POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	52	2	123–133	2004

Regular research paper

Izabella OLEJNICZAK

Centre for Ecological Research, Polish Academy of Sciences,
Dziekanów Leśny, 05-092 Łomianki, Poland,
e-mail: iza-olejniczak@wp.pl

COMMUNITIES OF SOIL MICROARTHROPODS WITH SPECIAL REFERENCE TO COLLEMBOLA IN MIDFIELD SHELTERBELTS

ABSTRACT: Density of microarthropods, Collembola and Acarina were studied in 2000 in soil and litter of 7-years old shelterbelt and in nearby field sown by winter wheat in Turew (Wielkopolska Region, West Poland). Samples were taken in the shelterbelt centre and in the field at a distance of 0.5 m, 10 m and 50 m from the tree line. Collembola were analysed in soil and in litter samples placed in containers and located in different sites, Acarina only in soil samples.

Density of Collembola in soil was found to be higher in the shelterbelt than in the adjacent field (P =0.003). Similar relationship was not, however, noted for insects in litter, density in open field was higher than in the shelterbelt. Density of Acarina in soil decreased gradually with the distance from the shelterbelt (P =0.007).

Twenty three species of springtails were found; the highest species richness (12) was noted in shelterbelts, but also in the litter in the open field. The dominant species common for soil and litter were *Isotoma notabilis* in the shelterbelt while *Isotomina thermophila* and *Isotoma viridis* in the field. With the increasing distance from shelterbelt *Proisotoma minuta* increased its contribution to the soil community, *Entomobrya multifasciata* was the dominant only in litter. In the field soil, 50 m from woods, the highest share of young individuals was noted.

The highest species richness of Oribatida was found in the field margin (18). The *Tectocepheus velatus* was the dominant species both in the shelterbelt and the field, accounted for 30–70% of the total number of individuals.

KEY WORDS: Collembola communities, Acarina, species diversity, migrations, shelterbelt

1. INTRODUCTION

Intensive studies have been carried out in recent decades on the role and functioning of shelterbelts in agricultural landscape. They are known to affect water budget, soil structure and biodiversity (Karg 1989b, Banaszak 2000). Animals may find shelters there, which enables further re-colonisation or penetration of adjacent regularly managed fields (Southerton 1984, Dennis and Fry 1992, Alvarez *et al.* 1997, Alvarez *et al.* 2000). Adequate data on the importance of shelterbelts for soil fauna, including microarthropods, are still scare. These animals, through modification of densities and species composition of microorganisms, may indirectly affect mineralisation and humification of organic matter (Cernova *et al.* 1971, Coleman 1985, Huhta *et al.* 1988, Czarnecki 1989, Striganova 1992). Known as indicative organisms, these animals could serve for characterising soil properties (Kopeszki 1997, Heisler 1995).

Presented studies are a part of the long-term project carried out in agricultural landscape separated by shelterbelts (Ryszkowski 1998). The study aimed at estimating to what degree the shelterbelts might affect species composition and numbers of microarthropods in adjoining fields.

2. STUDY AREA AND METHODS

Studies were carried out in the General D. Chłapowski Landscape Park near Turew (16°45', 52°01'N, Western Poland), in the research area of the Research Centre for Agricultural and Forest Environment, Polish Academy of Sciences. Forests in this area have largely been destroyed or fragmented and their function is expected to be taken over by shelterbelts (Ryszkowski 1998). Shelterbelts were planted in this landscape already 200 years ago (Bałazy *et al.* 1989) and now their network is protected and supplemented (Karg 1998a, Ryszkowski 1998).

Studies were carried out in one of such midfield shelterbelts 7 years after afforestation and in the easterly adjacent field. *Pinus silvestris* and *Larix decidua* dominated in the shelterbelt and besides *Quercus robur*, *Sorbus aria*, *Acer pseudoplatanus*, *Fraxinus excelsior*, *Betula verrucosa*, *Pyrrus communis*, *Salix caprea* were present there (Bernacki *et al.* in press). Underwood layer was dominated by *Agropyron repens, Agrostis alba, A.stolonifera, Apera spica venti, Calamagrostis epigeios, Cirsium arvense, Poa annua, Rumex acetosa, Stellaria media* and *Taraxacum officinale* (Bernacki *et al.* in press.). The field was sown by winter wheat. Both the shelterbelt and the field were situated on the same soil – arenic hapludalfs on slightly loamy sand over light loam (Marcinek 1996), they are poor in organic matter, slightly acid, of pH between 4.3 and 4.4 (Wojewoda and Russel 2003.).

During the study period i.e. between April and September 2000 the highest precipitation was recorded in July and August (Fig. 1). The highest temperatures were noted in August (Fig. 2). In June low precipitation was accompanied by high temperatures.

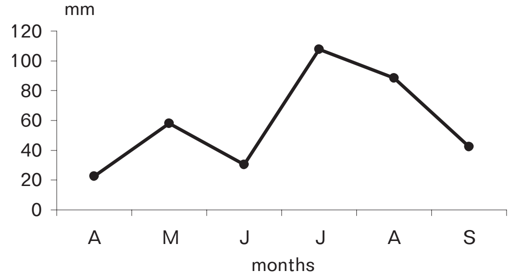

Fig. 1. Monthly rainfall during season of investigations – Turew area (Wielkopolska region, West Poland).

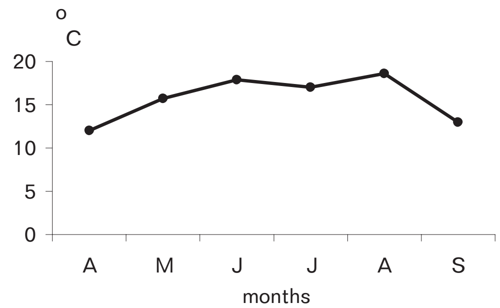

Fig. 2. Mean monthly temperatures during season of investigations – Turew area (Wielkopolska region, West Poland).

Material was collected three times in vegetation season – in April, June and September 2000. Sampling periods were selected in a way to involve key periods in crop growth. Both soil samples and litter were collected from the central part of the shelterbelt and in the field 0.5 m, 10 m and 50 m from the strip.

