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CARABID BEETLES (*COLEOPTERA, CARABIDAE*) OF MOIST MEADOWS ON THE MAZOVIAN LOWLAND

ABSTRACT

Carabid beetle communities living on seven *Arrhenatheretum medioeuropaeum* meadows (alliance *Arrhenatherion elatioris*) of the Mazovian Lowland were analysed. These meadows differed in the way and intensity of utilization, ranging from uncultivated to many times' mown, fertilized, and grazed. Species composition and structure (abundance, number of species, dominance structure) of carabid communities were related to the type of meadow management. Zoogeographical and ecological characteristics of the carabid fauna are discussed. The material was collected in 1976–1977 and 1980–1984, and it consists of about 4,000 adults representing 79 species. Barber's pitfall traps were used as the basic sampling method.

INTRODUCTION

There are a dozen or so papers dealing with carabids of European meadows and pastures (Thiele 1977). As for such a well-known group of insects, this is not many. Many more works are concerned with the fauna of crop fields. All the data available so far on carabids associated with meadows come from Czechoslovakia, the Federal Republic of Germany and German Democratic Republic. In Poland such studies have not been conducted. Only a few papers analyse carabid communities from moist meadows of the alliance *Arrhenatherion elatioris* (Doskočil and Hůrka 1962; Stein 1965; Bílý and Pavlíček 1970; Tietze 1967, 1973a, b, c, d).

This paper is a part of a set of zoocoenological papers on the composition and structure of animal communities inhabiting moist meadows of the Mazovian Lowland. The purpose and scope of these papers are presented in the introductory article (Bańkowska 1989a).

STUDY AREA AND METHODS

The analysed data were collected from seven meadows. Data on five meadows are new and those on the remaining two are taken from an earlier publication (Czechowski 1981b). The present study was conducted at Klembów, Białołęka Dworska (plots A and B), Chylice and Zbroszki, all located within a radius of 60 km from Warsaw (Bańkowska 1989b). Particular meadows differed in the soil composition and fertility, type and intensity of agricultural use, and floral composition. The meadow at Chylice and plot B at Białołęka Dworska represented fertile mown meadows; the former was mown and cultivated very intensely, the latter moderately. The plot at Klembów supported a fertile meadow mown and grazed at rather a low rate. Plot A at Białołęka Dworska represented a fertile meadow not utilized at all, and the meadow at Zbroszki was heavily grazed. All these meadows were located on the site of a potential linden-oak-hornbeam forest (*Tilio-Carpinetum*). Their detailed geobotanical characteristics are given by Kotowska and Okołowicz (1989).

To obtain a more complete characteristic of carabid communities associated with meadows, also the data already published from two other moist meadows at Białołęka Dworska are included here. One of these meadows (denoted here by C) was located on a linden-oak-hornbeam site, and the other (D) was located on the site of an alder-ash carr (*Circaeo-Alnetum*)[1] (Roo-Zielińska 1981). The two meadows were mown and grazed, plot C intensely, plot D occasionally.

The study was carried out in 1980–1984 (data for plots C and D at Białołęka Dworska were collected in 1976–1977). Each meadow was sampled for at least two years (Klembów, Białołęka Dworska A, B in 1980–1981; Chylice in 1981–1983; Zbroszki in 1983–1984). A quantitative analysis was based mostly on the data obtained by Barber's traps. Glass cylinders with a diameter of 4 cm and volume of 100–120 ml were used, partly filled with ethylene glycol, and run in periods from April to October. The material was removed at two-week intervals. On each plot there were 20 traps. Using this method, about 2,100 adult carabids were collected. Moreover, about 1,000 individuals were captured by other methods, not specific of the epigean fauna sampling (entomological net, Moericke's traps, window traps; Bańkowska 1989b). The earlier published materials from Białołęka Dworska consist of about 900 individuals.

[1] In the paper quoted (Czechowski 1981b), this meadow was unprecisely classified as wet. A transformation of wet meadows into moist meadows is a frequent effect of human activity (Nowiński 1967).

COMMUNITY ABUNDANCE AND SPECIES COMPOSITION

The number of individuals in carabid communities was characterized by an index calculated as a mean number of beetles captured by 10 traps during 14 days. The same index was used in earlier papers (Czechowski 1980a, b, 1981b, 1982).

The mean value of the abundance index for all the seven communities was 11.4, ranging from 5.4 (Klembów) to 22.3 (Białołęka Dworska B) (Tab. 1). No clear relationship was found between the type of meadow management and community abundance. The most abundant and the least abundant communities occurred on fertile mown meadows (generally both mown once a year; but the meadow at Klembów, however, was also grazed). In turn, carabid abundance closest to the mean value was found for meadows with extremely different utilization types: the uncultivated meadow at Białołęka Dworska (A) and the meadow at Chylice, mown 2–3 times a year, and intensely fertilized (mineral fertilizers).

But if the plots are arranged according to increasing abundance of carabids, then the first group (except for Klembów) consists of the meadows intensely exploited, e.g. frequently mown or grazed, such as Zbroszki and Białołęka Dworska C. The second group is made up of meadows fertilized less intensely or not at all (Białołęka Dworska A, D, B). Low numbers of carabids at Klembów (not intensely utilized meadow) was probably due to a secondary factor — seasonal flooding. In turn, at Chylice (very intensely exploited meadow) mean carabid numbers were relatively high, but they markedly decreased from one year to another. This will be farther discussed in detail.

A total of 79 carabid species of 28 genera was recorded from the study meadows. These species accounted for 24.5% of the carabid fauna occurring on the Mazovian Lowland, and for 15.5% of the carabid fauna of Poland. The richest

Table 1. Parameters of the structure of carabid communities from moist meadows of the Mazovian Lowland: n — abundance index; S — number of species (in parentheses the number of species recorded by Barber's pitfall traps); d — index of species' richness; $\%_D$ — proportion of the dominant species; $\overline{H}$ — Shannon index of general diversity; e — Pielou evenness index (d, $\overline{H}$, e were calculated only for the material obtained from Barber's pitfall traps)

Locality	n	S	d	$\%_D$	$\overline{H}$	e
Klembów	5.4	19 (18)	7.8	27.8	2.34	0.81
Białołęka Dworska A	10.6	34 (33)	10.1	38.7	2.34	0.67
Białołęka Dworska B	22.3	43 (43)	9.1	16.1	2.55	0.68
Białołęka Dworska C	8.2	30 (26)	9.1	24.4	2.36	0.69
Białołęka Dworska D	13.6	26 (25)	6.8	27.9	2.39	0.74
Chylice	13.2	40 (21)	5.8	51.7	2.01	0.65
Zbroszki	6.6	13 (13)	5.1	43.9	1.95	0.76

Table 2. Species composition, abundance and proportions of particular species in carabid communities inhabiting moist meadows of the Mazovian Lowland (n — abundance index; + — abundance less than 0.05; x — species recorded only by supplementary methods)

