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Species Diversity of Carabids (Coleoptera, Carabidae) in Different Types of Bydgoszcz Urban Green Belts and Suburban Environments

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Urban environments are ecosystems that differ clearly from the natural environment in numerous factors of nature and intensity. Under the conditions of the urban environment the parameters of climate change, the process of alkalization of the top soil layers and the accumulation of heavy metals, especially zinc, lead and copper as well as a considerable content of bitumen, are in progress (BANASZAK 1998). The species composition of urban phytocenoses becomes poorer and poorer and usually leads to the replacement of herbaceous plant associations with poorly-diversified grass associations. One of the elements of research into the structure deformations and operation rules of urban ecosystems is the evaluation of entomofauna communities, as essential indicators of changes which occur in them. Carabid (Carabidae) beetles are considered to be such bioindicators due to their sensitivity to various changes in the natural environment. At the end of the 1990s research was launched into communities of these beetles on selected green belts of Bydgoszcz and the areas adjacent to this urban area. The present results encompass 2002-2004 and are a continuation of research into Carabidae communities of successive urban green belts (the Kujawskie Roundabout, Dąbrowski Hill) as well as forest areas adjacent to the urban area (Myślęcinek, Forest Jastrzębie) and also two sites in the vicinity of Świecie upon Wisła. The following were clear dominants for suburban forest areas: *Pterostichus melanarius* (L.), *Pterostichus oblongopunctatus* (Fabr.) and for the area of Forest Jastrzębie: *Pterostichus niger* (Schall.) and as for genus *Carabus*: *C. hortensis* L., *C. violaceus* L. and *C. arvensis* Herbst. A high position in the dominance structure of the green belts of the city was recorded for the following species: *Calathus fuscipes* (Goeze), and *Calathus erratus* (C.R.Sahlb) and *Harpalus rufipes* (De Geer).

Key words: Coleoptera, Carabidae, urban environments, green belt, community.

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The appearance of an urbanized landscape leads to the transformation of biocenoses, which are usually considerably natural. The city is a permanent part of the landscape, which creates different conditions for the organisms living in it than those of natural environments (CZECHOWSKI 1981 a, b). These areas receive greater emissions of dust, fumes and smoke, a warmer and drier microclimate, varied directions and power of wind, greater air humidity and an increased total rainfall. These factors have an essential effect on the development and the character of the biotic component of the urban environment. The mosaic of urban green belts intertwined with the network of transport routes and buildings creates enclaves totally isolated from one another, or joined by ecological corridors formed by, e.g. tree lines or strips of lawns. The adaptation and functioning of biocenoses in these specific conditions is extremely interesting, and so the interest of natural scientists in urban areas has been growing for the last few years. Observations of the structure of zoocenoses are an essential element of ecological monitoring which allows for evaluating and forecasting changes which occur in different habitats. Epigeic Carabidae are a convenient object for the collection of such data.

Research area

The observations were carried out in the region of Bydgoszcz and Świecie as well as on 3 research areas located in Bydgoszcz (Fig. 1).

S u l n ó w k o near Świecie is located south of Świecie 7 km away from a paper-processing plant, Frantschach Świecie S.A. The observations

Fig. 1. Location of studied plots in Bydgoszcz and suburban areas.

were carried out in a forest where Scotch pine (*Pinus silvestris*) is a dominant species.

Myślęcinek near Bydgoszcz: area covered with beech wood developing as plantings in a dry-ground environment and a mixed tree stand, where deciduous trees (with rich undergrowth) prevail; English oak (*Quercus robur*) and common hornbeam (*Carpinus betulus*) dominate.

The Kujawskie Round-about – Bydgoszcz: area comprising a green belt located on a hill parallel to Kujawska Street. The area is overgrown with trees running wild and shrubs, e.g. whitebeam (*Sorbus aria*), Norway maple (*Acer platanoides*), wild pear (*Pinus communis*), garden plum (*Prunus domestica*), lilac (*Syringa vulgaris*), common snow-berry (*Symphoricarpos albus*).