Every time soil samples were taken with a steel soil corer of an area of 10 cm^2 to the depth of 10 cm. Ten soil samples were taken from each sampling plot, in line parallel to the shelterbelt, 2 m apart each other. In total 120 samples were taken.

Mesocosms consisted of frames of a size of 50 cm x 50 cm x 20 cm filled with sand and loam were dug in every plot, so that their edges were levelled with the soil surface to enable animal access (Szanser 2003). 18 such frames were installed in every studied plot in rows parallel to the shelterbelt. Eight containers (area 95 cm^2) formed by PCV rings, closed on both sides with a steelon net (ø 1 mm) with 10 g dry wt. of cocksfoot (*Dactylis glomerata*) litter were placed in each frame. To enable fauna penetration of the litter, a row of holes 1 cm in diameter were drilled in the rings (Szanser 2003.). In every sampling occasion 10 litter samples (5 g) were collected per plot, one per mesocosm. In total 120 samples were taken.

Springtails and mites from collected samples were extracted in the Tullgren's apparatus (Kaczmarek 1963, 1981). Then the species of Collembola were determined basing on Stach's (1955) and Gisin's (1960) keys and on taxonomic papers of Rusek (1982). Age of individuals was assessed upon their length. The species of mites were determined by courtesy of Peter Petrov.

For statistical analysis nonparametric Wilcoxon's test of rank differences for pairs and Kruskall-Wallis nonparametric analysis of variance (Siegel 1956) were used since the data distribution was not normal even after logarithm transformation.

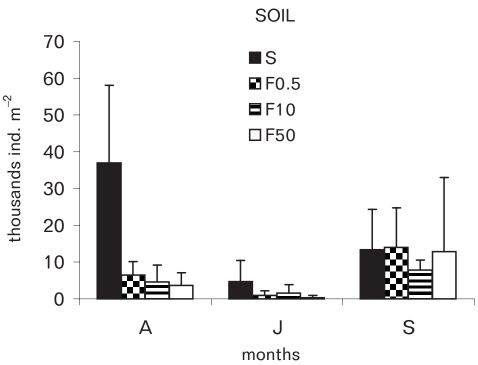

Fig. 3. Seasonal densities of collembolan communities in soil of 7-years old shelterbelt (S) and adjacent field: 0.5 m ($F_{0.5}$), 10 m (F_{10}), and 50 m (F_{50}) from the shelterbelt.

Species diversity of Collembola communities was calculated according to Shannon-Wiener (1963) equation using logarithms at a base of 2. Hutcheson's (1970) test was used to determine the statistical significance of differences between the H' indices.

Species similarity in Collembola communities was calculated with the equation of Marczewski and Steinhaus (1959).

Three groups were distinguished in Collembola communities basing on their preferences to a given soil layer (Christiansen 1964): epigeon, hemiedaphon and euedaphon.

3. RESULTS

Densities of Collembola in the soil of the shelterbelt differed significantly from those of the adjacent field (Kruskall-Wallis test, $P = 0.003$, Table 1) contrary to the insect densities in litter, where no significant differences were found between plots (Kruskall-Wallis test, $P = 0.6$, Table 1).

Seasonal variability of the numbers of studied insects was different in soil and in litter. In soil, significantly higher springtail densities were noted in the shelterbelt than in the adjacent field (Wilcoxon's test $P < 0.05$) during spring and summer. In the autumn the numbers were similar in both sites (Fig. 3). In litter, higher densities of insects were recorded in the field (0.5 and 10 m from the shelterbelt) than in the shelterbelt during spring (Wilcoxon's test, $P < 0.05$, Fig. 4).

The lowest densities of insects in both soil and litter were noted in June, in the period of low precipitation and high temperatures (Figs 1, 2, 3 and 4).

Table 1. Density (10^3 ind. m^{-2}) of Collembola and Acarina communities (means±SD) of 7 years old shelterbelt (S) and adjacent field ($F_{0.5}$ – 0.5 m from the shelterbelt, F_{10} – 10 m from the shelterbelt, F_{50} – 50 m from the shelterbelt).

		S	$F_{0.5}$	F_{10}	F_{50}
Collembola	soil	18.4±19.4*)	7.1±8.4	7.1±11.2	5.6±12.6
	grass litter	2.7.8±3.9	6.5±12.5	5.3±8.5	4.9±8.3
Acarina	soil				
	Oribatida	6.6±3.8	6.3±3.7	2.9±2.2	1.1±2.3
	Mesostigmata	4.2±2.8	4.8±3.0	0.7±1.7	0.0
	Prostigmata	2.4±2.5	1.9±2.5	0.8±2.2	0.7±1.7
	total	13.1±9.1	13.0±9.1	4.4±6.1	2.8±4.0

*) statistical significance between shelterbelt and adjacent field, Kruskal-Wallis $P = 0.003$, in soil

**) statistical significance between shelterbelt and adjacent field, Kruskal-Wallis $P = 0.007$, in soil, except the nearest field $F_{0.5}$

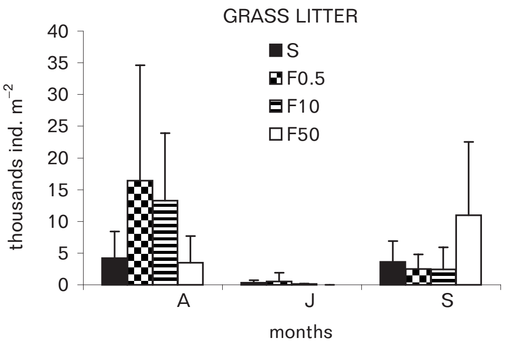

Fig. 4. Seasonal densities of collembolan communities in grass litter of 7-years old shelterbelt (S) and adjacent field: 0.5 m ($F_{0.5}$), 10 m (F_{10}), and 50 m (F_{50}) from the shelterbelt.

Densities of Acarina in the shelterbelt soil were higher than in the field (Kruskall-Wallis test, P =0.007). A regular decline in the numbers of all taxa was noted (Oribatida, Mesostigmata and Prostigmata) with the increasing distance from the wood edge. Only the differences between mean densities in the shelterbelt and in the field edge (0.5 m) were insignificant, due to Mesostigmata more abundant in the field margin, than in the other plots (Table 1).

