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COMMUNITY STRUCTURE OF SOIL-LITTER MACROFAUNA IN SHELTERBELT AND ADJACENT CROP FIELD

ABSTRACT: Studies were carried out in 1999 and 2000 in the vicinity of Turew near Poznań (West Poland) and dealt with the composition, density and biomass of soil-litter macrofauna with special reference to dipteran larvae in the agricultural landscape. Sites were located on a 7-years old mid-field shelterbelt and on adjacent field with maize crop in the first and wheat crop in the second year of study and – on 9 various patches of vegetation within the mid-field shelterbelt.

Studies carried out along the transect: the shelterbelt (S) – ecotone (E) – field 10 m (F 10)– field 50 m (F 50) demonstrated a decline of: 1) animal density (10 times) and biomass (30 times) of total macrofauna and (80 times) of dipteran larvae, 2) taxonomic richness and biodiversity measured with the H` index, 3) individual weight of the entire macrofauna, of dipteran larvae, saprophagous animals and predators so that the individuals became smaller with the distance from the shelterbelt, 4) similarity of macrofauna communities in terms of composition and dominance structure, with increasing distance between plots.

Close relationship was found between plant cover and soil-litter macrofauna. Species composition, density, biomass and trophic structure of soil invertebrate community depended on tree or herb species. Those soil animals and especially dipteran larvae were a sensitive indicator of small-scale habitat changes.

KEY WORDS: agricultural landscape, mid-field shelterbelts, macrofauna, dipteran larvae, dominance structure, trophic structure, biomass, density

1. INTRODUCTION

Shelterbelts near Turew (West Poland) were planted in the twenties of the XIX century by General D. Chłapowski – a precursor of modern agriculture in Poland. The main aim of these wood strips was to play a role of windshields. As demonstrated in later studies, old shelterbelts perform many important functions: they favorably affect local microclimate and water budget of surrounding fields (Ryszkowski and Kędziora 1987), they are biogeochemical barriers (Bartoszewicz and Ryszkowski 1996) and play a role of refuges and ecological corridors for organisms thus supporting and maintaining biodiversity of croplands (Dąbrowska-Prot 1987, Karg 1995, Karg and Ryszkowski 1996b).

New plantings of shelterbelts, which started near Turew in 1993 (Kujawa and Karg 1998) enabled to follow subsequent

stages of plant and animal succession and to evaluate the effect of shelterbelts on adjacent fields during their growth and "maturing". Mainly above-ground fauna was studied on newly established shelterbelts (Karg 1995, 1998, Karg and Ryszkowski 1996a), the soil fauna was studied less intensively. This fauna, being less mobile and thus more tightly associated with the habitat, is a more sensitive index of environmental changes. Soil invertebrates are a good indicator of habitat conditions like: type of soil and humus (Wallwork 1970, Stork and Eggleton 1992, David *et al.* 1993), soil fertility (Olechowicz 1986, 1995, Schaefer and Schauermann 1990), soil pH, moisture and temperature (Rubcova 1967, van der Drift 1967, Kaczmarek 1979). Soil animals are also sensitive to industrial pollution, fertilization and agrotechnical measures (Vanek 1967, Pfeffer 1968, Olechowicz 1976, 1995, Paplińska 1984, 1987, Lobry de Bruyn 1997). Decomposition rate and recycling of components of dead organic matter depend largely on the composition, density and biomass of soil invertebrates (Coleman 1985, Zlotin 1985, Anderson 1988).

The objective of the investigations was: 1) evaluation of the impact of young shelterbelts on composition, density and biomass of soil-litter macrofauna in arable land and 2) assessment of the impact of the patchiness of plant cover inside midfield shelterbelt on the structure of macrofaunal community.

2. STUDY AREA, METHODS AND MATERIAL

Studies were carried out in the vicinity of Turew near Poznań (West Poland) in 1999 and 2000.

A transect has been drawn from the shelterbelt towards the field center through the following plots: a 6-years old shelterbelt, an ecotone (contact zone between the shelterbelt and the field), adjacent field at a distance of 10 and 50 m from the wood's edge with maize crop in 1999 and wheat crop in 2000.

The effect of patches of different plant species (trees and undergrowth) within the shelterbelt on the composition and density of soil-litter animals was evaluated. The following small patches (area several m^2) of vegetation have been distinguished: 1) pine (*Pinus silvestris*), 2) spruce (*Picea excelsa*), 3) larch (*Larix decidua*), 4) birch (*Betula verrucosa*), 5) oak (*Quercus robur*), 6) thistle (*Cirsium ravens*), 7) couch grass (*Elymus repens*), 8) hawkweed (*Heracleum sp.*) and 9) dock (*Rumex acetosa*).

Detailed description of the area and study sites can be found in Ryszkowski *et al.* (2003), Kostro-Chomać (2003), Wojewoda and Russel (2003).

For assessing the effect of shelterbelt on the adjacent field 10 soil cores (100 cm^2 in area and 15 cm of depth) were taken along the transect from every plot on each sampling date. Samples were taken from May till October, four times in 1999, and three times in 2000. For evaluating the effect of mosaic structure of the shelterbelt on macrofauna 3 soil samples were taken per every patch, in June and September 2000.

Animals were extracted from soil by Kempson, Lloyd and Ghelardi method (1963). Extraction lasted 10 days – until total drying of the soil. Picric acid was used as preserving liquid during extraction.

Biomass was calculated as a product of density and mean dry weight of individuals within the size class of a given taxon. Before weighing the animals were dried at a temperature of 85°C.

The following statistical processing of results are involved:
- nonparametric analysis of variance – Kruskall-Wallis test,
- comparison between plots with the Student's t-test,
- Shannon and Weaver`s H' biodiversity index,
- indices of similarity of animal communities:
  - after Marczewski and Steinhaus (1959) which compares the composition of communities:
    $s = w/(a+b-w)$ (1)
  - Romaniszyn's (1970) modification which compares the dominance structure:
    $S=C/(200-C)$ (2)

where: s, S – similarity of two compared communities, a – the number of taxa in community A, b – the number of taxa in community B, w – the number of taxa common for community A and B, C – the sum of lower percentage shares of particular taxa of the two compared communities.

Soil-litter invertebrates, which, according to van der Drift (1951) may be classified as macrofauna (size between 2 and 20 mm), were the object of this study. Two groups were distinguished:
– Group I – soil animals, closely associated with soil and litter, in which they grow and feed,
– Group II – litter or epigeic animals, mainly present on the litter surface, and able to move to other ecosystem layers.

3. RESULTS

3.1. Macrofauna of the transect from the shelterbelt to the field

3.1.1. Composition and numbers of macrofauna

Nineteen soil-litter animal taxa were found in the studied transect (Table 1). Nine taxa of the I Group were represented by insect larvae, annelids and myriapods, Group II with 10 taxa comprised adult insects and arachnids. The greatest taxonomic richness (17 taxa) in each plot was found in the shelterbelt and ecotone and the lowest in the field 10 m from the shelterbelt (11 taxa). Numbers of dipteran larvae and imagines of Staphylinidae, Hymenoptera and Araneae decreased with the increasing distance from the shelterbelt. Other taxa like heteropteran larvae, Lumbricidae, Symphyla, imagines of Coleoptera, Formicidae and Thysanoptera decreased in numbers towards the field plot 10 m from the shelterbelt and then increased in the field plot 50 m from the shelterbelt. Still other taxa like coleopteran larvae and Homoptera reached maximum density in the ecotone. Chilopoda and imagines of Heteroptera did not enter the field.

The highest density of macrofauna in both groups (1728 ind.m^{-2}) was found in the

Table 1. Composition, mean density (x–ind.m^{-2}) and percent contribution of soil-litter macrofauna along the studied transect (two years of study, May – October) for two Groups of fauna: I – soil fauna, II – epigeic fauna.