No.	Locality	Klembów		Białołęka Dworska								Chylice		Zbroszki	
				A		B		C		D					
	Species	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	*Carabus granulatus* L.	0.1	1.9	—	—	—	—	—	—	+	0.3	0.6	4.6	—	—
2	*Carabus cancellatus* Ill.	—	—	0.1	0.9	0.1	0.4	+	0.4	—	—	—	—	—	—
3	*Carabus nemoralis* O. F. Müll.	—	—	0.6	5.7	+	0.3	+	0.4	0.2	1.5	—	—	—	—
4	*Leistus ferrugineus* (L.)	—	—	0.1	0.9	—	—	—	—	—	—	—	—	—	—
5	*Leistus rufescens* (Fabr.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
6	*Nebria brevicollis* (Fabr.)	0.6	11.1	+	0.4	0.6	2.7	1.4	17.1	0.4	2.9	0.1	0.8	0.4	6.1
7	*Nothiophilus aquaticus* (L.)	—	—	—	—	0.1	0.4	—	—	—	—	x	—	—	—
8	*Nothiophilus palustris* (Duft.)	—	—	0.3	2.8	—	—	x	—	—	—	—	—	—	—
9	*Loricera caerulescens* (L.)	0.1	1.9	—	—	—	—	—	—	—	—	0.1	0.8	—	—
10	*Clivina fossor* (L.)	1.3	24.1	—	—	0.2	0.9	—	—	0.1	0.7	+	0.3	0.1	1.5
11	*Dyschirius globosus* (Herbst)	—	—	—	—	—	—	—	—	0.3	2.2	—	—	—	—
12	*Broscus cephalotes* (L.)	—	—	0.1	0.9	0.4	1.8	+	0.4	—	—	—	—	—	—
13	*Asaphidion flavipes* (L.)	—	—	+	0.4	+	0.3	—	—	—	—	—	—	—	—
14	*Bembidion lampros* (Herbst)	—	—	0.3	2.8	3.5	15.7	—	—	—	—	—	—	—	—
15	*Bembidion properans* (Steph.)	—	—	0.1	0.9	0.8	3.6	—	—	—	—	x	—	0.2	3.0
16	*Bembidion ustulatum* (L.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
17	*Bembidion quadrimaculatum* (L.)	—	—	—	—	0.1	0.4	—	—	—	—	x	—	—	—
18	*Bembidion guttula* (Fabr.)	0.2	3.7	—	—	—	—	—	—	—	—	+	0.3	—	—
19	*Epaphius secalis* (Payk.)	+	0.9	—	—	—	—	0.1	1.2	0.4	2.9	x	—	—	—
20	*Trechus quadristriatus* (Schrank)	—	—	—	—	0.1	0.4	—	—	—	—	0.1	0.8	—	—
21	*Trechoblemus micros* (Herbst)	—	—	—	—	—	—	—	—	—	—	+	0.3	—	—
22	*Patrobus atrorufus* (Stroem)	—	—	—	—	—	—	+	0.4	+	0.3	—	—	—	—
23	*Amara plebeja* (Gyll.)	0.1	1.9	0.1	0.9	0.1	0.4	x	—	—	—	x	—	—	—
24	*Amara aenea* (De Geer)	—	—	0.1	0.9	0.1	0.4	0.6	7.3	0.2	1.5	—	—	2.9	43.9

25	*Amara communis* (Panz.)	—	—	+	0.4	+	0.3	—	—	0.4	2.9	1.5	14.4	—	—
26	*Amara convexior* Steph.	—	—	—	—	—	—	0.1	1.2	—	—	0.2	1.5	—	—
27	*Amara famelica* Zimm.	—	—	—	—	—	—	0.2	2.4	+	0.3	—	—	—	—
28	*Amara familiaris* (Duft.)	—	—	0.1	0.9	+	0.3	0.3	3.7	0.5	3.7	0.2	1.5	+	0.5
29	*Amara nitida* Sturm	—	—	—	—	—	—	—	—	—	—	+	0.2	—	—
30	*Amara pseudocommunis* Burak.	—	—	—	—	—	—	—	—	x	—	—	—	—	—
31	*Amara similata* (Gyll.)	—	—	—	—	0.1	0.4	0.1	1.2	0.2	1.5	—	—	—	—
32	*Amara tibialis* (Payk.)	—	—	—	—	+	0.3	—	—	—	—	—	—	—	—
33	*Amara ingenua* (Duft.)	—	—	—	—	0.1	0.4	—	—	—	—	—	—	—	—
34	*Amara bifrons* (Gyll.)	—	—	0.1	0.9	0.1	0.4	0.1	1.2	—	—	x	—	—	—
35	*Amara apricaria* (Payk.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
36	*Amara fulva* (O. F. Müll.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
37	*Amara aulica* (Panz.)	—	—	—	—	—	—	0.1	1.2	—	—	x	—	—	—
38	*Amara equestris* (Duft.)	—	—	+	0.4	—	—	1.0	12.2	—	—	x	—	—	—
39	*Stomis pumicatus* (Panz.)	—	—	—	—	—	—	+	0.4	—	—	—	—	—	—
40	*Pterostichus caerulescens* (L.)	—	—	0.2	1.9	0.5	2.2	0.1	1.2	1.1	8.1	0.6	4.6	0.2	3.0
41	*Pterostichus cupreus* (L.)	—	—	+	0.4	0.2	0.9	+	0.4	—	—	—	—	—	—
42	*Pterostichus virens* O. F. Müll.	—	—	0.2	1.9	3.7	16.6	—	—	—	—	—	—	—	—
43	*Pterostichus vernalis* (Panz.)	0.1	1.9	—	—	—	—	0.1	1.2	—	—	+	0.1	—	—
44	*Pterostichus oblongopunctatus* (Fabr.)	—	—	—	—	+	0.3	—	—	0.1	0.7	x	—	—	—
45	*Pterostichus niger* (Schall.)	1.5	27.8	0.3	2.8	0.1	0.4	—	—	0.3	2.2	0.2	1.5	—	—
46	*Pterostichus vulgaris* (L.)	0.4	7.4	4.1	38.7	3.6	16.1	0.2	2.4	2.9	21.3	6.8	51.7	0.9	13.6
47	*Pterostichus anthracinus* (Ill.)	0.2	3.7	—	—	—	—	—	—	—	—	+	0.1	—	—
48	*Pterostichus nigrita* (Fabr.)	—	—	—	—	+	0.3	—	—	—	—	x	—	—	—
49	*Pterostichus strenuus* (Panz.)	+	0.9	x	—	—	—	—	—	—	—	x	—	—	—
50	*Calathus ambiguus* (Payk.)	—	—	0.1	0.9	0.3	1.3	+	0.4	—	—	—	—	—	—
51	*Calathus erratus* (C. R. Sahlb.)	—	—	—	—	0.1	0.4	—	—	—	—	—	—	0.1	1.5
52	*Calathus fuscipes* (Goeze)	—	—	1.4	13.2	2.5	11.2	1.3	15.9	1.3	9.6	0.2	1.5	0.5	7.6
53	*Calathus melanocephalus* (L.)	0.1	1.9	+	0.4	0.2	0.9	—	—	—	—	1.4	10.6	+	0.5
54	*Calathus mollis* (Marsh.)	—	—	0.1	0.9	0.4	1.8	—	—	—	—	—	—	—	—
55	*Dolichus halensis* (Schall.)	—	—	+	0.4	0.1	0.4	+	0.4	—	—	—	—	—	—
56	*Synuchus nivalis* (Panz.)	—	—	+	0.4	—	—	—	—	+	0.3	0.3	2.3	0.1	1.5
57	*Agonum sexpunctatum* (L.)	+	0.9	—	—	0.1	0.4	—	—	—	—	—	—	—	—

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
58	*Agonum dorsale* (Pont.)	—	—	—	—	0.2	0.9	—	—	0.5	3.7	—	—	—	—
59	*Agonum gracile* Sturm	x	—	—	—	—	—	—	—	—	—	—	—	—	—
60	*Badister bipustulatus* (Fabr.)	—	—	—	—	—	—	x	—	+	0.3	—	—	—	—
61	*Badister dilatatus* Chaud.	—	—	—	—	—	—	+	0.4	—	—	—	—	—	—
62	*Chlaenius nigricornis* (Fabr.)	—	—	+	0.4	—	—	—	—	—	—	—	—	—	—
63	*Anisodactylus binotatus* (Fabr.)	0.1	1.9	0.1	0.9	—	—	—	—	0.4	2.9	0.3	2.3	—	—
64	*Anisodactylus nemorivagus* (Duft.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
65	*Anisodactylus signatus* (Panz.)	—	—	—	—	0.1	0.4	—	—	—	—	x	—	—	—
66	*Harpalus griseus* (Panz.)	—	—	+	0.4	—	—	—	—	—	—	—	—	—	—
67	*Harpalus rufipes* (De Geer)	0.2	3.7	1.6	15.1	3.1	13.9	2.0	24.4	3.8	27.9	0.4	3.0	0.8	12.1
68	*Harpalus affinis* (Schrank)	+	0.9	—	—	+	0.3	—	—	—	—	—	—	0.4	6.1
69	*Harpalus latus* (L.)	—	—	—	—	—	—	0.2	2.4	0.1	0.7	—	—	—	—
70	*Harpalus luteicornis* (Duft.)	—	—	+	0.4	—	—	—	—	—	—	—	—	—	—
71	*Harpalus modestus* Dej.	—	—	—	—	+	0.3	—	—	—	—	—	—	—	—
72	*Harpalus psittaceus* (Fourcr.)	—	—	—	—	0.1	0.4	—	—	—	—	—	—	—	—
73	*Harpalus rubripes* (Duft.)	—	—	0.1	0.9	+	0.3	—	—	—	—	—	—	—	—
74	*Harpalus rufitarsis* (Duft.)	—	—	—	—	—	—	—	—	—	—	x	—	—	—
75	*Harpalus tardus* (Panz.)	—	—	+	0.4	+	0.3	—	—	0.1	0.7	—	—	—	—
76	*Harpalus vernalis* (Fabr.)	—	—	—	—	+	0.3	—	—	—	—	—	—	—	—
77	*Bradycellus harpalinus* (Aud.-Serv.)	—	—	—	—	—	—	+	0.4	—	—	—	—	—	—
78	*Acupalpus dorsalis* (Fabr.)	0.2	3.7	—	—	—	—	—	—	—	—	x	—	—	—
79	*Metabletus truncatellus* (L.)	—	—	—	—	0.1	0.4	x	—	0.1	0.7	—	—	—	—
	Total	5.4		10.6		22.3		8.2		13.6		13.2		6.6	

genera were represented by *Amara* Bon. (16 species), *Pterostichus* Bon. (10 species), and *Harpalus* Latr. (11 species) (Tab. 2).