Seasonal course of the numbers of Oribatida, Mesostigmata and Prostigmata in particular sites was similar (Fig. 5).

Twenty three species of Collembola were distinguished in the collected material, 15 of them in soil and 17 in litter (Table 2). Species similarity between insect communities in soil and in litter was weak (43%). In both soil and litter the greatest similarity was found for Collembola communities in the field 10 and 50 m from the shelterbelt (Table 3). Similarity between communities in shelterbelt and the open field (F_{50}) was high in soil (67%) and much lower in the litter (41%) (Table 3).

In the shelterbelt, in both soil and litter, dominating species was *Isotoma notabilis,* accounted for > 40% of the total density. It was the only abundant species occurring exclusively in the shelterbelt; all the others were represented more or less abundantly also in the adjacent field. In the litter placed in the shelterbelt and in the adjacent field *Entomobrya multifasciata* was very important (12–70% of the density) (Table 2). In the field *Isotomina thermophila* (21–43%) and *Proisotoma minuta* (9–35%) dominated in the soil and *Entomobrya multifasciata, Isotoma viridis* and *Isotomina thermophila* – in the litter. The two latter species were numerous not only in the litter but also in the soil (Table 2).

With such a domination structure it is interesting to compare species diversity of Collembola community measured with the Shannon-Wiener H' diversity index. The highest values of the index in soil were noted for the shelterbelt and its nearest vicinity (i.e. at the field margin) (Table 4). The

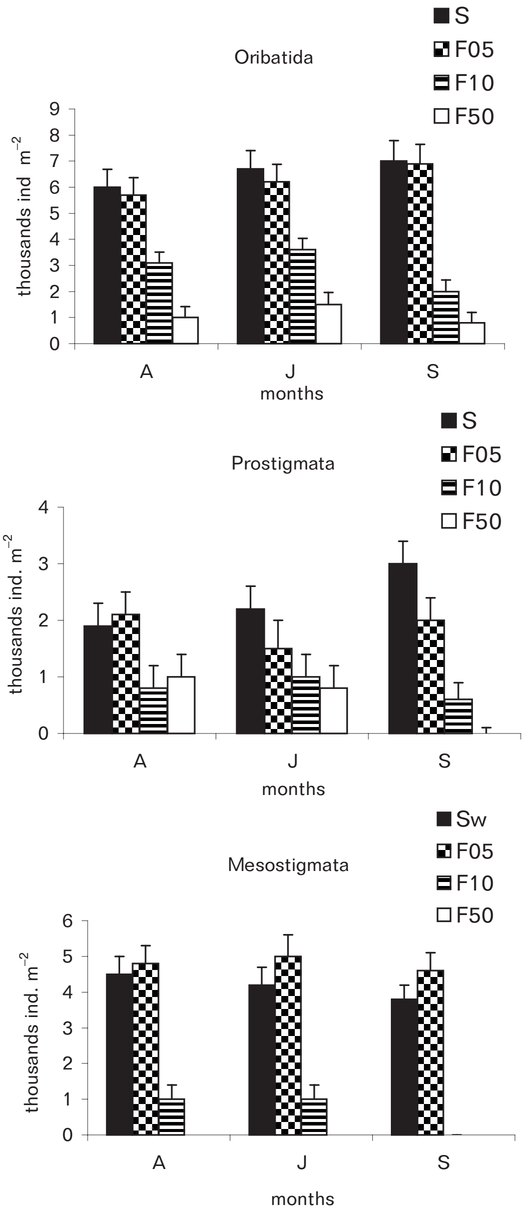

Fig. 5. Seasonal densities of soil communities of Acarina (Oribatida, Prostigmata, Mesostigmata) of 7-years old shelterbelt (S) and adjacent field: 0.5 m ($F_{0.5}$), 10 m (F_{10}), and 50 m (F_{50}) from the shelterbelt.

Table 2. Dominance structure (% of total numbers of individuals) among Collembola of 7 years old shelterbelt (S) and adjacent field ($F_{0.5}$ – 0.5 m from the shelterbelt, F_{10} – 10 m from the shelterbelt, F_{50} – 50 m from the shelterbelt) in soil and grasslitter exposed on the soil surface.

species	soil				grass litter			
	S	$F_{0.5}$	F_{10}	F_{50}	S	$F_{0.5}$	F_{10}	F_{50}
Entomobrya arborea Tulberg	–	–	–	–	4	–	–	–
E. marginata Tulberg	–	–	–	–	–	–	–	<1
E. multifasciata Tulberg	5	–	2	–	20	70	30	12
Isotoma notabilis Schäffer	48	9	–	1	45	–	–	–
I. viridis Bourlet	3	15	1	14	7	5	33	26
Isotomiella minor Schäffer	–	–	1	–	–	–	–	–
Isotomina thermophila Axelson	8	43	31	21	–	8	20	39
Isotomodes productus Axelson	–	1	–	–	–	–	–	–
Lepidocyrtus cyaneus Tulberg	–	–	–	–	3	–	–	2
L. ruber Schött	–	–	–	–	3	8	–	<1
Mesaphorura critica Ellis	1	–	–	–	–	–	–	–
Mesaphorura macrochaeta Rusek	4	7	14	3	1	–	–	–
Mesaphorura spp.	7	5	2	1	1	–	–	<1
Metaphorura affinis Börner	4	–	–	–	–	–	–	–
Orchesella bifasciata Nicolet	–	–	–	–	10	5	–	–
O. cincta Linnaeus	–	–	–	–	–	–	–	2
Pogonognatellus flavescens Tulberg	–	–	–	–	1	–	–	–
Proisotoma minima Absolon	1	2	–	–	–	–	–	–
P. minuta Tulberg	2	9	34	35	4	–	2	3
Pseudosinella alba Packard	–	–	–	–	–	–	3	1
Schoetella ununguiculata Tulberg	2	–	12	8	1	2	1	4
Sminthurinus aureus Lubbock	–	2	–	–	–	–	–	–
Xenyla brevicauda Tulberg	15	7	3	17	–	2	11	10

Table 3. Species similarity (% values of Marczewski and Steinhaus 1959, index for total individuals) of Collembola between communities, soil – on the right and grass litter on the left in the 7 years old shelterbelt – S, and adjacent field: $F_{0.5}$ – 0.5 m from the shelterbelt, F_{10} – 10 m from the shelterbelt, F_{50} – 50 m from the shelterbelt.

