POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGII

FRAGMENTA FAUNISTICA

Tom XXV Warszawa, 31 III 1980 Nr 12

Wojciech CZECHOWSKI

Influence of the manner of managing park areas and their situation on the formation of the communities of carabid beetles (*Coleoptera, Carabidae*)

[With 7 figures and 3 tables]

1. INTRODUCTION

This study was carried out within a project of the Institute of Zoology, Polish Academy of Sciences, called "Influence of urban pressure on the fauna". Changes within a communities of *Carabidae* due to the process of converting a primary forest environment into park areas – differently situated and variously utilized – are discussed here. Quantitative and qualitative differences in the species composition in communities of carabid beetles of those areas and differences in their domination structure are analysed. It was the objective of this study to show whether, and if so to what extent, these beetles can be considered as bioindicators of the condition and of changes of an environment also in a case where it is transformed and its character becomes garden-like or urban. These beetles are a group of organisms of already recognized bioindicatory qualities used for estimating the quality of agricultural and forest environments, environments polluted with pesticides and remaining under the influence of industrial emission (HEYDEMANN 1955, DUNGER 1968, KABACIK-WASYLIK 1970, PETRUŠKA 1971, TOBISCH and DUNGER 1973, PUSZKAR 1976, LEŚNIAK 1977, MARTIŠ – unpublished data).

1.1. Study area

The investigations were carried out in the vicinity of Warsaw and in Warsaw. The particular areas of the study constituted a chain determined by

a gradually increasing anthropogenic pressure on the environment. The first element was a hornbeam forest (*Tilio-Carpinetum*) – an environment only slightly influenced by anthropogenic factors and similar to a primary one. The successive elements were two village parks in which the intensity of gardening varied. That chain was completed by a typical urban park. All the parks investigated were situated in habitats typical of hornbeam forest ones. Here is a description of the particular areas (named after the corresponding places).

1. Hamernia. A hornbeam forest of a character of a primary environment. The tree stand was not exploited economically; the areas were only slightly penetrated by people picking mushrooms. The study site was situated in a large forest complex, about 50 km south-west of Warsaw. It was a control environment.

2. Młochów. It was an old neglected manor park situated among fields. There was no human interference in the tree-covered parts of the park. The only care taken of lawns was in the form of occasional scything (once or twice during a season). Grass cut lay on the ground for a long time. The herbaceous plants on the lawns had a large proportion of dicotyledonous species and were rich and tall (20–30 cm). The tree-covered part of the park was a place where children played and poultry fed. Młochów is about 30 km south-west of Warsaw. The degree of the anthropogenic influence on the environment was agreed upon as 1.

3. Radziejowice. It was an old manor park situated outside the village, near the Hamernia forest complex. The investigations were carried out in the cultivated part of the park (a considerable part of the park was wild). The type and frequency of gardening were similar to those in urban parks. The lawns were scythed several times during a season and grass cut was almost immediately removed. In the tree-covered parts litter was systematically raked off. The occupancy intensity of people in the park was low. The degree of the anthropogenic influence on the environment was agreed upon as 2.

4. Warsaw. The park at the Cemetery-Mausoleum of Soviet Soldiers. There is a housing estate at one side of the park and a complex of urban allotment gardens at another. The park adjoins Żwirko and Wigura Ave., one of the main transportation routes in Warsaw. It is a typical urban park and it was founded after the Second World War. The tree stand is sparse, mainly planted artificially. The lawns were mown every 2–3 weeks and formed almost a monoculture. Litter and grass mown were raked off and removed. The degree of the anthropogenic influence on the environment was agreed upon as 3.

1.2. Time of the studies and methods

The data presented here are the result of two-year investigations carried out in 1976 and 1977, with the exception of the park in Radziejowice in which data were collected during one season only (1977).

Beetles were caught in Barber's traps, the classic method used in studies on *Carabidae*. Due to the specific character of the areas studied small traps were the only means of catching beetles. They provided the required amount of material and left no distinct marks on the lawns. The glass cylinders used as traps had a diameter of 4 cm and a capacity of 120 ml. They were inserted into soil by means of an instrument for collecting soil samples. ⅓ of their capacity was filled with ethylene glycol in order to preserve the captured

insects. Traps were laid out for 14 days each month from April to October. Thus, 7 series of fortnight catches were carried out annually in each area. In Hamernia, Młochów and Radziejowice there were 40 traps in one series — 20 were laid out in an open area and 20 in a tree-covered one. In the park in Warsaw, where such a differentiation was impossible, traps were laid out on two lawns with a different degree of shadiness — 10 traps on each site. Earlier tests had revealed that such numbers of traps would provide enough representative material.

The mean number of individuals caught in a given park into 10 traps during a fortnight was considered to be an indicator of the relative abundance of *Carabidae*. An analysis of the data was carried out on the basis of the mean values of the abundance of beetles for a given season (from 7 one-month tests).

Data on the abundance of *Carabidae* must be treated on the distinct understanding that Barber's traps are selective. Data obtained by means of this method depend on the size and activity of individuals, weather conditions, density of herbaceous plants etc. (GREENSLADE 1964). However, since other methods are still less reliable, Barber's traps are considered to be a method most suitable for estimating the abundance of epigean carabid beetles (GREENSLADE 1964, LEŚNIAK 1975).

2. RESULTS

The collected material consisted of 1174 individuals from 49 *Carabidae* species belonging to 20 genera. A systematic list of the recorded species and information on their occurrence and abundance in different areas are presented in Table I. The composition of the communities and the percentages of particular species in each community are shown in Table II.

Table I. *Carabidae* species recorded during the investigations and their relative abundance in each study area: H — Hamernia; M — Młochów; R — Radziejowice; W — Warsaw (the seasonal mean number of individuals caught into 10 traps during a fortnight was considered to be an abundance index; + — occasional occurrence).

	Species	Abundance			
		H	M	R	W
1	*Carabus coriaceus* L.	0.2			
2	*Carabus violaceus* L.	0.5			
3	*Carabus auronitens* FABR.		0.1		
4	*Carabus convexus* FABR.	0.2			
5	*Carabus granulatus* L.		0.1		
6	*Carabus arcensis* HERBST	1.5			
7	*Carabus nemoralis* O. F. MÜLL.	0.7		+	0.6
8	*Carabus hortensis* L.	2.9	0.1		

Tab. I ctd.

