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MICROARTHROPODS AND DECOMPOSITION PROCESSES IN MEADOWS OF VARIOUS PLANT SPECIES RICHNESS

ABSTRACT: Density and biomass of Collembola and Acarina were estimated in soil and in experimentally introduced substrates (litter bags with stems and leaves of *Dactylis glomerata* and mineral bags containing sand) in five meadows of different plant diversity ranging from almost monoculture (youngest meadows) to rich vegetation (several year old and permanent meadows). Studies were conducted in the Suwałki Lanscape Park (northeastern Poland).

The intensity of humification was positively correlated with biomass of microarthropods in soil, however the rate of litter disappearance rate was found not to be related to this parameter. The rate of humification process proceeded in the lowest rate in the youngest meadow. It was coupled with the slowest rate of litter colonization by microarthropods and the rapid by bacteria. In the soil of the youngest meadow the lowest and most variable density of microarthropods was recorded. The Shannon-Wiener diversity index for group Collembola was the higest in the youngest meadow despite low plant diversity.

KEY WORDS: microarthropods, biomass, diversity, meadows, litter decomposition, accumulation of organic matter.

1. INTRODUCTION

Over the last few decades species diversity of plant communities decreases in many terrestrial ecosystems (Głowaciński et al. 1980, Kornaś 1990, Denisiuk 1990). There is still little information about the influence of these changes on the communities of soil invertebrates and the decomposition process. Some authors suggest that uniformity of plant cover decreases retention of soil organic matter (Odum 1985, Paoletti et al 1992, Vitousek and Hooper 1993, Łoginov et al. 1990).

The objective of this study was to compare the density and biomass of microarthropods and to analyse their influence on litter decomposition in meadows which vary in plant species richness. Also, to examine, using Collembola as an example, whether diversity of meadow vegetation is reflected in diversity of soil fauna.

In the studied habitats diversity of plant cover was related to secondary succession, increased with progressing time since tillage ceased. The study sites differed not only with respect to plant species richness but also with other properties changing with secondary succession. To reduce the effect of other factors mesocosms containing sand covered by grass litter, composed of stems and leaves of *Dactylis glomerata* were applied (Kajak 1997). The influence of microarthropods on the decomposition rate of the same substrate in every meadow and on accumulation of decomposed organic matter in introduced sand was analysed.

2. STUDY AREA

The study sites were located in the Suwałki Lanscape Park and in its buffer zone (north – eastern Poland). This is young-glacial terrain with very differrentiated relief. Areas occupied by particular meadows were relatively small (from 0.5–4 ha). Meadows and pastures account for a significant proportion of the land used. They are generally linked into rotation cycle, as leys, are tilled every six to ten years and utilized as cultivated fields. However areas too wet, excessively rocky or steep are used as permanent meadows or pastures. Different management and the age of the meadows determined contrasts in the plant species richness of compared sites. The sward of the youngest meadows in the first few years after tillage was dominated by one grass species, mainly *Dactylis glomerata*. The highest species richness (more than 30 species) was characteristic for the permanent meadows.

Sites have been located on outwash plain, among cultivated fields of the three villages (see Kajak 1997). In 1984 and 1985 investigations have been carried out in two adjacent meadow leys – two years old (LA_1) and eight years old (LC_1). In the next period 1988–1990 investigations have been carried out in the three meadows: one year old – LA, eight years old – LC, and permanent – P (Table 1). Soils were typical brown or leached brown, originated from medium sand (Kusińska and Łakomiec 1997) and belonged to the order of moist mead-

Table 1. Site characteristics

Properties	Meadows*				
	LA_1	LC_1	LA	LC	P
Years after tillage	2	8	1–2	8–9	
Number of plant species in sward [a)]	2	30	1–4	31	35
Biomass of litter g dry wt m^{-2}	–	–	60	197	233
Plant biomass g dry wt m^{-2}					
above ground [a)]	–	–	320	344	390
below ground [b)]	–	–	875	850	950
C org. content [c)] % dry wt of soil (0–10 cm)	1.4	1.7	1.1	1.9	2.7

According to: [a)] Jankowski 1997, [b)] Szanser 1997, [c)] Kusińska and Łakomiec 1997
* see Kajak 1997

ows – Arrhenatheretalia (Jankowski 1997). All the meadows were cut in June and pastured in autumn. The experimental areas were excluded from utilization.

3. METHODS

A field experiment was carried out to compare weight loss of litter and the increase of carbon content in underlying substratum. At each site 90 mesocosms (sand filled bags (20 × 30 cm × 30cm deep) were inserted into the soil profile. On the upper surface of 45 of these, litter bags were exposed. Each bag (12 × 14cm, mesh size 1mm) contained 10 g of air dry green parts of Dactylis glomerata (fig. 1). Sand and litter were of the same origin in every site, so of similar chemical composition at the beginning of the experiment. The experiment was repeated three times: in 1984–1985 (Ex. I), 1988–1989 (Ex. II), 1989–1990 (Ex. III) (Table 2).

To characterise the mesofauna several times in a season a series of samples (10 cm^2 × 7 cm) were collected using a metal soil corer (Kaczmarek 1963) from sand and adjacent meadow soil. Litter bags were collected also at the same time. All the samples were extracted at Tullgren funnel during 5 days. Collembola were identified to the species level and their body lenght was measured. Individuals smaller than half of the lenght of mature have been treated as "young" (Stach 1956). Acarina were divided into two size groups – large, more than 0.6 mm and small – the others. Basing on the body lenght of individuals biomass was calculated (Dunger 1968).

To estimate the significance of differences in animal biomass Wilcoxon matched – pairs signed rank test was applied and in the density – t test. Species diversity was measured by Shannon-Wiener diversity index H' basing on the data from Ex II and III .