SOIL				
	S	$F_{0.5}$	F_{10}	F_{50}
S		47	61	67
$F_{0.5}$	36		46	64
F_{10}	27	55		70
F_{50}	41	46	58	
GRASS LITTER				

Table 4. Diversity of collembolan communities measured as the Shannon-Wiener H' index of 7 years old shelterbelt (S) and adjacent field ($F_{0.5}$ – 0.5 m from the shelterbelt, F_{10} – 10 m from the shelterbelt, F_{50} – 50 m from the shelterbelt.) in soil and grass litter exposed on the soil.

	S	$F_{0.5}$	F_{10}	F_{50}
soil	2.6 [a)]	2.6 [b)]	2.3	2.4
grass litter	2.5 [c)]	1.6 [e)]	2.2 [d)]	2.4

statistical significance in soil :
a) shelterbelt and field 10 m, $P < 0.05$,
b) fields 0.5 m and 10 m, $P < 0.05$,
c) shelterbelt and field 0.5 m, $P < 0.001$

statistical significance in grass litter
d) shelterbelt and field 10 m, $P < 0.05$,
e) field 0.5 m and other sites, $P < 0.001$

values significantly differed from those in the open field (10 m and 50 m from the shelterbelt) ($P < 0.05$). Species diversity was different in the litter (Table 4). The highest (statistically significant, $P < 0.05$) values of the index were found for the shelterbelt and for the open field (Table 4).

The highest percentage of young individuals in soil was recorded in the open field (56%) 50 m from the shelterbelt. In the litter high proportion of young individuals was also recorded in the field, but at the marginal zone and in the distance of 10 m from it (Table 5).

In all plots Oribatida were the dominating group among Acarina. Within this group, the number of species in the open field was several times smaller (3–5) than in the shelterbelt (11–14) in all sampling occasions. The maximum number of spe-

Table 5. Age structure (% of young individuals in total numbers of individuals) among Collembola of 7 years old shelterbelt (S) and adjacent field ($F_{0.5}$ – 0.5 m from the shelterbelt, F_{10} – 10 m from the shelterbelt, F_{50} – 50 m from the shelterbelt.) in soil and grass litter exposed on the soil.

	S	$F_{0.5}$	F_{10}	F_{50}
soil	30	38	22	56
grass litter	43	52	47	33

cies (18) was found, however, not in the wood strip but at the field's edge (0.5 m from the shelterbelt). *Tectocepheus velatus* was the dominating species everywhere and its numbers contribution varied from 32 to 70% of the total numbers. The proportion of young individuals of Oribatida in contrast to Collembola, was similar in all plots (30–55%), but the highest in the shelterbelt (48–55% of the total numbers).

Recorded Collembola species are widely distributed, belonged to common groups associated with open areas. Hemiedaphic species dominated in communities (Fig. 6) though their contribution in litter decreased in the favour of epigeic species (Fig. 7). Contribution of the latter in litter placed on the field decreased with the increasing distance from the shelterbelt (Fig. 7). Euedaphic species were represented less numerously than the former and their least share in the communities was noted in the field soil 50 m from the shelterbelt (Fig. 6).

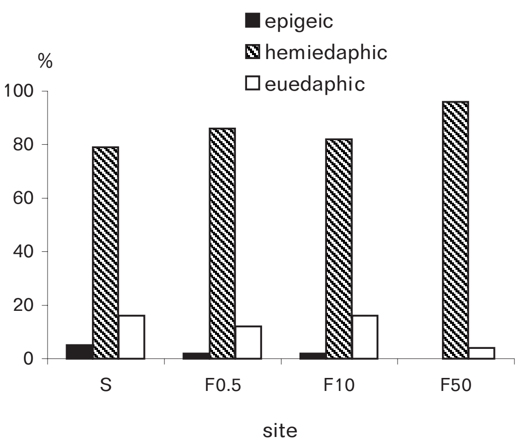

Fig. 6. Proportion (% of total numbers of individuals) of ecological groups in soil in 7-years old shelterbelt (S) and adjacent field: 0.5 m ($F_{0.5}$), 10 m (F_{10}), and 50 m (F_{50}) from the shelterbelt.

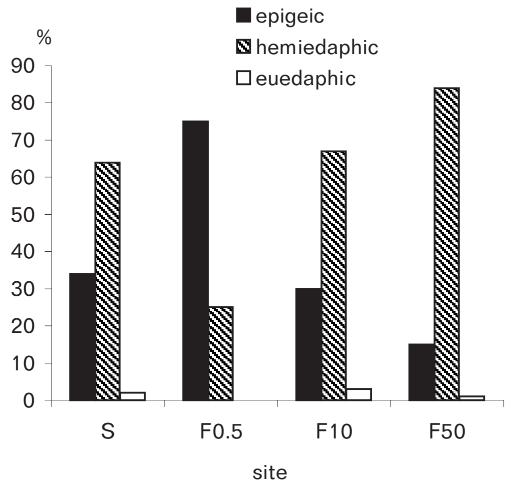

Fig. 7. Proportion (% of total numbers of individuals) of ecological groups in grass litter in 7-years old shelterbelt (S) and adjacent field: 0.5 m ($F_{0.5}$), 10 m (F_{10}), and 50 m (F_{50}) from the shelterbelt.

4. DISCUSSION

Collembola are represented numerously in soils of forest ecosystems. Agrocoenoses, can support similar or slightly lower densities of springtails than natural ecosystems situated on the same type of soil (Czarnecki 1989). Increasing intensity of management, using of pest control chemicals, herbicides and large doses of mineral fertilizers drastically reduce Collembola densities in the field soil (Edwards and Lofty 1975, Rusek 1998). Densities in the 7-years old shelterbelt recorded in this study (18.0×10^3ind. m^{-2} on average) were as high as the numbers found in a 5-years old pine thicket (11×10^3 ind. m^{-2} – 30×10^3 ind. m^{-2} (Czarnecki 1989). Observed phenomenon of decreasing density from the shelterbelts towards the middle of the field found in this study confirms the findings of other authors (Reddersen 1997).

