

Structural and functional changes in animal communities

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## STRUCTURE AND FUNCTIONING OF COMMUNITY OF *COCCINELLIDAE* (COLEOPTERA) IN INDUSTRIAL AND AGRICULTURAL-FOREST REGIONS\*

The effect of industry on occurrence of coccinellids (*Coccinellidae*, *Coleoptera*) was studied by comparison of their species and dominance structure as well as numbers and seasonal migrations in the regions strongly industrialized and in agricultural-forest regions. The compared surfaces were similar in the respect of spatial distribution of natural habitats and crops. It was found that the coccinellid community in the industrial regions had a considerably lower number of species and showed a clearly augmented dominance of *Coccinella septempunctata* (L.), an eurytopic species. The numbers were there lower and so was also migration of coccinellids to the forest for overwintering.

### 1. INTRODUCTION

Fast changes in natural habitats occurring under the effect of human management activity bringing about its degradation, evoked a necessity of studies both on trends of these changes and their main causes as well as on possibility to manage the environment in the way increasing its natural resistance.

The necessity of a rapid estimation of changes in landscapes and difficulties arising from the fact that we deal with a very complicated natural unit impels looking for good bioindicators that would most accurately determine the degree of degradation.

Indices have been used for evaluation of directional changes in the fauna under the long-termed impact of industry, basing on changes following in the community of *Coccinellidae*.

*Coccinellidae* were chosen as an indicatory group since they are affected, apart from local factor, by the overall conditions typical for a given landscape. This was found in

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agrocenotic studies where, depending on the type of crop, degree of differentiation, crop rotation system and the type of surroundings, this group shows considerable differences in occurrence on particular crops (Gałęcka 1962, 1966, 1969, Gałęcka, Karg 1980).

The response by coccinellids to an array of conditions in a large area and dependence of their local occurrence in this array renders a possibility to evaluate the landscape, relying on *Coccinellidae* as an indicatory group, through examining an appropriate part of this area.

Dependence of coccinellids on the overall system of conditions in the landscape results from their biology and ecology. This group often migrates locally and for a longer distance looking for an appropriate environment, habitats rich in food and suitable sites for overwintering.

The biocenotic indices that describe structure and functioning of a community were the aim of these studies, such as species and dominance structures, distribution of numbers in various habitats, all as a function of terrain occupation and seasonal migrations.

## 2. STUDY AREA AND METHODS

Silesia was the examined terrain strongly affected by industry. Parallel studies were carried out in the other regions of Poland where the impact of industry was not so strong: in Masurian Lakeland and in vicinity of Warsaw, in the Vistula valley, at the edge of Kampinos Forest. The studies lasted for two years in Silesia (1977, 1978) and at Mikołajki (1976, 1977) and for one year near Warsaw (1978).

Three study areas in question can be determined as follows: Silesia as industrial-forest-agricultural, Masurian Lakeland and vicinity of Warsaw — as agricultural-forest terrains.

The region of Silesia chosen for studies is characterized by mosaic pattern of distribution of industrial factors such as pollution and minery damage both in respect of occurrence and intensity. Various types of changes overlap forming a very diversified region.

In Silesia, *Coccinellidae* were sampled in three areas: Aniołki, Szczygłowice and Kamień, in Masurian Lakeland near Mikołajki and in Warsaw region — near the Institute of Ecology in villages of Sadowa and of Dziekanów Polski.

In each region the study areas were chosen so that they were similar in the spatial configuration and surface utilization. The factor distinguishing foremostly Silesia is coal industry. Naturally, between these regions there were some differences such as local climate or origin of rocks giving rise to soils, however, the range of these differences covered similar vegetation-habitat units in all regions. This has an important meaning in comparability of results concerning the pattern of coccinellid occurrence.

A detailed evaluation of the habitat (water and soil conditions, local climate, structure of arable land) is given for Silesia according to Langhamer (unpublished data), Celiński (unpublished data), Foik (1978), the phytosociological evaluation — in papers by Celiński and Wika (1980) and the floristic evaluation by Baron (1980). The industrial sources of emission such as  $SO_2$ , dustfall and the surface deformation were also evaluated for Silesia acc. to Langhamer (unpublished data). Data for Mikołajki were gathered by Bajkiewicz-Grabowska (unpublished data), elaboration of results and comparison of the two study areas for entomological needs can be found in paper by Dąbrowska-Prot (1980).

The coccinellids are insects that easily migrate for rather large distances. There are many eurytopic species in this group, that is why in biocenotic studies of this group it is insufficient to evaluate conditions over a limited space of the study area, since their occurrence depends not only on local conditions but also on conditions found in surrounding habitats.

As a main habitat factor the type of soil was accepted (Tischler 1971). Soil decides to a greater extent upon the plant communities of natural habitats and the crop structure as well as segetal plants. The plant communities, in turn, together with soil decide upon occurrence of insects under similar climatic conditions.

The study areas both in Silesia and in Masurian Lakeland had strongly differentiated soils but in the two areas similar soil types were present, although their proportions were different. In Silesia the highest percentage was that of podzolic soils, next were leached brown soils, black earth and silty-peaty soils and peat soils. In Masurian Lakeland — brown soils, black earth, peats and podzols and podzolic soils.

