POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGII

FRAGMENTA FAUNISTICA

Tom XXV Warszawa, 30 IX 1980 Nr 16

Wojciech CZECHOWSKI

Carabids (*Coleoptera, Carabidae*) of the Vistula escarpment in Warsaw

[with 8 figures and 4 tables in the text]

1. Introduction

Carabids belong to common insects almost in all terrestrial ecosystems. They show a large biological, ecological and morphological diversity. Due to this and also because of their susceptibility to environmental changes, carabids occupy an important position on the list of bioindicators of the state of the environment (EVERS 1977). Communities of these beetles are, therefore, an object of frequent studies on the faunistic effects of anthropogenic transformations in the environment (HEYDEMANN 1955, DUNGER 1968, TOBISCH and DUNGER 1973, PUSZKAR 1976, LEŚNIAK 1977, MARTIŠ 1977, CZECHOWSKI 1980b). The present paper is also concerned with this problem. It analyses changes in the fauna of carabids caused by urbanization processes. Moreover, the subject of the paper is to determine the role of remnant wooded areas within the town, as refuges of the primeval fauna that inhabited the whole area now built up. The study was carried out on the area of the Vistula escarpment in Warsaw[1]. River escarpments, and in fact their basal parts, are characterized by a particularly rich fauna as compared with that of the whole landscape (STEBAEV 1976).

2. Study area

2.1. General characteristics

The Vistula escarpment as the edge of the river erosive valley running paralelly to the Vistula dissects Warsaw in two parts (Fig. 1). Due to such

[1] Data on the fauna of this area can be found in NOWAKOWSKI (1979), who characterized *Elateridae*, JĘDRYCZKOWSKI (1980) on *Isopoda* terrestria, and CZECHOWSKI (1979), who generally described the communities of epigeic fauna.

a location, the escarpment crosses different urban zones, transformed to various degree and subjected to the anthropogenic pressure of different intensity. The parts of the escarpment located mainly on clay and sandy soils (in spots more fertile) correspond to the sites of oak-hornbeam forests (like most of the Warsaw area).

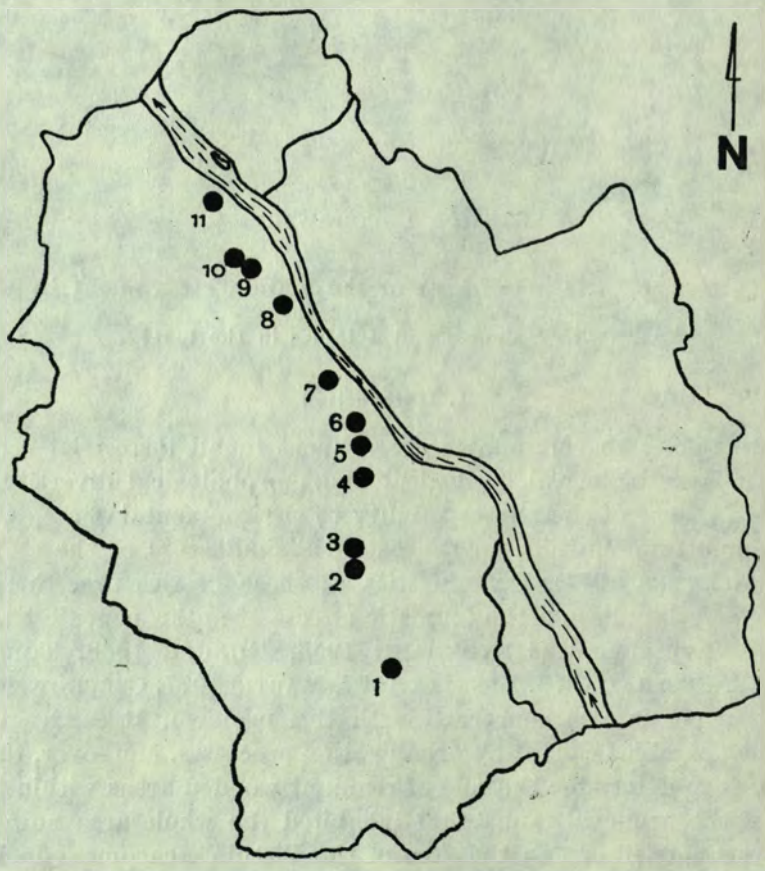


Fig. 1. Boundaries of Warsaw, the Vistula, and location of the study plots on the Vistula escarpment: 1 — Ursynów, 2 — Arkadia, 3 — Królikarnia, 4 — Łazienki, 5 — Sejm, 6 — Park Kultury, 7 — Uniwersytet, 8 — Cytadela, 9 — Gdańska, 10 — Kaskada, 11 — Bielany.

In the period of the town erection and during its subsequent development, a substantial part of the escarpment was deforested and covered with secondary grassland communities. In preserved parts of wooded areas, now being mostly included into urban parks, the tree stand is largely transformed. Only the forest communities located on the peripheries of Warsaw, like those in the region of Ursynów to the south and Bielany to the north, maintain a relatively natural state. The tree stands of the remaining areas are generally deprived of oaks (*Quercus* sp.) and hornbeams (*Carpinus betulus* L.) originally occurring there.

Instead, artificially planted maples (particularly *Acer negundo* L.), robinia (*Robinia pseudoacacia* L.) and limes (*Tilia* sp.) have become most important. Also the layer of herbaceous plants has been substantially changed. Apart from unfavourable effects of the factors strictly related to urbanization, also gardening treatments like the raking and removal for litter or even seasonal application of herbicides account for a qualitative and quantitative simplification of the sward. As a result, some patches of the escarpment are almost completely deprived of herbaceous vegetation.

The distribution of the intensity of urban pressure within the escarpment has been determined from unpublished maps prepared by the Biuro Planowania Rozwoju Warszawy (the Office for Planning Warsaw Development) (1976). A several-degree synthetic scale of urban pressure on the environment was used, in which the following factors were combined:

— demography (density of the population and its pressure on the environment);
— built-up areas (space occupied by buildings and the ratio of firm to green surface area);
— communication (intensity of traffic, concentration of combustion gases within the range of their influence);
— other than traffic sources of pollution (industrial and energetic);
— climate (conditions of air circulation, and thermal-moisture conditions)[1].

The study plots on the escarpment were selected according to the degree of urban pressure.

Among the factors of urban pressure listed above, very important to the fauna, at least to the carabids, are lacking, namely, the character and intensity of gardening treatments (Czechowski 1980b). Therefore, the pressure scale developed by the Biuro Planowania Rozwoju Warszawy has been modified for some plots so that they form a gradient ranging from 1 to 5 degrees of the urban pressure[2].

Of course, the scale of this type, based on the summary results of physical measurements of the intensity of selected factors, cannot strictly correspond to the susceptibility of the fauna. Particular factors of urban pressure must have various effects on animals, and of various intensity. The presence or absence of a definite factor can outweigh the total effect of their factors. It should be expected that a rapid development of the studies on bioindication will contribute soon to the development of anthropogenic pressure scales based on an ecological analysis. For the time being, however, the "technical" scale is the only one available. Thus the analysis in the present paper is carried out from a reverse

[1] The scale of the anthropogenic transformation of the environment in Finland is constructed on a similar basis; it is prepared for the whole country (Mansikkaniemi 1974).
[2] The complete scale for the whole area of Warsaw contains 8 degrees.

point of view, i.e., a relation between the degree of urbanization measured as the impressions of man and the state of the fauna is analysed. Therefore, it should be realized that these considerations are of a very inadequate character.

2.2. Description of the study plots

The sequence of the study plots on the escarpment stretched from the peripheral districts on both ends of Warsaw towards the centre of the town. All the plots were more or less wooded. The characteristics given below are mostly based on the paper by NOWAKOWSKI (1979). The plots are listed in the order corresponding to their location along the escarpment, from south to north (Fig. 1).

1. Ursynów. A relatively little changed oak-hornbeam forest on clay soil. At the base of the escarpment wet meadows, and higher up a park. The peripheral southern plot, with an urban pressure of 1 degree.