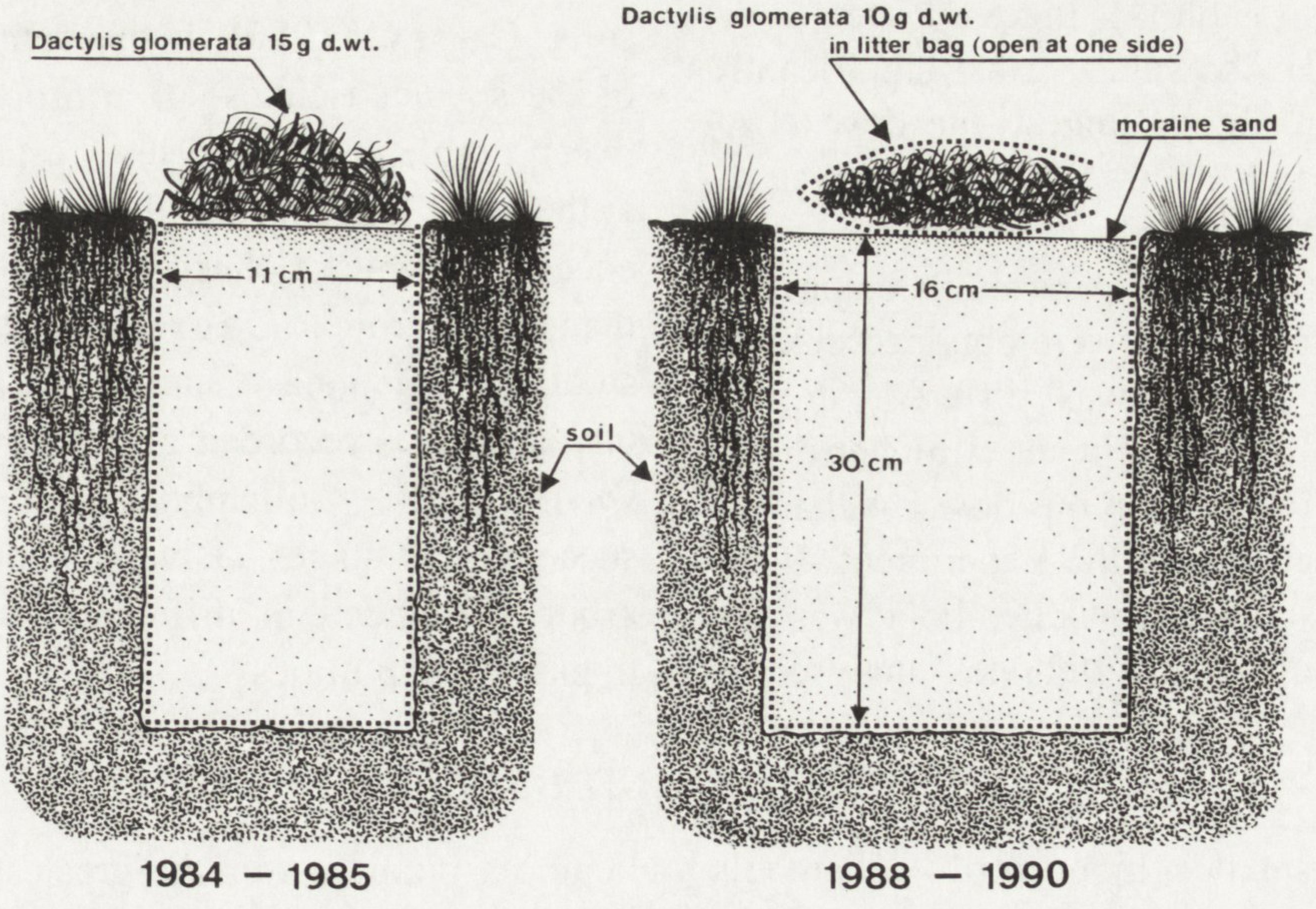

Fig. 1. Scheme of sand and litter bags used in analysis of sand and litter colonization by microarthropods

Table 2. Study sites, samplin gperiods, number of samples taken from sand and litter bags inserted in grasslands and from surrounding habitat

	Experiment I		Experiment II			Experiment III		
	Nov. 1984 – May 1985		June 1988 – Jan. 1989			May 1989 – Feb. 1990		
	Study sites (symbols)[a]							
	LA_1	LC_1	LA	LC	P	LA	LC	P
	Number of samples analyzed							
Litter bags	17	16	25	25	–	30	29	29
Sand bags ($10\ cm^2 \cdot 7\ cm$)	20	20	30	30	–	29	30	26
Sand cores ($10\ cm^2 \cdot 7\ cm$)	20	20	5	55	35	60	57	57

[a] see Table 1

4. RESULTS

4.1. SPECIES DIVERSITY OF COLLEMBOLA

The number of Collembola species in soil increased with an inceasing species richness of vegetation. This occurred throughout all the years of study. The number of species colonizing sand and litter was also in most cases, but not always, higher in older more diversified meadows (Table 3). Index of species diversity H' however, was significantly higher in the youngest meadow (LA) compared to others. Such pattern was repeated in two years of investigations. It was also true for the sprintails colonizing litter. Other results were obtained in sand, diversity pattern was different in two years. In the Experiment II higher diversity was recorded in meadow LA than in older meadows, in the Experiment III the opposite occurred. Collembola was the only group of invertebrates analysed in this volume which the diversity was shown to be significantly higher in young meadows, than in older ones (Kajak and Wasilewska 1997). It may be related to rapid community formation after tilllage in this group, and to relatively high Collembola diversity in cultivated soils. Curry (1986) in the comparison of the species richness of arthropods between arable crops and leys established at the same place, found the lower differences in species richness of Collembola than other groups. Czernova (1977) in studies of secondary succession in various substrates recorded also the high diversity of Collembola in early successional stages. Diversity of this group proceeded in different way, than in plant communities.