	Taxon	Shelterbelt			Ecotone			Field 10 m*			Field 50 m*		
		x	SD	%	x	SD	%	x	SD	%	x	SD	%
Group I	Insect larvae:												
	Diptera	307.6	227.3	18	137.1	139.7	12	35.7	60.2	21	25.7	13.9	8
	Coleoptera	339.3	301.6	20	341.4	280.6	30	35.7	45.4	21	58.6	90.4	18
	Heteroptera	58.6	104.3	3	10.0	15.1	1	2.8	4.8	2	15.7	41.5	5
	Homoptera	11.8	16.7	<1	14.3	25.0	1	2.8	7.5	2	7.1	18.9	2
	Others				1.4	3.7	<1				1.4	3.7	<1
	Lumbricidae	12.8	17.9	<1	7.1	9.5	<1				1.4	3.7	<1
	Enchytraeidae	45.7	70.2	3	14.3	25.7	1	25.7	68.0	15	2.9	7.5	1
	Symphyla	462.4	538.2	27	300.0	406.1	26	34.3	43.1	20	120.0	128.0	36
	Chilopoda	34.6	19.2	2	20.0	21.6	2						
	Total	1272.8	1032.5	74	845.6	572.8	74	137.0	127.6	81	232.8	237.6	70
Group II	Insect imagines:												
	Diptera	68.2	124.4	4	104.3	211.5	9	14.3	21.4	9	11.4	22.6	3
	Coleoptera	56.4	46.4	3	27.1	22.1	2	5.7	5.3	3	12.9	25.6	4
	Staphylinidae	82.4	80.1	5	32.9	38.1	3	2.9	4.8	2	1.4	3.7	<1
	Aphidoidea	3.0	5.1	<1							30.0	79.3	9
	Heteroptera	0.5	1.4	<1	1.4	3.7	<1						
	Hymenoptera	37.0	15.9	2	7.1	7.5	<1	4.3	5.3	3	1.4	3.7	<1
	Formicidae	131.2	269.5	8	95.7	200.9	8				37.2	93.9	11
	Thysanoptera	59.2	66.3	3	12.9	13.8	1				2.9	4.8	1
	Aranea	17.3	14.9	1	15.7	16.1	1	2.8	4.8	2			
	Opiliones										1.4	3.7	<1
	Total	455.4	362.8	26	297.1	466.1	26	30.0	26.4	19	98.6	113.6	30
	All macrofauna	1728.2	1163.6	100	1142.7	972.0	100	167.0	122.0	100	331.4	330.2	100
	Number of taxa	17			17			11			16		
	H' index	3.14			2.88			2.84			2.88		

* distance from shelterbelt.

shelterbelt. The density decreased towards the field to reach the lowest value of 167 ind.m^{-2} at a distance of 10 m and twice that value at a distance of 50 m from the shelterbelt (Table 1). Numbers of animals of the Group I were much higher than those of the Group II and varied from 70 to 82% of the total number of macrofauna. Most numerous animals of the Group I were Symphyla, larvae of Coleoptera and Diptera. Most numerous of the Group II were Formicidae and imagines of Coleoptera and Diptera.

Between-site differentiation of the numbers of animals was statistically significant (Table 2A), The highest differences were found between the shelterbelt and ecotone on the one hand and the field 10 and 50 m distance from shelterbelt – on the other. The least statistically significant differences were found between the shelterbelt and the ecotone and between two field plots (Table 2B).

Table 2. Statistical significance of the differences of mean values of animal densities (Groups: I – soil fauna, II – epigeic fauna and selected taxa). (S – shelterbelt, E – ecotone, F10, F50 – field). A. – among transect plots and inside shelterbelt patches (analysis of variance, the Kruskall-Wallis test) for spatial and temporal series of data; B.) between pairs of plots in the transect: shelterbelt – ecotone – field (t-test), a–g animal taxa as in Table 2A.

A.

Communities	Transect S-E-F10-F50		Patches inside shelterbelt	
	spatial	temporal	spatial	temporal
a) Total macrofauna	***	***	n.s.	***
b) Group I	***	***	n.s	***
c) Group II	**	*	n.s.	n.s.
d) Diptera larvae	**	n.s.	*	n.s
e) Coleoptera larvae	**	***	n.s.	**
f) Symphyla	***	***	n.s.	**
g) Chilopoda	***	n.s.	*	n.s.

B.

	Shelterbelt		Ecotone		Field 10m
Ecotone	a *				
	b *				
Field 10m	a ***	e ***	a ***	e ***	
	b ***	f ***	b ***	f **	
	c ***	g ****	c **	g ****	
	d **		d *		
Field 50m	a ***	e ***	a ***	e ***	a *
	b ***	f ***	b ***	g ****	c *
	c *	g ****	d **		f **
	d **				

* P <0.05 ** P <0.01 *** P <0.001 **** P <0.0001

Temporal variability of the animal numbers was high. The differences for entire macrofauna, for particular groups and for most taxa were statistically significant (Table 2A). Some differences in the numbers of animals were also noted between years (Fig. 1). The numbers of macrofauna and of both its groups in the shelterbelt were lower in 2000 than in 1999 while in the ecotone and in the field an increase in numbers between the two years was observed. A switch from maize to wheat crops on the field was probably the reason for such differences. Recorded differences were not, however, statistically significant.

Most similar as to the composition and domination structure were the communities from the shelterbelt and ecotone and the least similar – those in the field 10 m and 50 m from the shelterbelt (Table 3). Similarity of the shelterbelt to other plots decreased with the distance. Similar situation was with the ecotone. The shelterbelt showed a closer similarity of animal domination structure with the field than did the ecotone.

Differentiation of animal communities measured with the biodiversity index H' was highest in the shelterbelt (3.14) and relatively high and uniform (2.8) in other sites.

Table 3. Similarity of animal communities along the studied transect from shelterbelt to the field a) of entire macrofauna, b) of dipteran larvae measured by two indexes – s (Marczewski and Steinhaus 1959) and – S (Romaniszyn 1970) (see Methods).

		Shelterbelt		Ecotone		Field 10 m	
		s	S	s	S	s	S
Ecotone	a	0.8 8	70.3				
	b	0.56	39.3				
Field 10m	a	0.65	59.7	0.65	56.2		
	b	0.36	26.3	0.45	34.2		
Field 50m	a	0.73	58.6	0.73	55.1	0.59	40.6
	b	0.36	35.2	0.33	41.1	0.43	34.9

s – index of similarity of composition

S – index of similarity of dominance structure.