The number of species in different communities ranged from 13 (Zbroszki) to 43 (Białołęka Dworska B), being 29 on the average (Tab. 1). Thus, in this respect, the differences were large. The number of species in the community, like the community abundance vaguely depends on the intesnity of meadow exploitation. The number of carabid species was generally higher on not intensely exploited meadows.

Also an index of species' richness[2] showed a similar relation to the type of meadow utilization. It ranged from 5.1 to 10.1 (Tab. 1) and tended to decrease with increasing human interference. The highest species' richness was observed on the uncultivated meadow (Białołęka Dworska A) and the lowest one on the intensely grazed meadow (Zbroszki).

The most abundant species on the moist meadows (on the scale of all the study plots) were *Pterostichus vulgaris*, *Harpalus rufipes*, *Calathus fuscipes*, *Amara aenea*, and *Pterostichus virens* (Tab. 3). The dominants of particular communities comprised *Pterostichus niger* (Klembów), *P. vulgaris* (Białołęka Dworska A, Chylice), *P. virens* (Białołęka Dworska B), *Harpalus rufipes* (Białołęka Dworska C, D), and *Amara aenea* (Zbroszki). Thus, for the most communities dominants were specific. Other relatively abundant species in particular communities included *Clivina fossor* (Klembów), *Nebria brevicollis* (Klembów, Białołęka Dworska C), *Pterostichus vulgaris* (Białołęka Dworska B, D, Zbroszki), *Harpalus rufipes* (Bia-

Table 3. Most constant (C) and most abundant (D) carabid species on moist meadows of the Mazovian Lowland (asterisks indicate the species absent from the alternative list)

Class of constancy	C	D	%
absolutely constant	*Pterostichus vulgaris*	*Pterostichus vulgaris*	23.7
	Harpalus rufipes	*Harpalus rufipes*	14.9
	Nebria brevicollis	*Calathus fuscipes*	9.0
constant	*Calathus fuscipes*	*Amara aenea*	4.9
	Pterostichus caerulescens	**Pterostichus virens*	4.9
	Amara familiaris	**Bembidion lampros*	4.8
relatively constant	*Amara aenea*	*Nebria brevicollis*	4.4
	Pterostichus niger	*Pterostichus caerulescens*	3.4
	Calathus melanocephalus	*Pterostichus niger*	3.0
	**Clivina fossor*	*Calathus melanocephalus*	2.1
	**Amara plebeja*	*Amara familiaris*	1.4

[2] $d = \frac{S}{\sqrt{n}}$; where S is the number of species and n is an index of the community abundance.

łołęka Dworska A, B, Zbroszki), *Calathus fuscipes* (Białołęka Dworska A, B, C), *Bembidion lampros* (Białołęka Dworska B), *Amara equestris* (Białołęka Dworska C), and *A. communis* (Chylice). So, the differentiation among subdominants was also large.

Carabid communities from particular meadows were, however, much diversified in the respect of the species' composition. The index of similarity (a percentage version of the Sörensen's formula) varied from 29 to 65%. The mean similarity between two communities was only 43%. A similarity higher than 50% was found only for closely located meadows at Białołęka Dworska, and, rather unexpectedly, for Chylice and Klembów, which differed much not only in the type of exploitation but also in surrounding habitats. The lowest similarity was found between carabid communities from Klembów and particular communities from Białołęka Dworska (Tab. 4).

The highest mean similarity to other communities was found for the communities at Białołęka Dworska B (47%) and A (46%) (Tab. 3). They may thus be considered as most typical of the moist meadows of Mazovia with respect to the species composition of carabid communities. The least similar to others (36% on the average) was the community from Klembów. The meadow at Klembów was the only one adjoining a large forest (*Tilio-Carpinetum*), the other meadows being surrounded with crop fields. Moreover, it was partially wet (Kotowska and Okołowicz 1989). It should be noted here that the carabid community, living on the meadow developed on an alder-ash carr site (Białołęka Dworska D) and transformed into a moist meadow after drainage, did not significantly differ

Table 4. Index of similarity (calculated from Sörensen formula) for carabid communities from moist meadows of the Mazovian Lowland (in parentheses the similarity index calculated only for species from Barber's pitfall traps; asterisks indicate differences greater than 4% between the two values)

		Klembów	Białołęka Dworska				Chylice	Zbroszki
			A	B	C	D		
Klembów		—	30 (27)	29 (30)	29 (27)	36 (37)	54 (56)	38 (39)
Białołęka Dworska	A	30 (27)	—	65 (66)	53 (50)	43 (45)	43 (41)	43 (43)
	B	29 (30)	65 (66)	—	47 (43)	49 (50)	46 (34)*	43 (43)
	C	29 (27)	53 (50)	47 (43)	—	54 (51)	37 (34)	33 (36)
	D	36 (37)	43 (45)	49 (50)	54 (51)	—	42 (52)*	46 (47)
Chylice		54 (56)	43 (41)	46 (34)*	37 (34)	42 (52)*	—	38 (53)*
Zbroszki		38 (39)	43 (43)	43 (43)	33 (36)	46 (47)	38 (53)*	—

from other carabid communities. On the contrary, its mean similarity to the other communities was relatively high (45%), higher than an average value for all the study plots. The only indicator of the carr origin of this meadow was the presence of a hygrophilous species *Dyschirius globosus*, which besides also occurs, even in large numbers, on other moist meadows in Central Europe (Bílý and Pavlíček 1970).

Incidentally, it should be admitted that the close vicinity of plots A and B at Białołęka Dworska must have influenced the similarity in their species composition (an analogical pair is formed by plots C and D). Due to this the mean similarity in the carabid communities of these meadows to the other carabid communities, including adjacent communities, exceeds the value that could have been reached between isolated communities.

The data presented above show that both the species composition of carabid communities and the abundance of some species (the dominance of a forest species *Pterostichus niger* at Klembów, and field species of carabids on other plots) mostly depend on the location of the meadow among other habitats. The effect of management type seems to be considerably less important.

To determine the constancy of different species on moist meadows, the modified Tischler's scale was used. Five classes of species were distinguished: 1 — absolutely constant (occurring on all the seven plots), 2 — constant (occurring on six, i.e., on 86% of the plots), 3 — relatively constant (present on five, i.e., on 71% of the plots), 4 — accessory (on two-four, i.e., 29–57% of the plots), and 5 — accidental (found on one, i.e., on 14% of the plots).[3]

The absolutely constant species consisted of *Nebria brevicollis*, *Pterostichus vulgaris*, and *Harpalus rufipes*. The constant species comprised *Amara familiaris*, *Pterostichus caerulescens*, and *Calathus fuscipes*. There were 5 relatively constant species (Tab. 3), 45 accessory species, and 23 accidental species.

The check-list of the most constant species largely overlaps the check-list of dominant species for all the meadows (Tab. 3). Of 11 species of the highest constancy, only two do not belong to the group of most abundant species. These are *Clivina fossor*, the species abundant only on the meadow wet in places at Klembów, and *Amara plebeja*, the species scarce everywhere. Among the 11 most abundant species on the list of the most constant species there are no *Pterostichus virens* and *Bembidion lampros*, both occurring in large numbers but only on some plots at Białołęka Dworska.

Taking into account a small qualitative similarity of particular communities, this situation indicates that the large diversity of the component species is mostly due to a large number of sporadic species, which did not belong to the group

[3] According to the classical Tischler's scale (Trojan 1975), absolutely constant species occur on 76–100% of the plots. The modification introduced here limits the application of the term "absolutely constant", following its linguistic sense, to the species occurring on all the study plots. The percentage intervals for the other classes are the same for the two variants.

of dominants. This could be an indication that the habitat conditions were largely uniform on the study meadows but the fact that the dominant and at the same time the most constant species were represented by polytopic or even eurytopic forms precludes such conclusion.