4.2. DENSITY AND BIOMASS

The smallest biomass of Collembola and Acarina was recorded in soils of the youngest meadows (Table 4). The Collembola biomass was the greatest in the several years old ley meadows (LC), the mean annual biomass was during all years

Table 3. Species richness and Shannon-Wiener diversity index (H') of Collembola in meadow soil, sand and litter

Years	Meadow soil			Experimental substrates					
				Sand			Litter		
Study sites[1]	LA	LC	P	LA	LC	P	LA	LC	P
	Number of species								
1984–1985	11	12	n.a.	10	14	n.a.	10	12	n.a.
1988–1989	11	13	21	15	12	n.a.	17	18	n.a.
1989–1990	18	20	31	11	16	16	18	19	17
	Diversity index (H')								
1988–1989	4.8a***	2.6b	n.a.	3.1a***	2.8b	n.a.	4.7a***	2.8b	n.a.
1989–1990	3.1a***	3.0a	2.8	2.1a	2.4b**	2.3b	2.4a***	1.9b	2.4a

Different letters following index values indicate significant diffences between sites
** $p < 0.01$, *** $p < 0.002$; n.a. – not analysed.
[1] see Table 1.

of studies 3 – 7 times larger there, compared to new ones (Table 4, Fig. 2). The differences between the LC and other meadows were statistically significant. The biomass of Acarina did not differ significantly between meadows, but often the highest biomass was found in permanent meadow (Table 4).

The differences between sites with respect to the Collembola biomass settled in sand, were similar as in soil (Table 4). There was recorded greater density in the sand introduced to several years old meadows than in new meadows. This appeared over 3 study seasons. The differences between these sites were significant. Relations between the biomass in particular meadows were of the same pattern in sand as in soil (Table 4). The biomass of Acarina however exhibit quite different pattern in sand than in soil. In the mesocosms with sand it was significantly higher in new meadows than in several years old leys. This pattern was repeated in three years of study . The highest biomass was recorded in the permanant meadow.

The differences among meadows in the number and biomass of microarthropods colonizing litter did not show any constant tendency in study years. It was very characteristic that both groups – Collembola and Acarina occurred most numerously in 1988 (Table 4). This was not observed in soil or in sand.

4.3. MICROARTHROPODS AND LITTER DECOMPOSITION PROCESSES

In all the experiments grass litter was exposed on the sand surface in spring i. e. in May or June and remained in the field for over a period of 11 months. There was always an initial rapid weight loss, independent of climatic conditions (Fig. 2). The differences in the rate of decomposition between the study sites varied in particular years. For example the greatest weight loss was found in 1989 in the youngest meadow, but in 1984 and 1988 the smallest (Kajak et al. 1991, Bogdanowicz and Szanser 1997). The humus content in litter was greater in

Table 4. Mean annual density (no 10^3 m^{-2}) and biomass (mg dry wt m^{-2}) of microarthropods in experimental substrates (litter bags, sand bags) and in surrounding habitat (soil)

Years of study	Study sites (symbols)						Significance of differences in:		
							biomass		variability index
	LA LA_1	LC LC_1	P	LA LA_1	LC LC_1	P	LA–LC	LA–P	LA–LC
	Density			Biomass					
Soil									
Collembola									
1984–1985	14.7 ± 2.8	41.4 ± 1.0	n.a.	25.0	111.8	n.a.	LA<LC		LA<LC
1988–1989	9.3 ± 1.9	40.4 ± 9.6	8.6 ± 1.0	35.7	279.9	54.9	p<0.01	n.s.	p,0.01
1989–1990	21.4 ± 5.1	32.7 ± 3.9	18.0 ± 2.6	192.0	545.1	172.5	n=8		n=21
Acarina									
1984–1985	19.1 ± 5.2	12.8 ± 2.3	n.a.	397.6	227.0	n.a.	LA>LC	LA<P	LA<LC
1988–1989	38.8 ± 5.6	34.9 ± 4.7	54.9 ± 6.9	600.7	930.2	984.2	0.1>p>0.05	0.1>p>0.05	p<0.02
1989–1990	32.6 ± 3.0	29.4 ± 2.4	42.5 ± 4.8	499.7	767.3	687.2	n=8	n=6	n=27
Sand									
Collembola									
1984–1985	3.6 ± 2.1	19.6 ± 11.5	n.a.	29.2	62.9	n.a.	LA<LC		
1988–1989	12.9 ± 2.9	24.3 ± 5.1	n.a.	37.7	117.1	n.a.	p=0.06	n.a.	
1989–1990	12.8 ± 3.5	27.2 ± 6.4	9.3 ± 1.9	123.6	756.0	96.9	n=9		

				Acarina				
1984–1985	10.5 ± 2.1	7.0 ± 1.5	n.a.	449.0	129.6	n.a.	LA>LC	
1988–1989	57.6 ± 16.9	32.0 ± 5.7	n.a.	409.0	260.5	n.a.	p=0.02	n.a.
1989–1990	28.1 ± 5.3	37.4 ± 5.2	30.5 ± 6.9	181.2	165.0	249.3	n=9	
				Litter bags				
				Collembola				
1984–1985	1.2 ± 0.4	3.0 ± 1.0	n.a.	13.9	22.8	n.a.		
1988–1989	26.3 ± 17.2	18.1 ± 3.1	n.a.	315.9	127.4	n.a.	n.s.	n.a.
1989–1990	2.9 ± 1.2	13.1 ± 5.6	2.3 ± 0.7	80.3	127.5	25.3		
				Acarina				
1984–1985	11.5 ± 3.2	11.7 ± 3.2	n.a.	80.2	103.2	n.a.		
1988–1989	28.0 ± 6.6	49.6 ± 10.2	n.a.	406.9	571.8	n.a.	n.s.	n.a.
1989–1990	10.6 ± 4.5	7.9 ± 1.4	8.7 ± 2.6	148.1	11.0	126.2		

*Wilcoxon signed rank test calcutated for data combined from all compared years;
**Significance of differences in variability index based on all the data; n – number of means; n.a. – not analysed