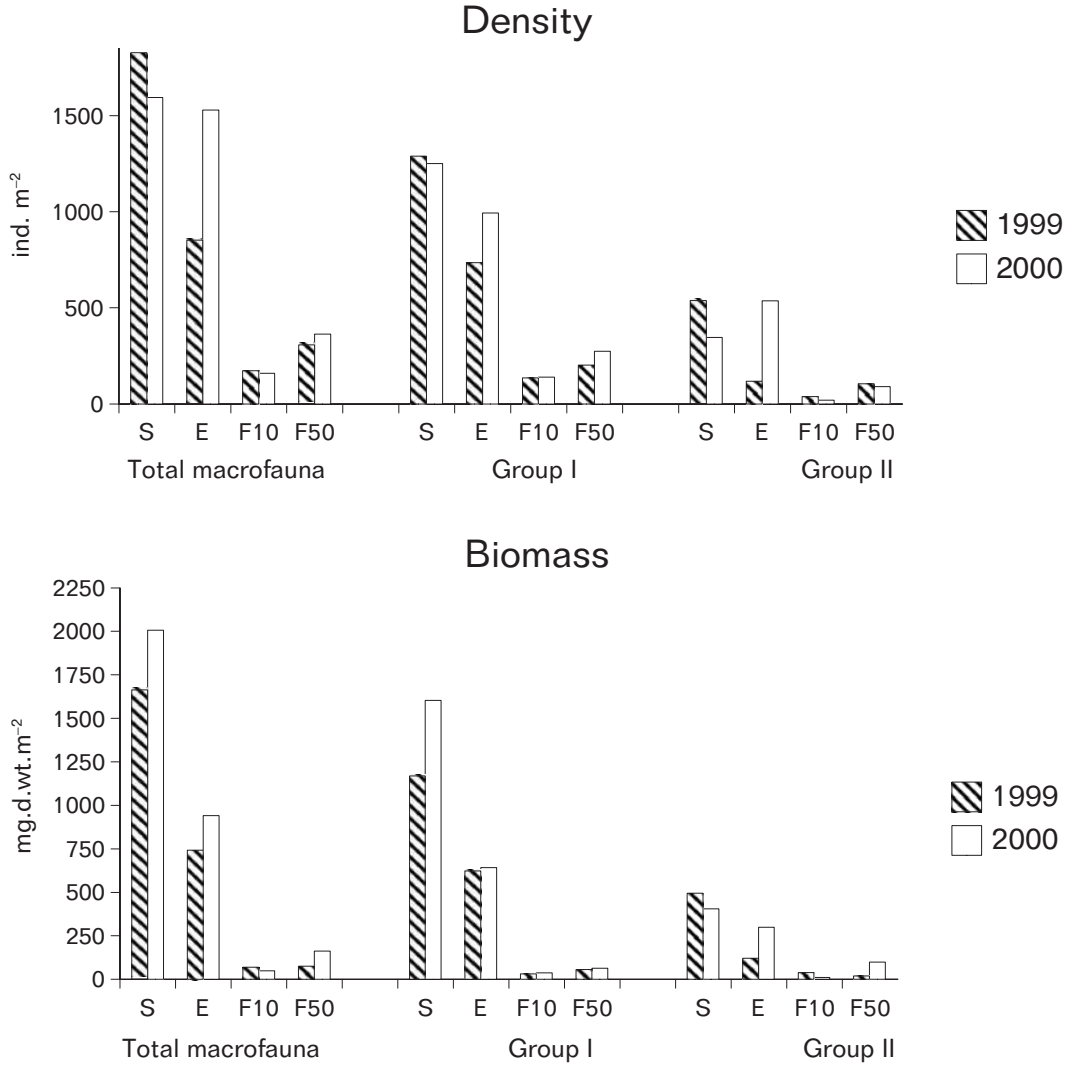

Fig. 1. Mean (May – October) density and biomass of animals along the transect in two subsequent years.
S – shelterbelt, E – ecotone, F10, F50 –field, (10 – 50; distance in meters from shelterbelt), Group I – soil fauna, Group II – epigeic fauna.

3.1.2. Composition and density of dipteran larvae

Larvae of Diptera were the most numerous taxon of the studied macrofauna. Representatives of 16 families of dipteran larvae were recorded along the transect (Table 4). Three families were common for all sites: Cecidomyiidae, Dolichopodidae and Empididae. Most families (14) were found in the shelterbelt, 11 – in the ecotone and only 5 families in both field plots. Diversity of the animals was markedly impoverished in the field, which was confirmed by the H' index value higher for the shelterbelt and ecotone (2.67–2.62) than for the field (1.39–1.98).

Density of dipteran larvae was the highest in the shelterbelt (308 ind.m^{-2}) and decreased towards the field to reach 26 ind.m^{-2} 50 m far from the shelterbelt. Most numerous in the whole transect were the larvae of Cecidomyiidae and Dolichopodidae, which attained the highest densities in the strip and whose numbers decreased towards the field. The highest percentage of Cecidomyiidae in the whole community (68%) was found in the field 10 m

Table 4. Composition, mean density (x – ind. m^{-2}), standard deviation (SD) and percentage contribution of families of dipteran larvae along the transect (means for two study years, May–October).

Family	Shelterbelt			Ecotone			Field 10 m			Field 50 m		
	x	SD	%	x	SD	%	x	SD	%	x	SD	%
Anthomyiidae	1.1	2.8	<1									
Asilidae	2.9	7.5	1	1.4	3.7	1						
Bibionidae	89.0	235.1	29									
Cecidomyiidae	76.6	76.8	25	52.8	94.5	38	24.3	55.6	68	7.1	14.9	28
Ceratopogonidae				10.0	26.4	7						
Chironomidae	35.2	17.3	11	31.4	38.0	23				5.7	7.8	22
Dolichopodidae	43.6	70.9	14	8.6	10.7	6	7.2	6.8	20	10.0	11.5	39
Empididae	0.5	1.4	<1	2.9	4.8	2	1.4	3.8	4	1.4	3.8	6
Muscidae				1.4	3.7	1						
Psychodidae	0.6	1.6	<1	1.4	3.7	1	1.4	3.8	4			
Sciaridae	39.2	76.7	13	12.9	19.7	9.4						
Sphaeroceridae	3.0	7.6	1	10.0	19.1	7.3						
Stratiomyiidae	6.9	7.1	2	4.3	11.3	3.1	1.4	3.8	4			
Therevidae	2.0	3.8	<1									
Tipulidae	3.6	4.7	1									
Trichoceridae	4.4	11.3	1							1.4	3.8	5
Total	307.6	227.3	100	137.1	139.7	100	35.7	60.2	100	25.7	13.9	100
Number of families	14			11			5			5		
H' index	2.67			2.62			1.39			1.98		

from the strip and that of Dolichopodidae in the field 50 m from the shelterbelt (39%). Larvae of Bibionidae attained the highest contribution (29%) in the shelterbelt and were present only in this site. Besides, larvae of Therevidae and Tipulidae were the exclusive inhabitants of the shelterbelt. Numerous in the shelterbelt were also larvae of Chironomidae and Sciaridae. Most numerous in the ecotone were larvae of Cecidomyiidae and Chironomidae.

The numbers of dipteran larvae communities showed a high statistically significant variability in all sites of the transect (Table 2A). A comparison between pairs of sites showed that the shelterbelt and ecotone significantly differed from both field sites in the densities of dipteran larvae (Table 2B). Differences in the density between the shelterbelt and ecotone and between the 10 m and 50 m field plots were not statistically significant.

Composition and numbers of dipteran larvae were most similar in the shelterbelt and ecotone (Table 3). The ecotone and the field 50 m from the shelterbelt were least similar in the community composition (Marczewski – Steinhaus index "s"). The least similar domination structures (Romaniszyn index "S") were found between the shelterbelt and the field 10 m apart.

3.1.3. Biomass of macrofauna

Variation of animal biomass was similar to that of animal numbers in particular sites of the transect (Table 5). Mean biomass of the entire macrofauna and of its both groups was highest in the shelterbelt (1810 mg d.wt. m^{-2} on average), decreased almost twice in the ecotone, dropped to 60.3 mg in the field 10 m from the strip and increased again to 112 mg d. wt. m^{-2} in the farther field plot. So, the between-plot differences in animal biomass were even higher than those in animal numbers. Group I of animals (soil fauna) had a great share in total biomass, particularly in the shelterbelt and ecotone (75–76%). In comparison with densities, contribution of this group to the total biomass decreased in the field (53–56%). Domination of particular taxa was also different; low-abundant Lumbricidae had a marked contribution to the biomass (from 13% in the field to 26% in the ecotone). Adult beetles and ants increased their share in the total biomass. Larvae of Coleoptera and Diptera contributed much to both the numbers and biomass. Different animals dominated in biomass in particular sites. In the shelterbelt, dipteran larvae were the dominants, abundant were also earthworms and beetles. Biomass in

the ecotone was dominated by larvae of Coleoptera and Lumbricidae, in the field 10 m from the shelterbelt – by larvae and imagines of Coleoptera and in the field 50 m from the shelterbelt – by Formicidae with a large contribution of coleopteran larvae and earthworms.