The area near Warsaw included to the studies in 1978, situated between the Kampinos Forest and the Vistula River, is also very differentiated. Phytosociological characteristics (against habitat differentiation) of the studied area of Kampinos Forest can be found in paper by H. Traczyk and T. Traczyk (1965), whereas soils and plant communities of particular sites were elaborated by Kotowska, Pasternak, Tatur (unpublished data). The following soils are here present: podzols and gleyey podzols, rusty soils and podzolized rusty soils, brown podzolized soils, gleyey soils, black earth, peat soils. Thus, in any one area studied a mosaic of soils was present, in which the same or similar types of soils recurred.

In Silesia, the sites were located on following soils: Aniołki: pseudogleyey soil and degraded meadow black earth, Szczygłowice: degraded meadow black earth, strongly gleyey; the crops in the two localities occurred mostly on podzolic soils (Langhamer, unpublished data). Sites at Mikołajki were situated on brown soil and black earth (Bajkiewicz-Grabowska, unpublished data). From the agricultural point of view the soils were moderately heavy and rather fertile in the two study areas (good rye-potato and rye-wheat land capability unit). The nutrient resources of these soils allow to crop clover in each of these areas.

The sites at Kamień (Silesia) deviated from the above described since their soils were podzols (gleyey); in terms of mechanical composition only sands were present. These sites differed from the former in other respects which will be discussed below.

In a newly chosen area near Warsaw sampling was done in two localities due to the fact that the main sites at Sadowa similar to those of Silesia (Aniołki, Szczygłowice) and of Masurian Lakeland (Mikołajki) in their spatial structure and way of management, were located on different soil type. These were podzolized rusty soils and rusty soils formed from sandy alluvial rock of the Vistula basin with the mechanical composition corresponding to loose sands or loamy sands. Rather low retention capacity brought about often overdrying. Agriculturally it is poor rye land capability unit. Another set of sites chosen at Dziekanów Polski, being about 1.5 km apart from the former, was situated on a heavier and more fertile soil. These were leached brown soils formed of loamy alluvial rocks. Land capability units: both rye and wheat — good. The second set of sites has been chosen in the same area to estimate the possible type and range of changes in coccinellid community brought about by the soil type,

From the analysis of papers dealing with phytosociological evaluation it results that in all areas the sites were located in strongly differentiated landscapes.

The forest habitats were foremostly differentiated, apart from them the sampling was mainly done in typical crop fields which formed in all instances rather similar habitats.

Not only in the landscape scale but also within sites the forests were not uniform but they formed sets of numerous phytosociological units. The main background of all surface studied was *Pino-Quercetum* (Kozł. 1925) Mat. et Pol. 1955 association — only site at Szczygłowie where *Tilio-Carpinetum* Tracz. 1962 association was present deviates from this rule.

Mosaic differentiation of landscapes in all investigated regions yielded possibility of occurrence of species with different requirements. This allowed to conclude that the possible differences in species structure of the coccinellid community in Silesia are not a result of diversity of habitats in respect of floristic characteristics.

Since the paper aimed at grasping changes following under the impact of industry on a rather vast terrain, much differentiated in various habitats, in the way of surface utilization and in intensity of harmful factors, a method differing somewhat from classical one was applied. It depended on the fact that the study unit used for comparisons formed a definite space i.e. a section of the area which included possibly all natural environments typical for this region, but occurring also commonly in the Polish landscape. On the other hand a given set of sites forming a common space was chosen so that the coccinellids were able to follow their full biological cycle including exchange between habitats and seasonal migrations for hibernation. Coccinellids gather in certain habitats or emigrate from them depending on the habitat suitability in the respect of abiding or feeding conditions (B i e l a w s k i 1959, G a ł e c k a 1962, H a g e n 1962, I p e r t i 1965, H o d e k 1973). Samples were taken from each site during the whole season in order to obtain a full dynamics of numbers. It was, thus, intended to prove with the material gathered a possible diversity of the coccinellid community in Silesia, apart from variation in their occurrence in a given site, resulting from biology and ecology, and from the type of individual site, e.g. on its phenology, plant vegetation period, application of agrotechnical treatments, etc.

In consequence, the "index surface" (representative for landscape examined) was used which covered a piece of forest and more precisely, the forest herb layer and adjacent crop fields. The fields covered possibly all main crops: cereals, legumes and root crops. The adjacent grassland habitat were also taken into account. The site at Kamień (Silesia) deviated from this scheme in being a vast forest complex differentiated phytosociologically and poor rye field getting into the forest area. That is why data at Kamień are not fully comparable with other areas (considered as a whole), where material was gathered from surfaces including a number of various habitats. It can be, however, considered as typical for forest being under a certain type and intensity of industrial pollution. The comparative index surface at Sadowa near Warsaw, analogous in respect of spatial structure of habitats (forest-field ecotone) differed from those of Silesia at Aniołki and Szczygłowie in type of soil, clearly lighter what affected the structure of crops in the cultivated fields. A high percentage of this area was taken under rye culturing and much less — by potatoes and oats. Other crops were scarcely represented. In order to make possible comparison of this surface with those of Silesia and Masuria, additional material was gathered in this area with heavier soil at Dziekanów Polski, being in analogous crops at a distance of about one and a half kilometer from the forest. These crops were situated amongst fields with more complex crop structure, which make them more similar to crops at Aniołki, Szczygłowie and Mikołajki. Such choice of sites enabled analysis whether the possible differences between surface at Sadowa and others are not evoked by a poverty of the habitat.