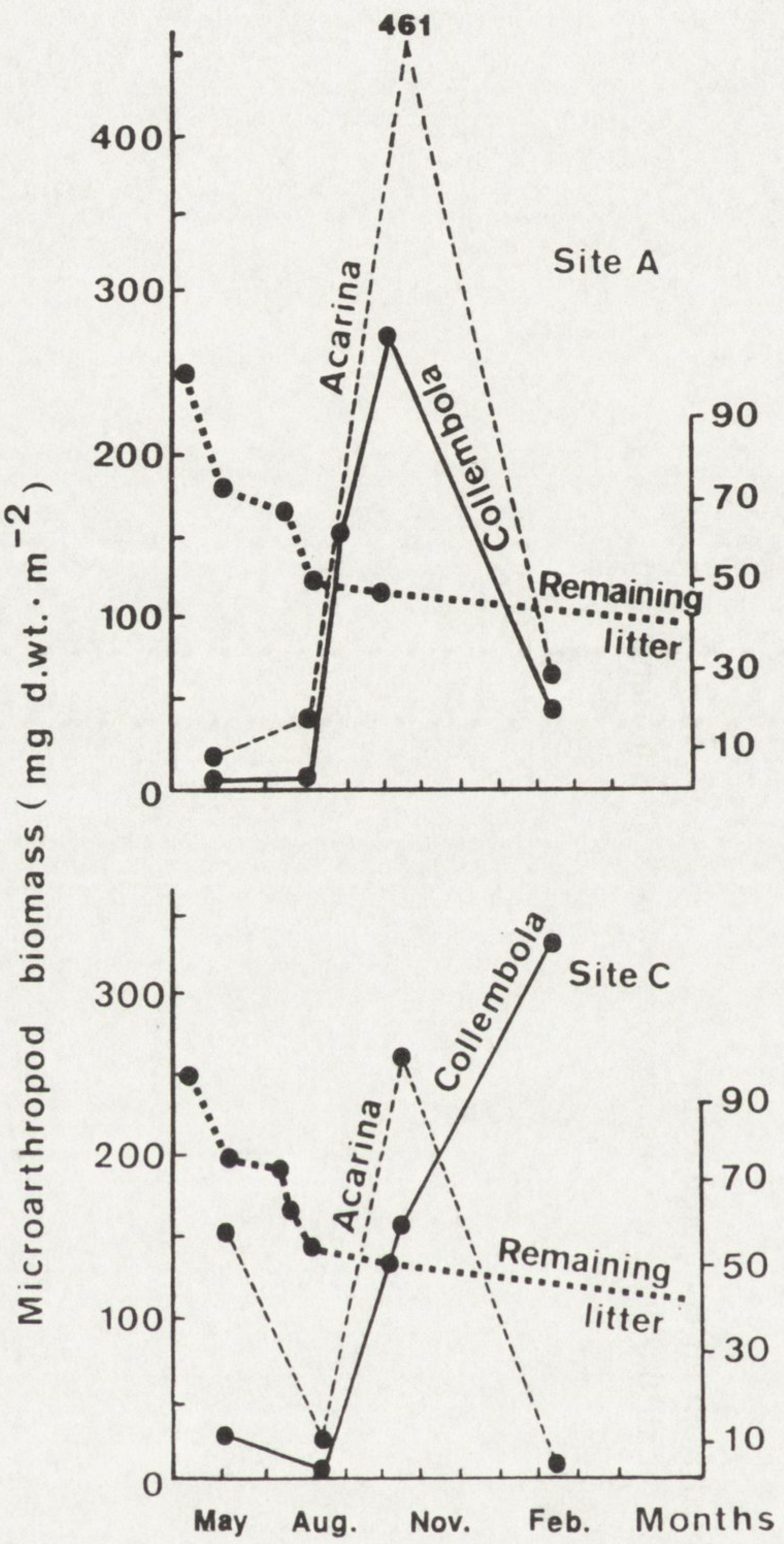

Fig. 2. Trends of the grass litter colonization by microarthropods and of disappearance rate of grass litter in new (LA) and older (LC) grass leys (Experiment 1989–1990)