The Dąbrowski Hill – Bydgoszcz: a park located on a hill with 50 species of trees and shrubs, e.g. sessile oak (*Quercus sessilis*), common alder (*Alnus glutinosa*), European beech (*Fagus silvatica*), common snow -berry (*Symphoricarpos albus*).

Forest Jastrzębie – Bydgoszcz: area located on the territory of Nadwiślański Landscape Park, about 600 m west from the largest Bydgoszcz housing estate, Fordon. The research area is a slope on the border of a mixed coniferous forest and wet alder carr.

Material and Methods

The material (TRAUTNER & GEIGENMÜLLER 1987) was obtained by catching beetles into Barber live traps (GÓRNY & GRÜM 1981), without bait and attractants. In each year the research was conducted May through mid October, controlling the soil traps every 5-6 days. The *Carabus* genus beetles caught were determined directly in the field and then released. The qualitative-and-quantitative structure of each Carabid community was defined with the following analytical indicators: the number of species, abundance, single species dominance. General species diversity (H') was also determined. The qualitative-and-quantitative similarity of the community was evaluated based on the significance of the differences between the H' values, applying the Hutcheson test (HUTCHESON 1970).

Results and Discussion

Based on the material caught from the research areas, 60 Carabidae species were observed (Table 1), which accounts for about 23% of Carabidae recorded in the northern zone of the country. Over two years (2002-2004) a total of 2412 Carabidae individuals were collected, out of which 14.7% were caught from green areas of the housing estates. The greatest number of species was noted for *Amara* Bon. (12 species), *Harpalus* Latr. (11 species), *Pterostichus* Bon. (9 species) and *Carabus* L. (9 species). The greatest number of species was recorded at Forest Jastrzębie (35 species), the lowest number – at Sulnówko (16 species). The dominance patterns observed for each Carabidae community analyzed over the 2002-2004 growing seasons are presented in Tables 2 to 6. The communities differed not only in the number of species of respective dominance classes, but also in their share. It is worth noting that the dominance position

Table 1

List of captured species together with life environment (E) and zoogeographical characteristics (Z): F – forest; Oa – open areas; OaAf – open areas and forests; Rp – riparian, (H – holarctic, P – palaearctic; Esib – Euro-Siberian, Ear – Euro-Arctic; Emed – Euro-Mediterranean) explanation of plots in study area chapter