2. Arkadia. Covered with maple-hornbeam-ulm tree stands on humic-clay soil. Herbaceous plants heavily destroyed. The area of the Arkadia park. Urban pressure 5.

3. Królikarnia. Also located in the Arkadia park, at the small palace called Królikarnia. A similar tree stand but thinned; grassy sward. Urban pressure 4.

4. Łazienki. Tree stand with a rich undergrowth and very poor herbaceous vegetation; clay-humic soil. The area of the Łazienki park. Urban pressure 5.

5. Sejm. Tree stand with maple, lime and robinia; herb layer completely destroyed in spots; clay-humic soil. The area of the "Culture and Leisure" park in the Powiśle district, behind the Sejm building. Urban pressure 3.

6. Park Kultury. Also located in the "Culture and Leisure" park. Tree stand much thinned, grassy sward. Urban pressure 4. (This plot has a little different location than that described under the same name by NOWAKOWSKI).

7. Uniwersytet. Tree stand with maple, lime and robinia; poor undergrowth and largely transformed herb cover; clay-humic soil. At the base a large area of open lawns, higher up buildings of the University of Warsaw. Urban pressure 5.

8. Cytadela. Tree stand with maple and lime; rich undergrowth and relatively poor herbage. Humus-clay soil with a high content of rubble. The only stand beyond the true escarpment, located on the artificial embankment of the Warsaw Citadel, adjoining the Vistula escarpment. Urban pressure 3.

9. Gdańska. Rather thin tree stand of old oaks mixed with hornbeams, limes and maples; well developed undergrowth and luxuriant herbs. Sandy soil. Urban pressure 2.

10. Kaskada. Habitat conditions similar to those on the preceding plot. The difference is that the tree layer is more closed and in this relation the herb layer less developed. Located in the Kaskada park. Urban pressure 2.

11. Bielany. Oak-hornbeam forest on sandy soil in the "Las Bielański" reserve. Peripheral northern plot. Urban pressure 1.

3. Methods

The study was carried out in 1976–1977. Barber's pitfall traps were mainly used to catch insects. In 1976 samples were taken in 4 plots (Ursynów, Łazienki, Park Kultury, Bielany) while in 1977 all the 11 plots were sampled. Glass cylinders 4 cm in diameter and about 10 cm deep were used as traps. They were put into hollows made with a soil sampler. The traps were filled with ethylene glycol by $^1/_3$ of their volume. Samples were taken for 14 days each month over the growing season, i.e. from April through October. On each plot, except for Bielany, a monthly series of samples contained the material from 10 traps. On the Bielany plot, where the habitat was most diversified, samples were taken at three points with 10–20 traps each. During the two years of the study 1330 traps were controlled and more than 1000 samples were taken (some traps being destroyed).

The collected materials have been complemented with the data on *Carabidae* from soil samples taken on the escarpment by E. Nowakowski in 1976. Using the two methods, about 2000 adult carabids were collected.

In the present paper also some unpublished data are used on the carabids inhabiting habitats typical of managed urban green areas such as lawns in the parks. These additional materials were collected from the same number of plots as on the escarpment, using the same methods and in the same period[1]. In most cases (8 per 11) the lawns compared with the escarpment were located in the same parks. Particularly important here is similarity in the location of the peripheral plots (Ursynów and Bielany) of the two categories. They are fully comparable.

4. Species composition

A total of 53 carabid species were recorded in the whole area of the Vistula escarpment under study, while 43 species in the compared lawns of urban parks. The tree stands of the escarpment were dominated by the polytopic forest species such as *Nebrida brevicollis* (Fabr.) and *Carabus nemoralis* O. F. Müll.

---

[1] Studies on the carabid fauna in natural and semi-natural tree stands of the Vistula escarpment were also carried out to complement a larger contribution to the occurrence of these beetles in different urban habitats of Warsaw, being prepared now.

Table I. Occurrence, numbers and percentage proportions of carabids on the Vistula escarpment in Warsaw (the index of numbers (n) is the number of specimens caught in 10 traps over a period of 14 days; + – sporadic occurence; × – the species found only in soil samples; percentage proportions of particular species are given to the nearest 0.1%)

No.	Species \ Plot	Ursynów	Arkadia	Królikarnia	Łazienki	Sejm	P. Kultury	Uniwersytet	Cytadela	Gdańska	Kaskada	Bielany	All plots, average	
		1	2	3	4	5	6	7	8	9	10	11	*n*	%
1	*Carabus auronitens* FABR.	7.1											0.6	5.7
2	*Carabus convexus* FABR.								0.8				0.1	0.9
3	*Carabus cancellatus* ILL.						1.8						0.2	1.9
4	*Carabus nemoralis* O. F. MÜLL.	3.2	0.5	0.1		3.7	0.3	0.2	0.9	2.6	2.0	1.0	1.3	12.3
5	*Carabus hortensis* L.	3.8										3.1	0.6	5.7
6	*Carabus glabratus* PAYK.	0.1											+	0.1
7	*Cychrus caraboides* (L.)	0.2											+	0.2
8	*Leistus ferrugineus* (L.)	0.2							0.3				+	0.5
9	*Leistus rufescens* (FABR.)	0.1											+	0.1
10	*Nebria brevicollis* (FABR.)	0.4	0.4	0.7	×	8.5	2.7	1.5	0.1	2.3	10.3	1.6	2.6	24.5
11	*Notiophilus biguttatus* (FABR.)			×				×		0.1	0.4	0.1	0.1	0.9
12	*Notiophilus palustris* (DUFT.)	0.1			×							0.1	+	0.2
13	*Elaphrus aureus* PH. MÜLL.										0.6	0.1	0.1	0.9
14	*Loricera caerulescens* (L.)										0.1		+	0.1
15	*Broscus cephalotes* (L.)							0.4			0.4		0.1	0.9
16	*Bembidion velox* (L.)	×												
17	*Bembidion ustulatum* (L.)										0.1	0.5	0.1	0.9
18	*Epaphius secalis* (PAYK.)											1.4	0.1	0.9
19	*Patrobus atrorufus* (STROEM)											5.8	0.5	4.7
20	*Amara aenea* (DE GEER)	0.1				×	×	0.2		1.6	0.3	0.1	0.2	1.9
21	*Amara familiaris* (DUFT.)									×				

22	*Amara similata* (GYLL.)				0.1	0.5	×					0.1	0.9
23	*Amara bifrons* (GYLL.)			0.1				0.3				+	0.4
24	*Amara consularis* (DUFT.)									0.1		+	0.1
25	*Amara aulica* (PANZ.)	0.1									0.1	+	0.2
26	*Stomis pumicatus* (PANZ.)										+	+	+
27	*Pterostichus virens* (O. F. MÜLL.)										0.1	+	0.1
28	*Pterostichus oblongopunctatus* (FABR.)	1.4			0.3						6.2	0.7	6.6
29	*Pterostichus niger* (SCHALL.)	0.3					0.2				0.4	0.3	0.1	0.9
30	*Pterostichus vulgaris* (L.)	0.6	0.3			1.4	0.1	2.4		0.1	1.1	1.6	0.7	6.6
31	*Pterostichus nigrita* (FABR.)											+	+	+
32	*Pterostichus strenuus* (PANZ.)	0.1										0.9	0.1	0.9
33	*Calathus erratus* (C. L. SAHLB.)			1.1							0.1		0.1	0.9
34	*Calathus fuscipes* (GOEZE)			0.1		0.4	0.1	0.4		0.4	0.3		0.2	1.9
35	*Calathus melanocephalus* (L.)							0.1		0.1		+	0.2
36	*Synuchus nivalis* (PANZ.)							0.5		0.1		0.1	0.9
37	*Agonum assimile* (PAYK.)	0.1			0.1	0.5	0.1			0.1		1.8	0.2	1.9
38	*Agonum obscurum* (HERBST)											+	+	+
30	*Agonum dorsale* (PONT.)					0.6	0.2						0.1	0.9
40	*Badister bipustulatus* (FABR.)					×	×		0.4			+	+	0.4
41	*Badister kineli* MAK.				0.2							+	+	0.2
42	*Licinus depressus* (PAYK.)								1.8				0.2	1.9
43	*Anisodactylus binotatus* (FABR.)										0.1		+	0.1
44	*Harpalus punctatulus* (DUFT.)	0.9		0.1									0.1	0.9
45	*Harpalus seladon* SCHAUB.	0.2				1.4		0.2					0.2	1.9
46	*Harpalus rufipes* (DE GEER)						0.1	0.2			0.2	+	+	0.5
47	*Harpalus affinis* (SCHRANK)			0.1		0.5							0.1	0.9
48	*Harpalus latus* (L.)									0.1	1.4	0.3	0.2	1.9
49	*Harpalus quadripunctatus* DEJ.											0.1	+	0.1
50	*Harpalus smaragdinus* (DUFT.)					0.3							+	0.3
51	*Harpalus tardus* (PANZ.)	0.1	0.1						0.1	0.6	0.1	+	0.1	0.9
52	*Harpalus winkleri* SCHAUB.	0.6	0.6	0.1		0.6			0.8		0.4	0.4	0.3	2.8
53	*Bradycellus collaris* (PAYK.)											×		
	Total	9.7	1.9	2.4	0.7	18.4	5.6	6.4	5.2	8.2	18.4	25.5	10.2	