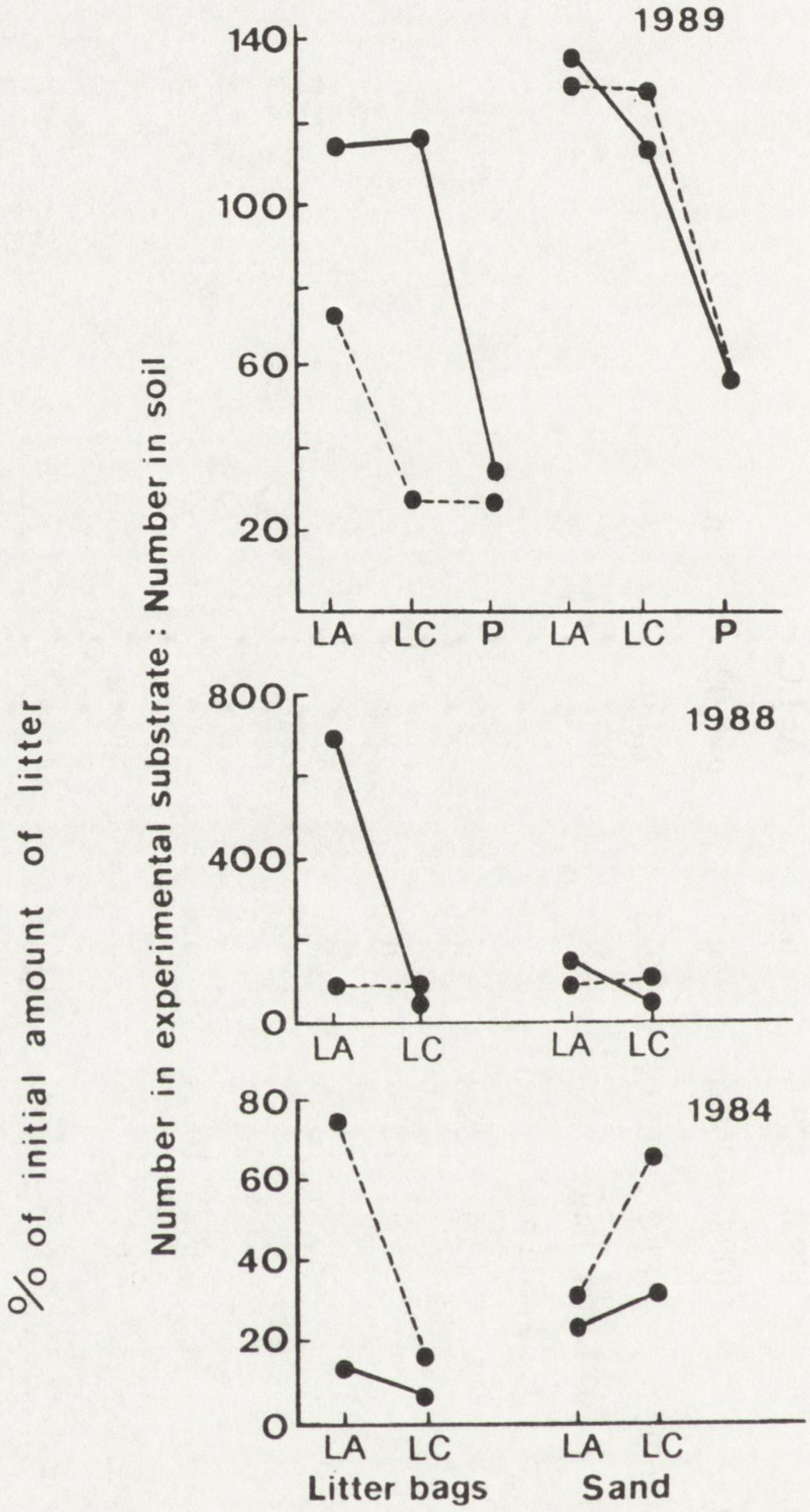

Fig. 3. Activity of microarthropods in the autumn (the ratio of the number of ind. in litter bag to the number of ind. in surrounding habitat) in grass litter colonization in young (LA) and older (LC, P) meadows.
Full line – Collembola, dashed line – Acarina

older than in young meadows (K a j a k et al. 1991, K u s i ń s k a 1997).

The pattern of litter colonization by microarthropods was very characteristic and stable in all the years. The biomass of these animals usually increased slowly, and not until autumn, that is after 5–6 months after litter bag exposure, the maximum has been reached (Figs. 2 and 3). Litter colonization was especially slow in the new meadows. During the initial period there was usually a smaller biomass of both Acarina and Collembola than in other meadows. In most cases in the initial period (1 – 3 months) the biomass ratio between older and young meadows was more than one (LC : LA, P : LA > 1) (Table 5). The reason for a slower litter colonization may be a smaller density of these animals in the surrounding soil. The same tendencies however were shown by comparing numbers of individuals in litter (Li) and in soil (So) – Li : So ratio. In the spring litter colonization in LA meadow was the slowest as compared to the density in soil. In autumn it was com-

Table 5. Biomass ratios of microarthropods colonizing litter bags – between old (LC, P) and new grasslands (LA) (data from Experiment II and III, see Table 1)

Months after start of the experiment	Collembola			Acarina		
	LC : LA		P : LA	LC : LA		P : LA
	1988	1989	1989	1988	1989	1989
1	–	52.2	0.1	–	7.8	2.5
3	8.6	5.5	5.7	1.9	0.5	0.6
5	0.2	0.5	0.1	1.4	0.6	0.9
8	3.4	7.6	0.8	0.1	1.1	0.1

pletely different, Li to So ratios were in many cases the highest in the young leys (Fig. 3). This tendency was detected both in Collembola and Acarina. So numbers of microarthropods in young meadows increased rapidly in autumn, after which another rapid decrease was observed. In other meadows numbers were less variable (Fig. 2, Table 5).

The body weight of microarthropod individuals in litter was significantly higher in the young meadow than in permanent one. It was coupled with the smallest weight of Collembola individuals in the soil of this meadow (Table 6). The differences between meadows with respect to individual weight of Collembola in litter did not result either from a decrease of the proportion of juveniles in new meadows, nor from differences in species composition. Differences in the weight of individuals between litter and soil were characteristic for Collembola only, Acarina individuals were of the similar weight in both substrates (Table 6).

The pattern of litter colonization by microarthropods shows that this group is not very important in mineralization rate of this substrate. It was indicated by the peak numbers of microarthropods achieved in autumn i. e. after the period of rapid litter disappearance, lack of weight loss acceleration in 1988, the year of extremely high numbers of microarthropods, and no correlation between litter disappearance rate and the number of Collembola and Acarina recorded in the litter exposed in compared meadows (Table 7).

Table 6. Dry weight of 1000 microarthropod individuals (mg) in grassland soil and in experimental substrates (litter bags, sand bags)

Study sites	Collembola			Acarina		
	LA	LC	P	LA	LC	P
Litter bags	16.2±0.8a***	14.5±1.9a	7.6±0.8b	15.2±0.6a***	23.7±2.6b***	8.6±2.7c
Sand	8.0±1.2a	10.3.±1.5a	6.6±0.5a	21.0±2.7a*	12.9±1.0b	14.9±5.0a
Soil	8.4±0.8a	12.8±0.8b**	8.9±0.6a	15.9±1.1a	23.1±1.1b*	14.0±2.0a

Different letters following index values indicate significant diffences between site LA and the others; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.002$.