Species	Sulnówko	Myślęcinek	Kujawskie Roundabout	Dąbrowski Hill	Jastrzębie Forest	Σ	E	Z
Calosoma inquisitor (L.)		17				17	F	P
Carabus violaceus L.	5	35			21	61	OaAF	P
Carabus convexus F.	1					1	Oa	ESib
Carabus marginalis F.	11					11	F	ESib
Carabus granulatus L.					9	9	Oa	ESib
Carabus cancellatus Ill.	3				5	8	Oa	ESib
Carabus arvensis (Herbst)	14	28			4	46	F	P
Carabus nemoralis (O.F. Müller)	7	124	15	2	48	196	OaAF	P
Carabus hortensis L.	25	142			59	226	F	P
Carabus glabratus Payk.		37				37	OaAF	P
Leistus ferrugineus (L.)	17				2	19	OaAF	ESib
Nebria brevicollis (F)		12	10	6	30	58	F	EMed
Notiophilus aquaticus (L.)			1	1		2	OaAF	H
Notiophilus biguttatus (F.)	3		1	1	2	7	F	P
Loricera caerulescens (L.)				1		1	Rp	H
Broscus cephalothes (L.)	2			2		4	Oa	ESib
Bembidion lampros (Herbst)					10	10	Oa	ESib
Panageus bipustulatus (F.)			4	2		6	Oa	EMed
Panageus cruxmajor (L.)			1			1	Rp	ESib
Amara plebeja (Gyll.)					5	5	Oa	P
Amara aenea (De Geer)				3	9	12	Oa	P
Amara communis (Panz.)		4	6		19	29	Oa	P
Amara convexior Steph.			1			1	F	P
Amara familiaris (Duft.)			4		7	11	Oa	P
Amara lunicollis Schiřdte					49	49	OaAF	P
Amara ovata (F.)				1		1	Oa	P
Amara similata (Gyll.)		1		3		4	Oa	P
Amara spreta Dej.				6		6	Oa	ESib
Amara ingenua (Duft.)					3	3	Oa	ESib
Amara brunnea (Gyll.)		6			6	12	OaAF	H
Amara fulva (O.F. Müller)			1	1		2	Oa	P
Stomis pumicatus (Panz.)					5	5	Oa	P
Pterostichus cupreus (L.)	2		3	1	8	14	OaAF	ESib
Pterostichus angustatus (Duft.)					19	19	OaAF	P
Pterostichus oblongopunctatus (F.)	92	27	7	12	134	272	F	P
Pterostichus niger (Schall.)	4	124			182	310	Rp	ESib
Pterostichus melanarius Ill.	1	42	6	10	324	383	Oa	ESib
Pterostichus anthracinus (Ill.)		17			13	30	OaAF	P
Pterostichus nigrita (F.)		53			106	159	F	P
Pterostichus diligens (Sturm)			2		3	5	F	ESib
Pterostichus strenuus (Panz.)					3	3	F	P
Calathus erratus (C.R.Sahlb)		12	10	37		59	OaAF	P
Calathus fuscipes (Goeze)		7	35	58	1	101	Oa	P
Calathus melanocephalus (L.)				4		4	OaAF	P
Calathus micropterus (Duft.)	5	3			5	13	F	ESib
Agonum micans (Nic.)				1		1	Rp	ESib
Agonum livens (Gyll.)					19	19	Rp	ESib
Platynus assimilis (Payk.)					30	30	Rp	P
Badister bipustulatus (F.)			1			1	OaAF	ESib
Licinus depressus (Payk.)			3	3		6	Oa	ESib
Harpalus brevicollis Aud-Serv.				1		1	Rp	EMed
Harpalus seladon Schaub.					2	2	Rp	Ear
Harpalus rufipes (De Geer)	1		15	21	20	57	Oa	P
Harpalus hirtipes (Panz.)		7				7	Oa	ESib
Harpalus cupreus Dej.					1	1	Oa	EMed
Harpalus anxius (Duft.)			1			1	Oa	P
Harpalus latus (L.)					7	7	OA	P
Harpalus luteicornis (Duft.)			4			4	OaAF	EMed
Harpalus picipennis (Duft.)			2			2	Oa	Ear
Harpalus rubripes (Duft.)			2			2	Oa	P
Harpalus tardus (Panz.)			34	5		39	OaAF	P
Number of individuals	193	698	169	182	1170	2412		

Table 2

Comparison of dominance indices for Carabidae species in Sulnówko

Dominance structure	Species	Domination (%)
Superdominants	*Pterostichus oblongopunctatus* (F.)	47.70
Eudominants	*Carabus hortensis* L.	12.95
Dominants	*Leistus ferrugineus* (L.)	8.81
	Carabus arvensis (Herbst)	7.25
	Carabus marginalis F.	5.70
Subdominants	*Carabus nemoralis* (O.F. Müller)	3.63
	Carabus violaceus L.	2.59
	Calathus micropterus (Duft.)	2.59
	Pterostichus niger (Schall.)	2.07
Recedents	*Carabus cancellatus* Ill.	1.55
	Notiophilus biguttatus (F.)	1.55
	Broscus cephalothes (L.)	1.04
	Pterostichus angustatus (Duft.)	1.04
Subrecedents	*Carabus convexus* F.	0.52
	Pterostichus melanarius Ill.	0.52
	Harpalus rufipes (De Geer)	0.52