Animal biomass varied only slightly between years (Fig. 1) being a bit higher in 2000, especially that of Group I (soil fauna).

Table 5. Mean biomass (x– mg d.wt. m^{-2}), standard deviation (SD) and percentage contribution of taxa of soil-litter macrofauna along the studied transect (two study years, May–October). Group I – soil fauna, Group II – epigeic fauna.

	Taxon	Shelterbelt			Ecotone			Field 10 m*			Field 50 m*		
		x	SD	%	x	SD	%	x	SD	%	x	SD	%
Group I	Insect larvae:												
	Diptera	730.8	1315.6	40	51.7	69.8	6	9.1	9.7	15	8.9	7.5	8
	Coleoptera	148.4	108.1	8	290.1	260.1	35	12.8	13.1	21	15.3	16.6	14
	Heteroptera	13.7	21.5	1	1.1	2.0	<1	0.3	0.5	<1	1.6	4.1	1
	Homoptera	2.8	3.8	<1	2.6	4.4	<1	0.6	1.5	1	1.4	3.8	1
	Others				0.6	1.5	<1				5.0	13.2	5
	Lumbricidae	360.7	694.5	20	214.3	298.2	26				14.3	37.8	13
	Enchytraeidae	19.0	21.1	1	20.6	44.4	3	7.7	20.4	13	0.7	1.9	<1
	Symphyla	46.3	53.8	3	30.0	40.6	4	3.4	4.3	6	12.0	12.8	11
	Chilopoda	33.1	23.6	2	20.4	22.8	3						
	Total	1354.8	1485.0	75	631.4	396.4	76	33.9	24.4	56	59.2	42.0	53
Group II	Insect imagines:												
	Diptera	41.1	100.9	2	19.4	40.3	2	2.3	3.1	4	1.4	2.5	1
	Coleoptera	225.2	205.4	12	66.1	69.5	8	14.4	29.4	24	8.7	16.8	8
	Staphylinidae	34.9	23.9	2	12.6	11.3	1	0.7	1.2	1	0.3	0.7	<1
	Aphidoidea	0.4	0.6		0.02						3.6	9.4	3
	Heteroptera	1.1	2.8	<1	1.4	3.7	<1						
	Hymenoptera	3.9	1.8	<1	0.7	0.8	<1	0.4	0.7	<1	0.1	0.2	<1
	Formicidae	132.9	268.8	7	88.6	182.1	11				37.1	93.9	33
	Thysanoptera	5.9	6.6	<1	1.4	1.3	<1				0.3	0.5	<1
	Araneae	10.4	9.6	<1	6.7	7.2	8	8.6	18.6	14			
	Opiliones										1.4	3.8	1
	Total	455.8	328.3	25	196.9	258.9	24	26.4	48.9	44	52.9	108.0	47
	All macrofauna	1810.6	1604.6	100	828.3	519.7	100	60.3	62.0	100	112.1	128.4	100

3.1.4. Biomass of dipteran larvae

Contribution of dipteran larvae to the total biomass of macrofaunal community varied from 6% in the ecotone to 40% in the shelterbelt. Though biomass of these animals decreased from the shelterbelt (730.8 mg d.wt.m^{-2}) to the field 50 m apart (8.9 mg d.wt.m^{-2}), its percentage share in the total biomass increased in the field as compared with the ecotone (Table 5). Biomass of dipteran larvae in the field was about 80 times lower than in the shelterbelt and 5 times lower than in the ecotone. Domination in biomass also differed in dipteran larvae communities; markedly decreased contribution of Cecidomyiidae larvae was noted in sites of high density and diversity of larval communities i.e. in the shelterbelt and ecotone. Definite dominants in the shelterbelt were the larvae of Bibionidae (71%), in the ecotone – Asilidae larvae and in both field plots – larvae of Dolichopodidae with a high contribution of Cecidomyiidae larvae (Table 6).

3.1.5. Trophic structure of macrofauna

Animals were divided into three basic trophic groups: saprophages, phytophages and zoophages (with parasitoids) considering the food preferences of mentioned taxa and, in the case of dipteran and coleopteran larvae, the trophic status of recorded families.

Densities of particular trophic groups along the transect changed in a way similar to the total animal density i.e. the highest numbers were noted in the shelterbelt and the lowest – in the field 10 m apart. (Table 7).

Table 6. Mean biomass (x – mg d.wt.m^{-2}), standard deviation (SD) and percentage contribution of dipteran larvae families along the studied transect during two study years (May–October).

Family	Shelterbelt			Ecotone			Field 10 m*			Field 50 m*		
	x	SD	%	x	SD	%	x	SD	%	x	SD	%
Anthomyiidae	1.3	3.5	<1									
Asilidae	1.1	3.0	<1	16.6	43.8	33						
Bibionidae	515.7	1364.0	71									
Cecidomyiidae	7.9	7.6	1	6.3	10.9	12	2.4	5.5	26	1.9	4.4	21
Ceratopogonidae				1.8	4.9	4						
Chironomidae	7.9	4.4	1	9.4	11.4	18				1.7	2.2	19
Dolichopodidae	30.3	49.4	4	3.3	5.7	7	5.5	6.5	60	4.7	7.0	53
Empididae	0.3	0.7	<1	1.8	3.2	4	0.1	0.3	1	0.1	0.3	1
Muscidae				0.7	1.5	1						
Psychodidae	0.2	0.4	<1	0.4	1.1	<1	0.4	1.1	4			
Sciaridae	67.6	156.0	9	5.3	8.2	10						
Sphaeroceridae	0.7	1.8	<1	1.8	3.1	4						
Stratiomyiidae	52.1	73.9	7	4.3	11.3	8	0.7	1.5	9			
Therevidae	9.1	17.3	1									
Tipulidae	26.6	55.4	4									
Trichoceridae	10.0	26.4	1							0.5	1.1	6
Total	730.8	1315.6	100	51.7	69.7	100	9.1	9.7	100	8.9	7.4	100

* – distance from shelterbelt.

Most numerous in all sites were saprophagous animals, from 107 ind.m^{-2} in the field 10 m from the shelterbelt – to 855 ind.m^{-2} in the woods. Predators were the second numerous group, their densities varied from 52 to 613 ind.m^{-2}. The share of saprophagous animals varied from 47% in the shelterbelt, ecotone and the field 50 m from the shelterbelt to as much as 64% in the field 10 m from the shelterbelt (Fig. 2). Predators tended to decline its share in the field in comparison with the shelterbelt and ecotone while herbivores showed a distinct decrease from the shelterbelt to the field 10 m apart and then a marked increase farther in the field. This regularity is repeated in both Groups of animals (soil fauna and epigeic fauna). Comparison of both Groups revealed a distinct domination of saprophages in the Group I (soil fauna), while the Group II (epigeic fauna) was dominated by predators, which markedly decreased in numbers from the shelterbelt towards the field.

Table 7. Mean number (ind.m$^{-2)}$ and biomass (mg d.wt.m^{-2}) of trophic groups of soil-litter animals on different plots of the transect (two years, May–October)
(Sa – saprophages, Ph – phytophages, Zoo – zoophages). (S, E, F10 m, F50 m – see Table 6).