	Species	Abundance			
		H	M	R	W
9	*Carabus glabratus* PAYK.	2.3			
10	*Cychrus caraboides* (L.)	0.3			
11	*Nebria brevicollis* (FABR.)		2.2	6.9	0.7
12	*Notiophilus aquaticus* (L.)	0.1			
13	*Notiophilus biguttatus* (FABR.)		0.1	0.1	
14	*Notiophilus germinyi* FAUV.	+			
15	*Notiophilus palustris* (DUFT.)		+		+
16	*Loricera caerulescens* (L.)		0.1	+	
17	*Clivina fossor* (L.)		+	0.2	
18	*Asaphidion flavipes* (L.)		+		+
19	*Bembidion lampros* (HERBST)		+	+	
20	*Bembidion properans* (STEPH.)				+
21	*Bembidion ustulatum* (L.)		+		
22	*Epaphius secalis* (PAYK.)			0.6	
23	*Trechoblemus micros* (HERBST)			+	
24	*Patrobus atrorufus* (STROEM)			+	
25	*Amara aenea* (DE GEER)	0.1	0.2	0.3	0.6
26	*Amara communis* (PANZ.)	+			
27	*Amara familiaris* (DUFT.)	+	0.1	0.2	
28	*Amara similata* (GYLL.)		0.6		
29	*Stomis pumicatus* (PANZ.)		0.1		
30	*Pterostichus caerulescens* (L.)	0.1	0.1		
31	*Pterostichus vernalis* (PANZ.)		+	+	
32	*Pterostichus oblongopunctatus* (FABR.)	0.8	0.1		
33	*Pterostichus niger* (SCHALL.)	1.4	0.1	0.4	0.1
34	*Pterostichus vulgaris* (L.)	0.2	0.7	1.2	1.2
35	*Calathus erratus* (C. R. SAHLB.)	+			
36	*Calathus fuscipes* (GOEZE)		0.2	+	0.6
37	*Calathus melanocephalus* (L.)		+	+	
38	*Calathus micropterus* (DUFT.)	0.5			
39	*Synuchus nivalis* (PANZ.)	0.5	0.2	0.2	
40	*Agonum assimile* (PAYK.)	+	0.4		
41	*Agonum dorsale* (PONT.)		0.1		
42	*Badister bipustulatus* (FABR.)				+
43	*Badister lacertosus* STURM			+	
44	*Anisodactylus binotatus* (FABR.)				0.2
45	*Harpalus punctatulus* (DUFT.)		0.1		
46	*Harpalus griseus* (PANZ.)				0.1
47	*Harpalus rufipes* (DE GEER)		0.8	+	0.3
48	*Harpalus affinis* (SCHRANK)	0.1	+		
49	*Harpalus latus* (L.)	0.1	+		
	Total	12.8	6.8	10.6	4.6

Table II. Species composition of the communities and the percentage of particular *Carabidae* species in particular study areas.

	Hamernia	%
1	*Carabus hortensis*	22.5
2	*Carabus glabratus*	18.0
3	*Carabus arcensis*	11.5
4	*Pterostichus niger*	11.0
5	*Pterostichus oblongopunctatus*	6.5
6	*Carabus nemoralis*	5.5
7	*Carabus violaceus*	4.0
8	*Calathus micropterus*	4.0
9	*Synuchus nivalis*	4.0
10	*Cychrus caraboides*	2.5
11	*Carabus coriaceus*	1.5
12	*Carabus convexus*	1.5
13	*Pterostichus vulgaris*	1.5
14	*Pterostichus caerulescens*	1.0
15	*Harpalus affinis*	1.0
16	*Harpalus latus*	1.0
17	*Amara aenea*	1.0
18	*Notiophilus aquaticus*	1.0
19	*Agonum assimile*	0.5
20	*Calathus erratus*	0.5
21	*Amara communis*	0.5
22	*Amara familiaris*	0.5
23	*Notiophilus germinyi*	0.5

	Radziejowice	%
1	*Nebria brevicollis*	65.0
2	*Pterostichus vulgaris*	11.5
3	*Epaphius secalis*	5.5
4	*Pterostichus niger*	4.0
5	*Amara aenea*	3.0
6	*Synuchus nivalis*	2.0
7	*Amara familiaris*	2.0
8	*Clivina fossor*	2.0
9	*Notiophilus biguttatus*	1.0
10	*Carabus nemoralis*	0.5
11	*Harpalus rufipes*	0,5
12	*Calathus fuscipes*	0.5
13	*Patrobus atrorufus*	0.5
14	*Pterostichus vernalis*	0.5
15	*Calathus melanocephalus*	0.5
16	*Loricera caerulescens*	0.5
17	*Badister lacertosus*	0.5
18	*Trechoblemus micros*	0.5
19	*Bembidion lampros*	0.5

	Młochów	%
1	*Nebria brevicollis*	32.5
2	*Harpalus rufipes*	12.0
3	*Pterostichus vulgaris*	10.5
4	*Amara similata*	9.0
5	*Agonum assimile*	6.0
6	*Calathus fuscipes*	3.0
7	*Synuchus nivalis*	3.0
8	*Amara aenea*	3.0
9	*Carabus hortensis*	1.5
10	*Carabus auronitens*	1.5
11	*Carabus granulatus*	1.5
12	*Pterostichus niger*	1.5
13	*Pterostichus caerulescens*	1.5
14	*Pterostichus oblongopunctatus*	1.5
15	*Harpalus punctatulus*	1.5
16	*Amara familiaris*	1.5
17	*Stomis pumicatus*	1.5
18	*Loricera caerulescens*	1.5
19	*Agonum dorsale*	1.5
20	*Notiophilus biguttatus*	1.5
21	*Harpalus latus*	0.5
22	*Harpalus affinis*	0.5
23	*Pterostichus vernalis*	0.5
24	*Clivina fossor*	0.5
25	*Calathus melanocephalus*	0.5
26	*Notiophilus palustris*	0.5
27	*Asaphidion flavipes*	0.5
28	*Bembidion ustulatum*	0.5
29	*Bembidion lampros*	0.5

	Warszawa	%
1	*Pterostichus vulgaris*	26.0
2	*Nebria brevicollis*	15.5
3	*Carabus nemoralis*	13.0
4	*Calathus fuscipes*	13.0
5	*Amara aenea*	13.0
6	*Harpalus rufipes*	6.5
7	*Anisodactylus binotatus*	4.5
8	*Harpalus griseus*	2.5
9	*Pterostichus niger*	2.0
10	*Badister bipustulatus*	1.0
11	*Notiophilus palustris*	1.0
12	*Asaphidion flavipes*	1.0
13	*Bembidion properans*	1.0

2.1. Number of species in the communities

In an environment almost untouched by man, i.e. in the *Tilio-Carpinetum* forest in Hamernia, the *Carabidae* community consisted of 23 species (9 genera). In areas under certain anthropogenic pressure there usually occurred significant variations from that number. The value and direction of those variations depended on the character and intensity of that pressure. In the park in Młochów there were 29 species of carabid beetles (14 genera), in Radziejowice — 19 species (15 genera) and in Warsaw — 13 species (11 genera).

A considerable enrichment (of about 26%) of the *Carabidae* community in the neglected village park in Młochów in relation to a community typical of a primary environment was undoubtedly due to a greater environmental differentiation in that park in comparison with the control site. The tree-covered areas of the park maintained a relatively natural character, but the lawns — introduced mosaically on part of the area — had once constituted new complexes of herbaceous plants. Those lawns had not been cultivated for years and, as a result of spontaneous succession, grew similar to meadow complexes. The proportion of ecotonal parts in that area increased simultaneously. Such a situation created favourable conditions for a qualitative enrichment of the fauna of that area. The variety of species was probably also influenced by the fact that the park was situated among fields. That situation made it possible for field *Carabidae* to visit the area while the local forest species remained there.