In the lawns an ubiquitous species *Calathus fuscipes* (GOEZE) and a polytopic field species *Pterostichus vulgaris* (L.) were most abundant.

The communities of carabids inhabiting different plots of the escarpment were more diversified than those living in particular lawn plots. On the escarpment 8 carabid species predominated in different plots. These were: *Nebria brevicollis* (FABR.) (dominant in 3 plots), *Pterostichus oblongopunctatus* (FABR.) (in 2 plots), and *Carabus auronitens* FABR., *C. nemoralis* O. F. MÜLL., *Licinus depressus* (PAYK.,) *Pterostichus vulgaris* (L.,) *Calathus erratus* (C. R. SAHLB.), and *Harpalus winkleri* SCHAUB. (dominant in one plot each). In the lawn plots the same number of communities included only 5 dominants: *Pterostichus vulgaris*. (L.) (4 plots), *Calathus fuscipes* (GOEZE) (3 plots), *Nebria brevicollis* (FABR.) (2 plots), and *Amara aenea* (DE GEER) and *A. bifrons* (GYLL.) (1 plot each).

Detailed data on the occurrence of carabids in all the escarpment plots, their relative number, and percentage proportions of particular species are set up in Tables I and II. The average number of individuals caught in 10 traps during a 14-day period is considered as an index of numbers.

Among the species recorded on the escarpment, *Licinus depressus* (PAYK.) merits special attention. It occurred and even dominated in the Cytadela plot. This is a xerothermophilous species, very rarely and usually singly noted in Poland (BURAKOWSKI, MROCZKOWSKI and STEFAŃSKA 1974). Tree stands of the Cytadela are its only site within a closely built-up area in Warsaw where this species has been recorded so far (CZECHOWSKI 1980a).

5. Zoogeographical analysis

Carabids with large geographical ranges are least susceptible to the urban pressure. The proportion of Holarctic, Palaearctic and Eurosiberian species increases with urban pressure. At the same time, the proportion of species with small ranges, including the European element, drops (CZECHOWSKI 1980). Such a tendency, as compared with nonurban habitats of the Mazovian lowland, can also be observed in the carabid communities of the Vistula escarpment. Transition from non-urbanized habitats of Mazovia to urban tree stands on the escarpment is associated with substantial changes in the proportion of the main geographical elements of carabids. The proportion of Holarctic species increased almost two times. The proportion of Palaearctic species increased insignificantly, and that of Eurosiberian species almost 1.5 times, while the proportion of European forms decreased 1.5 times (Tab. III).

Among the species with relatively small geographical ranges (southern-Eurosiberian, Subpontic, Submediterranean, Subatlantic, boreal and mountain)[1],

[1] Zoogeographical elements are distinguished on the basis of the criteria worked out by the Centre of Faunistic Documentation of the Institute of Zoology, PAS, in Warsaw (CZECHOWSKI and MIKOŁAJCZYK 1980).

which account for 12% of the carabid fauna in the Mazovian lowland (CZECHOWSKI 1980a), on the Vistula escarpment in Warsaw there was only one species, boreal-mountain *Carabus auronitens* FABR. (1.9%). This species occurs locally in lowlands (BURAKOWSKI, MROCZKOWSKI and STEFAŃSKA 1973). On the Vistula escarpment within the boundaries of the town, *C. auronitens* was recorded in only one plot, located in the southern periphery (Ursynów), but it was the dominant there (Tab. II).

These tendencies were still better pronounced in the carabid fauna of the park lawns, which were more transformed by the anthropogenic pressure than the urban tree stands of the escarpment.

6. Ecological analysis

As it has already been mentioned, *Carabidae* belong to insects of a high bioindicatory value, susceptible to environmental modifications of different types. In the case of industrial effects on forests, transformations in the carabid communities occur in several stages. Environmental pollution is firstly followed by changes in the so-called structure of frequency within the community. As a result, the proportion of common species increases at the expense of rarer species, inhabiting few sites. In the next stage, proceeding at a higher pollution rate, the dominance structure of the communities is changed. Namely the disproportion in the contribution of dominant and accessory species to the total number of individuals in the community increases. Subsequently, the number of individuals in the community drops and, finally, its ecological characteristics are changed (LEŚNIAK 1977).

The value of carabids as bioindicators is also revealed in the case of "gardening-urban" transformations of the environment (CZECHOWSKI 1980b). The town considered as an environment of living creatures is subjected not only to industrial pollution but also to many other complex anthropogenic factors, the intensity of which is higher than in any other habitat. As a result, changes in the urban communities of carabids are so deep that it is impossible to distinguish the stages characteristic of the forests. All features of carabid communities are modified at the same time, and only depending on the intensity of urban pressure this modification is more or less pronounced. It should be noted, however, that having richer materials and conducting more extensive study, it would be possible to recognize a definite sequence of changes.

The analysis of the effect of urban pressure on ecological properties of carabid communities of the Vistula escarpment is based on the scale of anthropogenic pressure already described. Such properties were examined as the number of species and individuals in carabid communities, proportions of particular species with a definite frequency, dominance structure, as well as the proportion of definite ecological, phenological and morphological elements. For most of these features their relation can be found to the urban pressure of a definite

Table II. Species composition and percentage proportions of species in carabid communities on particular plots of the Vistula escarpment in Warsaw (× — species found only in soil samples; proportions are calculated to the nearest 0.1%)

No.	Ursynów	%
1	*Carabus auronitens*	36.0
2	*Carabus hortensis*	19.3
3	*Carabus nemoralis*	16.2
4	*Pterostichus oblongopunctatus*	7.1
5	*Harpalus punctatulus*	4.9
6	*Pterostichus vulgaris*	3.0
7	*Harpalus winkleri*	3.0
8	*Nebria brevicollis*	2.0
9	*Pterostichus niger*	1.5
10	*Cychrus caraboides*	1.0
11	*Leistus ferrugineus*	1.0
12	*Harpalus seladon*	1.0
13	*Carabus glabratus*	0.5
14	*Leistus rufescens*	0.5
15	*Notiophilus palustris*	0.5
16	*Amara aenea*	0.5
17	*Amara aulica*	0.5
18	*Pterostichus strenuus*	0.5
19	*Agonum assimile*	0.5
20	*Harpalus tardus*	0.5
21	*Bembidion velox*	×

No.	Sejm	%
1	*Nebria brevicollis*	46.2
2	*Carabus nemoralis*	20.1
3	*Pterostichus vulgaris*	7.6
4	*Harpalus seladon*	7.6
5	*Agonum dorsale*	3.3
6	*Harpalus winkleri*	3.3
7	*Amara similata*	2.7
8	*Agonum assimile*	2.7
9	*Harpalus affinis*	2.7
10	*Calathus fuscipes*	2.2
11	*Harpalus smaragdinus*	1.6
12	*Amara aenea*	×
13	*Badister bipustulatus*	×