Below there are given the bionomic-ecological characteristics[4] of the most important species on moist meadows. They include species with the highest constancy (absolutely constant and constant) and the most abundant (on the scale of both the study meadows and particular plots).

Nebria brevicollis — a forest polytopic species. Inhabits moist humus soils. Zoophagous, autumn form.

Clivina fossor — an open-land polytopic species. Prefers moist loamy soils, with large sparse plant cover. Zoophagous, spring form. Constant though moderately abundant on moist meadows.

Bembidion lampros — a common, open-land polytopic species. Lives in moist and dry soils of different types, except for pure sands. Zoophagous, spring form. Constant but not numerous on moist meadows.

Amara aenea — a common, polytopic species associated with warm and dry open habitats with low plant cover, very common on crop fields. Inhabits mainly sandy and sandy-loam soils. Pantophagous, spring form.

Amara familiaris — a common, polytopic species from open habitats (rather cool), common on crop fields and meadows. Inhabits dry and moderately moist soils of different types, mostly sandy and sandy-loam soils. Pantophagous, spring form. Constant but not numerous on moist meadows.

Pterostichus caerulescens — a polytopic species associated with open habitats with sparse, low vegetation, numerous in croplands and wastelands. Inhabits dry and moist soils of different types. Zoophagous, spring form.

Pterostichus virens — a common, polytopic species associated with well-insolated open habitats with sparse plant cover, frequent in croplands. Inhibats mainly sandy and sandy-gravel soils. Pantophagous, autumn form.

Pterostichus niger — a common, polytopic forest species. Inhabits mainly deciduous and mixed forests on moderately moist, fertile soils of different types. Zoophagous, autumn form. Scarce or moderately numerous on moist meadows.

Pterostichus vulgaris — a common, polytopic species associated with open areas with low herbaceous vegetation, little shaded, and moderately moist. Inhabits different soils except for totally barren (pure sands, gravels, etc.). Frequent on crop fields (though not in all crop types), in gardens, parks, also at forest edges. Zoophagous, autumn form. On moist meadows almost always in the group of dominants.

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[4] After Larsson (1939), Lindroth (1949), Tietze (1973b), and Catalogue of the Fauna of Poland (Burakowski et al. 1973, 1974). Data on the occurrence on moist meadows of Central Europe only from the literature (Tietze 1973b).

Calathus fuscipes — a ubiquitous (eurytopic) species. Occurs in open habitats (including crop fields and meadows), in gardens and deciduous forests. Inhabits moderately moist soils of different types, except for barren sands. Zoophagous, autumn form. A constant component of moist meadows, though little or moderately numerous.

Harpalus rufipes — a common, polytopic species associated with rather dry, open habitats, mostly meadows and crop fields. Inhabits mainly loamy soils, avoids pure sands. Pantophagous, autumn form. On moist meadows constant and rather numerous.

DOMINANCE STRUCTURE OF COMMUNITIES

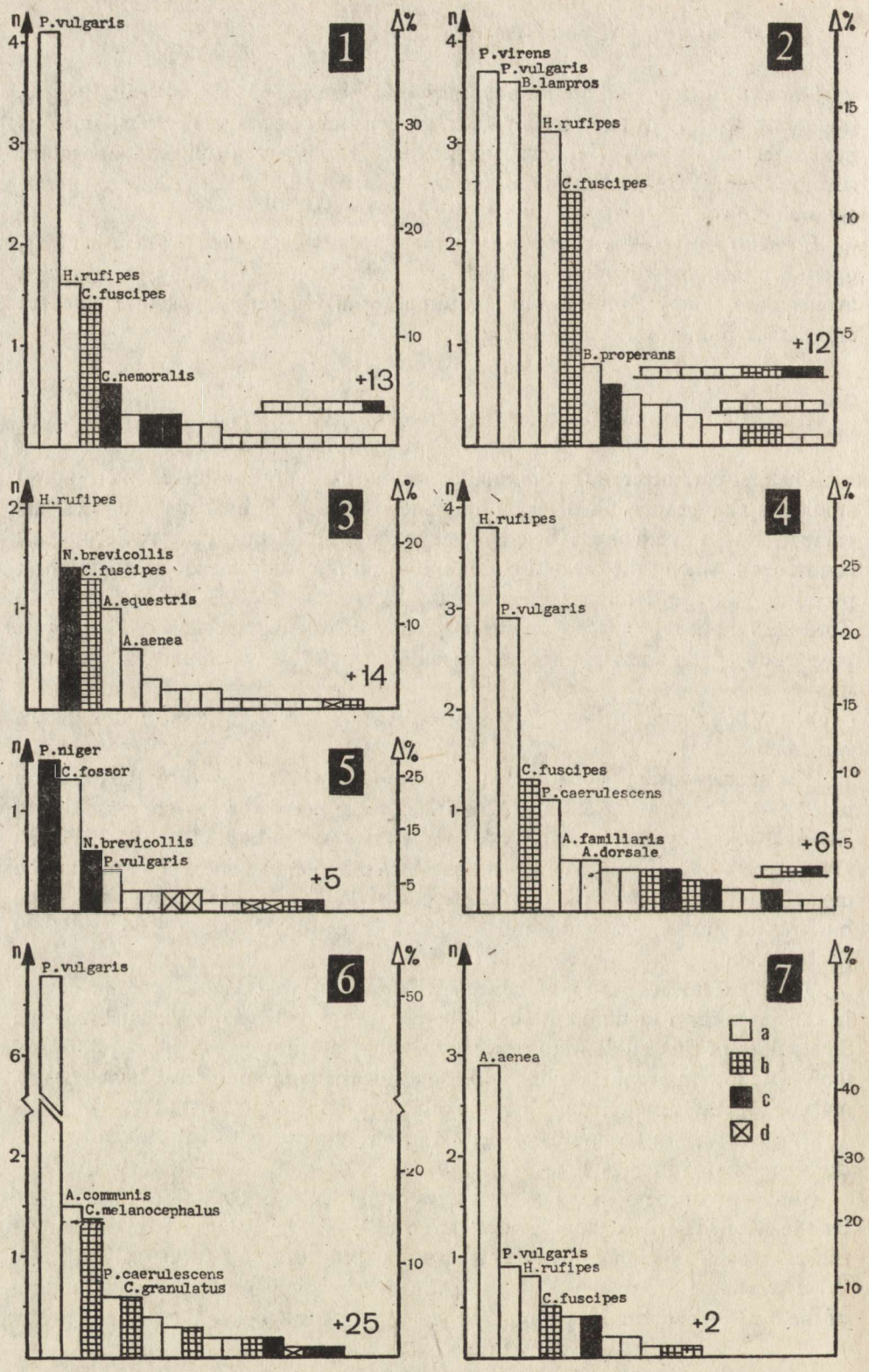
The first parameter of the dominance structure usually considered in ecological studies is the proportion of the dominant species in animal communities. Its value itself tells much about the character of the habitat (the diversity of ecological conditions). Among the carabid communities on the study meadows, the highest proportion of the dominant species was observed at Chylice (about 52%) and Zbroszki (about 44%), thus on most intensely exploited meadows. The lowest proportion of the dominant species, amounting to 16%, was found for the community at Białołęka Dworska B — the meadow subject to moderate management (Tab. 1). The range of the value discussed was thus large. The mean dominance was about 32%.

The species diversity of these communities was characterized by the Shannon index ($\bar{H}$). The lowest values of this index were noted for the communities at Zbroszki and Chylice (1.95 and 2.01, respectively); the highest one at Białołęka Dworska B (2.55). Thus, this arrangement of the plots is almost the same as the case of the proportion of the dominant species. The range of the index was large but most communities had similar species diversities between 2.34 and 2.39 (Tab. 1).

The correctness of the dominance structure of carabid communities (evenness in the proportion of different species) was determined by the Pielou index (e). The values of this index were generally similar, in most cases between 0.65 and 0.69. The lowest evenness index was found for the community at Chylice (0.65), and the highest (much higher than the others) at Klembów (0.81) (Tab. 1).

The dominance structures of the carabid communities on all the study meadows are shown in Figs 1–7.