In the cultivated village park in Radziejowice the number of species of carabid beetles was slightly lower than that in the forests in Hamernia. However, that value might have been lower due to a period of investigations shorter than in other areas (only one season). The actual number of species occurring there was most certainly similar to the number of species in Hamernia (Fig. 1). This opinion is based on results of previous studies which revealed that in such types of environment during the second season of investigations a few accessory species were added to the list of recorded *Carabidae* (the author's own unpublished data). The number of species in Radziejowice was only slightly changed in relation to the value for a primary environment. It was probably a result of the influence of two contradictory tendencies: 1 — environmental differentiation (introduction of lawns and ecotonal parts) resulting in greater variety of species; 2 — intensity of gardening (removal of grass mown and raking off of litter) which limited the occurrence of certain species. The park in Radziejowice was surrounded mainly by forests and bushes; there were no fields in its immediate vicinity. Due to a lack of that type of environmental base the ecological niches left by forest species incapable of living in a park could have remained empty longer than those in the park in Młochów which was situated among fields.

The number of species recorded in the park in Warsaw was considerably lower (over 43% lower in relation to the *Carabidae* community in Hamernia).

It was undoubtedly influenced by a number of factors constituting the two main types of the anthropogenic influence there: gardenizing pressure and urban pressure in its wider meaning. Gardening activities in urban parks are greatly varied and unduely frequent. Herbicides, chemical substances for plant protection and fertilizers are used. At the same time, urban green areas are influenced by all negative aspects of urbanization. For the flora and fauna the most important are air and soil pollution with toxic compounds – results of motorization and industry, soil salinity, vibration of the ground etc.

In the light of the above observation it is possible to state that a moderate anthropogenic pressure resulting in an environmental diversity has a positive influence on the specifical variety of *Carabidae* communities in a given area. But the number of species of carabid beetles decreased rapidly when the intensity of the pressure exceeded the critical value; the diversity of the changing environment was smaller and, at the same time, it became entirely different from the primary environment (Fig. 1).

2.2. Population density of the communities

Out of all the investigated areas the highest index of the abundance of *Carabidae* was in the control environment (Hamernia). In Hamernia it was 12.8, in Młochów – 6.8, in Radziejowice – 10.6, in Warsaw – 4.6. Thus, an increase in the anthropogenic pressure resulted in a considerable quantitative reduction of a community (Fig. 1). In the extreme case (the urban park) that reduction even reached 64%. The abundance of carabid beetles in Młochów was lower than in Radziejowice, an area of more intensive gardening, and it was probably due to factors secondary to the influence of the basic kind of pressure. Such an interpretation is justified by data on the distribution of the abundance of *Carabidae* in the two areas – in their lawn and tree-covered parts. On the lawns in Młochów the index of the abundance of carabid beetles was about 8, whereas in the forest part of the park it was about 5. In Radziejowice it was only about 3 on the lawns and as high as about 18 in the tree-covered parts. Theoretically, therefore, in relation to the situation in Radziejowice the abundance of the carabid community in the forest part in Młochów should have been higher. It was lower probably as a result of the presence of a numerous flock of hens feeding there and constantly stirring the litter. The lawns, possibly thanks to their rich vegetation, were left almost untouched by hens. In the park in Radziejowice there were no hens at all and that made it possible for local communities of *Carabidae* to reach an abundance higher than their total abundance in Młochów – in spite of the tendency created by gardening pressure. That is why in Fig. 1 only the mean value of the abundance index for the village parks was marked (point "M/R").

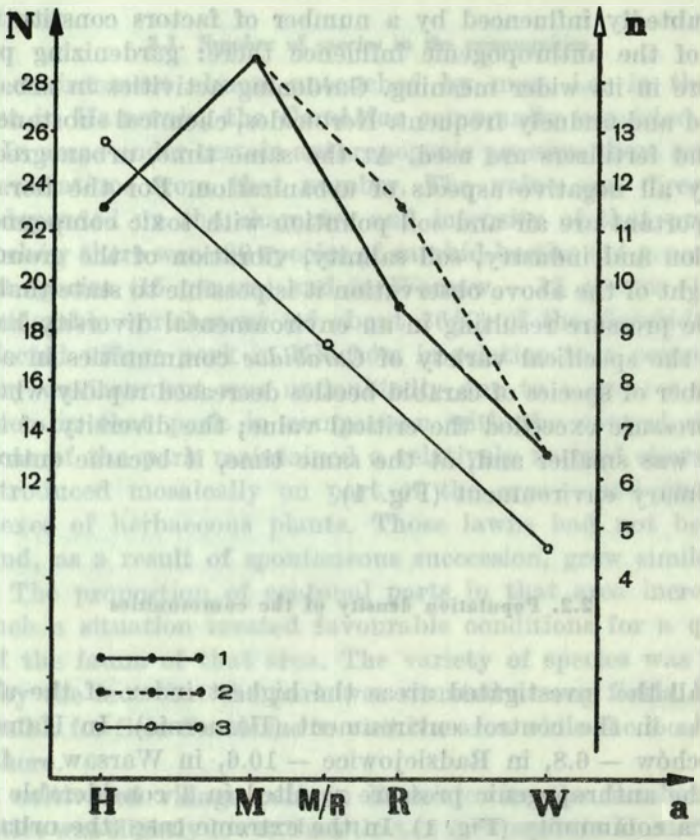


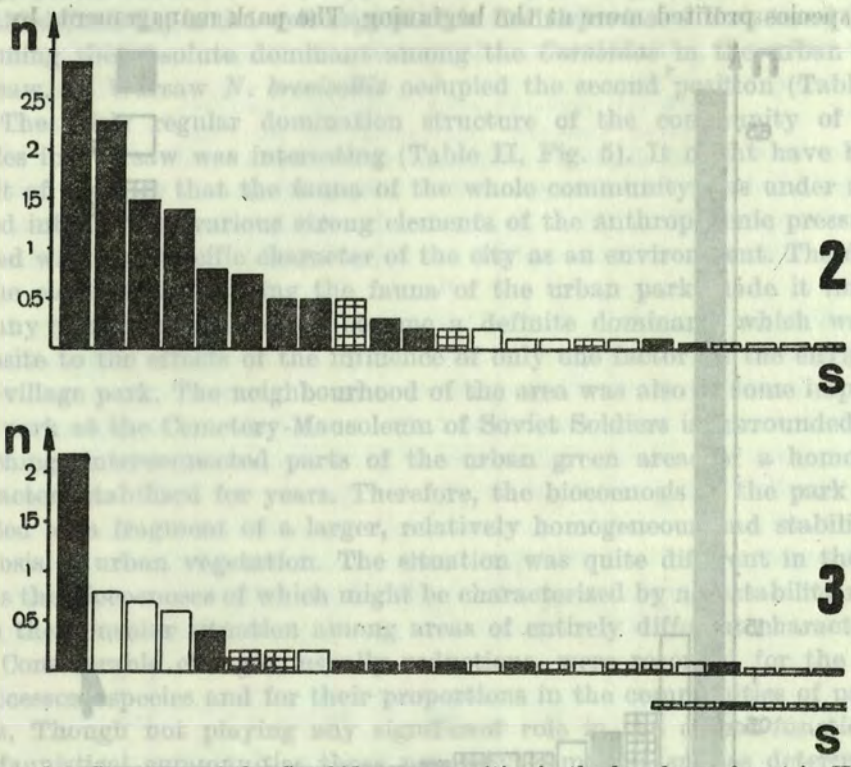
Fig. 1. Changes in the number of species and the abundance of individuals in the *Carabidae* communities under the influence of anthropogenic pressure: N – number of species; n – abundance index; a – anthropogenic pressure; H – Hamernia; M – Młochów; M/R – village parks on average; R – Radziejowice; W – Warsaw; 1 – changes in the number of species; 2 – supposed change in the number of species (see the explanation in the paper); 3 – abundance changes.