Table 7. Kendall correlation coefficient (tau) between decomposition rate or carbon accumulation in sand, and biomass of microartropods in litter bags, sand and surrounding soil

	Biomass of microartropod taxa in various substrates		
	Collembola	Acarina	Oribatida[a]
Disappearence rate of litter (sand covered with litter bags)		Litter bags	
	–0.12	0.07	n.a.
Increase of organic matter in sand:		Litter bags	
	0.24	–0.095	n.a.
		Sand	
	0.14	0.24	n.a.
		Sourronding soil	
	0.52*	0.52*	1.0**

[a] data of Petrov (1997) used in calculations; n.a.. – not analysed
* p = 0.068, ** p = 0.008.

4.3. HUMIFICATION AND MICROARTHROPOD COMMUNITY

An increase of organic carbon in sand was in all replicates the smallest in young meadows and the highest in permanent meadow .The highest increase was found in 1989, the smallest in 1984 (Kajak et al. 1991, Kusińska 1997). The analysis of the whole material shows that there was no correlation between the total microarthropod biomass in sand and the estimated increase of organic matter content. There is however positive correlation between this increase and the biomass of microarthropod in adjacent soil. The highest correlation coefficient was found between the biomass of Oribatida in soil and the increase of organic matter recorded in sand inserted in this meadow (Table 7). It has been assumed that processes going on in sand reflect the processes proceeding simultaneously in the surrounding soil, show the same tendencies. Increase of organic matter content during a year is too small in comparison to its resources in soil to be measured using available methods. So the obtained results suggest, that microarthropods could influence accumulation rate of organic carbon in soil.

4.4. SPECIES COMPOSITION OF COLLEMBOLA AND GRASS LITTER DECOMPOSITION

Differences between species composition of Collembola in litter bags exposed in particular study sites have been analysed in three consecutive experiments. It was considered if changes in dominant species could influence decomposition pattern. Although in all the years the same grass species was used in litter-bags – namely above ground parts of *Dactylis glomerata*, the Collembola community differed greatly from year to year.

In the Experiment I litter bags in two adjacent meadows were colonized by different Collembola community. In 8 years old meadow (LC_1) *Folsomia quadriocu-lata* predominated, constituting 62% of all individuals, which was almost absent in 1 year old meadow (0.52 %). In the Experiments II and III the species *F. quadrioculata* also belonged to the group of dominating species in 8 years old meadow (LC) but its proportion was much lower (19 and 17.5% in consecutive years). Low density of this species was found not only in young leys (LA_1, LA) where humification process was less intensive, but also in the permanent meadow, where humification was the highest. In 1988 *Folsomia fimetaria* (68.7% of the total number) and *Isotoma notabilis* (18%) predominated in meadow LA. The last species dominated also in meadow LC. Both these species appeared in low numbers in 1989. In this period in all the meadows *Onychiurus variabilis*, *O. armatus* and *Mesaphorura* sp. belonged to the dominants, only the proportions among them varied in particular study sites (Appendix 1).

Results of studies suggest that the constantly higher increase in the organic matter content in older meadows was not related to any specific community composition, as far as it changes from year to year, whereas humification pattern is relatively stable. It was found in the Experiment II and III that humification intensity was positively related to Acarina : Collembola biomass ratio in the litter (Table 7). The higher the ratio, the higher was organic matter accumulation in sand. It was not true for the Experiment I in which the matter accumulation was the lowest, and which was done in another area.

5. DISCUSSION

According to literature data the influence of microarthropods on the litter decomposition is very variable. They may accelerate significantly organic carbon decomposition, by stimulating the bacteria development, or retard it (Hanlon and Anderson 1979, Hanlon 1981, Seastedt and Crossley 1980 Ineson et al. 1982, Petersen and Luxton 1982, Uvarov 1982, Seastedt 1984, Anderson 1988, Moore et al. 1988, Hagvar 1988). Many data indicate that the role of these animals is negligible, as compare to the role of microbial populations (Visser et al. 1981, Swift and Anderson 1993, Anderson 1988, Faber and Verhoff 1991). However most of the estimates based on the experiments excluding microarthropods indicate, that they accelerate decomposition rate by several to several dozen percent (Seastedt 1984).

In our studies, it was very characteristic, that the litter exposed in the young meadows had been initially colonized slowly by microarthropods, as compared with older meadows, whereas most rapidly by bacteria (Stefaniak et al. 1997). So in the initial period there was important difference between structure of colonizers in the new and older meadows. It is likely that this may lead to slow humification found in this meadow.

Few studies have attempted to estimate the influence of microarthropods on humification. These have been mostly laboratory experiments, which demonstrated that Collembola and Acarina excrements contain humus acids (Ghilarov 1970, Butcher et al. 1971, Striganova 1980). In the microcosm experiments using coniferous forest soil, an increase of humus acids was determined in treatments with meso- and microfauna compared to systems with microbes only (Huhta et al. 1988). In studies of succession it was also determined that in the early stages, when mesofauna dominated and there was no macrofauna, humification processes occured, leading to the formation of moder or mor type humus. So representatives of mesofauna – Collembola and Acarina are treated as microhumifages (Dunger 1968, 1991).

The present experiment showed relationship between organic matter increase in introduced sand and microarthropod biomass in adjacent soil. The importance of particular species composition or species diversity of Collembola in enhancing humification seems to be low.

Characteristic properties of microarthropod communities in young meadows, which have been repeated in all the successive experiments have been – relatively slowly occuring litter colonization, relatively large body size of colonizing Collembola and short period of high biomass in autumn. Number of individuals is more variable during the season. This was related to relatively less intense humification of decomposed litter. In contrast in meadows of high carbon accumulation during the experiment higher proportion of Acarina in total microarthropod biomass was found. So several regularities have been found in the microarthropod communities which might influence humification rate.

6. CONCLUSIONS

Species diversity of Collembola did not increase with successional stages, it was the highest in the new grass ley being almost monoculture.