No.	Cytadela	%
1	*Licinus depressus*	34.6
2	*Carabus nemoralis*	17.3
3	*Carabus convexus*	15.4
4	*Harpalus winkleri*	15.4
5	*Badister bipustulatus*	7.7
6	*Leistus ferrugineus*	5.8
7	*Nebria brevicollis*	1.9
8	*Harpalus tardus*	1.9

No.	Królikarnia	%
1	*Calathus erratus*	45.8
2	*Nebria brevicollis*	29.2
3	*Carabus nemoralis*	4.2
4	*Amara bifrons*	4.2
5	*Calathus fuscipes*	4.2
6	*Harpalus punctatulus*	4.2
7	*Harpalus affinis*	4.2
8	*Harpalus winkleri*	4.2
9	*Notiophilus biguttatus*	×

No.	Łazienki	%
1	*Pterostichus oblongopunctatus*	42.9
2	*Badister kineli*	28.5
3	*Amara similata*	14.3
4	*Agonum assimile*	14.3
5	*Nebria brevicollis*	×
6	*Notiophilus palustris*	×

No.	P. Kultury	%
1	*Nebria brevicollis*	48.2
2	*Carabus cancellatus*	32.1
3	*Carabus nemoralis*	5.4
4	*Pterostichus niger*	3.6
5	*Agonum dorsale*	3.6
6	*Pterostichus vulgaris*	1.8
7	*Calathus fuscipes*	1.8
8	*Agonum assimile*	1.8
9	*Harpalus rufipes*	1.8
10	*Amara aenea*	×
11	*Amara similata*	×
12	*Badister bipustulatus*	×

No.	Gdańska	%
1	*Carabus nemoralis*	31.7
2	*Nebria brevicollis*	28.1
3	*Amara aenea*	19.5
4	*Harpalus tardus*	7.3
5	*Calathus fuscipes*	4.9
6	*Notiophilus biguttatus*	1.2
7	*Amara consularis*	1.2
8	*Pterostichus vulgaris*	1.2
9	*Calathus melanocephalus*	1.2
10	*Synuchus nivalis*	1.2
11	*Agonum assimile*	1.2
12	*Harpalus latus*	1.2
13	*Amara familiaris*	×

Table II. Continued

No.	Uniwersytet	%
1	*Pterostichus vulgaris*	37.5
2	*Nebria brevicollis*	23.4
3	*Synuchus nivalis*	7.8
4	*Broscus cephalotes*	6.3
5	*Calathus fuscipes*	6.3
6	*Amara bifrons*	4.7
7	*Carabus nemoralis*	3.1
8	*Amara aenea*	3.1
9	*Harpalus seladon*	3.1
10	*Harpalus rufipes*	3.1
11	*Calathus melanocephalus*	1.6
12	*Notiophilus biguttatus*	×

No.	Kaskada	%
1	*Nebria brevicollis*	56.0
2	*Carabus nemoralis*	10.9
3	*Harpalus latus*	7.6
4	*Pterostichus vulgaris*	6.0
5	*Elaphrus aureus*	3.3
6	*Notiophilus biguttatus*	2.2
7	*Broscus cephalotes*	2.2
8	*Pterostichus niger*	2.2
9	*Harpalus winkleri*	2.2
10	*Amara aenea*	1.6
11	*Calathus fuscipes*	1.6
12	*Harpalus rufipes*	1.1
13	*Loricera caerulescens*	0.5
14	*Bembidion ustulatum*	0.5
15	*Pterostichus virens*	0.5
16	*Calathus erratus*	0.5
17	*Anisodactylus binotatus*	0.5
18	*Harpalus tardus*	0.5

No.	Arkadia	%
1	*Harpalus winkleri*	31.6
2	*Carabus nemoralis*	26.3
3	*Nebria brevicollis*	21.0
4	*Pterostichus vulgaris*	15.8
5	*Harpalus tardus*	5.3

No.	Bielany	%
1	*Pterostichus oblongopunctatus*	24.0
2	*Patrobus atrorufus*	22.5
3	*Carabus hortensis*	12.0
4	*Agonum assimile*	7.0
5	*Nebria brevicollis*	6.2
6	*Pterostichus vulgaris*	6.2
7	*Epaphius secalis*	5.4
8	*Carabus nemoralis*	3.9
9	*Pterostichus strenuus*	3.5
10	*Bembidion ustulatum*	1.9
11	*Harpalus winlkeri*	1.6
12	*Pterostichus niger*	1.2
13	*Harpalus latus*	1.2
14	*Notiophilus palustris*	0.4
15	*Elaphrus aureus*	0.4
16	*Amara aenea*	0.4
17	*Amara aulica*	0.4
18	*Notiophilus biguttatus*	0.4
19	*Harpalus quadripunctatus*	0.4
20	*Stomis pumicatus*	0.1
21	*Pterostichus nigrita*	0.1
22	*Agonum obscurum*	0.1
23	*Badister bipustulatus*	0.1
24	*Badister kineli*	0.1
25	*Harpalus rufipes*	0.1
26	*Harpalus tardus*	0.1
27	*Bradycellus collaris*	×

Table III. Percentage proportions of particular geographical elements in the carabid fauna of the Mazovian lowland, Vistula escarpment and park lawns in Warsaw (the number of species in parentheses)[1]

Zoogeographical elements	Mazovian lowland	Warsaw	
		Vistula escarpment	Park lawns
Holarctic	6 (19)	11 (6)	9 (4)
Palaearctic	30 (98)	32 (17)	35 (15)
Eurosiberian	29 (93)	40 (21)	42 (18)
European	23 (74)	15 (8)	9 (4)
Others	12 (40)	2 (1)	5 (2)

[1] Data for the Mazovian lowland after Czechowski (1980a).

degree. Only some features there was not such a distinct relation. But even in this case there was a difference between the values obtained for the communities occupying least transformed plots (pressure 1) and those in more urbanized plots (pressure > 1). In such cases the peripheral plots were regarded as control. The peripheral plots can be opposed to all the other plots on the Vistula escarpment. Although the total intensity of urban pressure changed gently on this transition, the peripheral plots were not subjected to any gardening treatments carried out in the other plots, this being an important factor limiting the occurrence of carabids (Czechowski 1980b).

6.1. Urbanization and the number of species in carabid communities

On the Vistula escarpment there were 13 carabid species, on the average, with a range of 5–27 species, while 9 species, on the average, with a range of 2–18 species, in the park lawns. The Student t test showed, however, that the difference was not statistically significant at the confidence level 0.95. The number of species in the carabid communities markedly dropped with increasing urban pressure. In the peripheral plots of the escarpment in Warsaw, where tree stands largely preserved their original character, carabid communities

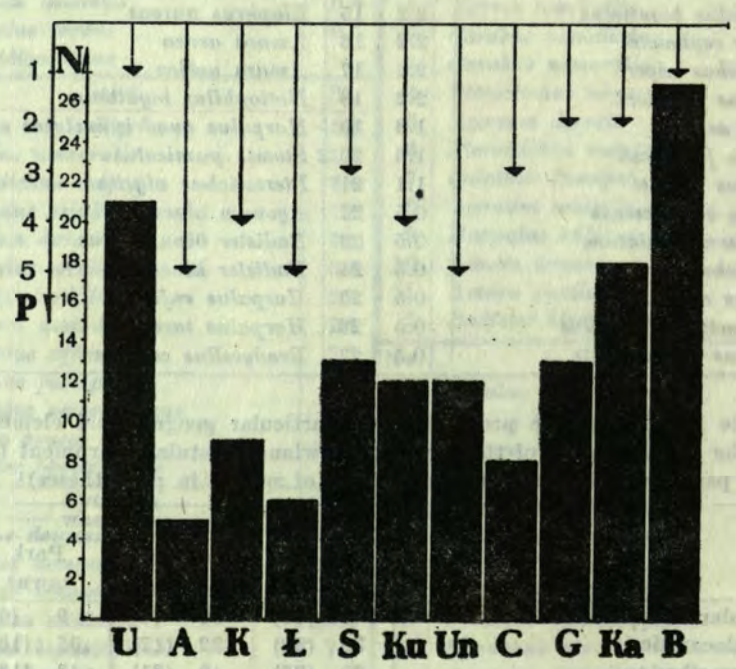


Fig. 2. Urban pressure and the number of species in carabid communities of the Vistula escarpment in Warsaw: N – number of species, P – degree of urban pressure; U – Ursynów, A – Arkadia, K – Królikarnia, Ł – Łazienki, S – Sejm, Ku – Park Kultury, Un – Uniwersytet, C – Cytadela, G – Gdańska, Ka – Kaskada, B – Bielany.

were made up of 24 species, on the average (21 and 27 species). For the remaining plots the average value was 11 (5–18 species). Simplification of the species composition was proportional to the intensity of urban pressure. The relationship between the urban pressure and the number of species was generally well pronounced (Figs 2 and 7). An increase in the urban pressure by one degree was usually followed by almost 1.5 times decrease in the number of species in the community.