Table 3

Comparison of dominance indices of Carabidae species in Myślęcinek

Dominance structure	Species	Domination (%)
Eudominants	*Carabus hortensis* L.	20.34
	Carabus nemoralis (O.F. Müller)	17.77
	Pterostichus niger (Schall.)	17.77
Dominants	*Pterostichus nigrita* (F.)	7.59
	Pterostichus melanarius Ill.	6.02
	Carabus glabratus Payk.	5.30
	Carabus violaceus L.	5.01
Subdominants	*Carabus arvensis* (Herbst)	4.01
	Pterostichus oblongopunctatus (F.)	3.87
	Calosoma inquisitor (L.)	2.44
	Pterostichus anthracinus (Ill.)	2.44
Recedents	*Nebria brevicollis* (F)	1.72
	Calathus erratus (C.R.Sahlb)	1.72
	Calathus fuscipes (Goeze)	1.00
	Harpalus hirtipes (Panz.)	1.00
Subrecedents	*Amara brunnea* (Gyll.)	0.85
	Amara communis (Panz.)	0.57
	Calathus micropterus (Duft.)	0.43
	Amara similata (Gyll.)	0.14

of some *Carabidae* species changed in the structure of respective communities while comparing the areas of suburban forests with the areas within the city. The species which reached the highest positions in the dominance structure of *Carabidae* in suburban areas were e.g. *Pterostichus oblongopunctatus* (Tables 2, 6), *Pterostichus melanarius* (Tables 3, 6) and *Carabus hortensis* (Tables 2, 3, 6). However, as for the suburban areas, they included *Calathus fuscipes*, *Calathus erratus* and *Harpalus rufipes* (Tables 4, 5). The species of *Pterostichus oblongopunctatus*, *Pterostichus melanarius* and *Carabus nemoralis* were noted in all the research areas, however their share differed considerably across habitats (Table 7). The evaluation of the beetle communities based on

Table 4

Comparison of dominance indices of Carabidae species in the Kujawskie Roundabout

Dominance structure	Species	Domination [%]
Eudominants	*Calathus fuscipes* (Goeze)	20.71
	Harpalus tardus (Panz.)	20.12
Dominants	*Carabus nemoralis* (O.F. Müller)	8.88
	Harpalus rufipes (De Geer)	8.88
	Nebria brevicollis (F)	5.92
	Calathus erratus (C.R.Sahlb)	5.92
Subdominants	*Pterostichus oblongopunctatus* (F.)	4.14
	Amara communis (Panz.)	3.55
	Pterostichus melanarius Ill.	3.55
	Panageus bipustulatus (F.)	2.37
	Amara familiaris (Duft.)	2.37
	Harpalus luteicornis (Duft.)	2.37
Recedents	*Pterostichus cupreus* (L.)	1.78
	Licinus depressus (Payk.)	1.78
	Pterostichus diligens (Sturm)	1.18
	Harpalus picipennis (Duft.)	1.18
	Harpalus rubripes (Duft.)	1.18
Subrecedents	*Notiophilus aquaticus* (L.)	0.59
	Notiophilus biguttatus (F.)	0.59
	Panageus cruxmajor (L.)	0.59
	Amara convexior Steph.	0.59
	Amara fulva (O.F. Müller)	0.59
	Badister bipustulatus (F.)	0.59
	Harpalus anxius (Duft.)	0.59

Table 5

Comparison of dominance indices of Carabidae species at Dąbrowski Hill

Dominance structure	Species	Domination (%)
Superdominants	*Calathus fuscipes* (Goeze)	31.87
Eudominants	*Calathus erratus* (C.R.Sahlb)	20.33
	Harpalus rufipes (De Geer)	11.54
Dominants	*Pterostichus oblongopunctatus* (F.)	6.59
	Pterostichus melanarius Ill.	5.50
Subdominants	*Nebria brevicollis* (F)	3.30
	Amara spreta Dej.	3.30
	Harpalus tardus (Panz.)	2.75
	Calathus melanocephalus (L.)	2.20
Recedents	*Amara aenea* (De Geer)	1.65
	Amara similata (Gyll.)	1.65
	Licinus depressus (Payk.)	1.65
	Carabus nemoralis (O.F. Müller)	1.1
	Broscus cephalothes (L.)	1.1
	Panageus bipustulatus (F.)	1.1
Subrecedents	*Nebria brevicollis* (F)	0.55
	Notiophilus biguttatus (F.)	0.55
	Loricera caerulescens (L.)	0.55
	Amara ovata (F.)	0.55
	Amara fulva (O.F. Müller)	0.55
	Pterostichus cupreus (L.)	0.55
	Agonum micans (Nic.)	0.55
	Harpalus brevicollis Aud-Serv.	0.55