Taxa	Trophic groups	Number				Biomass			
		S	E	F 10 m	F 50 m	S	E	F 10 m	F 50 m
All macrofauna	Sa	855.3	558.0	107.6	155.5	1105.9	400.4	23.6	36.1
	Ph	260.7	112.1	7.5	91.4	80.2	92.8	1.1	17.6
	Zoo	612.6	472.7	51.9	84.3	622.9	334.4	35.6	58.4
	Total	1728.6	1142.8	167.0	331.2	1809.0	827.6	60.3	112.1
Diptera larvae	Sa	250.9	118.5	25.7	14.2	624.6	25.0	2.8	4.1
	Ph	1.8	0.0	0.0	0.0	13.3	0.0	0.0	0.0
	Zoo	55.9	18.6	10.0	11.4	92.9	26.0	6.3	4.8
	Total	308.6	137.1	35.7	25.6	730.8	51.0	9.1	8.9
Coleoptera larvae	Sa	15.3	13.8	7.6	5.7	15.2	91.1	7.3	3.6
	Ph	125.8	72.1	1.9	34.3	43.0	85.7	0.2	5.7
	Zoo	198.2	255.6	26.2	18.6	90.3	113.3	5.2	6.0
	Total	339.3	341.5	35.7	58.6	148.5	290.1	12.7	15.3

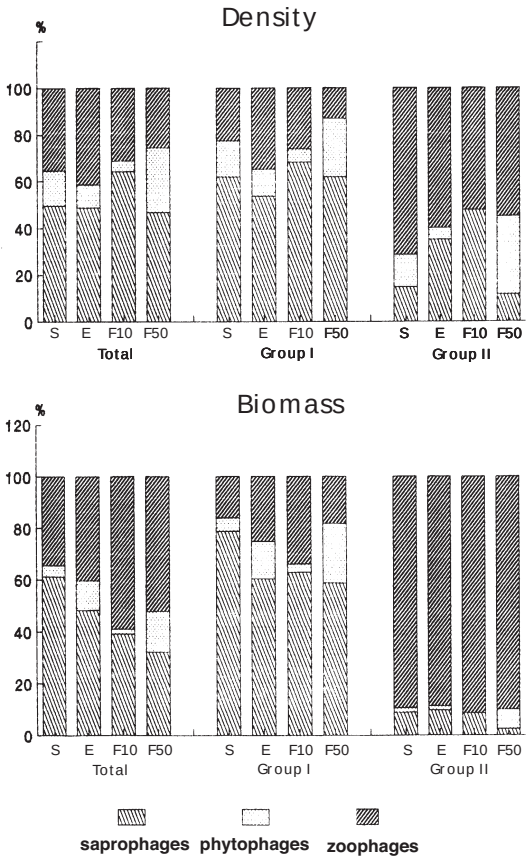

Fig. 2. Trophic structure of soil macrofauna along the studied transect based on mean values of numbers and biomass for two years (May–October). Symbols see Fig. 1.

Quite different trophic relationships were noted in two important taxa: dipteran and coleopteran larvae (Fig. 3). Dipteran larvae were dominated by saprophagous animals, whose share attained 86% in the ecotone while predators prevailed among coleopteran larvae in most plots. Communities of dipteran larvae in three plots comprised exclusively of saprophages and predators; herbivores were noted in small numbers only in the shelterbelt. Within Diptera larvae a decrease of saprophages and an increase of predators was found in the field as compared with the shelterbelt and ecotone. Within Coleoptera the share of saprophagous larvae was very low and, contrary to dipteran larvae, it increased in the field. Herbivores among coleopteran larvae varied accordingly to the entire macrofaunal community i.e. a gradual decrease of their contribution was noted from the shelterbelt to the 10 m field site and a marked increase farther in the field.

As in case of density, biomass of particular trophic groups was highest in the shelterbelt and lowest in the field in the distance of 10 m from the shelterbelt (Table 7). Biomass of saprophagous animals varied from 23.6 to 1106.0 mg d.wt.m^{-2}, that of herbivores from 1.1 to 93.0 and that of predators – from 35.0 to 623.0 mg d.wt.m^{-2}. Amplitude of biomass variation between sites was huge, even several dozen times. Saprophages share in the total biomass of macrofauna, in contrast to the densities, decreased and predators share increased from the shelterbelt to the farther field site (Fig. 2). Differences in the trophic structure between the Group I (soil fauna) and the Group II (epigeic fauna) also deepened. A distinct predominance of saprophagous animals was noted in the Group I and of predators in the Group II (about 90%).

Biomass relations of the mentioned trophic groups within dipteran and coleopteran larvae was also different from numbers relations (Fig. 3). In dipteran larvae communities, saprophagous larvae contributed less

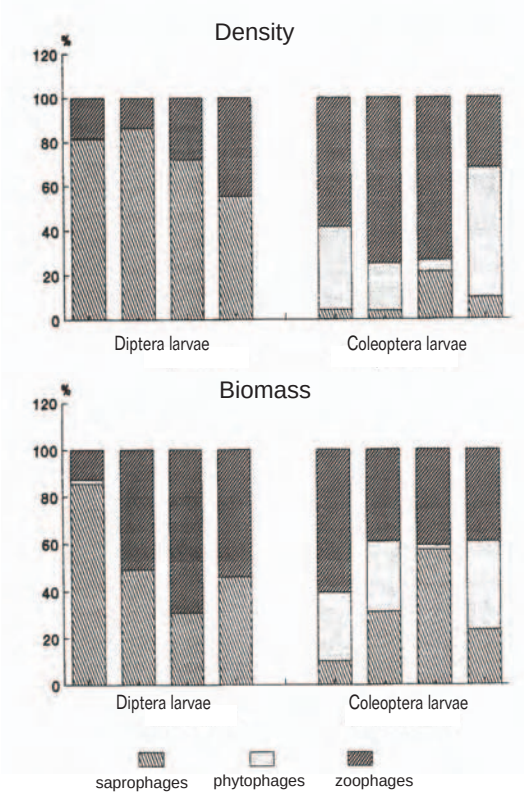

Fig. 3. Trophic structure of dipteran and coleopteran larvae along the studied transect based on mean density and biomass for two years (May–October). Symbols see Fig. 1.

and predators contributed more to the biomass than to numbers. The reverse relationship was found for coleopteran larvae. In the shelterbelt, contribution of biomass of predatory dipteran larvae was small in opposition to other plots of the transect. This was counterbalanced by the second important insect group – coleopteran larvae, whose contribution to the total predatory biomass was highest in the shelterbelt.

3.1.6. Mean individual weight in animal communities

Mean weight of an average individual is an important biocoenotic indicator. Biomass of an average individual of macrofauna was the highest in the shelterbelt (1.05 mg d.wt.) and decreased with the increasing distance to attain the lowest value of 0.34 mg d.wt. in the field 50 m from the shelterbelt (Table 8).

Similar tendency was found for communities of dipteran larvae; an average larva from the shelterbelt weighed 6.2 times more than that in the ecotone and 9.5 times more than that in the field.

Representatives of particular trophic groups showed also the highest individual biomass in the shelterbelt, lower – in the ecotone and the lowest one in the field. In the shelterbelt saprophagous animals were the largest and the herbivores were the smallest; the largest animals in the ecotone were phytophages. The field was inhabited by very small phytophagous and saprophagous animals and relatively big individuals of predators.

3.2. Macrofauna of various patches of vegetation inside the shelterbelt

3.2.1. Composition and densities

Species composition, numbers and biomass of soil-litter animals were studied in relation to the dominating plant species covering a given patch of the shelterbelt. Selected patches (area of several m^2) covered by: coniferous tress: 1) pine (*Pinus silvestris*), 2) spruce (*Picea excelsa*), 3) larch (*Larix decidua*), deciduous trees: 4) birch (*Betula verrucosa*), 5) oak (*Quercus robur*), and by herbs: 6) thistle (*Cirsium ravens*), 7) couch grass (*Elymus repens*), 8) hawkweed (*Heracleum sp.*) and 9) dock (*Rumex acetosa*). Species composition and densities of the soil-litter animals were found to vary markedly in dependence on plant cover. In total, 16 taxa of macrofauna were present on selected patches (Table 9). Common for all patches were only coleopteran larvae and imagines. The highest animal diversity was noted on patches covered with hawkweed – 15 taxa; 13 taxa were found on patches covered with dock and 11 – on plots covered with other herb species. So, more favorable for the species richness appeared to be the plots overgrown with herbs than

Table 8. Mean individual weight (mg d.wt.) in particular animal taxa. A. – along the transect (two years, May–October); B. – inside shelterbelt (plant patches: 1–9)* (June and September 2000).