The density of Collembola was estimated on the same area as presented here in the 80.s at 5.0×10^3 ind. m^{-2} – 41×10^3 ind. m^{-2} in loamy sand soils with various annual plant crops (Czarnecki 1989). Results (5.6×10^3 ind. m^{-2}– 7.1×10^3 ind. m^{-2}) obtained in this study fall within the minimal values of this range. Sterzyńska (1990) recorded lower densities, between 1.5×10^3 ind. m^{-2} and 6.9×10^3 ind. m^{-2} for crop-fields on loess soils derived from alluvial loam.

Densities of Acarina in field soils of the studied area were analysed in the seventies by Wasylik (1975) and in the beginning of the 80s by Czarnecki (after Karg and Ryszkowski 1996). Wasylik (1975) estimated mean density on the rye field to be 10×10^3 ind. m^{-2}. Czarnecki comparing various crops found an average density of 2.6×10^3 ind. m^{-2}, i.e the value similar to those presented here (2.8×10^3 ind. m^{-2} – 4.4×10^3 ind. m^{-2}).

In soils of crop fields Collembola constitute the main proportion of microarthropods, both in biomass and numbers, while in soils of meadows and forests dominate Oribatida (Żyromska-Rudzka 1976, Lagerlöf and Andren 1988, Kaczmarek and Kajak 1997, Vrecken-Buijs and Brussard 1996). Collembola are particularly important in ecosystems in the initial stage of succession after disturbances (Petersen 1994). In our study area, where the shelterbelts had been planted on post-crop soil, Collembola were the dominant group in both the shelterbelt and in the field.

The springtail density and seasonal variability of the numbers are however affected by many factors like temperature, moisture, food resources, soil pH or cultivation (Łosiński 1962, Kaczmarek 1963, 1973, 1975, 1978, Christiansen 1964, Butcher *et al.* 1971, Alvarez *et al.* 1997, Olejniczak 2000). Higher density of Collembola in 7-years old shelterbelt can probably be explained by the effect of vegetation cover (Czarnecki 1989) though this effect is exerted only indirectly through providing appropriate habitat for springtails (Dunger 1963, Christiansen 1964, Ponge 1993).

Many authors have reported two peaks of numbers, in spring and autumn, which coincided with a high moisture and relatively low temperature, the factors important for the springtail growth (Joosse 1969, Takeda 1979, Petersen 1980, Huhta and Mikkonen 1982). Such a seasonal dynamics is typical for communities in forest and meadow ecosystems. Agrocoenoses are characterised by a single peak in summer, which is associated with the growth of a crop (Blinnikov 1987, Czarnecki 1989). In the studied shelterbelt and adjacent field, two peaks (the spring and the autumn) of the density of Collembolla were found (Figs 1, 2, 3 and 4).

The number of Collembola species (8–10) present in the field soil as well as the density of animals was close to the minimum values (10–14) found on the same area by Czarnecki (1989) 25 years earlier. Diversity indices (H') calculated now (2.3–2.6) are, however, similar to those obtained previously (2.0–2.5). The number of species found in the shelterbelt (12) was not so much higher than that noted in the field. Nevertheless, diversity of the shelterbelt communities, in both soil and litter, was significantly higher than in various field plots. It may thus be assumed that the shelterbelt is important in preserving species diversity of Collembola in agricultural landscape. This conclusion is strengthened by experiments (Alvarez *et al.* 2000), which showed that hedgerows are the important sources for colonisation of adjacent fields, at least for some species. Species diversity decreased after introducing barriers obstructing this colonisation.

Higher number of insect species found in the shelterbelt soil as compared with the field might be associated with higher organic matter content (Hågvar 1982), with the presence of permanent vegetation or with management (Trojanowski and Szeptycki 1985).

In the field soil 50 m from the shelterbelt young individuals predominated in communities of Collembola. Similar tendencies were observed by Czarnecki (1989) who correlated it with the faster "turnover" of individuals and lower stability of agrocoenoses in comparison with the forest ecosystems. No such tendencies were noted in litter exposed on insect penetration.

Wind plays a great role in spreading of Collembola (Edwards and Lofty 1975). An active directional migration of individuals caused by changes in temperature, moisture, searching for food, competition or pheromones, is also possible (Christiansen 1970, Joosse and Verhoef 1974, Kaczmarek 1978, Fabian and Petersen 1994, Mebes and Filser 1997). Rate of this migration is species specific. Euedaphic species migrate much slower than epigeic ones (Petersen 1978, Usher 1985, Bauer and Christian 1993, Faber and Joosse 1993). Hågvar (1995) found that *Hypogastrura socialis* may cover 200 to 300 m daily on snow, although edaphic forms cover only small distances, e.g. less than 10 cm per day (Faber and Joose

1993, Ojala and Huhta 2001). Dispersal ability of oribatids is even weaker; for example specimens from the genus *Tectocepheus sp.*, most abundant in the area, it equals only 5 cm per week (Ojala and Huhta 2001).

It is likely that some species of Collembola could penetrate adjoining fields from the shelterbelt and that their dispersal was enhanced by the litter exposed in the field. The litter placed on the soil surface was also an attractive source of food and cover for Collembola. Dominant species in the litter on the field – *Entomobrya multifasciata* and *Isotoma viridis* are the pioneer species able to colonize rapidly a new areas, often found in early successional stages in disturbed habitats e.g. on coal-mining dumps. A colonizer *Proisotoma minuta*, numerous in the field soil also belongs to the group of pioneer species (Moore and Luxton 1986, Petersen 1995, Dunger 1968, 1991, Dunger *et al.* 2001). *Isotoma notabilis*, typical for later successional stages, was the only dominant species numerous in the shelterbelt but absent in the field. Our suggestion is, that collembolans dispersion from shelterbelt to the proximate fields can be supported by a high species similarity between soil communities of these two habitats, by common for both habitats dominant species and by the ability of some of them to colonize rapidly new areas. It is noteworthy, however, that the similarity of litter communities was smaller though the same kind of litter was placed in all the plots.