The new grass leys were characterized by lowest and most variable microarthropod density and biomass in soil and in experimentally introduced substrates – grass litter and sand. The colonization of grass litter exposed in spring was the slowest there.

The intensity of humification was positively correlated with the biomass of Collembola and Acarina in soil. Especially high correlation coeficient was found between humification rate and the biomass of Oribatida. Data from the two experiments (Experiment II and III), in which high humification rate was recorded, indicate that high carbon accumulation was coupled with high proportion of Acarina in the total biomass of microarthropods colonizing litter.

7. SUMMARY

The results of the field experiment (Fig. 1, Table 2) carried out in meadows of the Suwałki Lanscape Park (north-eastern Poland) (Table 1) indicate that humification processes are more intense in the old meadows with diversified sward than in new grass leys with almost monoculture of *Dactylis glomerata* (Kajak et al. 1991, Kusińska 1997).

In the present study the microarthropod density and biomass was estimated in meadow soils and in mesocosms inserted in the soil profile. They were filled with sand, covered by litter bags at the surface. The main objective of

the study was to analyse if differences in the microarthropod community might explain the differences between meadows found in decomposition of the litter. Positive correlation has been found between microarthropod biomass in soil and amount of organic matter accumulated in sand during the experiment. The highest correlation coefficient has been found between matter accumulation and biomass of Oribatida (Table 7). However the litter weight loss was not related to biomass of microarthropods. In the initial period of rapid decomposition rate the litter exposed in the new meadow was rapidly colonized by bacteria but very slowly by microarthropods (Table 5, Fig 2). In this period decomposition was to a lower degree affected by Collembola and Acarina in young than in older meadows. Although in autumn in the young meadows the highest microarhropod activity (ratios of the number of individuals colonizing substrate to the density in soil) was found (Fig. 3). The body weight of colonizers was significantly higher in young leys than in permanent meadow (Table 6).

Density and biomass of microarthropods was lower and more variable in soil of young leys than in older meadows (Table 4).

Species composition of Collembola varied from year to year (App. 1)

Species richness of this community increased with the plant species richness in sward. In contrast Shannon-Wiener diversity index H' proceeded in the different way, it was the highest (differences significant) in the young ley characterized by simplified sward (Table 3).

Basing on the obtained results it may be concluded that the microarthropod biomass . and proportion of Acarina and Oribatida in it are important in processes of humification. The influence of these animals on disappearance rate of litter was not found.

8. POLISH SUMMARY

Na łąkach Suwalskiego Parku Krajobrazowego (tab. 1) przeprowadzono eksperyment terenowy (rys. 1), w którym stwierdzono, że procesy humifikacji zachodzą intensywniej w podłożu starszych łąk, o bardziej urozmaiconym składzie roślinności, niż na nowozałożonych łąkach, które są niemal monokulturami kupkówki (Kajak et al. 1991, Kusińska 1997).

W niniejszej pracy przeanalizowana została liczebność i biomasa mikroarthropoda w glebach tych łąk, oraz we wprowadzonych na łąki substratach – ściółce i piasku (tab. 4). Poszukiwano, czy występowanie tych zwierząt na nowej łące jest na tyle odmienne, że mogłoby tłumaczyć stwierdzony tam inny przebieg rozkładu materii roślinnej. Wykazano dodatnią korelację między wielkością biomasy Collembola i Acarina glebie, a intensywnością humifikacji. Największa była zależność między humifikacją a biomasą Oribatida (tab. 7). Natomiast nie stwierdzono zależności między liczebnością mikroarthropoda, a szybkością ubywania ściółki (tab. 7, rys. 2). Jest to jednak bardzo charakterystyczne, że w początkowym okresie ściółka wyłożona na nowej łące zostaje szybko opanowana przez bakterie, podczas gdy kolonizowanie jej przez mikroarthropoda zachodzi bardzo powoli (tab. 5). W ciągu pierwszych miesięcy mikroarthropoda mają wiec mniejszy wpływ na rozkład ściółki na nowej łace, niż na pozostałych.

W glebie nowych łąk liczebność i biomasa Collembola i Acarina była mniejsza niż na starszych łąkach (tab. 4). Ściółka wyłożona na powierzchni pojemników z piaskiem na nowej łące jest bardzo powoli zasiedlana przez te zwierzęta (rys 2). Na jesieni jednak, tam właśnie występuje maksymalna liczebność w porównaniu z liczebnością panującą w glebie (rys. 3). Charakterystyczna jest też większa na nowej łące zmienność biomasy, zarówno zwierząt występujących w glebie, jak zasiedlających wprowadzone podłoża (tab. 4).

Skład gatunkowy Collembola nie wykazuje zasadniczych odrębności powtarzających się w kolejnych latach badań (App. 1). Mimo podobieństwa składu gatunkowego, ściółkę wyłożoną na nowej łące zasiedlają wieksze osobniki Collembola, niż na pozostałych łąkach. Rożnice są istotne (tab. 6).

Liczba gatunków Collembola rośnie wraz z powiekszaniem się bogactwa gatunkowego rośliności. Odwrotne tendencje wykazuje wskaźnik rożnorodności Shannona-Wienera. W glebie nowej łąki, przybiera on istotnie większe wartości, niż w glebie starszych łąk (tab. 3).

Na podstawie przeprowadzonych badań można sądzić, że wielkość biomasy mikroarthropoda, a także wielkość udziału Acarina i

Oribatida w tej biomasie wywiera wpływ na przebieg procesów humifikacji. Nie stwierdzono natomiast, żeby skład gatunkowy analizowanej grupy miał bezpośredni wpływ na przebieg tych procesów (App.1).