The coccinellids were gathered by means of entomological sweep net. One sample consisted of 10 × 25 net sweeps at each site (the samples were collected only from sites covered with plants during a given sampling period). The number of estimates in particular index surfaces<sup>1</sup> within season and the number of sites in each of them were in subsequent years as follows:

	year:	no. estimates:	no. sites:
Masurian Lakeland			
– Mikołajki	1976	7	7
	1977	8	7
Silesia			
– Aniołki	1977	7	5
– Szczygłowiec	1977	7	3
– Kamień	1977	7	2
– Aniołki	1978	10	5
– Szczygłowiec	1978	10	6
– Kamień	1978	10	2
Vicinity of Warsaw			
– Sadowa	1978	6	3
– Dziekanów Polski	1978	6	2

### 3. RESULTS

#### 3.1. SPECIES STRUCTURE

A total of 25 species was gathered. From comparison of the numbers of species captured in Silesia localities (Aniołki, Szczygłowiec) with that in other localities of Poland (Mikołajki, Sadowa) it was found that the number of coccinellid species in Silesia are clearly lower (Table 1). The lower number of species in Silesia recurs in subsequent years of studies being relatively less variable. Rather considerable difference in number of species gathered in 1977 and 1978 at Kamień resulted from a broader sampling area in the second year of studies obtained by including other plant associations. That is why the data of these years are incomparable each other but they were included in this paper on account of a valuable characteristics of forest environment of Silesia.

Table 1  
Number of species in *Coccinellidae* community

Region	Locality	1976	1977	1978	Total for two years
Silesia	Aniołki	–	5	4	6
	Szczygłowiec	–	7	7	10
	Kamień	–	6	10	10
Masurian Lakeland	Mikołajki	12	13	–	15
Vicinity of Warsaw	Sadowa	–	–	16	

<sup>1</sup>By the estimation of index surface it is understood the sampling covering all chosen sites in a given area.

The fact of lower species diversity in Silesia is corroborated by finding lower total number of species captured there within two years from each surface than that found in Masurian Lakeland and lower from the number of species found only in 1978 in the vicinity of Warsaw. It is noteworthy that after two years of studies the increase in species number as related to each year separately is inconsiderable one which proves that in subsequent years the same species were captured at a majority.

In spite of the fact that the above data omit some species of coccinellid community it seems plausible to infer that the Silesia community consists of lower number of coccinellid species. An additional corroboration of this fact can be found in that the Aniołki surface, showing higher degradation degree in plant communities than the Szczygłowiec (Celiński 1980), reveals continuously decreasing number of species.

Higher species differentiation in Masurian Lakeland than in Silesia although these areas are similar in the respect of incidence of forests, share of other natural environments and the type of agricultural management but they differ in the degree of habitat degradation, has been also found by Łuczak (1980) for plant-living crop field spiders and by Dąbrowska-Prot (1980) for *Chloropidae*. The latter author showed also higher number of dipteran families at Mikołajki.

### 3.2. DISTRIBUTION OF NUMBERS OF VARIOUS SPECIES IN STUDIED SURFACES AND THEIR PERCENTAGE INCIDENCE IN COCCINELLID COMMUNITY

According to the accepted presupposition that the structural features of coccinellid community occurring along an array of various habitats are an appropriate index of occurrence of coccinellids in the landscape, the obtained materials have been described for the whole, above characterized areas. It does not mean, however, that the features typical for a given habitat e.g. forest or a certain crop were not taken into account. Thus, the material in Tables 2-6 denotes numbers of individuals of a given species captured in various sites of a given surface irrespective to the duration of the period of vegetation (thus irrespective to the suitability for coccinellid colonization). The figures are not arithmetical means per sample but quantitative "index of presence", during the growing season, of a given species in a given site. Their sum denotes an index valid for the whole surface. Such approach to the material was feasible since all sites of a given index surface were estimated simultaneously since April until October if only the plant cover was present, and lack of plants in a given site was considered as a zero sample. In consequence the numbers of individuals given in Tables 2-6 for each site are proportional to its inhabitation by coccinellids during the growing season.

In Table 6 including data for the terrain in the vicinity of Warsaw, both results from the main site in Sadowa and additional one, at Dziekanów Polski, are given. The latter, as already has been mentioned was chosen for studies on account of more similar soil type to soils of Silesia sites than was the Sadowa site. The coccinellid communities of crop fields (rye, potato) at Sadowa and at Dziekanów did not differ much one from another. In each of these two localities 11 species were found, 9 species being common for both. *Coccinella septempunctata* L. was a clear dominant species in the two surfaces. Because of great similarity of communities only main site at Sadowa was included in the further analysis.

The percentage incidence of each species in the coccinellid community has been calculated for each site and for the whole surface examined.