A.

Taxa	Shelterbelt	Ecotone	Field 10 m	Field 50 m
Macrofauna total	1.05	0.72	0.36	0.34
Diptera larvae	2.37	0.38	0.25	0.23
Coleoptera larvae	0.44	0.85	0.36	0.26
Saprophages	1.41	0.72	0.22	0.23
Phytophages	0.31	0.83	0.15	0.19
Zoophages	1.02	0.71	0.69	0.69

B.

Taxa	1	2	3	4	5	6	7	8	9
Macrofauna total	0.69	0.96	0.38	0.55	0.90	0.71	0.53	0.54	4.21
Diptera larvae	–	0.23	0.83	1.05	2.05	0.20	0.20	0.16	5.42
Coleoptera larvae	0.29	0.45	0.26	0.41	0.95	0.28	1.31	0.30	0.46
Saprophages	0.11	0.12	0.19	0.38	0.89	0.14	0.30	0.18	5.15
Phytophages	0.26	0.15	0.18	0.29	0.31	0.21	0.33	0.17	0.32
Zoophages	1.33	1.73	0.69	1.53	1.02	1.27	1.08	1.32	1.95

*1 – 9 plant patches: 1 – pine, 2 – spruce, 3 – larch, 4 – birch, 5 – oak, 6 – thistle, 7 – couch grass, 8 – hawkweed, 9 – dock.

those covered with trees, where from 6 to 10 taxa only were recorded.

Animal density varied from 650 to 4183 ind.m^{-2} on particular patches. The density decreased in the following order: dock > hawkweed > oak > larch > couch grass > birch > spruce > thistle > pine.

Density of animals of the Group I (soil) and II (epigeic) Group varied in a bit different manner (Table 9). Animals of the Group II were most abundant under oaks and spruces. Percentage share of animals of this group in the total number of macrofauna varied from 12% to 79%. Though dif-

Table 9. Composition, mean density (d – ind.m^{-2}), biomass (b – mg d.wt.m^{-2}) of macrofauna communities and percent contribution of particular animal taxa on various plant patches (1–9)* inside the shelterbelt (June and September 2000). Group I – soil fauna, Group II – epigeic fauna.

			Plant patches								
			1	2	3	4	5	6	7	8	9
	All macrofauna										
	Density (ind.m^{-2})	(d)	650	1032	1500	1117	1600	817	1217	1733	4183
	Biomass (mg d.wt.m^{-2})	(b)	446	988	573	617	1441	580	699	930	17615
	Number of taxa		7	10	9	6	11	11	11	15	13
	H' index		2.17	3.06	2.52	1.23	3.09	3.01	2.79	3.22	1.67
			Contribution of taxa in%								
Group I	Insect larvae:										
	Diptera	d		13	3	2	4	20	8	19	72
		b		3	7	3	10	6	3	6	92
	Coleoptera	d	39	20	30	75	8	25	18	16	11
		b	16	9	21	55	9	10	41	9	1
	Heteroptera	d		5				6		3	1
		b		1				2		1	<1
	Homoptera	d								1	<1
		b								<1	<1
	Enchytraeidae	d				3		2		12	1
		b				3		1		8	<1
	Symphyla	d	33	8	11	3			32	22	2
		b	5	1	3	<1			6	4	<1
	Chilopoda	d	5		2		8	4	7	4	1
		b	6		2		10	3	16	11	<1
	Total	d	77	45	47	82	21	57	64	77	88
		b	27	14	33	61	29	22	65	39	94
Group II	Insect imagines:										
	Diptera	d		2			6	10		1	1
		b		<1			1	2		<1	<1
	Coleoptera	d	10	19	4	1	15	14	1	7	4
		b	67	75	36	9	52	61	17	5	6
	Staphylinidae	d	8	13	26		27	10	7	2	3
		b	5	4	25		6	11	4	<1	<1
	Aphidoidea	d							1	2	
		b							<1	<1	
	Heteroptera	d					2				
		b					4				
	Hymenoptera	d	3	5	1		10	4	1	6	2
		b	<1	<1	<1		1	1	<1	1	<1
	Formicidae	d		5		16	2	2	3	1	
		b		5		30	2	3	5	2	
	Thysanoptera	d	3	11	20		12	2	19	2	<1
		b	<1	1	5		1	<1	3	<1	<1
	Araneae	d			2		4		3	3	2
		b			1		2		7	2	<1
	Total	d	23	55	53	18	79	43	36	23	12
		b	73	86	67	39	71	78	36	61	6

*1 – 9 plant patches: 1 – pine, 2 – spruce, 3 – larch, 4 – birch, 5 – oak, 6 – thistle, 7 – couch grass, 8 – hawkweed, 9 – dock.

ferences in numbers were large, their statistical significance, due to a small number of samples, was hard to be proved (Table 2A). Only dipteran larvae showed a statistically significant differences of numbers among the mosaic of vegetation cover in the shelterbelt.

H' index of biodiversity varied from 1.23 on birch plot and 1.67 on plot covered with dock to 3.22 for animals inhabiting the plot covered with hawkweed (Table 9). According to the index, studied patches may be arranged in the following order: hawkweed > oak > spruce > thistle > couch grass > larch > pine > dock > birch. As can be seen, animal biodiversity on particular plant patches was not correlated with animal density.

Mosaic character of the shelterbelt reflected even more in species composition, densities and percentage share of dipteran larvae (Table 10). In total, 10 families of Diptera were found on various plots and none appeared on all patches. From 0 to 5 families were recorded on particular plots. The greatest number of families of dipteran larvae communities was noted on plots overgrown with spruce and dock.

Density of dipteran larvae on various patches varied from 0 to 3000 ind.m^{-2} and their percentage share in the entire macrofauna ranged from 0% to 72%. Pine and birch appeared unfavorable for dipteran larvae, none was found on plots covered with the former and larvae of only one family were found on plots overgrown by the latter.

Table 10. Composition, density (d – ind.m^{-2}) and biomass (b – mg d.wt.m^{-2}) of dipteran larvae and percent contribution of families on various plant patches (1–9)* inside the shelterbelt (June and September 2000).

		Plant patches								
		1	2	3	4	5	6	7	8	9
All dipteran larvae:										
Density (ind.m^{-2})	(d)	0.0	133.3	50.0	16.7	66.6	166.8	100.0	333.3	3000.0
Biomass (mg d.wt.m^{-2})	(b)	0.0	30.8	41.6	17.5	136.5	33.6	20.0	53.5	16258.4
Number of families		0	5	3	1	2	4	2	4	5
H' index			2.0	1.58	0.0	1.0	1.72	1.0	1.19	0.49
		Contribution of families in%								
Anthomyiidae	d					50			10	
	b					2			31	
Bibionidae	d					50				93
	b					88				99
Cecidomyiidae	d		50	33			40	50	75	3
	b		24	8			20	25	47	<1
Chironomidae	d		13						10	3
	b		11						9	<1
Empididae	d								5	
	b								13	
Dolichopodidae	d						10			
	b						50			
Psychodidae	d						10			
	b						10			
Sciaridae	d		13	33				50		<1
	b		11	12				75		<1
Sphaeroceridae	d		12				40			
	b		6				20			
Stratiomyiidae	d		12							<1
	b		49							<1
Therevidae	d			33						
	b			80						
Tipulidae	d				100					
	b				100					

*1 – 9 plant patches: 1 – pine, 2 – spruce, 3 – larch, 4 – birch, 5 – oak, 6 – thistle, 7 – couch grass, 8 – hawkweed, 9 – dock.