2.3. Domination structure of the communities

The domination structure within faunistic communities typical of natural environments is usually characterized by slow transitions between gradually decreasing values of the percentage of particular species (Odum 1977). Such an "ideal" structure was recorded for the *Carabidae* of the hornbeam forest in Hamernia (Table II, Fig. 2).

In environments under a strong pressure of a definite anthropogenic factor there was recorded a distinct disproportion between the percentages of particular species within the communities occurring there. One or several dominant species, adapted to the specific conditions of a given habitat had a considerable quantitative advantage over other species, simply because of

the influence of the factor selective for the community was favourable for them. The limiting effect of that factor on other species reduced their abundance or even excluded the most sensitive species from the community (ODUM 1977).

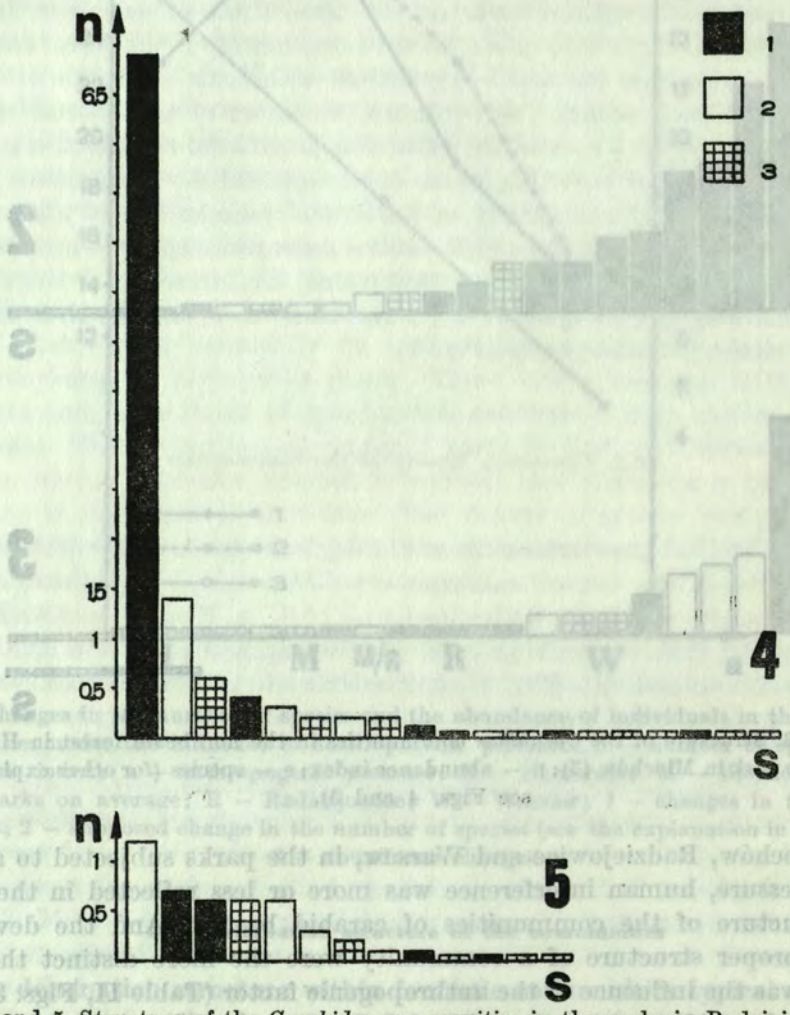


Figs. 2 and 3. Structure of the *Carabidae* communities in the hornbeam forest in Hamernia (2) and in the park in Młochów (3): n — abundance index; s — species (for other explanations see Figs. 4 and 5).

In Młochów, Radziejowice and Warsaw, in the parks subjected to anthropogenic pressure, human interference was more or less reflected in the domination structure of the communities of carabid beetles. And the deviations from the proper structure of a community were the more distinct the more one-sided was the influence of the anthropogenic factor (Table II, Figs. 3, 4, 5).

In the *Carabidae* community in Hamernia the group of dominants consisted of two species — *Carabus hortensis* — 22.5% and *C. glabratus* — 18.0%. Thus, the total percentage of dominants in that community was 40.5%. In the communities of all the other areas only one species was definitely dominant. In Młochów and Radziejowice it was *Nebria brevicollis* — 32.5% and 65.0% respectively, in Warsaw it was *Pterostichus vulgaris* — 26.0% of the total abundance of the community. Both species were obviously favoured by the described type of environmental anthropogenization. In the carabid beetle community of the hornbeam forest in Hamernia *N. brevicollis* was never recorded

and *P. vulgaris* was one of the less numerous accessory species. Up to a certain point the increasing anthropogenization of the environment was favourable to both species simultaneously, though *N. brevicollis* — a stenothermic, polytopic forest species profited more at the beginning. The park management, by main-



Figs. 4 and 5. Structure of the *Carabidae* communities in the parks in Radziejowice (4) and in Warsaw (5): n — abundance index; s — species; 1 — forest species; 2 — field species; 3 — other species.

taining clearance spaces among trees resulted in increasing the temperature of the area, but there still were parts densely covered by trees (Młochów and Radziejowice) and they determined the advantage of that species. However, along with the process of destroying trees converting the environment into areas fairly open and covered with specifically poor herbaceous plants (thus making them similar to fields) the eurythermic, polytopic field species — *P.*

vulgaris become a more and more favoured one. In respect of abundance that species occupied only the thirteenth position in the community in Hamernia (1.5 % of the whole community). In the neglected park in Młochów it was the third (10.5 %), in the well-kept park in Radziejowice – the second (11.5 %), becoming the absolute dominant among the *Carabidae* in the urban park in Warsaw. In Warsaw *N. brevicollis* occupied the second position (Table II).