Table 2

Numbers of coccinellid individuals captured on an index surface and the percentage share of species in the community (Aniołki)

Species	1977						1978							
	forest	clover	wheat	potato	balk	total	per cent	forest	clover	wheat	potato	rye	total	per cent
1. <i>Coccinella septempunctata</i> L.	18	85	2	11	23	144	86	14	10	28	19	25	96	79
2. <i>Propylea quatuordecimpunctata</i> L.	3	12	1	1	3	20	12		2		1		3	2
3. <i>Adalia bipunctata</i> (L.)								19			1		20	17
4. <i>Adalia decempunctata</i> (L.)	3					3	2							
5. <i>Exochomus quadripustulatus</i> (L.)	1					1	< 1	2					2	2
6. <i>Subcoccinella vigintiquatuorpunktata</i> (L.)					1	1	< 1							

1-5 — predatory species, 6 — herbivorous species, 5 — species of forest habitats only.

Table 3

Numbers of coccinellid individuals captured on an index surface and the percentage share of species in the community (Szczygłowiec)

Species	1977					1978							
	forest	potato	clover	total	per cent	forest	potato	wheat	clover	broad bean	meadow	total	per cent
	1. <i>Coccinella septempunctata</i> L.	15	40	67	122	82	3	29	46	10	18	18	124
2. <i>Coccinella quinquepunctata</i> L.						1	1					2	1
3. <i>Coccinella undecimpunctata</i> L.								1				1	<1
4. <i>Propylea quatuordecimpunctata</i> L.	7		12	19	13	3		7	1		1	12	8
5. <i>Adalia bipunctata</i> (L.)	1			1	<1	1						1	<1
6. <i>Adalia decempunctata</i> (L.)	3			3	2	3	2	1		1	1	8	5
7. <i>Hippodamia tredecimpunctata</i> (L.)			1	1	<1								
8. <i>Adonia variegata</i> (Goeze)		1	1	1	<1								
9. <i>Anatis ocellata</i> (L.)											1	1	<1
10. <i>Calvia quatuordecimguttata</i> (L.)	1			1	<1								

1-10 - predatory species, 9-10 - species of forest habitats only.



Table 4

Numbers of coccinellid individuals captured on an index surface and the percentage share of species in the community (Kamień)

Species	1977				1978			
	forest	rye	total	per cent	forest	rye	total	per cent
1. <i>Coccinella septempunctata</i> L.	35	8	43	74	11	10	21	51
2. <i>Propylea quatuordecimpunctata</i> L.	6	1	7	12	2		2	5
3. <i>Adalia bipunctata</i> (L.)					1		1	2
4. <i>Adalia conglomerata</i> (L.)	3		3	5	1		1	2
5. <i>Anatis ocellata</i> (L.)						1	1	2
6. <i>Exochomus quadripustulatus</i> (L.)	1		1	2	1		1	2
7. <i>Aphidecta oblitterata</i> (L.)					1		1	2
8. <i>Scymnus</i> sp.					1		1	2
9. <i>Calvia quatuordecimguttata</i> (L.)					1		1	2
10. <i>Chilocorus renipustulatus</i> (Scriba)	1		1	2				
11. <i>Subcoccinella vigintiquatuorpunctata</i> (L.)	1	2	3	5	10	2	12	30

1-10 - predatory species, 11 - herbivorous species, 5, 6, 7, 9, 10 - species of forest habitats only.

The data point that *C. septempunctata* predominates quantitatively in all terrains examined. It is the only species which has been found to occur in any region of Poland, any site and in all years of studies.

The second abundant species but much less numerous is *Propylea quatuordecimpunctata* L., which occurs rather commonly. It is also eurytopic species.

Of herbivorous species, *Subcoccinella vigintiquatuorpunctata* (L.) is commonly represented. At Kamień in Silesia and in comparative areas it was caught in many sites. The species was only sporadically found at Aniołki and Szczygłowiec.

Attention is brought to the fact of lack or occurrence of only individual specimens in Silesia sites of an eurytopic species, *Coccinella quinquepunctata* L. It is one of commonest species in Poland, encountered in most diverse habitats, both arid and wet, natural and in crops (Bielański 1959). It is also common in other European countries (Hodek 1973). In the present studies it was rather numerously caught in the comparative areas.

Data on biology, ecology, habitat requirements, on communities typical for various habitats were derived from following papers: Bielański (1959, 1961), Hagen (1962), van Emden (1965), Iperti (1965, 1966, 1978), Semjanov (1965), Bombosch (1966), Ewert and Chiang (1966), Hodek (1966, 1967, 1973, 1978), Skuhra-vý and Novák (1966), Leclant and Remaudière (1970), Smith (1971), Remaudière et al. (1973), Hämäläinen, Markkula, Raij (1975), Frazer and Gilbert (1976), Honek (1978), Zelený (1978).