Most favorable appeared to be the plot overgrown with dock, where the highest numbers of individuals and families of dipteran larvae were recorded. According to the density of dipteran larvae, studied patches can be arranged in the following order: dock > hawkweed > thistle > spruce > couch grass > oak > larch > birch > pine.

Quantitative and qualitative structure of dipteran larvae communities revealed a high variability. This was reflected by the H` diversity index, which varied from 0.0 to 2.0 (Table 10).

Coleopteran larvae, the second most numerous taxon, inhabited all studied patches. Their density was more uniform than that of dipteran larvae and varied from 133 to 833 ind.m^{-2} and their percentage share in the whole community ranged from 8% to 75% (Table 9).

3.2.2. Biomass

Biomass of animals, of entire community and of particular groups or taxa varied even more than densities (Table 9). Biomass varied from 440 mg d.wt.m^{-2} under pine to 17615 mg d.wt.m^{-2} under dock. The greatest biomass variability was found for dipteran larvae from 0 on pine plot to over 16 000 mg d.wt.m^{-2} on dock overgrown plot (Table 10). Due to this plot, dipteran larvae attained the dominance in biomass (70% on average) in the entire shelterbelt. Their share on other plots remained, however, low, much lower than that of coleopteran larvae. A high percentage share on particular patches and in the entire shelterbelt was noted for adult beetles. Domination of particular taxa and of families within dipteran larvae in biomass was quite variable on studied patches (Table 9 and 10).

A great variability of numbers and biomass of animals resulted in great variations in mean individual weight (Table 8B). The smallest individuals were found in soil under larch (0.38 mg d.wt.) and the largest on plot covered with dock (4.21 mg d.wt.). Similarly variable were the mean weight values of dipteran and coleopteran larvae and of particular representatives of trophic groups.

3.2.3. Trophic structure

A great variability of trophic structure was characteristic for studied plant patches of the shelterbelt (Fig. 4). However some regularities were noted. Saprophagous ani-

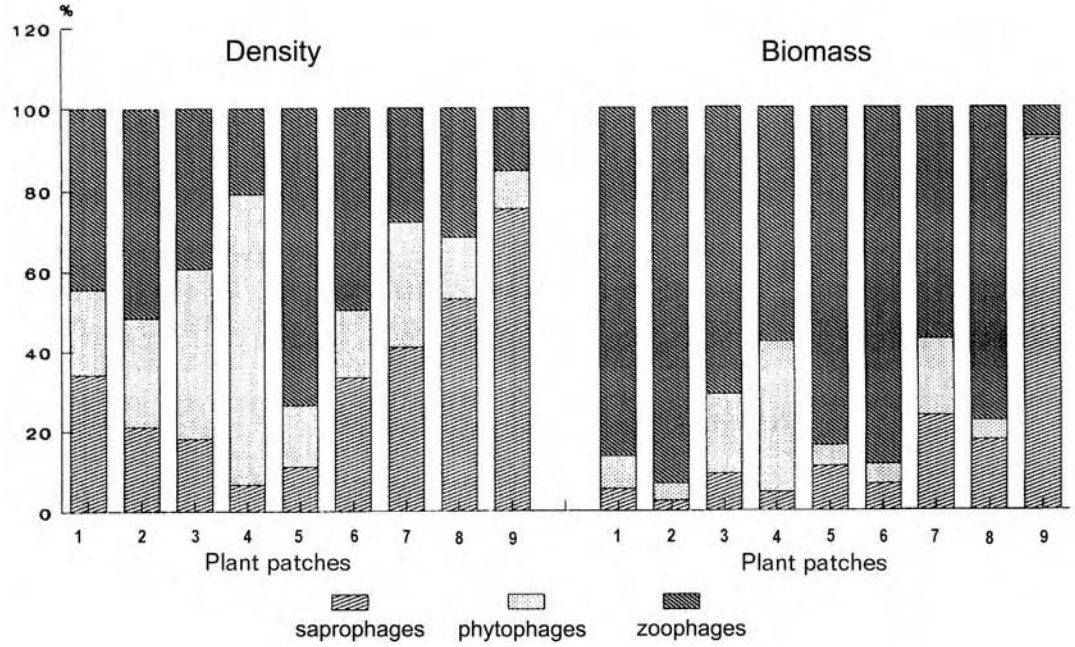

Fig. 4. Trophic structure of macrofauna on various plant patches inside the shelterbelt based on mean values of numbers and biomass (June and September 2000).
Plant patches: 1 – pine, 2 – spruce, 3 – larch, 4 – birch, 5 – oak, 6 – thistle, 7 – couch grass, 8 – hawkweed, 9 – dock.

mals contributed more to total numbers on plots covered with herbs than on those overgrown by trees. In contrast to herbivores, saprophages were least numerous on the birch plot but dominated definitely on the plot covered with dock. Most favorable for predators appeared to be the soil under oaks. Predators dominated distinctly on studied patches of the shelterbelt except for the one overgrown by dock.

4. DISCUSSION

Few papers in the world literature deal with the entire soil macrofauna (e.g. van der Drift 1967, Wallwork 1970, Olechowicz 1986, 1995, 1998, Dangerfield 1990, Schaefer and Schauermann 1990, Loranger *et al.* 1998). Usually selected taxa are studied i.e. orders or families (Górny 1968a, Nabiałczyk-Karg 1980, Paplińska 1984, 1987, Frouz 1994, 2001, Borowski 1995, Szujecki 1995). It appears, that agroecosystems, in comparison with other terrestrial systems, are characterized by the lower diversity, density and biomass of macrofaunal communities. This is also true for entomofauna of the herb layer (epigeion) (Dąbrowska-Prot 1987, 1991, Ryszkowski *et al.* 1993, 1999, Karg and Ryszkowski 1996a). Introducing shelterbelts on croplands definitely increases diversity, density (several times) and biomass (several dozen times) of animals as compared with the adjacent fields, the effect confirmed also by other authors (Górny 1968a, b, Karg 1985, 1995, Ryszkowski 1985, Boudry 1988, Thomas *et al.* 1991, Karg and Ryszkowski 1996b). Density and biomass of animals and numbers of macrofaunal taxa found in the shelterbelt fall within the range of variability typical for forest ecosystems: pine and mixed forests (Olechowicz 1998). The number of taxa found in 16 forest habitats of various regions in Poland ranged between 12 and 21, density varied between 722 and 2325 ind.m^{-2} and biomass between 635 and 2263 mg d.wt.m^{-2}. The same is true for the most numerous taxa i.e. dipteran and coleopteran larvae (Paplińska 1980, 1984, Olechowicz 1986, 1998).

Observed significant decrease in numbers of animals in the field 10 m from shelterbelt and subsequent increase (of the entire macrofauna, the Group II – epigeic and Symphyla) in the farther field site may prove that the shelterbelt being a place more convenient for the growth and development of animals acts as a trap attracting animals from its close vicinity. Another reason may lie in microhabitat differences between plots. Wojewoda and Russel (2003) and Kostro-Chomać (2003) demonstrated that organic matter content and pH in the 0–10 cm soil layer of the field site 10 m from the shelterbelt were the lowest of all plots. This would confirm the statement that soil animals are a very sensitive bioindicator of small-scale habitat changes (Paoletti 2001).

Similar regularity of decreasing numbers of animals in the field 10 m from the shelterbelt and increasing again at a larger distances was observed by Górny (1968a) for insect larvae and by Karg (1995) for some epigeic insects.