6.2. Urbanization and the number of individuals in carabid communities

There were considerable differences in carabid numbers among the habitats subjected to the urban-gardening pressure of various degrees (Czechowski 1980b). For the tree stands of the escarpment in Warsaw the index of the relative number of carabids was 10.2, on the average, which is a rather high value, taking into account that the corresponding figure for a natural oak-hornbeam forest located near Warsaw was 15.3. But the number of individuals in the carabid communities of the escarpment varied largely between 0.7 and 25.5(!) from one plot to another. The number of carabids in the park lawns in Warsaw was 6.0, on the average, and also largely varied (0.7–22.4) from plot to plot. Because of this marked variability in the results, there are not

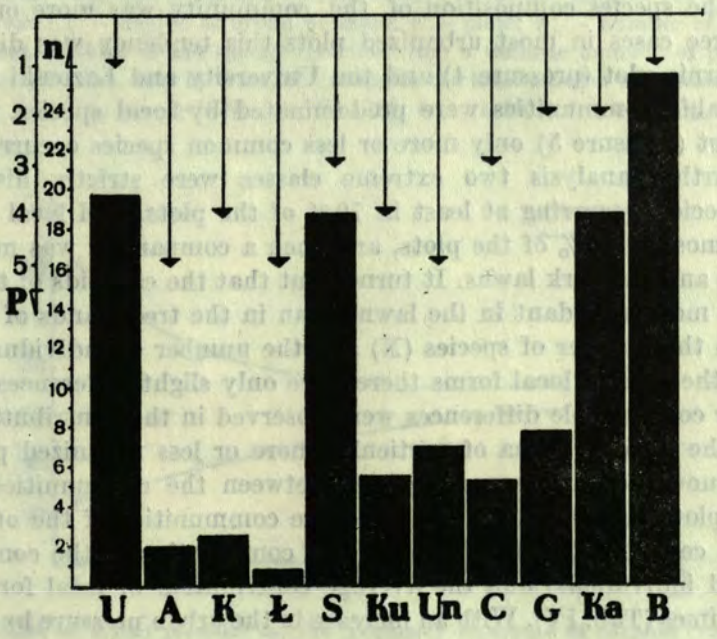


Fig. 3. Urban pressure and the number of individuals in carabid communities of the Vistula escarpment: n – index of numbers, P – degree of urban pressure (plots denoted as in Fig. 2).

statistically significant differences in the average values of this index between the escarpment and the lawns (Student t test, confidence level 0.95).

Increasing urbanization of the habitat considerably limits the number of individuals in carabid communities. The average index of their numbers was 22.6 (19.7 and 25.5) in the peripheral plots of the escarpment, while only 7.5 (0.7–18.4) in the other plots. There is a well defined relationship between the intensity of urban pressure and community numbers (Figs 3 and 7). An increase in the pressure by one degree lowered carabid numbers 1.8 times.

6.3. Urbanization and the structure of frequency in carabid communities

According to LEŚNIAK (1977), relative proportions of species of particular frequency classes of the forest carabid communities are most susceptible of all their features to industrial pollution of the environment. Under urban conditions changes in the frequency are rather important but it seems that their possible role as bioindicators is less considerable. In the carabid communities on different plots of the Vistula escarpment a general tendency was observed towards a gradual replacing of locally occurring species (that is, found only in a limited number of plots) by still more common species (that is, occurring in many plots) when the urban pressure increased. Among carabids inhabiting the plots subjected to the smallest pressure (1–2 degrees) there were mostly local species. In the plots under moderate pressure (3–4 degrees) the contribution of all frequency groups to the species composition of the community was more or less even. Only in three cases in most urbanized plots this tendency was disturbed. In the Królikarnia plot (pressure 4) and the University and Łazienki plots (pressure 5) carabid communities were predominated by local species. But in the Arkadia plot (pressure 5) only more or less common species occurred (Fig. 4).

For further analysis two extreme classes were strictly distinguished: common species, occurring at least in 70 % of the plots, and local species, occurring at most in 30 % of the plots, and then a comparison was made for the escarpment and the park lawns. It turned out that the carabids of the common group were more abundant in the lawns than in the tree stands of the escarpment. Both the number of species (N) and the number of individuals (n) were higher. In the case of local forms there were only slight differences (Tab. IV).

Rather considerable differences were observed in the contribution of these classes to the carabid fauna of particular more or less urbanized plots. Particularly pronounced differences occurred between the communities from the peripheral plots (Ursynów, Bielany) and the communities of the other escarpment plots, considered jointly. The average contribution of the common forms (species and individuals) and the average contribution of local forms differed about two times (Tab. IV). With an increase in the urban pressure by one degree, the proportion of common species increased 1.3 times, on the average (apart from the exceptions noted above). At the same time the proportion of local species decreased 1.2 times, on the average (Fig. 5).

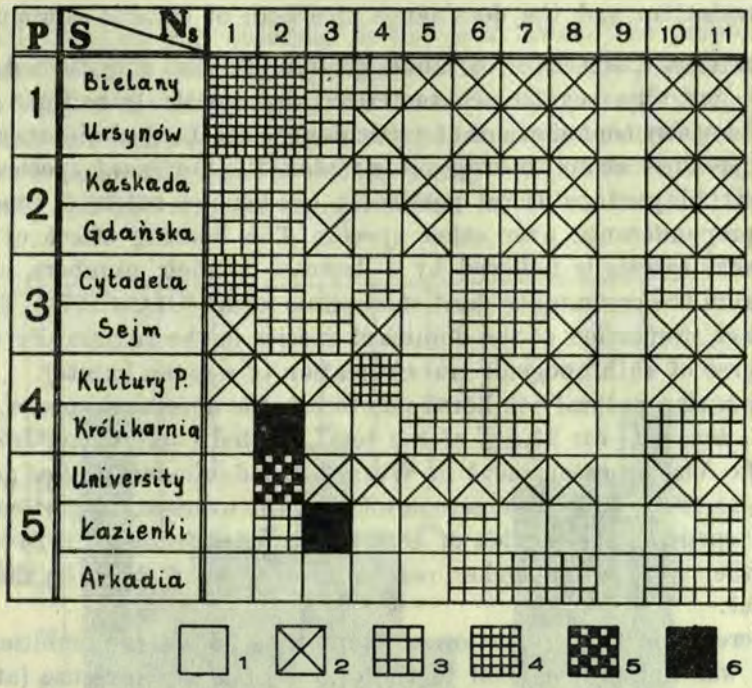


Fig. 4. Frequency structure of carabid communities in particular plots of the Vistula escarpment in Warsaw: P – degree of urban pressure, S – plots, N_s – number of plots, 1–6 – percentage contributions of the species recorded from a definite number of plots (N_s) (i.e. only in one, only in two, only in three, etc. plots) to the total number of species in particular communities: 1 – 0%, 2 – 1–10%, 3 – 11–20%, 4 – 21–30%, 5 – 31–40%, 6 – 41–50%.