The fairly regular domination structure of the community of carabid beetles in Warsaw was interesting (Table II, Fig. 5). It might have been the result of the fact that the fauna of the whole community was under a many-sided influence of various strong elements of the anthropogenic pressure connected with the specific character of the city as an environment. The diversity of the elements influencing the fauna of the urban park made it impossible for any particular species to become a definite dominant, which was quite opposite to the effects of the influence of only one factor on the environment of a village park. The neighbourhood of the area was also of some importance. The park at the Cemetery-Mausoleum of Soviet Soldiers is surrounded by far-reaching, interconnected parts of the urban green areas of a homogeneous character, stabilized for years. Therefore, the biocoenosis of the park may be treated as a fragment of a larger, relatively homogeneous and stabilized biocoenosis of urban vegetation. The situation was quite different in the village parks the biocoenoses of which might be characterized by non-stability resulting from their insular situation among areas of entirely different character.

Considerable changes, usually reductions, were recorded for the number of accessory species and for their proportions in the communities of particular areas. Though not playing any significant role in the actual functioning of the faunistical communities those not very numerous species determined, to a great extent, their homeostatic abilities. When the agreed upon, three-degree scale of domination (dominants, influents, accessory species) was used the number of accessory *Carabidae* species in Hamernia could be defined as 19. It constituted 83 % of the total number of species in the community. In Młochów there were 24 – also 83 %, in Radziejowice 17 – 89 %, in Warsaw 8 – 62 %. The approximate percentage of individuals of those species in the total abundance of the communities was 37 %, 30 %, 25 % and 20 % respectively.

A considerable proportion of accessory species in the village parks (particularly in Młochów) might have been connected with a greater environmental diversity of those areas. In the urban park the environment was less diversified and unfavourable to most animal forms. There survived only a few resistant species, for the anthropogenic pressure created possibilities for getting rid of their competitors.

2.4. Similarity of the communities

The degree of the qualitative similarity of particular *Carabidae* species of the studied areas was calculated on the basis of the percentage version of the Sørensen formula (1948).

The values of the similarity indices of each pair of the communities corresponded to the values of the differences in the intensity of the anthropogenic pressure influencing particular areas (Table III). The similarity between the *Carabidae* communities of the areas differing by one degree of pressure (Hamernia — Młochów; Młochów — Radziejowice; Radziejowice — Warsaw) was

Table III. Similarity index (SØRENSEN's number) between *Carabidae* communities in particular study areas: H — Hamernia; M — Młochów; R — Radziejowice; W — Warsaw.

	H	M	R	W
H		42	29	22
M	42		54	38
R	29	54		44
W	22	38	44	

47 % on average. For the areas differing by two degrees of pressure (Hamernia — Radziejowice; Młochów — Warsaw) that value was only 34 %, and for the areas differing by three degrees (Hamernia — Warsaw) — merely 22 %.

2.5. Percentage of forest and field forms

In order to establish the quantitative advantage of a definite ecological type of carabid beetles in the communities of particular areas all the recorded species were divided into three groups, their habitat requirements being the criteria of the division. Into group I were included typically forest species (irrespective of the type of forest they most readily inhabited) — e.g. the majority of species from the genus *Carabus* L., and also *Nebria brevicollis*, *Pterostichus oblongopunctatus*, *P. niger* and others. Group II comprised forms typical of open areas, often occurring in fields — among others were species from the genus *Amara* BON., *Pterostichus vulgaris*, *Harpalus rufipes* and *H. affinis*. A differentiation between forest and field species was the basis for a further analysis. Group III comprised all the remaining species not falling

into the first two groups. In it were both ubiquistic forms (e.g. species from the genus *Calathus* Bon. and species typical of environments other than forests and fields (e.g. *Carabus convexus*).

A typical characteristic of many forest species is a preference for relatively low temperatures, considerable humidity and shadiness, contrary to field species preferring higher temperatures, lower humidity and exposure to the sun (Tischler 1971).

In the *Carabidae* community in the forest environment in Hamernia forest species dominated distinctly (Fig. 2) both in respect of the number of species — 52 % and the total abundance of individuals — 86 %. The respective values for field forms were 26 % and 6 % (all the field species belonged to the accessory group).

A gradually increasing intensity of the park management, in the critical area (the park in Warsaw) supplemented by the influence of urban pressure, resulted in a very distinct increase in the percentage of individuals belonging to field species and a decrease in that of forest species (Figs. 3, 4, 5). That phenomenon was accompanied by a noticeable process of disappearing of forest species which were mainly substituted by forms called "others" (species from group III). The changes in the percentage of field species in the composition of particular communities were insignificant — most frequently only their abundance increased (Fig. 6). The regularity of those processes was slightly disturbed by the different situations of the parks in Młochów and Radziejowice.

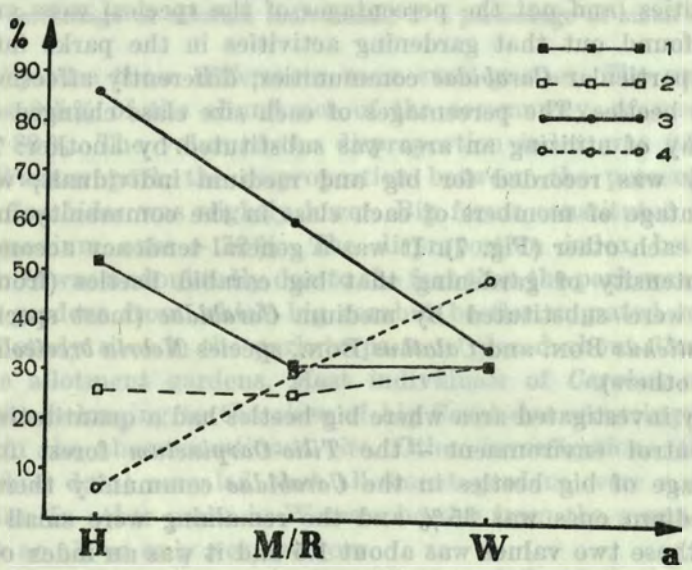


Fig. 6. Changes in the percentage of forest and field forms in the *Carabidae* communities under anthropogenic pressure: a — anthropogenic pressure; H — Hamernia; M/R — village parks; W — Warsaw; 1 — percentage of forest species; 2 — percentage of field species; 3 — percentage of indyviduals of forest species; 4 — percentage of indyviduals of field species.

That is why the values for those areas were calculated as means and thus the general data for the village parks were obtained (Fig. 6 – point "M/R").

In the *Carabidae* communities of the village parks the percentage of forest species was on average 31% and individuals belonging to those species constituted 60% of the total abundance of those communities. For field forms those values were 25% and 29% respectively.

In the urban park forest species also constituted 31% of the qualitative composition of the community, but their abundance was only 34% of the total. For field forms those values were: 31% (proportion of species) and 48% (proportion of individuals).

2.6. Percentage of forms of different body sizes

The species caught during the investigations were divided into 3 classes, the size of particular individuals being the criterion of the division. Species with individuals over 20 mm long were considered as big forms, from 10–20 mm – medium and below 10 mm – small. The class of big forms comprised 7 species from the genus *Carabus* L. The class of medium forms comprised 16 species from those of a size of *Harpalus affinis* to those of a size of *Carabus arcensis*. The class of small forms comprised 26 species among which were members of genera such as *Notiophilus* Dum., *Amara* Bon., *Bembidion* Latr. Only the total percentages of the members of a given class in the total abundance of the communities (and not the percentages of the species) were analysed.