Similarity in the dominance structures of particular communities is expressed by the Morisita index modified by Horn (1966). The values of this index for different pairs of communities ranged from 0.11 to 0.84 (Tab. 5). The mean value was 0.42. Thus, the degree of the diversification of dominance structures of the carabid communities compared was almost the same as the degree of their



diversity in species composition (as determined by the mean Sörensen index). A similarity of more than 0.50 (0.57–0.84) generally was between communities from particular meadows at Białołęka Dworska, and between the communities from meadows A and D at Białołęka and those at Chylice. It is clear then that similar dominance structures of carabid communities can develop on meadows with differential management type. And on the other hand, the similarity of community structures on similarly exploited meadows in some cases may be very low.

The highest mean similarity in the dominance structure to the structures of other communities was found for the communities from Białołęka Dworska A and D (0.57 each). They retain their positions even when their similarity to the neighbouring communities from plots B and C, respectively, is excluded from the calculations. The least similar to other communities (mean index value of 0.2) was the community from Klembów. Thus, the dominance structures of the communities mentioned can be considered respectively as the most typical (Figs 1 and 4) and the least typical (Fig. 5) of the carabid communities associated with moist meadows of Mazovia. Earlier, analogically, the community from

Table 5. Similarity of dominance structures (Morisita index) for carabid communities from moist meadows of the Mazovian Lowland

		Klembów	Białołęka Dworska				Chylice	Zbroszki
			A	B	C	D		
Klembów		—	0.24	0.17	0.20	0.25	0.21	0.13
Białołęka Dworska	A	0.24	—	0.70	0.42	0.84	0.83	0.40
	B	0.17	0.70	—	0.48	0.67	0.44	0.30
	C	0.20	0.42	0.48	—	0.68	0.11	0.46
	D	0.25	0.84	0.67	0.68	—	0.57	0.42
Chylice		0.21	0.83	0.44	0.11	0.57	—	0.28
Zbroszki		0.13	0.40	0.30	0.46	0.42	0.28	—

Figs 1–7. Dominance structures of carabid communities from moist meadows of the Mazovian Lowland: 1 — Białołęka Dworska A; 2 — Białołęka Dworska B; 3 — Białołęka Dworska C; 4 — Białołęka Dworska D; 5 — Klembów, 6 — Chylice; 7 — Zbroszki (a — species associated with open habitats; b — ubiquitous species; c — species associated with forests; d — other species)

Table 6. A sequence of the moist meadows under study in the Mazovian Lowland, arranged according to the mean values of similarity in species composition (So) and similarity in dominance structures (Mo) for local carabid communities and other carabid communities (figures in parentheses as in Tab. 4)

Locality	So	Locality	Mo
Białołęka Dworska B	47 (44)	Białołęka Dworska A	0.57
Białołęka Dworska A	46 (45)	Białołęka Dworska D	0.57
Białołęka Dworska D	45 (47)	Białołęka Dworska B	0.46
Chylice	43 (45)	Chylice	0.41
Białołęka Dworska C	42 (40)	Białołęka Dworska C	0.39
Zbroszki	40 (44)	Zbroszki	0.33
Klembów	36 (36)	Klembów	0.20

meadow A at Białołęka Dworska (and to a large extent also from meadow B) was considered as most representative with respect to its species composition, while the community from Klembów as the least typical (Tab. 6).

STABILITY OF COMMUNITIES

The stability of carabid communities was determined by comparing their structures in successive years. Changes in the total community abundance, in the proportion of dominant species, and possible changes in the dominant species itself were considered. Changes in the number of species were not taken into account. The possible differences (even when sampling was totally comparable) could have been caused to a higher extent by changes in the abundance of species than by changes in their number. The Morisita index was used as a measure of total stability of the communities. It characterizes the similarity in dominance structures of the same community in successive years.

The data compared are largely diversified (Tab. 7). A serious shortcoming of this analysis is that particular meadows were sampled in different years, which limited the conclusiveness of the results. Some suggestions can be made, however.

The study at Klembów and Białołęka Dworska A and B was conducted in the same years (1980–1981). The abundance of carabid communities on these meadows markedly changed from one year to another. It increased at Klembów 2.6 times and at Białołęka Dworska A 1.9 times, while decreased 1.5 times at Białołęka Dworska B. The meadows A (uncultivated) and B (cultivated) were separated only by a country road, and their carabid communities were very similar (Tabs 4 and 5). In this situation the increase in the community abundance on the uncultivated meadow A (and at Klembów) can be assigned to natural factors (climatic, intrapopulation), and the decrease in the abundance on meadow B to a change in management. It is known that in 1981, i.e., in the second season

Table 7. Variation in the dominance structure of carabid communities on moist meadows of the Mazovian Lowland in successive study years (n — abundance index; Mo — similarity in dominance structures between communities in different years)

Locality	Years	n	Dominant (%)	Mo
Klembów	1980	3.0	*Pterostichus niger* (29)	0.86
	1981	7.7	*Pterostichus niger* (32)	
Białołęka Dworska A	1980	7.2	*Pterostichus vulgaris* (51)	
	1981	14.0	*Pterostichus vulgaris* (33)	0.85
Białołęka Dworska B	1980	26.9	*Pterostichus vulgaris* (22)	
	1981	17.6	*Pterostichus virens* (23)	0.79
Białołęka Dworska C	1976	9.7	*Harpalus rufipes* (31)	
	1977	6.7	*Nebria brevicollis* (21)	0.83
Białołęka Dworska D	1976	14.7	*Harpalus rufipes* (30)	
	1977	12.4	*Harpalus rufipes* (31)	0.90
Chylice	1981	17.6	*Pterostichus vulgaris* (66)	(1981/1982) 0.97
	1982	12.7	*Pterostichus vulgaris* (62)	(1982/1983) 0.37
	1983	9.3	*Amara communis* (30)	(1981/1983) 0.32
Zbroszki	1983	6.7	*Amara aenea* (45)	
	1984	6.4	*Amara aenea* (44)	0.97

of the study, the owner of this meadow increased the intensity of treatments (first of all, fertilization). The decrease in the community abundance was combined with change in the dominant species (*Pterostichus vulgaris* was replaced by *P. virens*) and with total change in the dominance structure (Tab. 7).

The carabid community at Chylice proved to be little stable. This meadow was not only intensely mechanically cultivated (frequently mown) but also heavily fertilized with chemicals. In 1982, the community abundance was 72% of that from the preceding year. The proportion of the dominant (*Pterostichus vulgaris*), as well as the total dominance structure, remained almost unchanged. But in 1983, the carabid abundance declined again to 73% of the preceding year and to 53% of the year 1981, the dominant was replaced by *Amara communis*, and the total dominance structure of the community was changed (Tab. 7).

The most stable was the community at Zbroszki, on a meadow intensely grazed but not cultivated mechanically or chemically. The total number of carabids, the dominant species (*Amara aenea*), its proportion, and the total dominance structure remained unchanged there over the two years (Tab. 7).

Also the community inhabiting the grazed and weakly exploited (rarely mown, unfertilized) meadow D at Białołęka Dworska was stable. The community from meadow C, grazed but also intensely cultivated, was less stable. The least stable was the carabid community from meadow B, cultivated und ungrazed (Tab. 7).

ZOOGEOGRAPHICAL COMPOSITION

A vast majority of the carabids of the Mazovian Lowland belong to local species, established in this region long ago. The species originally alien to the fauna of Poland are scarce in Mazovia (Czechowski 1981a) and none of them was recorded from moist meadows.

The carabid fauna of the study meadows was represented by Holarctic, Palaearctic, Euro-Siberian, south-Euro-Siberian, and European elements.[5] These are mostly forms with wide ranges, especially Palaearctic and Euro-Siberian (Tab. 8), thus also forms with large ecological spectra.

With respect to the proportion of the species representing particular zoogeographical elements, the carabid fauna of moist meadows very significantly differed from the carabid fauna of whole Mazovia ($\chi^2 = 20.81$, $P = 0.001$).[6] The differences lie in higher proportions of widely dispersed species and correspondingly lower proportions of the species with narrow ranges in the fauna of meadows. The proportion of the Holarctic element on the meadows was increased more than 2 times, that of Palaearctic 1.4 times, and Euro-Siberian 1.3 times. Thus, the wider the geographical range of a given element, the higher its proportion in the carabid fauna of moist meadows as compared with that of whole Mazovia. The proportion of European species was 3 times lower and that of south-Euro-Siberian species 3.7 times lower. The latter group was represented on meadows only by *Anisodactylus nemorivagus*, a Euro-Caucasian species (only one individual was recorded).