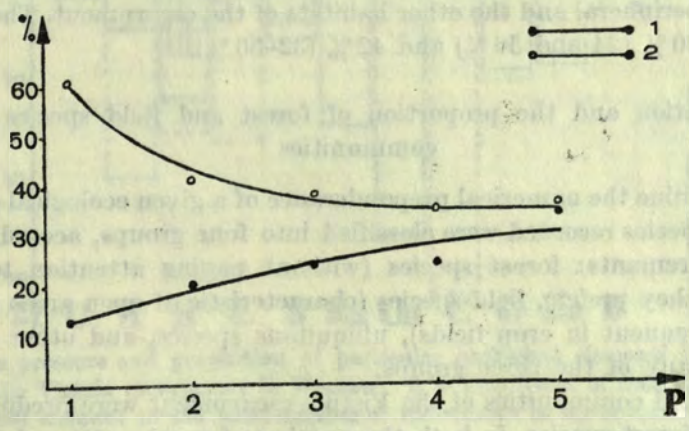


Fig. 5. The effect of urban pressure on the frequency structure of carabid communities on the Vistula escarpment in Warsaw: % – average proportion of the species from a given frequency class to the total number of species in the community, P – degree of urban pressure, 1 – common species, 2 – local species.

6.4. Urbanization and the dominance structure of carabid communities

The dominance structure of fauna communities in undisturbed, natural habitats is generally regular, characterized by gentle transitions between gradually decreasing contributions of particular species. In the habitats subjected to a heavy pressure of an anthropogenic factor, the dominant species of local communities (adapted to these particular conditions) reach a considerable numerical preponderance over other species. The limiting effect of a given factor on most species is followed by a decrease in their numbers, and even eliminates from the community most susceptible forms (Odum 1977). Therefore, the precentage proportion of the dominant species in the community can indicate the degree of anthropogenic transformation of a given habitat.

In a Mazovian natural oak-hornbeam forest, the dominant species, *Carabus hortensis* L., accounts for 27.5 % of the total carabid community. In the tree stands of the Vistula escarpment in Warsaw the dominant species accounted for as much as 40 % of the total community, on the average. In particular plots of the escarpment the proportion of dominants varied from 24 to 56 %. In the park lawns they were a little higher, reaching from 24 to 61 %, or on the average 41 % per plot.

The increase in the proportion of dominants in the communities on the escarpment was not proportional to the degree of urban pressure (at least if considered totally). It is probable that the percentage contribution of the dominant depends on the diversity of the factors of anthropogenic pressure rather than on the total intensity of this pressure. The diversity of factors, even harmful but acting in a multisided way on the fauna, discourages a distinct increase in the number of anyone species in the community (Czechowski 1980b). There was, however, a clear difference in the average proportion of the dominant between the peripheral and the other habitats of the escarpment. The respective values were 30 % (24 and 36 %) and 42 % (32–56 %).

6.5. Urbanization and the proportion of forest and field species in carabid communities

To determine the numerical preponderance of a given ecological component the carabid species recorded were classified into four groups, according to their habitat requiremants: forest species (without paying attention to the type of the forest they prefer), field species (characteristic of open areas and, at the same time, frequent in crop fields), ubiquitous species, and other species not belonging to any of the three groups.

The carabid communities of the Vistula escarpment were predominated by the group of forest species, in both the number of species (N) and the number of individuals (n). The proportion of field species was here 1.7 times as low as forest ones and the contribution of individuals of the field species to the total number of individuals in the community was 3.5 times as low as forest forms.

A reversed situation was observed in the park lawns. The proportion of the field species (N) was only slightly higher than forest ones, but the number of individuals (n) of the field species was more than 5 times of that of the forest species. Also the number of ubiquitous species was considerably higher in the lawns. The number of species (N) of this group was 1.5 times as high as on the escarpment, and the number of individuals (n) as much as 7 times higher! (Tab. IV).

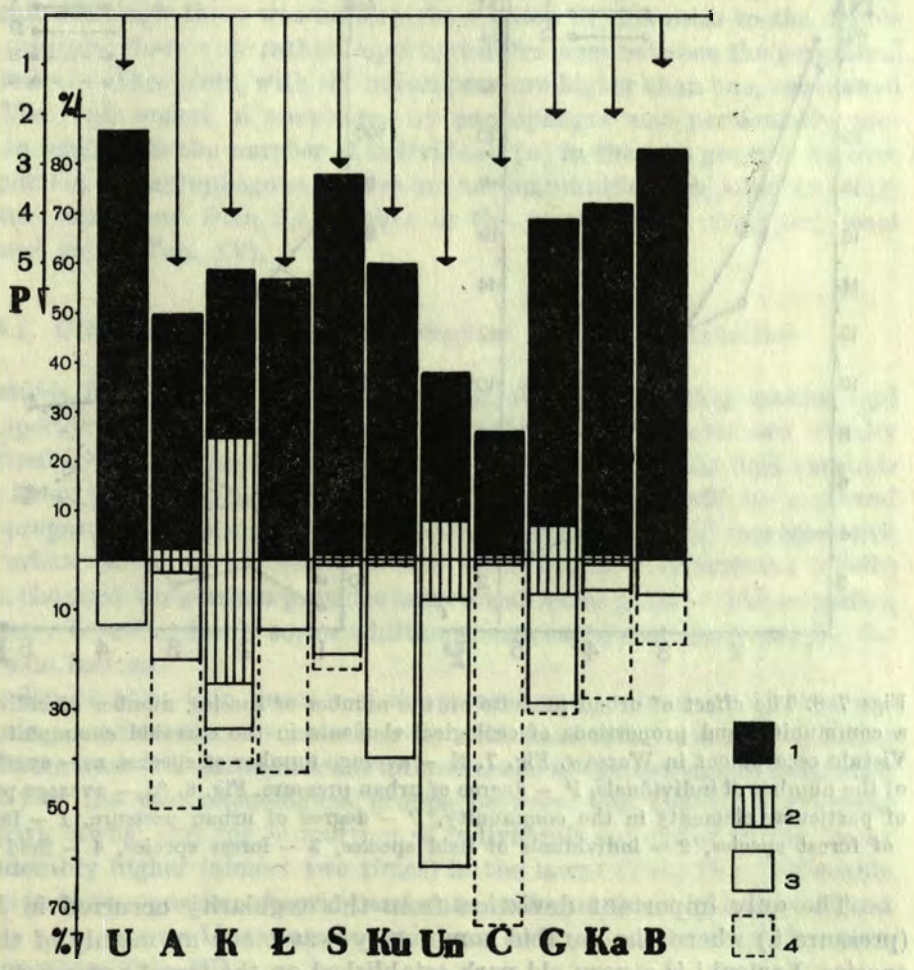
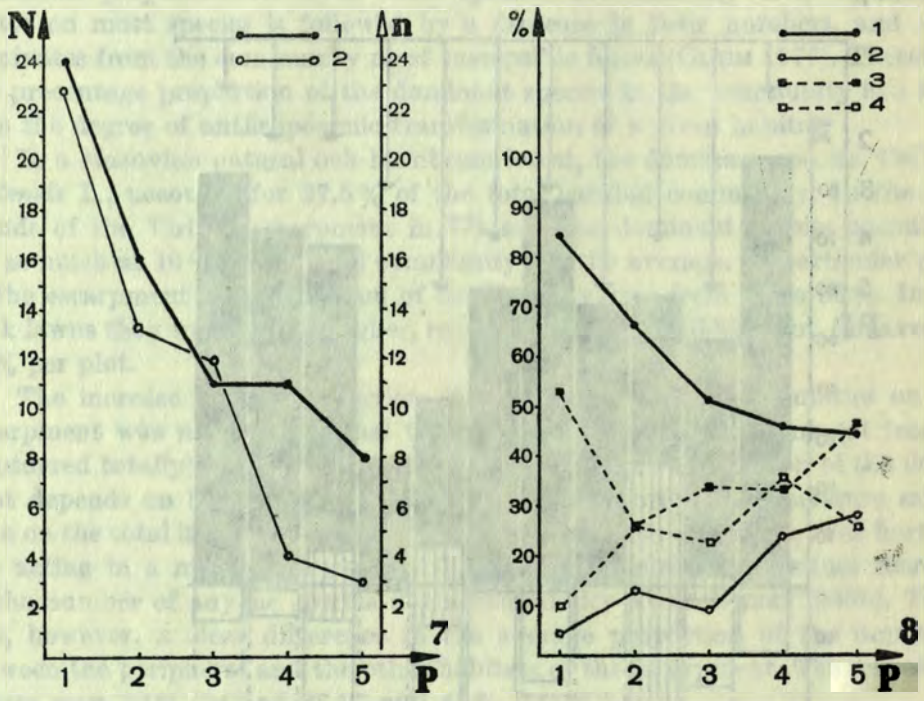


Fig. 6. Urban pressure and proportion of particular ecological elements in carabid communities of the Vistula escarpment in Warsaw: % – proportion of individuals of a particular ecological element to the total number of individuals in the community, P – degree of urban pressure, 1 – forest element, 2 – ubiquitous element, 3 – field element, 4 – other species (plots denoted as in Fig. 2).