Table 6

Comparison of dominance indices of Carabidae species at Forest Jastrzębie

Dominance structure	Species	Domination (%)
Eudominants	*Pterostichus melanarius* Ill.	27.69
	Pterostichus niger (Schall.)	15.56
	Pterostichus oblongopunctatus (F.)	11.45
Dominants	*Pterostichus nigrita* (F.)	9.06
	Carabus hortensis L.	5.04
Subdominants	*Amara lunicollis* Schiřdte	4.19
	Carabus nemoralis (O.F. Müller)	4.10
	Nebria brevicollis (F)	2.56
	Platynus assimilis (Payk.)	2.56
Recedents	*Carabus violaceus* L.	1.79
	Harpalus rufipes (De Geer	1.71
	Amara communis (Panz.)	1.62
	Pterostichus angustatus (Duft.)	1.62
	Agonum livens (Gyll.)	1.62
	Pterostichus anthracinus (Ill.)	1.11
Subrecedents	*Bembidion lampros* (Herbst)	0.85
	Carabus violaceus L.	0.77
	Amara aenea (De Geer)	0.77
	Pterostichus cupreus (L.)	0.68
	Amara familiaris (Duft.)	0.6
	Harpalus latus (L.)	0.6
	Amara brunnea (Gyll.)	0.51
	Carabus cancellatus Ill.	0.43
	Amara plebeja (Gyll.)	0.43
	Stomis pumicatus (Panz.)	0.43
	Calathus micropterus (Duft.)	0.43
	Carabus arvensis (Herbst)	0.34
	Amara ingenua (Duft.)	0.26
	Pterostichus diligens (Sturm)	0.26
	Pterostichus strenuus (Panz.)	0.26
	Leistus ferrugineus (L.)	0.17
	Notiophilus biguttatus (F.)	0.17
	Harpalus seladon Schaub.	0.17
	Calathus fuscipes (Goeze)	0.08
	Harpalus cupreus Dej.	0.08

Table 7

Comparison of dominance indices for the most frequently caught ground beetle species in assemblages inhabiting different research plots: SPD – superdominants, ED – eudominants, D – dominants, SD – subdominants, R – recedents, SR – subrecedents

Species	Sulnówko	Myślęcinek	Kujawskie Roundabout	Dąbrowski Hill	Forest Jastrzębie
Carabus violaceus L.	2.59(SD)	5.01(D)	–	–	1.79(R)
Carabus arvensis (Herbst)	7.25(D)	4.01(SD)	–	–	0.34(SR)
Carabus nemoralis (O.F. Müller)	3.63(SD)	17.77(ED)	8.88(D)	1.1(R)	4.10(SD)
Carabus hortensis L.	12.59(SD)	20.34(ED)	–	–	5.04(D)
Nebria brevicollis (F)	–	1.72(R)	5.92(D)	–	2.56(SD)
Amara lunicollis Schiřdte	–	–	–	–	4.19(SD)
Pterostichus oblongopunctatus (F.)	47.7(SPD)	3.87(SD)	4.14(SD)	6.59(D)	11.45(ED)
Pterostichus niger (Schall.)	2.07(SD)	17.77(ED)	–	–	15.56(ED)
Pterostichus melanarius Ill.	0.52(SR)	6.02(D)	3.55(SD)	5.50(D)	27.69(ED)
Calathus erratus (C.R.Sahlb)	–	1.72(R)	5.92(D)	20.33(ED)	–
Calathus fuscipes (Goeze)	–	1.0(R)	20.71(ED)	31.87(SPD)	0.08(SR)
Harpalus tardus (Panz.)	–	–	20.12(ED)	2.75(SD)	–