Almost the same is true of the abundances (number of individuals) of particular zoogeographical elements. In this case the predominance of forms with large geographical ranges is even higher (Tab. 8).

Table 8. Zoogeographical composition of the carabid fauna on moist meadows of the Mazovian Lowland: S — number of species; $\%_S$ — proportion of particular elements in the species composition; n — mean abundance index; $\%_n$ — proportions of particular elements in the number of individuals

Element	S	$\%_S$	n	$\%_n$
Holarctic	10	12.5	1.3	11.5
Palaearctic	32	40.5	4.4	38.5
Euro-Siberian	30	38.0	5.1	44.5
South-Euro-Siberian	1	1.5	—	—
European	6	7.5	0.6	5.5
Total	79	100.0	11.4	100.0

[5] This is a very general classification (Czechowski and Mikołajczyk 1981), so these data should be considered as a gross approximation.

[6] Comparative data after Czechowski (1981a, 1982).

ECOLOGICAL COMPOSITION

This analysis of the meadow carabid fauna comprises ecological amplitudes of particular species, their habitat preferences, moisture requirements, trophic types, and phenological types. The criteria for distinguishing particular ecological elements are given in earlier papers (Czechowski 1981a, 1982). The analysis of each of these aspects is based on the number of species representing a given element and on their abundance.

Ecological amplitude. The vast majority of carabid species associated with meadows represented polytopic fauna forms. Also the number of eurytopic species was high. The number of oligotopic species was low, and stenotopic species were totally absent (Tab. 9). With this respect, the carabid fauna of moist meadows was very significantly different from the carabid fauna of whole Mazovia ($\chi^2 = 40.14$, $P < 0.001$).[7] As compared with the whole Mazovian fauna, the proportion of eurytopic species on meadows was 2.3 times higher and that of polytopic species 1.7 times higher. The proportion of oligotopic species was 4.4 times lower. Thus, the species with large ecological amplitudes were most success-

Table 9. Ecological composition of the carabid fauna on moist meadows of the Mazovian Lowland (symbols as in Tab. 8)

Criterion	Element	S	%S	n	%n
Ecological amplitude	Eurytopic	13	18.0	1.4	12.0
	Polytopic	53	73.5	9.9	87.0
	Oligotopic	6	8.5	0.1	1.0
	Total	72	100.0	11.4	100.0
Habitat preferences	Ubiquitous	13	17.0	1.4	12.0
	Forest	12	15.5	1.1	10.0
	Open areas	42	54.5	8.8	77.0
	Coastal, marshy, etc.	10	13.0	0.1	1.0
	Total	77	100.0	11.4	100.0
Moisture requirements	Hygrophilous	21	28.5	0.4	4.0
	Mesohygrophilous	28	38.5	8.1	75.5
	Xerophilous	24	33.0	2.2	20.5
	Total	73	100.0	10.7	100.0
Trophic type	Zoophagous	42	57.5	7.2	65.5
	Pantophagous	31	42.5	3.8	34.5
	Total	73	100.0	11.0	100.0
Phenological type	Spring	48	63.0	3.2	29.0
	Autumn	28	37.0	7.9	71.0
	Total	76	100.0	11.1	100.0

[7] Comparative data after Czechowski (1981a, 1982).

ful in colonizing moist meadows. This situation is analogous to the pattern emerging from zoogeographical analysis. Zoogeographical analysis concerned the range of tolerance on a "macro" scale (in relation to different biomes). In the ecological analysis this problem is reduced to the level of different habitats within a single biome (deciduous forests).

The dominance of polytopic species and low proportions of oligotopic species are even more pronounced in the case of abundance of particular elements (Tab.9).

Habitat preferences. The majority of carabids inhabiting meadows are obviously represented by the species associated with the open areas.[8] There are many ubiquitous species, but also the species typical of forests and other habitat types are well represented (Tab. 9). The difference in these categories of carabid fauna between meadows and the whole region is highly significant ($\chi^2 = 21.05$, $P < 0.001$). First of all, the proportion of ubiquitous species on meadows was 2.3 times higher and the proportion of open areas species was 1.4 times higher. The proportions of other species were lower than in Mazovia.

With respect to the number of individuals, apparently carabids associated with the open areas were in the first place on the moist meadows (Tab. 9).

Moisture requirements. The proportions of hygrophilous, mesohygrophilous, and xerophilous species were almost equal on the moist meadows (Tab. 9), accounting for a highly significant difference in comparison with the carabid fauna of the whole Mazovian Lowland ($\chi^2 = 62.43$, $P < 0.001$). The proportion of hygrophilous species in the fauna of meadows was 1.8 times lower than in the Mazovian fauna in general, while the proportions of mesohygrophilous and xerophilous species were 1.9 and 1.2 times higher, respectively.

The individuals of mesohygrophilous species accounted for three-fourths of all the carabids captured on the meadows. The number of individuals of hygrophilous species was negligible (Tab. 9).

Trophic type. There were more predatory than pantophagous species on the study meadows (Tab. 9). With this respect, no significant difference was found in relation to the fauna of whole Mazovia ($\chi^2 = 2.76$, $P > 0.05$).

The dominance of zoophages over pantophages was even more pronounced in the number of individuals (Tab. 9).

Phenological type. Most of the carabid species found on moist meadows belonged to the spring forms (Tab. 9). These species dominate over the autumn forms also in the carabid fauna of the whole region, however in different proportions ($\chi^2 = 5.67$, $P < 0.05$). In the fauna of meadows the proportion of spring species was 1.2 times higher than in the fauna of Mazovia while the proportion of autumn species was 1.6 times lower.

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[8] In contrast to similar earlier analyses (Czechowski 1981a, b, 1982), also the species typical of crop fields are included here.

Although the number of spring species was higher on meadows, the autumn carabids were more abundant (Tab. 9). Of the 11 most abundant species on moist meadows (Tab. 3), as many as 7 were autumn forms, including three species on the first positions.

DISCUSSION

Carabid communities associated with moist meadows (*Arrhenatherion elatioris*; *Arrhenatheretum medioeuropaeum*) of the Mazovian Lowland are rather largely differentiated. First, such characteristics are variable as the community abundance, the number of component species, species composition, and some elements of the dominance structure. The difference in abundance between extreme communities (Klembów, Białołęka Dworska B) reaches a factor of 4. The difference in the number of species (Zbroszki, Białołęka Dworska B) reaches a factor of 3.

The community abundance, the number of species, and the index of species' richness, derivative of these two parameters, show some relation to the intensity of meadow management, decreasing with its increase. The decrease in the value of the species' richness index for carabid communities with increasing intensity of meadow management is consistent with a general tendency for homogenization of the fauna in managed habitats (Müller 1968). However, this is not a simple relationship. Unequivocal conclusions (in this and in other aspects) are thus, unfortunately, not allowed for. The reason is that the study plots were rather unique with respect to the type and degree of human influence. Also precise data on such an influence are lacking.

Differences in the species composition and also the structure of carabid communities largely depend on the type of surrounding habitats. Obviously, the way of management is also important, but as already noted the character of this relationship cannot be precisely defined. The decisive role of surrounding habitats is well illustrated by the case of the community at Klembów. As the only one of the study plots, it was dominated by a species typical of forests, *Pterostichus niger*. A numerous occurrence of this species on meadows is nothing unusual (Gersdorf 1937; Boness 1953; Doskočil and Hůrka 1962). The community from Klembów, however, was also the least similar to the others with respect to the species composition and dominance structure (Tabs 4, 5, 6). It was characterized with the lowest and not much stable abundance (Tab. 7), and poor species composition (Tab. 1). Besides untypical location (direct neighbourhood of a forest), the meadow at Klembów differed from the other habitats in a high water table. It was permanently wet in places, and in spring, when water table was higher, most of its area was flooded. In this situation, the carabid fauna temporarily disappeared, and then reappeared as a result of immigration from surrounding habitats (Müller 1968). This fact, combined with the low abundance of carabids

at Klembów explains a relatively correct (seemingly) structure of the community. In fact, this may partly be a random aggregation of individuals.

The stability indices of meadow communities used in this paper (Fig. 7) suggest that this stability depends on the type of anthropogenic pressure. Regular cultivation treatments, and especially grazing, are factors artificially maintaining the stability of the meadow habitat, ensuring the stability of floral composition and physico-chemical conditions. The effect of grazing on the stability of carabid communities was more defined than the effect of cultivation treatments probably because grazing was a permanent and not variable factor. Mowing and especially chemical treatments were applied from time to time and suddenly, thus they could stress or even destroy the fauna.