It was found out that gardening activities in the parks influenced the diversity of particular *Carabidae* communities, differently affecting big, small and medium beetles. The percentages of each size class changed considerably when one way of utilizing an area was substituted by another. The greatest changeability was recorded for big and medium individuals, with changes in the percentage of members of each class in the community inversely proportional to each other (Fig. 7). It was a general tendency accompanying the increasing intensity of gardening that big carabid beetles (from the genus *Carabus* L.) were substituted by medium *Carabidae* (most species from the genera *Pterostichus* Bon. and *Calathus* Bon., species *Nebria brevicollis*, *Harpalus rufipes* and others).

The only investigated area where big beetles had a quantitative advantage was the control environment – the *Tilio-Carpinetum* forest in Hamernia. The percentage of big beetles in the *Carabidae* community there was about 52%, of medium ones was 35% and the remaining were small forms. The quotient of those two values was about 1.5 and it was an index of the disproportion between the abundance of big and medium carabid beetles in the community. For the other areas that index was fractional, which meant a quantitative advantage of small individuals.

In Młochów the percentage of big forms was only about 5%, but of medium

ones 68 %. The value of the disproportion index was 0.07. Thus, not only were the quantitative proportions between the size classes reversed, but the absolute disproportion between them increased considerably as well.

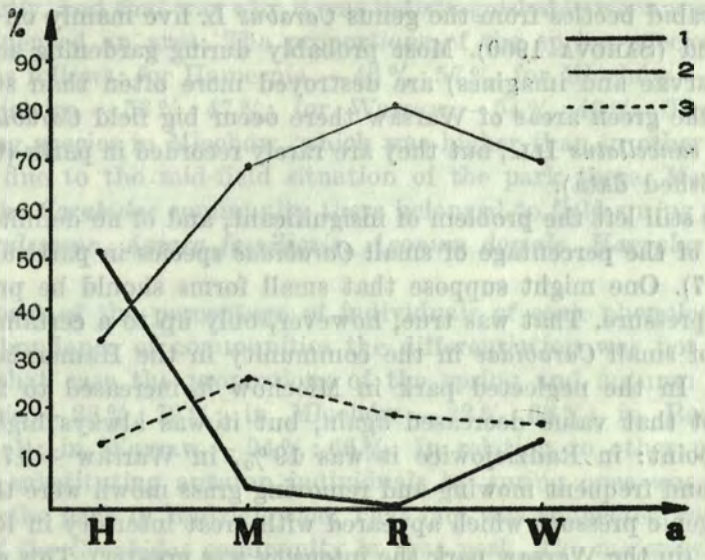


Fig. 7. Changes within the *Carabidae* communities in the percentage of individuals of different body sizes resulting from anthropogenic pressure: a — anthropogenic pressure; H — Hamernia; M — Młochów; R — Radziejowice; W — Warsaw; 1 — percentage of big individuals; 2 — percentage of medium individuals; 3 — percentage of small individuals.

In Radziejowice those differences were even greater. The percentage of big forms was 0.5 % of the abundance of the community, of medium forms it was about 82 %. The value of the disproportion index was 0.006 (!).

In the Warsaw park the disproportion between the percentage of big and medium *Carabidae* was slightly lower. Big forms constituted 13 % of the community, medium ones — 70 %. The disproportion index between them was about 0.2. It was undoubtedly due to the fact that the park was surrounded by allotment gardens from which big carabid beetles migrated to the park. In one of the study sites in the park traps were placed about 30 m from the border of the allotment gardens. Most individuals of *Carabus nemoralis* — the only species belonging to the class of big *Carabidae* occurring in the park were caught in the above-mentioned site. Other investigations (the author's own unpublished data) revealed that allotment gardens were a refuge area for that species. In other parks in Warsaw beetles from the genus *Carabus* L. did not occur at all or only very seldom.

A decrease in the percentage of big forms of *Carabidae* accompanying an increase in the intensity of gardening in the areas inhabited by them was due to several reasons. It seemed that the most important was a limitation of the possibilities of their occurrence caused by reducing the siez of areas

covered with trees or dense bushes (all the recorded species considered big forms were typically forest species). Their situation grew worse as a result of raking off of litter in the parks in Radziejowice and Warsaw. Predaceous larvae of carabid beetles from the genus *Carabus* L. live mainly on the surface of the ground (ŠAROVA 1960). Most probably during gardening activities big *Carabidae* (larvae and imagines) are destroyed more often than smaller individuals. In the green areas of Warsaw there occur big field *Carabidae* as well, e.g. *Carabus cancellatus* ILL., but they are rarely recorded in parks (the author's own unpublished data).

There is still left the problem of insignificant, and of no definite tendency, fluctuations of the percentage of small *Carabidae* species in particular communities (Fig. 7). One might suppose that small forms should be prefferred by gardenizing pressure. That was true, however, only up to a certain point. The percentage of small *Carabidae* in the community in the Hamernia forest was about 13%. In the neglected park in Młochów it increased to 27%. From that moment that value decreased again, but it was always higher than at the initial point: in Radziejowice it was 19%, in Warsaw — 17%. Raking off of litter and frequent mowing and removing grass mown were those factors of anthropogenic pressure which appeared with great intensity in Radziejowice and Warsaw (in the Warsaw park the intensity was greater). This gave ground for a supposition that very small insects of low speed were particularly exposed to constant removal from the park together with litter and hay (on very hot days the *Carabidae* were found under heaps of drying grass). If so, it is clear why the percentage of medium individuals in the communities of carabid beetles increased along with an increasing intensity of gardenizing pressure.

2.7. Percentage of forms of a definite phenological type

Two basic phenological types are distinguished among *Carabidae*. They are spring and autumn species (LARSSON 1939, LINDROTH 1945). Individuals belonging to spring species winter as imagines, reproduce in spring and finish their metamorphosis cycle in autumn. Autumn species winter as larvae, their transformation occurs in summer and their reproductive period occurs in autumn. It has been found out that spring species are generally characterized by a wider tolerance for environmental conditions. To these belong most *Carabidae* inhabiting fields (TISCHLER 1971). When they occur in forests, spring species inhabit areas with soils poor in organic substances more readily than autumn species (SZYSZKO 1974). Therefore, it could be expected that an analysis of the composition of the studied communities of carabid beetles would reveal that autumn forms were gradually substituted by spring forms along with an increasing anthropogenic pressure on particular areas. Specially arranged study sites there differed, in their character, from forest areas and, at the same time, were more and more similar to agricultural areas. It was sus-

pected that the amount of organic matter in the soil decreased proportionally to the intensity of removing litter and grass mown from the parks.