In general it can be stated that in spite of a considerable number of species only several of them occur relatively numerously and are commonly encountered. That is why a dominance set can be distinguished for each surface by accepting that a given species belongs to this set if it shows the percentage incidence higher than 5% at least in one year of studies. This rule was neglected only in one case, namely, at Aniołki *Adalia bipunctata* (L.) was not included in the dominance group in spite that in 1978 it showed an incidence of 17%. This incidence resulted, however from one discovery of aggregation of this species gathered

Table 5  
Numbers of coccinellid individuals captured on an index surface and the percentage share of species in the community (Mikołajski)

Species	1976								1977									
	forest	potato	wheat	barley	rye	clover	meadow	total	per cent	forest	potato	oats	barley	rye	clover	balk	total	per cent
1. <i>Coccinella septempunctata</i> L.	34	50	38	32	13	37	17	221	47	12	4	13	29	7	9	13	87	30
2. <i>Coccinella quinquepunctata</i> L.	4	34	29	41	1	7	11	127	27	5	7	3	4		3	22	8	
3. <i>Propylea quatuordecimpunctata</i> L.	24	5	4	12		10	7	62	13	6	8	7			12	23	56	19
4. <i>Coccinella quatuordecimpunctata</i> (L.)	3	1	2			2		8	2	1						5	6	2
5. <i>Adalia bipunctata</i> (L.)										1							1	<1
6. <i>Hippodamia tredecimpunctata</i> (L.)												1				1	2	1
7. <i>Adonia variegata</i> (Goeze)			1			1		2	<1									
8. <i>Anatis ocellata</i> (L.)	1							1	<1									
9. <i>Exochomus quodripustulatus</i> (L.)	1							1	<1	2						2		<1
10. <i>Celaia quatuordecimguttata</i> (L.)	2							2	<1						1		1	<1
11. <i>Harmonia quadripunctata</i> (Pont.)	1							1	<1									
12. <i>Myrrha octodecimguttata</i> (L.)										1					1		2	<1

13. <i>Neomysia oblongoguttata</i> (L.)											1	< 1	
14. <i>Subcoccinella vigintiquatuor-punctata</i> (L.)	10	2	4	7	1	4	28	6	7	2	6	47	23
15. <i>Tythaspis sedecimpunctata</i> (L.)			3			3	6	1	1		3	18	10
16. <i>Thea vigintiduopunctata</i> (L.)	15				1		16	3	11		4	15	5

1-13 - predatory species, 14 - herbivorous species, 15-16 - fungivorous species, 8-13 - species of forest habitats only.

for hibernation in the herb forest layer. Beside this one sample only one specimen was encountered that year and in preceding year - none (Table 2). In the other localities of Silesia it also occurred at minimum numbers. At Szczygłowice in the two years the incidence of this species was 0.7%, at Kamień it was not encountered in 1977, but in 1978 - in 2%. Therefore it was not a species common for the herb layer. During the vegetation season it dwells mostly in the tree crowns (I p e r t i 1978).

The discerned dominance sets (Fig. 1) show some common traits. All include two most numerous occurring species: *Coccinella septempunctata* and *Propylea quatuordecimpunctata*. In all sets *C. septempunctata* shows a high level of dominance. In spite of this the dominance sets, similarly as the whole communities, differ much and these differences show the same trends as in the case of the whole communities, namely Silesian surfaces reveal less species in spite of the fact that the dominance sets in all surfaces form a similar percentage, from 81 to 98% of the total community numbers.

Most alike are dominance sets at Aniołki and Szczygłowice including the same two species. The set at Kamień includes 3 species since a herbivorous species, *Subcoccinella vigintiquatuor-punctata* was added, also commonly found in all further communities. The set in Masurian Lakeland consists of 5 species and on the margin of Kampinos Forest - of 7 species.

Another trait differing the dominance sets of *Coccinellidae* in Silesia from others is a very high level of dominance of *Coccinella septempunctata*, much higher than in the comparative surfaces. For Aniołki and Szczygłowice the dominance percentage equals to 83% on the average for the years of studies, at Kamień - 62%, whereas in Mikołajki and Sadowa - 39 and 32%, respectively.

The described traits of coccinellid communities, namely, number of species and the dominance level point to clearly lower differentiation in Silesia. The least differentiated communities occur at Aniołki and Szczygłowice.

### 3.3. NUMBERS

Comparison of numbers in examined areas was based on average numbers within season per sample. Table 7 comprises the values for each site in subsequent years of observation. Average numbers for types of habitats were

Table 6

Numbers of coccinellid individuals captured on an index surface and the percentage share of species in the community (vicinity of Warsaw, 1978)

Species	Sadowa					Dziekanów Polski			
	forest	potato	rye	total	per cent	potato	rye	total	per cent
1. <i>Coccinella septempunctata</i> L.	24	56	10	90	32	152	26	178	63
2. <i>Coccinella quinquepunctata</i> L.	3	15	5	20	7	10	1	11	4
3. <i>Coccinella undecimpunctata</i> L.		1		1	1	4		4	1
4. <i>Propylea quatuordecimpunctata</i> L.	12	7	1	20	7	11	1	12	4
5. <i>Coccinula quatuordecimpustulata</i> (L.)	34	3	1	38	14	1		1	1
6. <i>Adalia bipunctata</i> (L.)	1	32	1	34	12	55		55	20
7. <i>Adalia decempunctata</i> (L.)		5		5	2	3		3	1
8. <i>Hippodamia tredecimpunctata</i> (L.)		2		2	1	2		2	1
9. <i>Adonia variegata</i> (Goeze)	2	11		13	5	13		13	5
10. <i>Anatis ocellata</i> (L.)	1			1	1	1		1	1
11. <i>Exochomus quadripustulatus</i> (L.)	2			2	1	1		1	1
12. <i>Calvia quatuordecimguttata</i> (L.)	1			1	1				
13. <i>Rhyzobius litura</i> (Fabr.)	6		2	8	3				
14. <i>Subcoccinella vigintiquatuor punctata</i> (L.)	26	1	1	28	10				
15. <i>Tythaspis sedecimpunctata</i> (L.)	13	1		14	5				
16. <i>Thea vigintiduopunctata</i> (L.)	1			1	1				

1-13 - predatory species, 14 - herbivorous species, 15-16 - fungivorous species, 10-12 - species of forest habitats only.

also calculated: for the forest herb layer, cereals, potatoes, legumes and grassland habitats for the two years of studies in Masurian Lakeland and Silesia.