With increasing urban pressure, the forest forms of carabids were replaced by the field forms. This is particularly well pronounced when the proportion

of individuals (n) of each form to the total number of individuals is analysed (Tab. IV). Even in the case when some plots on the escarpment did not show this tendency, these deviations were usually compensated by changes in the proportion of ubiquitous forms (Fig. 6). An increase in the urban pressure by one degree lowered the proportion of forest species 1.2 times, on the average, and increased the proportion of the field species almost 1.9 times (Fig. 8).



Figs 7–8. The effect of urban pressure on the number of species, number of individuals in a community, and proportions of ecological elements in the carrabid communities of the Vistula escarpment in Warsaw. Fig. 7. N — average number of species, n — average index of the number of individuals, P — degree of urban pressure. Fig. 8. % — average proportion of particular elements in the community, P — degree of urban pressure, 1 — individuals of forest species, 2 — individuals of field species, 3 — forest species, 4 — field species.

The only important deviation from this regularity occurred in Łazienki (pressure 5) where the carabid community was made up mainly of the forest species. Łazienki is a very old park established on the forest areas not changed before. Due to this some terrains of the park and, in particular, the escarpment preserved the tree stand similar to primeval one. Hence, a considerable contribution of forest forms in the carabid fauna. At the same time very intense gardening treatments (particularly, frequent raking of this litter) and proximity of a street with much traffic contribute to a high pressure on this plot. As a result, on the escarpment in Łazienki the number of species is small as well as the number of individuals.

6.6. Urbanization and the trophic structure of carabid communities

Though carabids belong to the suborder *Adephaga* (predatory beetles), their food requirements are rather diversified. Apart from zoophages, there are many omnivorous species and even phytophages. For the purpose of the present analysis, the carabids recorded in this study have been divided into two groups: zoophages and pantophages.

The ratio of zoophages to pantophages varied for particular plots of the escarpment. Although there was no straight relation of this ratio to the degree of urban pressure, there were rather important differences between the peripheral plots and all the other plots, with the urban pressure higher than one, considered jointly. The replacement of zoophages by pantophages was particularly pronounced in relation to the number of individuals (n) in the two groups. An average proportion of pantophagous species in the communities subjected to a higher pressure was more than 2.5 of that in the communities occupying least transformed plots (Tab. IV).

6.7. Urbanization and the phenology of carabid communities

Carabidae belong to two main phenological groups: spring species and autumn species (LARSSON 1939, LINDROTH 1945). Spring species are usually characterized by a wider range of ecological tolerance. Most of the field carabids originate from this group (TISCHLER 1971). Therefore, it should be expected that the proportion of spring forms in carabid communities will increase with growing urban pressure. However, it has been found (CZECHOWSKI 1980b) that when the gardening-urban pressure is involved (rural parks – urban parks), this tendency is rather feeble so, in addition, more easily overshadowed by the effect of side factors.

A similar situation is in the case of the present study, although the domination of spring over autumn forms in heavily urbanized areas was a little better marked. There were still not significant differences in the proportion of particular species (N) of the two phenological groups between the Vistula escarpment and the park lawns. But the proportion of individuals (n) of the spring forms was considerably higher (almost two times) in the lawns (Tab. IV). Noticeable differences in the proportion of spring and autumn forms (both species – N and individuals – n) occurred between the peripheral escarpment plots and the other escarpment plots (Tab. IV).

6.8. Urbanization and the proportion of forms with different body sizes in carabid communities

The carabids occurring in the study plots have been classified into three size groups: large forms (more than 20 mm long), medium forms (10–20 mm) and small forms (less than 10 mm). The same classification was used in the

Table IV. Percentage proportions of particular ecological, phenological, and morphological elements in the carabid fauna of the Vistula escarpment and park lawns in Warsaw (average values per plot). P – urban pressure; %N – proportion in the number of species; %n – proportion in the total number of individuals

Criterium of classification	Elements	Vistula escarpment						Park lawns	
		Total		P = 1		P > 1			
		%N	%n	%N	%n	%N	%n	%N	%n
Frequency	Common	6	45	13	19	26	49	10	51
	Local	77	44	61	73	37	33	79	43
Environment	Forest	40	57	53	85	36	51	22	9
	Ubiquitous	10	5	4	+	16	10	15	35
	Field	24	17	10	10	28	20	24	49
Trophic group	Zoophagous	68	92	71	93	67	82	65	66
	Pantophagous	32	8	29	7	33	18	35	34
Phenology	Spring forms	54	41	56	37	61	49	58	23
	Autumn forms	46	59	44	63	39	51	42	77
Body size	Large forms	11	24	13	44	12	19	5	2
	Medium forms	34	54	36	33	42	59	35	58
	Small forms	55	22	51	23	46	22	60	40

paper analysing changes in the carabid communities subjected to the gardening-urban pressure (Czechowski 1980b). It was found then that the anthropogenic pressure of this kind was followed by disappearance of large carabids, which were mostly replaced by forms of medium length.

A similar tendency was found when the wooded escarpment plots were compared with more or less opened lawn plots. The proportion of species (N) of large forms, which were poorest in species, decreased almost two times in the lawns, while the proportion of individuals (n) of this group to the total number of individuals in the carabid community decreased 12 times (!). The proportion of medium forms, however, increased insignificantly. Large forms were mainly replaced by small carabids, particularly, as far as their numbers (n) are concerned. Their proportions in the lawns were almost twice as high as on the escarpment (Tab. IV).

The changes occurring in the fauna of carabids within the escarpment were of a slightly different character. They did not depend directly on the intensity of urban pressure. It seems that the degree of the closeness of tree canopy on particular plots is the main factor. Nevertheless, the comparison between the plots subjected to the lowest pressure (Ursynów, Bielany), thus most resembling primeval tree stands, and the other plots, under heavier anthropogenic pressure, is interesting. Changes in the proportion of species (N) representing

particular forms were relatively small. But there were distinct differences in the number of individuals (n) of different body size. In the communities inhabiting more urbanized plots, the proportion of large individuals was 2.3 times lower than in those occupying the peripheral plots. The proportion of medium individuals increased 1.8 times with increasing urbanization. At the same time the proportion of small individuals slightly dropped (Tab. IV).

The decrease in the number and proportion of large carabids with increasing anthropogenic pressure may be caused by several factors. It seems that mostly the reduction in the surface of wooded areas or, at least covered with dense shrubs, is responsible for the limitation of the occurrence of these mobile insects, mainly belonging to forest forms. The situation is additionally aggravated by the raking and removing of litter, since the larvae of carabids firstly dwell on the soil surface (ŠAROVA 1960). It is also possible that during such treatments large carabids are more frequently destroyed mechanically, as compared with smaller forms.

7. Final remarks

An increasing urbanization of the environment accounts for large changes in the fauna of carabids. Since the factors of urban pressure are complex, the modifications in carabid communities go in many directions and involve a number of structural features of these communities. In most cases a degree of the changes depends on the intensity of anthropogenic pressure. This confirms the view that carabid beetles are useful bioindicators of the state of the environment.