It appeared, however, that the supposed tendency did occur, but not very distinctly, and that was why it was indistinguishable when some additional factors influenced an area. The proportions of the spring species to autumn ones were as follows: for Hamernia – 43 % : 57 %; for Młochów – 62 % : 38 %; for Radziejowice – 53 % : 47 %; for Warsaw – 54 % : 46 %. The percentage of the spring species in Młochów, which was higher than in other areas, could have been due to the mid-field situation of the park there. Many accessory species in the *Carabidae* community there belonged to field spring forms (*Pterostichus caerulescens*, *Amara familiaris*, *Agonum dorsale*, *Harpalus rufipes* and others).

In respect of the percentage of individuals of each phenological type in the total abundance of communities the differentiation was not considerable either. In that case the proportions of the spring and autumn forms were: in Hamernia – 28 % : 72 %; in Młochów – 32 % : 68 %; in Radziejowice – 10 % : 90 % (!); in Warsaw – 34 % : 66 %. In relation to other parks the regularity of substituting autumn individuals by spring ones was significantly different in the park in Radziejowice. That fact was connected with a peculiar structure of the *Carabidae* community in that park. The majority of the community (65 %) consisted of individuals of one species – *Nebria brevicollis* – belonging to the autumn developmental type. Thus the high value of the proportion of individuals of the autumn forms in the community in the Radziejowice park was a result of the specifical homogeneity of that community. But it must be remembered that although *N. brevicollis* is a species of the autumn developmental type, it belongs to the forms of a high ecological plasticity. Some populations of that species also demonstrate deviations from the typically autumn phenological cycle (Lindroth 1945, Jørum 1976).

3. CONCLUSIONS

The above results support the opinion that carabid beetles are useful as bioindicators of the condition of an environment. Their bioindicatory value is not diminished by some deviations from the general tendencies in community transformations under the influence of anthropogenic pressure. On the contrary, those deviations, caused by secondary factors and easy to be rightly interpreted, seem to stress the significance of *Carabidae*. The obtained results may be a basis for further detailed investigations on the influence of urban anthropogenic pressure on communities of carabid beetles.

REFERENCES

Dunger W. 1968. Die Entwicklung der Bodenfauna auf rekultivierten Kippen und Halden des Braunkohlentagebaues. Ein Beitrag zur pedozoologischen Standortsdiagnose. Abh. Ber. Naturk. mus. Görlitz, Leipzig, **43**: II/1–II/256, 2 maps, 106 ff., 49 tt.

Greenslade P. J. M. 1964. Pitfall trapping as a method for studying populations of *Carabidae* (*Coleoptera*). J. Anim. Ecol., Oxford, **33**: 301–310, 2 ff., 5 tt.

Heydemann B. 1955. Carabiden der Kulturfelder als ökologische Indikatoren. Ber. 7. Wandervers. dtsch. Ent., Berlin, 172–185, 1 f., 2 tt.

Jørum P. 1976. Life cycle and population density of *Nebria brevicollis* F. (*Coleoptera, Carabidae*) in a Danish beech forest. Vidensk. Meddel. dansk naturh. Foren., København, **31**: 244–261, 1 f., 9 tt.

Kabacik-Wasylik D. 1970. Ökologische Analyse der Laufkäfer (*Carabidae*) einiger Agrarkulturen. Ekol. pol., Warszawa, **18**: 137–209, 35 ff., 25 tt.

Larsson S. G. 1939. Entwicklungstypen und Entwicklungszeiten der dänischen Carabiden. Ent. Medd., København, **20**: 277–560, 39 ff., 11 tt.

Leśniak A. 1975. Metody odłowu epigeicznych *Carabidae, Col.* w środowiskach leśnych. Pr. Kom. nauk. – Kom. Biol. Gleby, Warszawa, **15**: 3–16, 3 + 1 tt.

Leśniak A. 1977. Alterations in structures of communities of epigeic *Carabidae, Col.*, as a bioindicator of pollution in forest habitats. III International Conference: Bioindicators Deteriorisationis Regionis, Liblice, 16–17 (abstract).

Lindroth G. H. 1945. Die fennoskandischen *Carabidae*. I. Spezieller Teil. Göteborgs Vetensk. Samh. Handl., Göteborg, (B), 4, 709 pp., 1 map.

Martiš M. Štrevlíkovití brouci (*Col., Carabidae*) jako bioindikátory ekologické rovnováhy krajiny. Preliminary report (manuscript).

Odum E. P. 1977. Podstawy ekologii. PWRiL, Warszawa, 678 pp.

Petruška F. 1971. Vliv pěstované plodiny na vývoj populací polních střevlíkovitých. Acta Univ. palack. olomuc. Fac. Rer. nat., Olomouc, **34**: 151–191, 13 ff., 18 tt.

Puszkar T. 1976. Próba zastosowania fauny glebowej jako bioindykatora stopnia zniszczenia i odbudowy środowiska przyrodniczego w rejonie oddziaływania emisji Zakładów Azotowych w Puławach. Pam. puław., Puławy, **66**: 229–239, 3 ff., 1 t.

Šarova I. H. 1960. Morfo-ekologičeskije tipy ličinok žuželic (*Carabidae*). Zool. Ż., Moskva, **39**: 691–708, 6 ff.

Sørensen T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Biol. Skr., København, **5**: 1–34, 10 ff., 4 tt.

Szyszko J. 1974. Relationship between the occurence of epigeic Carabids (*Coleoptera, Carabidae*), certain soil properties, and species composition of a forest stand. Ekol. pol., Warszawa, **22**: 237–274, 13 ff., 9 tt.

Tischler W. 1971. Agroekologia. PWRiL, Warszawa, 487 pp.

Tobisch S., Dunger W. 1973. Carabiden des Neissetales bei Ostritz (Oberlausitz) und ihre Reaktion auf Industrie-Emissionen. Abh. Ber., Naturk. mus. Görlitz., Leipzig, **48**: II/1–II/20, 2 tt.

Instytut Zoologii PAN
00-950 Warszawa, ul. Wilcza 64

STRESZCZENIE

[Tytuł: Wpływ sposobu zagospodarowania i położenia terenów parkowych na ukształtowanie zgrupowań chrząszczy biegaczowatych (*Coleoptera, Carabidae*)]

Carabidae są grupą owadów o znacznych walorach bioindykacyjnych. Coraz powszechniej wykorzystywane są do oceny stanu i zmian środowisk, podlegających różnego rodzaju wpływom antropogenicznym. Niniejsze opracowanie jest wstępną analizą przekształceń zachodzących w obrębie zgrupowań tych chrząszczy w wyniku oddziaływania presji antropogenicznej o charakterze ogrodniczo-urbanizacyjnym. Obiekty badawcze — różnie położone i w różnym stopniu zagospodarowane parki — uszeregowano w ciąg, odpowiadający stopniowemu przekształcaniu środowiska lasu grądowego. Obiektem kontrolnym był las typu *Tilio-Carpinetum* (środowisko o cechach pierwotnych) w pobliżu miejscowości Hamernia (woj. skierniewickie). Obiekty badawcze to 2 parki wiejskie: stary, zaniedbany park w Młochowie (woj. warszawskie) — położony wśród pól uprawnych i stary, uprawiany park pałacowy w Radziejowicach (woj. skierniewickie) — leżący w pobliżu kompleksu leśnego oraz typowy wielkomiejski park w Warszawie. Wszystkie badane obiekty położone są w promieniu 30 km i są potencjalnymi środowiskami lasu grądowego.