By comparing analogous types of sites in Silesia and Masurian Lakeland in 1977 as well as in Silesia and in vicinity of Warsaw in 1978 (years of simultaneous studies in these areas) it can be said that the numbers of coccinellids in Silesia are considerably lower than in other regions.

From this regularity deviates lower than in Silesia numbers of coccinellids at Mikołajki on potatoes in 1977. This resulted from application of herbicides which brought about death of all plants in this field of a score of hectares in the end of summer. If, however, one compares numbers characterizing these crops in 1978 in Silesia (Aniołki - 3.5, Szczygłowice - 7.2) and in Sadowa near Warsaw (23.9) one can conclude that even potato crops in Silesia reveal lower numbers of coccinellids.

This regularity is observed also when comparing two-year averages in Silesia and Masurian Lakeland. All habitats in Silesia reveal lower numbers. Sometimes the difference is very high. Grassland habitats show 4.5 times higher numbers in Masurian Lakeland, cereals 3.7, forests 2.2, and legumes 1.6 than in Silesia.

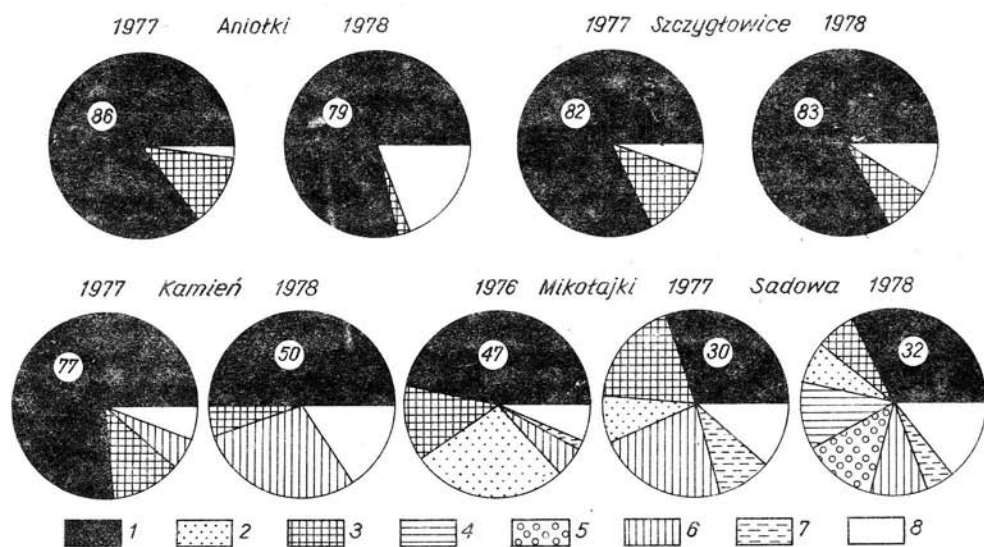


Fig. 1. Percentage incidence of predominant species in *Coccinellidae* community in various regions of Poland

1 - *Coccinella septempunctata* L., 2 - *C. quinquepunctata* L., 3 - *Propylea quatuordecimpunctata* L., 4 - *Adalia bipunctata* (L.), 5 - *Coccinula quatuordecimpustulata* (L.), 6 - *Subcoccinella vigintiquatuor-punctata* (L.), 7 - *Tythaspis sedecimpunctata* (L.), 8 - other species

Table 7

Numbers of coccinellids in season (average per sample)

Sites	Silesia						Masurian Lakeland			Vicinity of Warsaw	
	Aniołki		Szczygłowie		Kamień		average for two years	Mikołajki		Sadowa	
	1977	1978	1977	1978	1977	1978		1976	1977		1978
Forest	4.9	3.8	3.9	1.1	7.6	2.7	4.0	10.5	7.1	8.8	18.6
Wheat	1.5	3.0		7.3				20.2			
Rye					5.5	1.9	3.8	5.3	7.7	14.1	3.8
Barley								23.2			
Potato	4.0	3.5	10.2	7.2			6.2	14.0	1.3	7.7	23.9
Clover	19.4	1.6	11.4	2.7			7.8	16.5	7.8		
Broad bean				3.7						12.2	
Grasslands	6.4			3.0			4.7	17.5	22.2	19.9	

In general it can be said that the numbers of coccinellids are more variable than the community structure. Hence it is a worse index although here regular differences were proved between the areas examined.

## 3.4. SEASONAL MIGRATION

It has been often reported in literature (Melniženko 1949, Gałeczka 1962, Tischler 1971) that coccinellids together with other insects inhabiting crop fields undergo seasonal migrations for overwintering to forests and mid-field copses.

The dynamics of displacement of coccinellids in the area of crop field bordering with forest is described in details by Gałeczka (1962). Presently, this process has been traced from the courses of numbers' dynamics in crop fields and in the forest in order to check the regularity of its course under the impact of industry. The data were obtained in Masurian Lakeland in 1977, in Silesia in 1977 and 1978, and near Warsaw in 1978.