Table 8

Similarity of dominance structure of ground beetle communities in the research areas (Renkonen index in %)

	Sulnówko	Myślęcinek	Kujawskie Roundabout	Dąbrowski Hill	Forest Jastrzębie
Sulnówko					
Myślęcinek	30.53				
Kujawskie Roundabout	10.44	20.76			
Dąbrowski Hill	13.40	15.53	49.00		
Forest Jastrzębie	28.36	49.77	25.39	19.03	

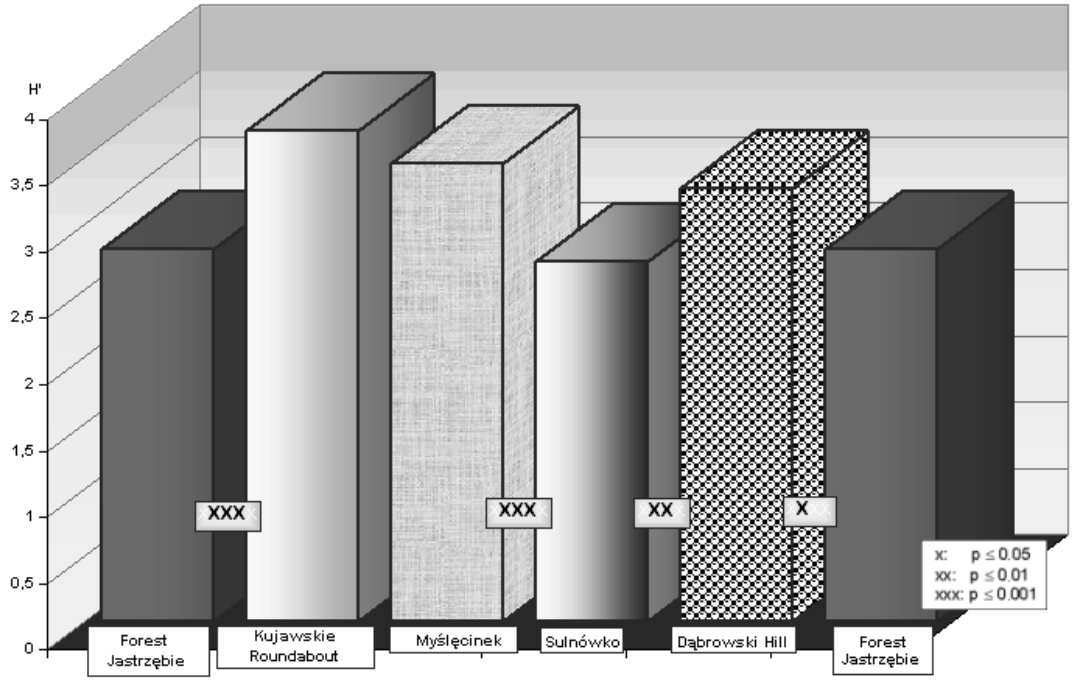

Fig. 2. Differences between the respective values of Shannon and Weaver's (H') between Carabidae communities on the research areas (Hutcheson's index).

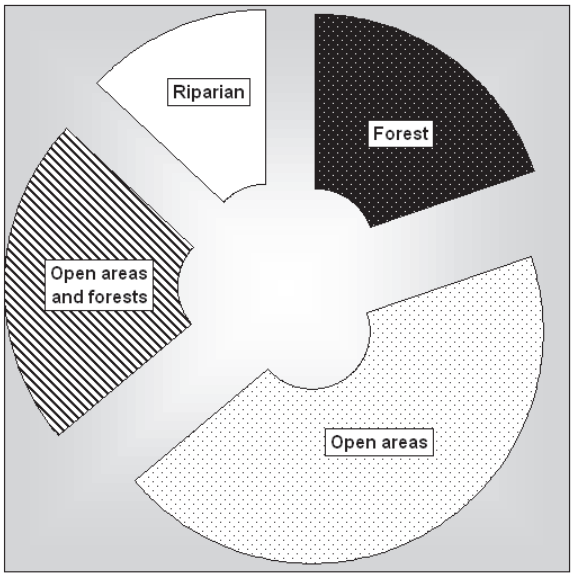

Fig. 3. Share of respective Carabidae species in different types of habitat.