Analizując zmiany w obrębie zgupowania *Carabidae* każdego z obiektów, zwrócono uwagę na takie parametry tych zgrupowań, jak liczba gatunków, liczebność, struktura dominacji, udział form leśnych i polnych, udział form o różnych rozmiarach ciała oraz udział form o określonym typie fenologicznym (wiosennych i jesiennych). Stwierdzono następujące zależności:

1. Umiarkowana presja antropogeniczna, powodująca urozmaicenie środowiska (wprowadzenie trawników i zwiększenie partii ekotonowych, przy zachowaniu znacznych jeszcze obszarów w stanie mało zmienionym) wpływa korzystnie na bogactwo gatunkowe zgrupowań *Carabidae*. Po przekroczeniu jednak krytycznej wartości nasilenia presji, kiedy znów zmniejsza się zróżnicowanie środowiska, liczba gatunków raptownie maleje.

2. Zwiększanie intensywności parkowych zabiegów ogrodniczych oraz nasilająca się presja urbanizacyjna powodują wyraźne ograniczanie liczebności zgrupowań.

3. Zmiany struktury dominacyjnej zgrupowań *Carabidae* wyrażają się rosnącą dysproporcją między udziałem gatunków dominujących a udziałem pozostałych gatunków. Odkształcenia od prawidłowej struktury, właściwej zgrupowaniu ze środowiska naturalnego, są tym poważniejsze, im bardziej jednostronne jest oddziaływanie czynnika antropogenicznego.

4. Wzrastające stopniowo nasilenie gospodarki ogrodniczej, uzupełnione w krytycznym punkcie (park miejski) wpływem presji urbanizacyjnej powoduje bardzo wyraźne zwiększanie się udziału osobników z gatunków polnych, kosztem udziału osobników z gatunków leśnych. Zjawisku temu towarzyszy także wyraźny proces zanikania gatunków leśnych.

5. Zabiegi ogrodnicze wpływają w istotny sposób na zróżnicowanie zgupowań *Carabidae*, w różny sposób oddziałując na chrząszcze duże, średnie i małe. Największej zmienności podlega udział osobników dużych (zmniejsza się wraz ze zwiększeniem presji) i średnich (zwiększa się). Zmiany udziału osobników małych są nieznaczne.

6. Zmiany udziałów w zgrupowaniach *Carabidae* gatunków i osobników należących do wiosennego i jesiennego typu rozwojowego są najmniej wyraźne spośród cech analizowanych. Zaznacza się jednak pewna preferencja form wiosennych w środowiskach zantropogenizowanych.

РЕЗЮМЕ

[Заглавие: Влияние способа устройства и положения территорий парков на формирование сообществ жужелиц (*Coleoptera, Carabidae*)]

Carabidae являются группой, обладающей значительными биоиндикаторными свойствами. Они все чаще используются для оценки состояния и изменений среды, подвергающейся различного рода антропогенным влияниям. Настоящая работа является предварительным анализом изменений, происходящих в сообществах этих жуков в результате действия антропогенного пресса в форме урбанизации и устройства зеленых насаждений. Объектом исследований послужили парки, различающиеся по своему положению и степени устройства, которые автор расположил в ряд, соответствующий степени преобразования условий среды леса типа груда. В качестве контроля служил лес типа *Tilio-Carpinetum* (биотоп с первоначальными свойствами), расположенный вблизи местности Гамерния (Скерневицкое воеводство). В качестве объекта исследований послужили два старых сельских парка: старый, запущенный парк в Млохове (Варшавское воеводство) — лежащий среди возделываемых полей, и старый, ухоженный дворцовый парк в Радзеевицах (Скерневицкое воеводство), лежащий вблизи лесного комплекса; а также типичный городской парк в Варшаве. Все исследованные объекты лежат в радиусе 30 км и являются потенциальными биотопами типа груда.

Анализируя изменения в пределах сообщества *Carabidae* в каждом из объектов, автор обращает внимание на такие параметры этих сообществ, как число видов, численность, структура доминирования, содержение лесных и полевых форм, содержание форм с различной величиной тела, а также форм, характеризующихся определенным типом фенологии (весенних и осенних). Констатированы следующие зависимости:

1. Умеренный антропогенный пресс, способствующий большему разнообразию среды (введение газонов и увеличение экотоновых территорий при сохранении значительных мало еще видоизмененных пространств) положительно влияет на богатство видового состава сообщества *Carabidae*. Однако, при пересечении кри-

тической величины силы пресса, когда разнообразие условий среды снова уменьшается, число видов резко падает.

2. Повышение интенсивности мероприятий по уходу за зеленью и увеличивающийся урбанизационный пресс четко ограничивает численность сообществ.

3. Изменения структуры доминирования сообществ *Carabidae* проявляется в увеличении диспропорции между содержанием доминирующих видов по отношению к остальным видам. Деформация нормальной структуры, характерной для сообществ из природных биотопов, тем серьезнее, чем действие антропогенных факторов имеет более одностороннее направление.

4. Постепенная интенсификация работ по устройству парков, дополненная в критическом пункте (городской парк) влиянием урбанизационного пресса, вызывает очень четкое увеличение содержания особей из полевых видов за счет особей из лесных видов. Сопутствует этому явлению также четкий процесс исчезновения лесных видов вообще.

5. Уход за парком существенным образом влияет на дифференциацию сообществ *Carabidae*, воздействуя по-разному на жуки крупные, средние и мелкие. Наибольшей изменчивости подвергается содержание крупных особей (уменьшается вместе с ростом пресса) и средних (повышается). Изменения содержания мелких особей незначительны.

6. Изменения содержания в сообществах *Carabidae* видов и особей, принадлежащих к весеннему и осеннему типу развития, менее всего обозначаются по сравнению с другими анализированными признаками сообществ. Обозначается только некоторое преферирование весенних форм в урбанизированных биотопах.

Redaktor pracy — doc. dr hab. B. Pisarski

Państwowe Wydawnictwo Naukowe — Warszawa 1980
Nakład 750 + 90 egz. Ark. wyd. 1,75; druk. 1 3/8. Papier druk. sat. kl. III, 80 g. B1. Cena zł 10.—
Nr zam. 490/78 — Wrocławska Drukarnia Naukowa

ISBN 83-01-02257-4
ISSN 0015-9301

Redaktor pracy — doc. dr hab. B. Pisarski

Państwowe Wydawnictwo Naukowe — Warszawa 1980
Nakład 750+90 egz. Ark. wyd. 1,75; druk. 1 3/8. Papier druk. sat. kl. III, 80 g. Bl. Cena zł 10.—
Nr zam. 450/75 — Wrocławska Drukarnia Naukowa

ISBN 83-01-01211-0
ISSN 0015-9301