5. CONCLUSIONS

1. Mean density of microarthropods in soil was higher in the shelterbelt than in the adjacent field, but there was no difference between the numbers of these invertebrates which colonized the grass litter.
2. The estimated density of Collembola and Acarina was close to the lower values of the range recorded twenty years ago in the same sites and research areas.
3. The results suggest that Collembola disperse from the shelterbelt to the proximate field. This conclusion is based on the high species similarity between both ecosystems, common dominant species, ability of dominants to colonize new areas, low proportion in the total numbers of euedaphic species of low migratory ability.

ACKNOWLEDGEMENTS: This research was supported by a grant 6P0402816 of Polish Research Committee. I am grateful to dr Peter Petrov for access to his unpublished data. I wish to thank also dr Jerzy Karg for his generous help in receiving environmental characteristics and choosing the study site.

6. SUMMARY

Studies of Collembola communities were carried out during a year 2000 in a 7-years old shelterbelt and in the adjacent field 0.5 m, 10 m and 50 m from the afforestation. Soil and litter samples were taken on three sampling occasions in April, June and September to cover key periods in the crop plant growth. Ten soil samples of a diameter of 10 cm^2 were taken with the soil corer and ten samples (5 g each) of the cocksfoot litter (*Dactylis glomerata*) were taken on each sampling occasion. In total 120 soil samples and 120 litter samples were collected. The cocksfoot litter was exposed in containers on the surface of soil and covered with the nylon net of a mesh size of 1.0 mm. Ten grams of the cocksfoot litter was placed in each container. The containers had drilled holes 1 cm in diameter to enable free penetration by fauna. Collembola from collected samples were extracted in the Tullgren's apparatus. Significant differences were found in the density of Collembola in soil of the shelterbelt and of the adjacent field (P =0.003) but no such relationships were recorded for litter (P =0.06) (Table 1). Differences in the density of Acarina between the afforestation and the field were significant (Kruskall-Wallis test, P =0.0070). Densities of all taxa (Oribatida, Mesostigmata and Prostigmata) regularly decline with the increasing distance from the wood line (Table 1). The lowest densities of Collembola in all stands (in both soil and litter) were recorded in June of the low atmospheric precipitations and high temperature (Figs 1, 2, 3, 4). Dynamics of the numbers of Acarina was equalled during the vegetative season (Fig. 5).

Twenty three species of Collembola were found in collected material (Table 2). Both in soil and grass litter, in the shelterbelt the dominating species was *Isotoma notabilis* and in the adjacent field – *Entomobrya multifasciata* and *Isotomina thermophila*. *Proisotoma minuta* prevails in soil and *Isotoma viridis* in litter (Table 2). The Oribatida were dominated by *Tectocepheus velatus*, common to all plots.

The greatest species similarity of collembolans both in soil and litter was recorded in the field between plots 10 and 50 m from the shelterbelt (Table 3). The highest indices of species diversity of Collembola communities were found in soil of the shelterbelt and its closest vicinity (Table 4). In litter, however, the highest

indices were found for both the shelterbelt and the field 50 m apart (Table 4). The highest proportion of young individuals was noted in Collembola communities in the field, 50 m from the shelterbelt and in litter close to the shelterbelt (0.5 m) (Table 5). Insect communities were dominated by hemiedaphic species; the euedaphic ones were more numerous in litter than in soil (Figs 6 and 7).

It is likely that the studied shelterbelt plays an important role in supporting species diversity and density of Collembola in the field. Suggestion is supported by high community similarity between these ecosystems, and high ability of the dominant species to colonize new areas.

7. REFERENCES

Alvarez T., Frampton G. K., Goulson D. 1997 – Population dynamics of epigeic Collembola in arable fields: the importance of hedgerow proximity and crop type – Pedobiologia 41: 110–114.

Alvarez T., Frampton G. K., Goulson D. 2000 – The role of hedgerows in the recolonisation of arable fields by epigeal Collembola – Pedobiologia, 44: 516–526.

Bałazy S., Ziomek K., Weyssenhoff H., Wójcik A., 1998 – Zasady kształtowania zadrzewień śródpolnych [Guidelines for introduction of network of midfield shelterbelts] (In: Kształtowanie środowiska rolniczego na przykładzie Parku Krajobrazowego im gen. D. Chłapowskiego [Management of agricultural environment. The case of gen. Chłapowski Lanscape Park] Eds.: L. Ryszkowski, S. Bałazy) – Zakład Badań Środowiska Rolniczego i Leśnego PAN, Poznań, 49–65. (in Polish)

Banaszak J. 2000 – Ecology of forest islands – Bydgoszcz University Press, 313 pp.

Bauer R., Christian E. 1993 – Adaptations of three springtail species to granite boulder habitats (Collembola) – Pedobiologia 37: 280–290.

Bernacki Z., Szeflińska D., Łęcki R., Sobczyk D. (in press) – The development of midfield woodlots in the General D. Chłapowski Landscape Park – Pol. J. Ecol.

Blinnikov V. J. 1987 – Seasonal changes of soil microarthropod population in winter weat crops (In: Soil fauna and soil fertility. Proceedings of the 9th International Colloquium on Soil Zoology. Ed. B. R. Striganova) – Moscow.

Butcher J. W., Snider R., Snider J. 1971 – Bioecology of edaphic Collembola and Acarina – Ann. Rev. of Entomol. 16: 249–287.

Cernova N. M., Byzova Ju. B., Cernova A. I. 1971 – Relationship of number, biomas and gaseous exchange rate indices in microarthropods in substrates with various organic matter contents – Pedobiologia 11: 306–314.

Christiansen K. 1964 – Bionomics of Collembola – Ann. Rev. of Entomol. 9: 147–178.

Christiansen K. 1970 – Experimental studies on the aggregationand dispersion of Collembola. – Pedobiologia 10: 180–198.