abundance and diversity is supplemented by the analysis of dominance structure similarity, measured with Renkonen's index (Re). It is assumed that a coefficient value exceeding 50% shows the similarity of the dominance structure of the Carabid communities of the two habitats compared (ROMANISZYN 1972). Based on the results obtained, none of the areas analyzed exceeded the value of 50% (Table 8), however some of them reached threshold values (Myślęcinek and Forest Jastrzębie, 49.77% and the Kujawskie Roundabout and Dąbrowski Hill 49%).

The highest diversity of the community both in terms of quality and quantity was recorded for the area of the Kujawskie Roundabout (H' 3.69) (Fig. 2). The significance of differences between H' values evaluated with variance analysis using the Hutcheson test (1970) showed that the most similar ones (no significant differences), quantity- and quality-wise, were the habitats of Myślęcinek, Kujawskie Roundabout, Forest Jastrzębie and Sulnówko. Sig-

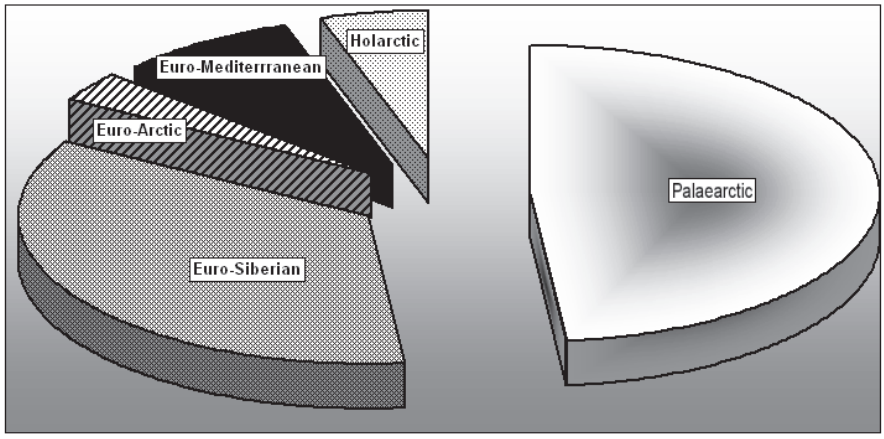

Fig. 4. Share of zoogeographical element in the Carabidae fauna of the areas researched.

nificant differences in diversity were, however, recorded between the communities of Myślęcinek (H' 3.45) and Sulnówko (H' 2.71 P=0.001), Myślęcinek (H' 3.45) and Forest Jastrzębie (H' 2.80 P=0.001) and between the area of the Kujawskie Roundabout and the others, except for Myślęcinek (Fig. 2).

Out of all the Carabidae caught, the greatest share was recorded for the species characteristic of open areas (Fig. 3). Carabidae clearly dominate on dry grasses, in the fields and ecoton zones. However, while considering the zoogeographic elements, a clear advantage of the palaearctic element was recorded (Fig. 4). The species accounted for almost half of the Carabidae communities. While comparing the communities of Carabidae from the areas which are not exposed to the direct pressure of anthropogenic factors of urban habitats, there is a clear disproportion between the shares of respective species (TROJAN 1992). In urban areas one or a few dominant species (Table 4, 5) win a quantitative advantage over the others (ŻELAZNA & BŁAŻEJEWICZ-ZAWADZIŃSKA 2003). The characteristics of Carabidae communities in the habitats of forests adjacent to cities do not show essential disturbances in their bio-equilibrium, and so they can constitute a control in research into the biodiversity of entomofauna from the areas of heavy anthropogenic stress.

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