Generally, the carabid communities of *Arrhenatherion elatioris* meadows in the Mazovian Lowland did not differ much in their species composition and structure from the communities of other Central-European meadows of this type. For comparative purpose, carabid communities from three study meadows have been selected: from plots A, B, and D at Białołęka Dworska, as the most representative with respect to their species composition and dominance structure (Tab. 6). They have been compared with the literature data on carabid communities from six *Arrhenatherion elatioris* meadows in Czechoslovakia (Doskočil and Hůrka 1962), the Federal Republic of Germany (Stein 1965), and German Democratic Republic (Tietze 1973a).[9]

The mean indices of similarity in species composition and dominance structure of carabid communities compared were similar to respective mean values for the whole pool of the communities from the study meadow of Mazovia. The

Table 10. Similarity of the selected carabid communities from moist meadows of the Mazovian Lowland to the communities from other moist meadows in Central Europe: So — similarity index of species composition (calculated from Sörensen formula); Mo — similarity index of dominance structure (calculated from Morisita formula) (? — not calculated because of the lack of data in the papers quoted)

Author	Mazovian Lowland	Białołęka Dworska A So	A Mo	B So	B Mo	C So	C Mo
Tietze (1973a); GDR	I	37	0.81	35	0.59	39	0.88
	II	43	0.28	36	0.15	39	0.22
	III	49	0.11	38	0.06	53	0.07
	IV	53	0.58	45	0.56	48	0.48
Stein (1965); FRG		39	0.81	52	0.40	48	0.53
Doskočil, Hůrka (1962); Czechoslovakia		40	?	34	?	48	?

[9] These papers contain comparable qualitative and quantitative data.

Table 11. Proportions and ranks[1] (in parentheses of main species in carabid communities from moist meadows of the Mazovian Lowland, as compared with proportions and ranks of these species in carabid communities from other moist meadows of Central Europe

Locality or the source of data	Original data (Mazovian Lowland)								Literature data (GDR, FRG)					
		Białołęka Dworska							Tietze (1973a); GDR				Stein (1965); FRG	Mean[2]
Species	Klembów	A	B	C	D	Chylice	Zbroszki	Mean[2]	I	II	III	IV		
Pterostichus vulgaris	7.4 (4)	38.7 (1)	16.1 (2)	2.4 (8)	21.3 (2)	51.7 (1)	13.6 (2)	21.6	26.0 (2)	17.9 (2)	9.5 (2)	18.7 (1)	58.7 (1)	26.4
Harpalus rufipes	3.7 (5)	15.1 (2)	13.9 (4)	24.4 (1)	27.9 (1)	3.0 (6)	12.1 (3)	14.3	27.9 (1)	1.1 (6)	1.1 (6)	0.5 (22)	0.8 (9)	6.3
Calathus fuscipes	—	13.2 (3)	11.2 (5)	15.9 (3)	9.6 (3)	1.5 (11)	7.6 (4)	8.4	0.8 (16)	0.4 (13)	1.0 (9)	2.0 (10)	0.1 (16)	0.9
Amara aenea	—	0.9 (10)	0.4 (15)	7.3 (5)	1.5 (13)	—	43.9 (1)	7.7	—	—	—	—	0.1 (15)	+
Nebria brevicollis	11.1 (3)	0.4 (22)	2.7 (7)	17.1 (2)	2.9 (8)	0.8 (15)	6.1 (5)	5.9	—	0.1 (21)	0.1 (18)	—	0.3 (11)	0.1
Pterostichus niger	27.8 (1)	2.8 (6)	0.4 (16)	—	2.2 (11)	1.5 (12)	—	5.0	—	0.2 (18)	0.3 (16)	1.2 (15)	1.3 (7)	0.6
Clivina fossor	24.1 (2)	—	0.9 (12)	—	0.7 (16)	0.3 (16)	1.5 (9)	3.9	0.2 (24)	—	—	1.5 (13)	—	0.3
Pterostichus caerulescens	—	1.9 (8)	2.2 (8)	1.2 (10)	8.1 (4)	4.6 (4)	3.0 (7)	3.0	1.7 (11)	15.8 (3)	1.7 (5)	17.6 (2)	13.9 (2)	10.1
Bembidion lampros	—	2.8 (5)	15.7 (3)	—	—	—	—	2.6	—	0.2 (17)	0.1 (17)	15.0 (3)	—	3.1
Amara communis	—	0.4 (21)	0.3 (32)	—	2.9 (7)	11.4 (2)	—	2.6	5.0 (5)	0.1 (20)	0.4 (15)	4.8 (7)	0.3 (10)	2.1
Pterostichus virens	—	1.9 (9)	16.6 (1)	—	—	—	—	2.6	—	—	—	—	—	—

values of Sörensen similarity index were little variable, ranging between 34 and 53%. The similarity of dominance structures was more diverse. Some communities were very similar (Morisita index over 0.80), others were very different (index even lower than 0.10) (Tab. 10). These German carabid communities structurally little similar to Mazovian were dominated by *Carabus auratus* L., the west-European species not occurring in Mazovia.

The qualitative-quantitative structure of the carabidae communities from moist meadows of Mazovia differed from the structure of German communities (Stein 1965, Tietze 1973a) in higher importance (higher proportions and higher rank in the dominance structure) of such species as *Harpalus rufipes*, *Calathus fuscipes*, *Amara aenea*, *Pterostichus virens*, *P. niger*, *Nebria brevicollis*, and *Clivina fossor*. In Mazovian communities the importance value of *Pterostichus caerulescens* was lower. Generally similar positions in the structure of both Mazovian and German communities were occupied (among most abundant species) by *Pterostichus vulgaris*, *Bembidion lampros*, and *Amara communis* (Tab. 11).

It is possible to compare carabid communities from moist meadows with their communities from other anthropogenic plant communities of the order *Arrhenatheretalia* in Mazovia, since the carabid fauna of urban lawns in Warsaw[10] was examined in the same way (Czechowski 1982). Carabid communities from meadows did not differ significantly from those inhabiting lawns with respect to their abundance, but they were richer in species. Their species composition, including dominants, was similar.

The carabid fauna of the moist meadows under study differs from the potential, i.e., typical of whole Mazovia, in increased proportions of the species with a wide spectrum of habitat requirements. This can be traced in the zoogeographical composition of this fauna, and also in its ecological composition (increased proportions of species with large ranges and high ecological amplitudes). This type of faunal changes is a common symptom of anthropogenic effects in the habitats. They occur, for example, in the habitats subject to settlement pressure, especially in its extreme form — urbanization. Not only carabids are affected (Czechowski 1981a, b, 1982), but also many other faunal groups (Czechowski and Pisarski 1981, Czechowski et al. 1982a, b; Garbarczyk and Pisarska 1982). In the case of moist meadows, a similar phenomenon was observed, for example, in *Elateridae* (Nowakowski 1989).

A considerable preponderance of species associated with open habitats and also mesohygrophilous species on moist meadows is easily understood. The trophic and phenological profiles of the carabid fauna on meadows can be considered as a derivative of the species composition and dominance structure. With respect to the trophic type, predatory carabids predominate. They outweigh pantophages in both the number of species and the number of individuals. This

[10] Phytosociological characteristics of these habitats is given by Kubicka et al. (1985).