A comprehensive comparison of the carabid fauna inhabiting wooded areas of the Vistula escarpment in Warsaw with that inhabiting nearby managed park lawns showed that the fragments of natural or paranatural wooded areas preserved within the town are both quantitative (at least in less changed patches) and, particularly, qualitative refuges of the forest fauna originally occupying the whole terrain built up now. Thus, these habitats should be an object of particularly careful protection (and not of "shaping" as it is in fashion now). We may expect then that due to inevitable random migrations they will be a source of new components for heavily transformed or even degraded habitats of cultivated urban green areas. This will increase their self-regulatory ability, and will make more efficient the functioning of urban ecosystems.

REFERENCES

Biuro Planowania Rozwoju Warszawy. 1976. Ocena przydatności badań terenowych problemu 114 z lat 1972–76 w aspekcie zagospodarowania przestrzennego terenów miejskich. Warszawa (manuscript, 11 maps).

BURAKOWSKI B., MROCZKOWSKI M., STEFAŃSKA J. 1973. Chrząszcze – *Coleoptera*. Biega-

czowate – *Carabidae*, część 1. Katalog fauny Polski, 23, 2. Warszawa, 233 pp., 1 t., 1 map.

Burakowski B., Mroczkowski M., Stefańska J. 1974. Chrząszcze – *Coleoptera*. Biegaczowate – *Carabidae*, część 2. Katalog fauny Polski, 23, 3. Warszawa, 430 pp., 1 t., 1 map.

Czechowski W. 1979. Urban woodland areas as the refuge of invertebrate fauna. Bull. pol. Acad. Sci., Warszawa, **27**: 179–182, 2tt.

Czechowski W. 1980a. Carabids (*Coleoptera, Carabidae*) of Warsaw and Mazovia. Memorabilia zool., Warszawa, (in print).

Czechowski W. 1980b. Influence of the manner of managing park areas and their situation on the formation of a community of carabid beetles (*Coleoptera, Carabidae*). Fragm. faun., Warszawa, **25**: 199–219, 7ff,. 3tt.

Czechowski W., Mikołajczyk W. 1980. Methods for the study of urban fauna. Memorabilia zool., Warszawa, (in print).

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, 106 ff., 49 tt., 2 maps.

Evers A. 1977. Rote Liste der im nördlichen Rheinland gefährdeten Käferarten (*Coleoptera*) mit einer Liste von Bioindikatoren. Ent. Bl., Krefeld, **73**, 39 pp.

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

Jędryczkowski W. 1980. Równonogi lądowe (*Isopoda, Oniscoidea*) skarpy wiślanej w Warszawie. Fragm. faun., Warszawa, 25: 317–324.

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

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

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

Mansikkaniemi H. 1974. Ympäristöön kohdistuvan potentiaalisen paineen alueellisista eroista Suomessa. Terra, Helsinki, **86**: 99–110, 4 ff.

Martiš M. 1977. The carabid beetles as bioindicators of the ecological balance of a landscape. III International Conference „Bioindicatores Deteriorisationis Regionis", Liblice, p. 19 (abstract).

Nowakowski E. 1979. Skarpa warszawska jako teren ostojowy dla fauny – na przykładzie sprężyków glebowych (*Coleoptera, Elateridae*). Fragm. faun., Warszawa, **23**: 355–341, 1 f., 1 t.

Odum E. P. 1977. Podstawy ekologii. Warszawa, 678 pp., 277 ff.

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.

Stebaev I. V. 1976. Prostranstvennaja struktura životnogo naselenija i biogeocenozov v stokovo-geohimičeskih serijah landšaftov. Zool. Ž., Moskva, **55**: 191–204, 8 ff.

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

Tischler W. 1971. Agroekologia. Warszawa, 487 pp., 150 ff.

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
00-679 Warszawa, Wilcza 64

STRESZCZENIE

[Tytuł: Biegaczowate (*Coleoptera, Carabidae*) skarpy wiślanej w Warszawie]

Chrząszcze biegaczowate są grupą owadów o znacznych walorach bioindykacyjnych. Powszechnie wykorzystywane są do oceny stanu i zmian środowisk podlegających różnego rodzaju wpływom antropogenicznym. W niniejszym opracowaniu przeanalizowano zmiany, jakie następują w zgrupowaniach *Carabidae*, zasiedlających naturalne i półnaturalne zadrzewienia skarpy wiślanej w Warszawie. W środowiskach tych stwierdzono występowanie 53 gatunków biegaczowatych. Najliczniejsze są tam politopowe gatunki leśne: *Nebria brevicollis* (Fabr.) i *Carabus nemoralis* O. F. Müll. [na odkrytych trawnikach w parkach dominują: *Calathus fuscipes* (Goeze) — gatunek ubikwistyczny i *Pterostichus vulgaris* (L.) — politopowy gatunek polny]. W porównaniu z karabidofauną pozamiejskich środowisk Niziny Mazowieckiej na skarpie w Warszawie większy jest udział gatunków o szerokich zasięgach geograficznych: holarktycznych, palearktycznych i eurosyberyjskich. Wzrastająca presja urbanizacyjna wyraźnie wpływa na skład gatunkowy, liczebność i strukturę zgrupowań biegaczowatych, zasiedlających różnie położone stanowiska na skarpie. Liczba gatunków i liczebność zgrupowań obniża się. Zwiększa się udział gatunków powszechnych kosztem rzadziej występujących. Zwiększa się dysproporcja między liczebnością gatunków dominujących, a liczebnością pozostałych gatunków w zgrupowaniach. Formy leśne zastępowane są przez polne i ubikwistyczne. Zoofagi ustępują pantofagom. Wzrasta udział form wiosennych kosztem jesiennych. Obniża się udział dużych i małych biegaczowatych, zastępowanych przez chrząszcze o średnich rozmiarach ciała.

Przeprowadzona analiza ekologiczna wykazała, że zachowane w obrębie Warszawy fragmenty dawnych zadrzewień pełnią rolę ostoi dla karabidofauny leśnej, pierwotnie zasiedlającej obszar zajęty obecnie przez miasto.

РЕЗЮМЕ

[Заглавие: Жужелицы (*Coleoptera, Carabidae*) откоса Вислы в Варшаве]

Жужелицы обладают значительными достоинствами как биоиндикаторы. Их повсеместно используют для оценки состояния и изменений среды под влиянием разного рода антропогенных факторов. В настоящей статье проанализированы те изменения, которые произошли в сообществах жужелиц, населяющих природные и полуприродные древонасаждения откоса Вислы в Варшаве. В этих биоценозах найдено 53 вида жужелиц. Наиболее многочислены тут политопные лесные виды: *Nebria brevicollis* (Fabr.) и *Carabus nemoralis* O. F. Müll. [на открытых газонах и в парках доминирует убиквист *Calathus fuscipes* (Goeze) и *Pterostichus vulgaris* (L.) — эвритопный полевой вид]. По сравнению с фауной жужелиц внегородских биото-

пов Мазовецкой низменности на откосе Вислы в Варшаве высшее процентное содержание имеют виды с широким географическим ареалом (голарктические, палеарктические и европейско-сибирские). Возрастающий урбанизационный пресс четко влияет на видовой состав, численность и структуру сообществ жужелиц, населяющих различные биотопы вислинского откоса. Количество видов и численность сообществ падает, а увеличивается содержание обычных видов за счет более редких. Увеличивается диспропорция между численностью доминирующих и всех остальных видов в сообществах. Лесные виды замещаются полевыми и убиквистами. Зоофаги уступают пантофагам. Возрастает содержание весенних форм за счет осенних. Снижается содержание крупных и мелких жужелиц, а появляется больше жуков средней величины.

Экологический анализ показал, что сохранившиеся в границах Варшавы фрагменты былых древостоев играют роль пристанища для лесной карабидофауны, населяющей первоначально территорию, использованную под застройку города.

Redaktor pracy — dr hab. A. Liana

Państwowe Wydawnictwo Naukowe — Warszawa 1980
Nakład 770+90 egz. Ark. wyd. 2; druk. 1,5. Papier druk. mat. kl. III 80 g. B1. Cena zł 20,—
Nr zam. 982/79 — Wrocławska Drukarnia Naukowa

ISBN 83-01-03007-0
ISSN 0015-9301