Demonstrated decrease of taxonomic richness, diversity and individual biomass along the transect proves the impoverishment, transformation and degradation of habitat with the increasing distance from the shelterbelt (Ryszkowski 1981, Karg 1985, Olechowicz 1995, Szujecki 1995). Moreover, decreasing individual size of animals with the distance means increasing energy losses for animal metabolism (Reichle 1971, Ryszkowski 1985).

Changes in trophic structure of soil animals along the transect were not unequivocal and differed from those of biomass. Besides, the trophic structure of important taxa i.e. dipteran and coleopteran larvae showed different trends.

Contribution of saprophagous animals to the total biomass of macrofauna and to the biomass of dipteran larvae decreased with the distance from the shelterbelt. It was consistent with decreasing amount of litter and organic matter content in soil (Kostro-Chomać 2003, Wojewoda and Russel 2003). The share of predators' biomass increased in the same direction. Similar relationships were reported for epigeic insects along the same transect by Karg (1995). The same conclusion can be derived from data of Ryszkowski (1985) and Karg (1985), who found that fields are characterized by a lower share of saprophagous biomass than meadows.

Presented results demonstrate an important role of shelterbelts in increasing di-

versity, density and biomass of animal communities in agricultural landscape. The shelterbelts together with other forms of environmental islands (balks, fallows, tree clumps etc.) make animal communities more diversified and abundant in such a mosaic landscape as opposed to extent uniform fields (Ryszkowski *et al.* 1993).

Studies on various patches of vegetation within the shelterbelt showed a great variability of composition, numbers and biomass of soil and litter animals and demonstrated a close relationship between soil fauna and small-scale plant cover. The latter is widely discussed in literature. Composition and richness of animals depends on the type of ecosystem like field, meadow, forest (Ryszkowski 1985, Zlotin 1985, Paoletti 2001), as well as on the kind of ecosystem e.g. plant association in a forest (Olechowicz 1986, 1995, 1998), shelterbelt (Dąbrowska-Prot 1999), field crops (Dąbrowska-Prot and Karg 1975, Karg 1985, Ryszkowski *et al.* 1993) or group of trees in the shelterbelt (Karg 2004) and on particular tree species (Kaczmarek 2000).

A great differentiation of fauna on particular plant patches in the shelterbelt confirms the statement that soil animals are very sensitive to small-scale habitat changes and therefore are good indicators of habitat conditions (Paoletti 2001).

The differences in composition, density and biomass of animal communities and in their trophic structure between different plant patches observed within this study may serve for appropriate composing of shelterbelts.

5. CONCLUSIONS

Studies carried out along the transect: the shelterbelt – ecotone – field 10 m – field 50 m demonstrated a decline with the increasing distance from the shelterbelt, of:
- animal density and biomass,
- taxonomic richness and biodiversity measured with the H` index,
- the proportion of predators in the total number of macrofauna and saprophages in the total biomass,
- individual weight of the entire macrofauna, of dipteran larvae, saprophagous and predatory animals,
- similarity of macrofaunal communities in terms of composition and dominance structure with increasing distance between plots.

Studies on the effect of plant cover inside shelterbelt on community structure of macrofauna showed that:
- soil animals and especially dipteran larvae were a sensitive indicator of small-scale habitat changes,
- herbs, contrary to trees, enhance the increase of diversity in soil-litter animals,
- from among analyzed herbs, dock appeared to exert most favorable effect while couch grass was the least favorite,
- distinct differences in environmental demands were found between dipteran and coleopteran larvae.

Close relationship was found between composition of plant cover and soil-litter macrofauna. The vegetation affects species composition, density, biomass and trophic structure of soil and litter invertebrates.

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6. SUMMARY

Studies on composition, density and biomass of soil-litter macrofauna were carried out in a 7-years old mid-field shelterbelt and in adjacent crop field near Turew (West Poland). The studies aimed at assessing the changes in community structure of soil invertebrates caused by 1) an introduction of the shelterbelt onto crop fields and 2) floristic differentiation of the shelterbelt.

Animals were collected from soil samples of an area of 100 cm^2 and a thickness of 15 cm with the use of Kempson`s method (Kempson *et al.*1963). Ten soil samples were taken from each site on every sampling occasion.

The studies showed, that:

1. The density of total macrofauna as well as its particular Groups (I – soil and II – epigeic invertebrates) and particular taxa gradually decreased (ten times) from the shelterbelt to the field plot in the distance 10 m from the wooded area (Table 1). The differences were statistically significant (Table 2 A, B). In the field plot 50 m from the shelterbelt an increase in the animal numbers was observed, significant for the entire macrofauna, for epigeic Group II and for Symphyla. This regularity was noted in the two subsequent years of study (Fig. 1). Density of one of the most numerous taxa (dipteran larvae) decreased from

the shelterbelt to the field site 50 m apart (Table 4), though differences in their numbers between the two field plots were not statistically significant (Table 2B). Similar changes were recorded for imagines of Staphylinidae, Hymenoptera and for Araneae.

2. Total faunal biomass decreased accordingly by 30 times from the shelterbelt to the field plot 10 m from the tree line to increase again in the farther plot (Table 5). Still higher differences in biomass (80 times) between the shelterbelt and the field were noted for dipteran larvae (Table 6).
3. Taxonomic richness and biodiversity measured with the H` index was lower in the field than in the shelterbelt, which was especially clear for dipteran larvae (Tables 1, 4). It means that shelterbelts enable the occurrence of new taxa, families and species formerly absent in agricultural landscape like Chilopoda, Bibionidae, Therevidae, Tipulidae etc.
4. Similarity of composition and structure of animal communities between studied plots generally decreased from the shelterbelt to the plots located at the field. The lowest indices found for the field plots at 10 and 50 m proved the important influence of the shelterbelt on field dwelling animal communities (the communities should be almost identical since the habitat was homogenous i.e. the indices should be high) (Table 3).
5. Most numerous in all plots were saprophagous animals, from 107 ind.m^{-2} in the field 10m from the shelterbelt to 855 ind.m^{-2} in the woods. Predators were the second numerous group, their densities varied from 52 to 613 ind.m^{-2} respectively (Table7).

   The proportion of predatory forms in the total number of macrofauna tended to decrease in the field as compared with the shelterbelt and ecotone, the tendency especially distinct in the epigeic animals (II Group) (Fig. 2). Biomass displayed a reverse tendency – contribution of predators' biomass increased from the shelterbelt to the field with a parallel decrease of saprophages share. Biomass of animals of the II Group had a very similar trophic structure in all plots – over 90% of it comprised the biomass of predators. This might suggest mutual influence among studied plots since mobile animals of the II Group tend to uniform the trophic structure of all plots.

   In dipteran larvae both the numbers and biomass of saprophages decreased and those of predators increased in the field in comparison with the shelterbelt (Fig. 3).
6. An important biocoenotic index – the mean weight of average individual in a community – decreased with the increasing distance from the shelterbelt. It is true for the entire macrofauna, dipteran larvae, saprophagous animals and predators (Table 8).
7. Herbs, as compared with tress, favor the increase of diversity of soil-litter animals (Table 9).
8. Most favorable among herb patches (area of several m^2) for the animal (density and biomass) were those overgrown by dock while the most impoverished in this aspect were those covered with couch grass.
9. From among coniferous trees, animals abundantly inhabited the soil under larch and among deciduous trees oak appeared to be more favorable for animals, especially of the II Group, than birch (Table 9).
10. Dipteran larvae were a very sensitive bioindicator of environmental changes (under the effect of different vegetation cover), which was evidenced by statistically significant differentiation of their densities on compared patches (Tables 2A and 10).
11. Larvae of Diptera and Coleoptera revealed different environmental demands. Dipteran larvae, in contrast to coleopteran larvae, were more numerous on plots covered with herbs than on tree covered plots (Table 9).
12. An important effect of particular tree species was found on the trophic structure of animals dwelling the adjacent soil (Fig. 4).

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