In a typical course of seasonal dynamics of coccinellid numbers in forest area and in adjacent crop fields three periods can be discerned. In the first – vernal, the numbers increase in the forest herb layer when the coccinellids emerge from hibernation pits and there, in the herb layer, make up the loss of water after winter diapause (Hodek 1973). In the crop fields their numbers in this period are at a minimum. This lasts more or less until June. The second, summer period lasts until the middle of August and is characterized by an increase in numbers in the two habitats, resulting from reproduction of insects which have overwintered. In this period the numbers in crops exceed those in the forest. In the third, autumnal season a sharp decrease in numbers in crops is observed with a simultaneous initial increase in the forest caused by mass migration of coccinellids from crop fields to the forest for overwintering. At the end of September the numbers in the forest also decrease due to falling into winter diapause. The durations of the above described periods depend to a certain degree on actual meteorological conditions and can be somewhat shifted in time.

Such seasonal changes in distribution of numbers in the contact zone of forest and crop fields were observed at Mikołajki and ot Sadowa (Figs.) thus in areas not affected by industry. In these two areas a basic regularity was recorded, namely, in the autumnal period a considerable increase in numbers of coccinellids was always observed in forest with a simultaneous drop in crop fields. However, between the two areas some differences were observed, since at Mikołajki, during the summer peak, numbers in crops exceeded those in forest whereas at Sadowa they were always higher in the forest. However, the directional trends in seasonal changes were in the two areas in question alike.

In Silesia these phenomena followed different course and they differed between the two subsequent years. In 1977 (Fig. 2) especially high numbers of coccinellids were observed in May in crop fields, gathering on clover and balks. In the forest the numbers were much lower. In Silesia coccinellids preferred crop fields during the vernal flights, although in most of crops the conditions of life were not good yet. It was an unusual phenomenon as compared with its normal course. The fact of altered spatial distribution in agrocoenoses under the impact of industrial emissions as expressed in forming by insects large aggregations was also observed by Puzsakar (in press). In June and in the first half of July the numbers of coccinellids decreased due to dispersal towards many crop fields whose vegetation started later. The true peak in numbers in crop fields, brought about by reproduction is much lower and somewhat delayed. In the forest, on the other hand, no clear augmentation of numbers, caused by immigration for overwintering, was observed. In 1978 (Fig. 2) no mass aggregations in early crops were observed in spring. Numbers both in crops and in the forest were very low and increased in normal sequence. Similarly as in the previous year they were always higher in crop fields than in the forest and no clear autumnal, immigrational increase was apparent.

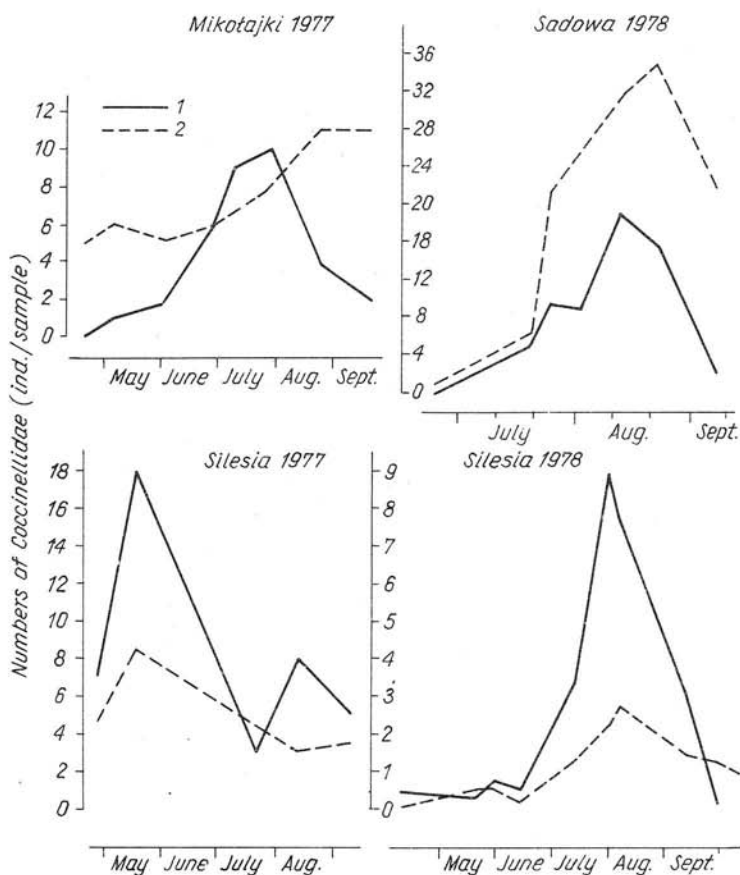


Fig. 2. Dynamics of numbers of coccinellids in crop fields and in the forest  
1 - crop fields, 2 - forest

Table 8

Autumnal increments in numbers of coccinellids in forest

Area	Year	Numbers in summer	Numbers in autumn	Autumnal increment of numbers in per cent
Silesia (Anioki + Szczygłowice)	1977	2.5	3.5	40
	1978	1.8	2.5	39
Mikołajki	1977	6.8	10.8	59
Sadowa	1978	16.3	30.5	87

Differences in intensity of seasonal migrations for overwintering in the industrial area of Silesia and in agricultural-forest areas at Mikołajki and Sadowa can be expressed quantitatively by calculating autumnal increment of numbers in the forest in relation to the summer abundance (Table 8). The autumnal increments of numbers in the forest are much

lower in Silesia than in other areas, which points to a lower suitability of these forests for hibernation.

