the Bray-Curtis similarity coefficient on the Collembola communities of the sampled agro-habitats
(WW – winter wheat, MA – maize, SR – summer rape, SB – shelterbelt, EM – grassy embankment)

The dendrogram of agglomerative hierarchical cluster analysis based on Bray-Curtis similarity measure (*Figure 2*) well emphasises the difference between the two main habitat types: intensively managed fields and line ecotones.

The final results suggested that the types of land use affected the species richness and abundance, and human activity had a significant impact on the soil Collembola communities. Increasing the density of shelterbelts and grassy ecotones may, however, have a positive effect on the overall Collembola diversity.

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