Coleman D. C. 1985 – Through a ped darkly: An ecological assessment of root-soil-microbial-faunal interactions. (In: Ecological Interactions in Soil. Eds.: A.H. Fitter, D. Atkinson, D. J. Read and M. B. Usher) – Special Publ. No 4, Br. Ecol. Soc.: 1–21.

Czarnecki A. 1989 – Collembola jako element biologicznego systemu na obszarach podlegających silnej antropopresji [Collembola as a component of biological system of the areas under strong anthropopresion] Habilitation Thesis – UMK, Toruń 156 pp. (in Polish)

Dennis, Fry 1992 – Field margins: can they enhance natural enemy population densities and general arthropod diversity on farmland? – Agric.Ecosystem Environ. 40: 95–115.

Dunger W. 1963 – Leistungsspezifität bei Streuzersetzern (In: Soil organisms, Eds.: J. Doeksen, J. Van der Drift) – North-Holland Publ. Comp. Amsterdam: 92–102.

Dunger W. 1968 – Die Entwicklung der Bodenfauna auf rekultivierten Kippen und Halden des Braunkohlentagebaues – Abb. Ber. Natur., Görlitz, 43: 1–256.

Dunger W. 1991 – Zur Primärsukzession humiphager Tiergruppen auf Bergbufachen – Zool. Jb. Syst., 118: 423–447.

Dunger W., Wanner M., Hauser M., Hohberg K., Schulz H., Schwalbe T., Voigtläder K., Zimdars B., Zulka P. 2001 – Development of soil fauna at mine sites during 46 years after afforestration – Pedobiologia, 45: 243–272.

Edwards, Lofty 1975 – The influence of cultivations on soil animal populations. In: Progress in Soil Zoology. Vanek J. (Ed.) Prague. Academia, 399–407.

Faber J. H., Joosse E. N. 1993 – Vertical distribution of Collembola in a Pinus nigra organic soil – Pedobiologia, 37: 336–350.

Fabian M., Petersen H. 1994 – Short term effects of the insecticide dimethoate on activity and spatial distribution of a soil inhabiting collembolan *Folsomia fimetaria* Linne (Collembola: Isotomidae) – Pedobiologia 38: 289–302.

Gisin H. 1960 – Collembolenfauna Europas – Museum D'HIstorie Naturelle, Geneva.

Hågvar S. 1982 – Collembola in Norwegian coniferous forest soils I. Relations to plant communities and soil fertility – Pedobiologia 24: 255–296.

Hågvar S. 1995 – Long distance, directional migration on snow in a forest collembolan, Hypogastrura socialis (Uzel) – Acta Zool. Fennica, 196: 200–205.

Heisler C. 1995 – Collembola and Gamasina – bioindicators for soil compaction – Acta zool. Fennica 196: 229–231.

Huhta V., Mikkonen M. 1982 – Population structure of Entomobryidae (Collembola) in a mature spruce stand and in a clear-cut reforested area in Finland – Pedobiologia 24: 231–240.

Huhta V., Setala H., Haimi J. 1988 – Leaching of N and C from birch leaf litter and raw humus with special emphasis on the influence of soil fauna – Soil Biol. Biochem. 20: 875–878.

Hutcheson K. 1970 – A test for comparing diversities based on the Shannon formula – J. Theor. Biol. 29: 151–154.

Joosse E. N. G. 1969 – Population strucure of some surface dwelling Collembola in coniferous forest soil – Neth.J.Zool. 19: 621–634.

Joosse E. N., Verhoef H. A. 1974 – On the aggregation habits of surface dwelling Collembola – Pedobiologia, 14: 245–249.

Kaczmarek M. 1963 – Jahreszeitliche Quantitasschwankundgen der Collembolen versche=iedener Waldbiotope der Puszcza Kampinoska – Ekol. pol. A, 11: 127–139.

Kaczmarek M. 1973 – Collembola in biotopes of Kampinos National Park distingushed according to the natural succesion – Pedobiologia 13: 257–272.

Kaczmarek M. 1975 – An analisis of Collembola communities in different pine forest environments – Ekol. pol. 23: 265–293.

Kaczmarek W. 1978 – Die lokomotorische Aktivität der Bodenfauna als Parameter der tropischen Struktur und der Sukzession von Waldöekosystemen – Pedobiologia 18: 434–441.

Kaczmarek M. 1981 – Metody oceny gęstości populacji. Collembola [Methods for estimating collembolan densities] (In: Metody stosowane w zoologii gleby [Methods for studying soil zoology] Eds.: M. Górny, L. Grüm) – PWN, Warszawa, 482 pp. (in Polish)

Kaczmarek M., Kajak A. 1997 – Mcroarthropods and decomposition processes in meadow of various plant richness – Ekol. pol., 45: 795–813.

Karg J. 1998a – Ogólna charakterystyka obszaru Parku Krajobrazowego im. gen. D. Chłapowskiego [General characteristics of an area of gen. Chłapowski Landscape Park] (In: Kształtowanie środowiska rolniczego na przykładzie Parku Krajobrazowego im gen. D. Chłapowskiego [Management of agricultural environment. The case of gen. Chłapowski Lanscape Park] Eds.: L. Ryszkowski, S. Bałazy) – Zakład Badań Środowiska Rolniczego i Leśnego PAN, Poznań, 11–18. (in Polish)

Karg J. 1998b – Różnorodność zwierząt Parku Krajobrazowego im gen. D. Chłapowskiego i ich ochrona [Species diversity of animals and their protection in the gen. D. Chłapowski Landscape Park] (In: Kształtowanie środowiska rolniczego na przykładzie Parku Krajobrazowego im gen. D. Chłapowskiego [Management of agricultural environment. The case of gen. Chłapowski Lanscape Park] Eds.: L. Ryszkowski, S. Bałazy) – Zakład Badań Środowiska Rolniczego i Leśnego PAN, Poznań: 133–142. (in Polish)

Karg J. Ryszkowski L. 1996 – Animals in arable land. (In: Dynamics of an agricultural landscape. Eds.: L. Ryszkowski., N. R. French, A. Kędziora)

Kopeszki H. 1997 – An active bioindication method for the diagnosis of soil properties using Collembola – Pedobiologia 44: 159–166.