Generally higher depletion of the value of forest herb layer than crop fields in Silesia as dwelling environment for coccinellids can be characterized by comparing average numbers for season in these two habitats (Table 9). In Silesia, during the two years the numbers of coccinellids in forest herb layer are lower than in the crop fields, whereas at Mikołajki and Sadowa, on the contrary, they were higher in the forest.

The above described results suggest a more general conclusion concerning resistance of different ecosystems to industrial pressure. It seems, namely, that the negative effect of industry for coccinellids is lower in agrocoenoses than in forests. The contrary was stated for spiders (Łuczak 1980).

Table 9

Average numbers of coccinellids per season in the forest herb layer and in crop fields

Area	Year	Mean numbers in forest	Mean numbers in crop fields
Silesia	1977	4.3	8.5
(Aniołki + Szczygłowice)	1978	2.5	2.7
Mikołajki	1977	7.1	4.9
Sadowa	1978	21.0	11.0

#### 4. CONCLUSIONS

As a result of two-year studies in Silesia it can be said that coccinellid communities reveal there a different structure than in other areas, depending foremostly on considerably diminished number of species and augmented dominance of eurytopic species, *Coccinella septempunctata*. This regularity recurs both in space (Aniołki, Szczygłowice) and in subsequent years. Taking into account natural characteristics of Silesian area and biological and ecological properties of coccinellids acc. to the literature cited in the present paper one can assume that diversity of coccinellid community of Silesia is not brought about mainly by primary specificity of live conditions in Silesia. It is rather a result of terrain degradation and impact of pollution.

The diminishing total abundance of coccinellid community in the examined localities of Silesia becomes apparent more clearly in 1978 than in 1977. The lack of autumnal increase in numbers in forest of Aniołki and Szczygłowice would suggest the presence of a factor causing depletion of forest suitability for overwintering the coccinellids inhabiting the crop fields in summer.

#### 5. STRESZCZENIE

Badano zespoły *Coccinellidae* w trzech rejonach Polski – na Śląsku, na Mazurach oraz pod Warszawą w dolinie Wisły. Pierwszy z nich jest rejonem przemysłowym, charakteryzującym się znaczną degradacją środowisk przyrodniczych. Czynniki związane z obecnością przemysłu występują tam mozaikowo i w różnym stopniu natężenia. Dwa pozostałe tereny można scharakteryzować jako rolniczo-leśne.



Badania prowadzono na Śląsku w 1977 i 1978 r., na Mazurach w 1976 i 1977 r., a w okolicy Warszawy w 1978 r. Na Śląsku pobierano próby w trzech miejscach: Aniołki, Szczygłowice i Kamień.

Przedmiotem analizy były zjawiska biocenotyczne z zakresu struktury i funkcjonowania zespołu: struktura gatunkowa, struktura dominacji, liczebność oraz sezonowe migracje. Wytypowano powierzchnie wskaźnikowe obejmujące runo leśne i graniczące z lasem pola uprawne, na których uwzględniono podstawowe typy upraw: zbożowe, motylkowe i okopowe. Uwzględniono też przylegające środowiska trawiaste.

Biedronki zbierano metodą czerpakową. Uzyskano materiał obejmujący 25 gatunków. Stwierdzono, że zespół biedronek na Śląsku różni się znacznie od zespołów w terenach o krajobrazie rolniczo-leśnym.

Po pierwsze na Śląsku wyławiano mniej gatunków, co powtarzało się w kolejnych latach, przy czym wzrost liczby gatunków po dwóch latach łącznie jest niewielki w stosunku do każdego roku. Świadczy to, że w kolejnych latach wyławiano w większości te same gatunki. Na terenach nie objętych wpływem przemysłu liczba gatunków jest kilkakrotnie wyższa (tab. 1).

Drugą cechą odróżniającą zespoły biedronek na Śląsku jest bardzo wysoki stopień dominacji eurytopowego gatunku *Coccinella septempunctata* L. (tab. 2–6). Dla Aniołków i Szczygłowic za dwa lata badań wynosi on średnio 83%, w Kamieniu 62%, w Mikołajkach 39%, a w Sadowej (jeden rok badań) 32%.

Porównanie liczebności w latach jednoczesnych badań wykazuje, że analogiczne typy stanowisk mają na Śląsku niższą liczebność. Prawidłowość ta ujawnia się również przy porównaniu średniej za dwa lata na Śląsku i Mazurach (tab. 8).

Znane zjawisko sezonowej migracji biedronek z pól do lasów na zimowanie, ujawniające się w znacznym wzroście ich liczebności jesienią w runie leśnym, na Śląsku (Aniołki, Szczygłowice) w odróżnieniu od terenów bez przemysłu było zaznaczone bardzo słabo (fig. 2). Wskazywałoby to na małą przydatność lasów śląskich dla zimowania biedronek.

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