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Appendix1. Density of dominant species ($10^3 \cdot m^{-2}$) and species

Species	Ley A 1–2 years								
	sand			litter			habitat		
	I	II	III	I	II	III	I	II	III
Folsomia fimetaria (L.)		1.2	0.27		180.6	0.83		0.17	1.05
Onychiurus variabilis Stach		0.56	0.04		1.52	9.13		1.24	2.88
Mesaphorura krausbaueri grup Börn.	1.05	3.23	7.03	0.12	0.6	11.1	9.55	2.06	4.43
Isotoma notabilis Schäff.	0.55	0.63	0.31	2.82	54.12	1.36	2.95	0.71	2.65
Folsomia quadrioculata (Tullb.)		0.93	0.65	0.06	0.84	0.03			5.79
Onychiurus armatus (Tullb.)		0.7	1.0	0.06	4.92	4.1	0.50	1.49	1.75
Isotoma viridis (Bourl.)	0.30	1.76	0.21	0.47	7.62	0.50	0.75	0.4	1.95
Isotoma olivacea Tullb.		0.01			5.56				0.05
Metaphorura affinis (Börn.)	0.10	0.66	0.31		0.16	0.57	0.10	0.47	1.25
Lepidocyrtus ruber Schött		0.3			5.1	0.77		0.1	0.33
Isotomodes productus (Axels.)		1.0	3.93				0.3	0.11	0.21
Lepidocyrtus lignorum (Fabr.)	0.06	0.06			0.16	0.5		0.04	0.12
Lepidocyrtus cyaneus Tullb.	0.1			3.12	0.08				
Ceratophysella armata (Nic.)	•						•		
Ceratophysella sigillata (Uzel)	•			•					
Hypogastrura manubrialis (Tullb.)	•			•					
Isotomiella minor Schäff.	•					•	•		
Isotoma propinqua Axelson									
Micranurida pygmaea Börn.		•			•	•	•	•	
Folsomides parvulus Stach					•	•			•
Stenaphorura quadrispina Börn.		•						•	•
Neanura muscorum (Templ.)		•			•	•			
Xenyllodes armatus Axels.							•		
Willowsia nigromaculata (Lubb.)									
Pseudosinella alba (Pack.)									
Sinella curviseta Brook									
Orchesella cincta (L.)									•
Hypogastrura assimilis (Krausb.)						•			
Entomobrya muscorum (Nic.)									
Brachystomella parvula (Schäff.)					•	•	•		
Entomobrya nivalis (L.)									
Orchesella villosa (L.)				•					
Isotoma intermedia (Schött)									
Cryptopygus bipunctatus (Axels.)									

composition of Collembola in meadows and in experimental substrates

Ley C 8–9 years									Pernament meadow				Total number of ind.
sand			litter			habitat			sand	litter	habitat		
I	II	III	I	II	III	I	II	III	III	III	II	III	
	0.36	0.53		0.28	1.69		2.35	1.19				0.03	4911
	6.27	9.96		29.92	69.10		9.11	7.10	0.08	0.10		0.02	4592
1.2	3.77	7.27	0.12	7.48	38.75	12.5	1.15	5.68	4.35	10.93	0.62	4.82	4216
1.35	2.93	0.23	2.69	41.36	1.24	1.2	6.17	5.53	0.19	4.07	3.6	6.15	4193
15.6	4.13	2.03	18.62	32.08	10.21	19.15	2.77	6.28			0.72	0.02	3194
0.05	4.56	4.37	0.06	16.6	5.31	2.35	5.29	7.52			1.17		2251
0.35	0.1	0.63	0.87	9.16	2.93	2.9	0.42	1.86	0.08	0.62	0.1	0.53	1017
	0.5	0.03	0.03	25.44		0.02	0.02	0.38	0.30		0.07		828
	0.47	0.13		0.36	0.03		0.2	0.59	0.26	1.24	0.9	1.42	377
	0.16			3.8	0.17		0.24	0.05			0.4		320
	0.56	0.86		0.08		0.25		0.26	0.04	0.03	0.02	0.09	253
0.15		0.06	0.69	0.72	1.38	0.15	0.11	0.51	0.04	0.34	0.6	1.09	238
0.25			3.87	0.04	0.27	0.05						0.02	136
•						•			•	•		•	86
			•										64
•			•			•							55
						•		•		•		•	53
											•	•	58
				•	•			•					31
		•						•					30
•							•	•			•	•	30
				•	•								26
•			•		•	•		•			•	•	23
										•	•	•	45
•							•	•	•		•	•	21
				•			•						14
				ù	•					•			15
•												•	15
							•						13
				•									11
												•	10
			•										7
				•					•				7
		•	•					•					5

Species	Ley A 1–2 years								
	sand			litter			habitat		
	I	II	III	I	II	III	I	II	III
Proisotoma minima (Abs.)									
Sinella myrmecophila (Reut.)			•	•					
Sinella coeca (Schött.)									
Tomocerus minor (Lubb.)									
Entomobrya corticalis (Nic.)									
Pseudosinella immaculata (Lie Pett.)									
Isotoma olivacea var. Stachi									
Isotoma hiemalis Schött.									
Entomobrya marginata (Tullb.)									
Lepidocyrtus sp.			•			•			•
Tomocerus sp.						•			
Folsomia sp.									
Proisotoma sp.					•				
Xenyllodes sp.									
Isotomidae sp. sp. juv.								•	•
Hypogastruridae juv.					•				
Entomobryidae sp. sp. juv.									
Lepidocyrtus juv.									
Lepidocyrtus lanuginosus (Gmel.)									
Tullbergia tricuspis Börner									

Points (•) – rare species; I – Experiment I (1984–1985), II – Experiment II (1988–1989), III – Experiment III (1989–1990)

Ley C 8–9 years									Pernament meadow				Total number of ind.
sand			litter			habitat			sand	litter	habitat		
I	II	III	I	II	III	I	II	III	III	III	II	III	
									•		•		8
							•						4
												•	2
												•	2
												•	2
												•	2
			•										2
		•											1
					•			•				•	46
												•	2
					•								1
													2
	•												1
		•			•			•				•	59
						•				•	•		67
		•								•	•		8
											•		18
											•		4
											•		1