Lagrlöf J., Andren O. 1988 – Abundance and activity of soil mites (Acari) in four cropping systems – Pedobiologia, 32: 129–145.

Łosiński J. 1962 – Dalsze studia nad liczebnością Collembola w glebach pól uprawnych. [Further studies on abundamnce of Collembola in arable fields] – St. Soc. Sci. Tor. 6, 14: 1–30. (in Polish)

Marcinek J. 1996 – Soils of the Turew agricultural landscape (In: Dynamics of an agricultural landscape. Eds.: L. Ryszkowski, N. French, A. Kędziora) – PWRiL, Poznań, 19–26.

Marczewski E., Steinhaus H. 1959 – Zastosowanie matematyczne [Mathematical application] – Warszawa–Wrocław, 195–203. (in Polish)

Mebes K. H., Filser J. 1997 – A method for estimating the significance of surface dispersal for population fluctuations of Collembola in arable land – Pedobiologia, 41: 115–122.

Moore F. R., Luxton M. 1986 – The collembolan fauna of two coal skale tips in northwest England – Pedobiologia, 29: 359–366.

Ojala R., Huhta V. – 2001 – Dispersal of microarthropods in forest soil – Pedobiologia 45: 443–450.

Olejniczak I. 2000 – Effect of simplification of grass cultures and soil conditions on Collembola(Apterygota) communities in a lysimetric experiment – Pol. J. Ecol., 48, 3: 209–224.

Petersen H. 1978 – Sex ratio and the extent of parthogenetic reproduction in some Collembola populations. (In: Dallai R. Ed). First International Seminar on Apterygota. Accademia della Scienze di Siena detta de' Fisiocritici, Siena 19–35.

Petersen H. 1980 – Population dynamic and metabolic characterization of Collembola species in a beech forest ecosystem (In: Soil Biology as Related to Land Use Practices. Ed. D. L. Dindal) – EPA, Washington, 806–833.

Petersen H. 1994 – A review of Collembolan ecology in ecosystem context – Acta Zool. Fenn., 195: 111–118.

Petersen H. 1995 – Temporal and spatial dynamics of soil Collembola during secondary succession in Danish heatland – Acta Zool. Fenn., 196: 190–194.

Ponge J. F. 1993 – Biocenoses of Collembola in atlantic temperate grass-woodland ecosystems – Pedobiologia 37: 223–244.

Reddersen J. 1997 – The arthropod fauna of organic versus conventional cereal fields in Denmark. Biological Argiculture and Horticulture 15, 15: 61–71.

Rusek J. 1982 – European Mesaphorura species of the sylvatica – group (Collembola, Onychiuridae, Tullbergiine) – Acta ent. Bohemoslow, 79: 14–30.

Rusek J. 1998 – Biodiversity of Collembola and their functional role in the ecosystem – Biodivers. Conserv., 7: 1207–1219.

Ryszkowski L. 1998 – Opracowanie ekologicznych zasad ochrony i kształtowania Parku Krajobrazowego im. gen D. Chłapowskiego [Ecological guidelines for management of gen. D. Chłapowski Landscape Park] (In: Kształtowanie środowiska rolniczego na przykładzie Parku Krajobrazowego im gen. D. Chłapowskiego [Management of agricultural environment. The case of gen. Chłapowski Lanscape Park] Eds.: L. Ryszkowski, S. Bałazy) – Zakład Badań Środowiska Rolniczego I Leśnego PAN, Poznań, 5–9. (in Polish)

Shannon C. E., Wiener W. 1963 – The mathematical theory of communication – Univ. of Illionois Press, Urbana 117 pp.

Siegel S. 1956 – Nonparametric statistics for the behavioral sciences – Mc Graw-Hill Book Comp. New York, Toronto, London, 312 pp.

Southerton N. W. 1984 – The distribution and abundance of predatory arthropods overwintering on farmland. – App. Biol. 105: 423–429.

Stach J. 1955 – Klucze do oznaczania owadów Polski. Cz. II, Skoczogonki – Collembola [Guide of insects of Poland. Part II, Springtails – Collembola] – PWN, Warszawa. (in Polish)

Sterzyńska M. 1990 – Communities of Collembola in natural and transformed soils of the linden-oak-hornbean sites of Mazovian Lowland – Frag. fau. 34: 165–262.

Striganova B. R. 1992 – Trophic relations in soil animal communities and decomposition rates – Pol. Ecol. Stud. 16: 119–130.

Szanser M. 2003 – The effect of shelterbelts on litter composition and fauna of adjacent fields: *in situ* experiment – 3: 309–323.

Takeda H. 1979 – Ecological studies on collembolan populations in a pine forest soil. 3. Life cycles and population dynamics of some surface dwelling species – Pedobiologia 19: 34–47.

Trojanowski H., Szeptycki A. 1985 – Fauna drobnych bezkręgowców lucerny. II. Apterygota (Collembola). [Fauna of small inverttebrates of alfaalfa crop] – Prace Naukowe Instytutu Ochrony Roślin, 27, 1: 43–71. (in Polish)

Usher M. B. 1985 – Population and community dynamics in the soil ecosystem. In: Biological interactions in soil. Eds.: Fitter A. H., Atkinson D.) – Blackwell Scientific Publishers, Oxford 243–265.

Wasylik A. 1975 – The mites (Acarina) of potatoes and rye fields in the environs of Coryń in 1973 – Pol. Ecol. Stud., 1: 83–93.

Wojewoda D., Russel S. 2003 – The impact of a shelterbelt on soil properties and microbial activity in an adjacent crop field – Pol. J. Ecol., 51: 291–309.

Vrecken Buijs M. J., Brussard L. 1996 – Soil mesofauna dynamics wheat residue decomposition and nitrogen mineralization in burried litterbags – Biology and Fertility of Soils, 23: 374–381.

Żyromska-Rudzka H. 1976 – The effect of mineral fertilization of a meadow on the oribatid mites and other soil mesofauna – Pol. ecol. Stud., 2: 157–182.

(Received after revising November 2003)