Table 12. Comparison of the result of carabid sampling by window traps and pitfall traps on the meadow at Chylice (N — number of individuals)

No.	Method / Species	Window traps					Pitfall traps					
		Trap			Total		Row of traps				Total	
		I	II	III	N	%	I	II	III	IV	N	%
1	*Carabus granulatus*	1	1	1	3	0.4	1	2	—	—	3	0.8
2	*Leistus rufescens*	2	—	—	2	0.3	—	—	—	—	—	—
3	*Nebria brevicollis*	—	—	—	—	—	—	1	—	—	1	0.3
4	*Loricera caerulescens*	—	—	1	1	0.1	1	—	—	—	1	0.3
5	*Clivina fossor*	—	—	—	—	—	1	—	—	—	1	0.3
6	*Bembidion properans*	1	—	—	1	0.1	—	—	—	—	—	—
7	*Bembidion guttula*	—	—	—	—	—	—	—	—	1	1	0.3
8	*Epaphius secalis*	—	1	—	1	0.1	—	—	—	—	—	—
9	*Trechus quadristriatus*	—	1	—	1	0.1	—	—	—	—	—	—
10	*Amara plebeja*	—	2	—	2	0.3	—	—	—	—	—	—
11	*Amara communis*	3	3	—	6	0.7	4	4	—	3	11	2.8
12	*Amara familiaris*	—	—	1	1	0.1	—	—	—	—	—	—
13	*Amara bifrons*	1	—	—	1	0.1	—	—	—	—	—	—
14	*Amara apricaria*	1	—	—	1	0.1	—	—	—	—	—	—
15	*Amara equestris*	—	1	—	1	0.1	—	—	—	—	—	—

16	*Pterostichus caerulescens*	4	8	2	14	1.7	5	1	—	—	6	1.5
17	*Pterostichus vernalis*	—	—	—	—	—	—	—	1	—	1	0.3
18	*Pterostichus oblongopunctatus*	1	—	—	1	0.1	—	—	—	—	—	—
19	*Pterostichus niger*	10	10	6	26	3.2	2	4	—	1	7	1.8
20	*Pterostichus vulgaris*	158	219	117	494	60.6	46	97	60	62	265	68.3
21	*Pterostichus anthracinus*	—	—	—	—	—	1	—	—	—	1	0.3
22	*Pterostichus nigrita*	—	—	1	1	0.1	—	—	—	—	—	—
23	*Pterostichus strenuus*	5	2	1	8	1.0	—	—	—	—	—	—
24	*Calathus fuscipes*	26	28	21	75	9.2	1	—	—	3	4	1.0
25	*Calathus melanocephalus*	43	35	83	161	19.7	24	12	15	25	76	19.6
26	*Synuchus nivalis*	1	1	3	5	0.6	3	2	1	2	8	2.1
27	*Anisodactylus binotatus*	—	—	—	—	—	2	—	—	—	2	0.5
28	*Harpalus rufipes*	5	2	2	9	1.1	—	—	—	—	—	—
29	*Acupalpus dorsalis*	—	1	—	1	0.1	—	—	—	—	—	—
	Total number of individuals	262	315	239	816		91	123	77	97	388	
	Number of species	15	15	12	23		12	8	4	7	15	

is consistent with findings of other authors (Boness 1953, Doskočil and Hůrka 1962). Phenologically the situation is not so unequivocal. Most species belong to spring forms, which is consistent with the general character of the carabid fauna of open areas (Larsson 1939, Greenslade 1965, Thiele 1969). But with respect to the number of individuals, the autumn carabids predominate. The main dominants of meadow habitats, *Pterostichus vulgaris*, *Harpalus rufipes*, and *Calathus fuscipes*, belong to this group.

METHODOLOGICAL APPENDIX

In 1981, on the meadow at Chylice, window traps were used as one of the methods of sampling invertebrates, especially flying insects. Three traps were used of an area of 1/3 m^2 each. On each side of these windows two oblong containers were placed on the ground so that they touched the windows. They were filled with ethylene glycol. Insects sliding down the windows were trapped there. They were removed from the trap at 7-day intervals throughout the season. At the same time Barber's pitfall traps were used, which is the classical method of sampling epigean animals, especially carabids. The pitfall traps at Chylice were set in four rows of five traps each. Since sampling by the window traps provided an unexpectedly rich material of carabids, it seems useful to compare the efficiency and the result of each method.

The results of the two methods are compared in Tab. 12. It can be seen that 3 window traps collected over twice as many specimens as 20 pitfall traps in the same period. What is more important, the number of species recorded by the window traps was 1.5 times higher. However, the dominance structures revealed by the two methods were almost identical. Their similarity as expressed by the Morisita index is 0.99 (!). This does not mean, however, that the selectiveness of the window traps and pitfall traps was identical, or at least similar. Depending on the habitat type, or rather on the composition of a local carabid community, differences in the results obtained by the two methods can vary. (It is evident that pitfall traps cannot be considered as an objective method of carabid sampling).

In any case, window trapping, a very effective method of quantitative and qualitative sampling, should be taken into account in the studies of carabid communities. For obvious reasons, however, it can be used only in places inaccessible to large animals, especially farm animals, and also to accidental human visitors. This imposes a serious limit to the application of this method.

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BIEGACZOWATE (*COLEOPTERA, CARABIDAE*) ŁĄK ŚWIEŻYCH NIZINY MAZOWIECKIEJ

STRESZCZENIE

Na siedmiu łąkach świeżych (*Arrhenatherion elatioris*; *Arrhenatheretum medioeuropaeum*) Mazowsza odłowiono w latach 1976–1977 i 1980–1984 ok. 4000 imagines *Carabidae*, głównie pułapkami Barbera. Stwierdzono występowanie 79 gatunków — od 13 do 43 na poszczególnych

łąkach. Gatunkami najbardziej liczebnymi były: *Pterostichus vulgaris, Harpalus rufipes, Calathus fuscipes, Amara aenea* i *Pterostichus virens*. Gatunki te oraz *Pterostichus niger* dominowały w poszczególnych zgrupowaniach. Zróżnicowanie jakościowe zgrupowań było duże — ich podobieństwo (wg wzoru Sörensena) wahało się od 29 do 65% (przeciętnie 43%). Gatunkami najbardziej stałymi na łąkach były: *Nebria brevicollis, Pterostichus vulgaris, Harpalus rufipes* (100% stanowisk) oraz *Amara familiaris, Pterostichus caerulescens* i *Calathus fuscipes* (86%) — a więc na ogół gatunki o największej liczebności. Wskaźnik liczebności zgrupowań wynosił od 5,4 do 22,3 (średnio 10,8), a wskaźnik bogactwa gatunkowego od 5,1 do 10,1. Wymienione parametry struktury zgrupowań (liczba gatunków, liczebność i wskaźnik bogactwa gatunkowego) wykazywały pewną zależność od intensywności użytkowania łąki — malały wraz z jej wzrostem.

Ze sposobem zagospodarowania łąki była też związana struktura dominacyjna zgrupowań *Carabidae*. Na łąkach najintensywniej użytkowanych dysproporcja między udziałem dominanta a udziałami pozostałych gatunków była największa. Najmniejsza była też tam ogólna różnorodność gatunkowa zgrupowań (wskaźnik Shannona). Struktury dominacyjne badanych zgrupowań były do siebie podobne w bardzo różnym stopniu — wartości wskaźnika Morisity wahały się od 0,13 do 0,86 (przeciętnie 0,43).

Największą stabilnością w czasie (znikome wahania liczebności w kolejnych latach, stały dominant, małe zmiany w obrębie całej struktury dominacyjnej) odznaczały się zgrupowania z łąk wypasanych (nawet intensywnie), lecz mało intensywnie uprawianych (koszonych i nawożonych rzadko lub wcale).

Karabidofauna łąk świeżych Mazowsza była złożona w ogromnej większości z gatunków palearktycznych i eurosyberyjskich. Spośród fauny całej Niziny Mazowieckiej wyróżniała się zwiększonymi udziałami elementów o szerokim rozmieszczeniu (obu wyż. wym. i holarktycznego). Gatunki reprezentujące te elementy były też najbardziej liczebne.

Pod względem ekologicznym badana karabidofauna była złożona głównie z gatunków politopowych, właściwych terenom otwartym, mezohigrofilnych, zoofagicznych i wiosennych. Od fauny całego Mazowsza różniła się zwiększonymi udziałami gatunków o dużej plastyczności ekologicznej (eurytopowych i politopowych), gatunków ubikwistycznych i związanych ze środowiskami otwartymi, mezohigrofilnych i sucholubnych oraz jesiennych. Największą liczebność osiągały formy politopowe, terenów otwartych, mezohigrofilne, zoofagiczne i jesienne.

ЖУЖЕЛИЦЫ (*COLEOPTERA, CARABIDAE*) СВЕЖИХ ЛУГОВ МАЗОВЕЦКОЙ НИЗМЕННОСТИ

РЕЗЮМЕ

Исследованы сообщества *Carabidae* из семи лугов *Arrhenatheretum medioeuropaeum* (сообщество *Arrhenatherion elatioris*) на Мазовецкой низменности. Способ использования и степень агротехнических мероприятий, проводимых на изучаемых лугах, были очень различны — от совершенно не культивируемых до многократно кошенных, удобряемых и используемых как пастбища. Установленный видовой состав и структура сообществ *Carabidae* (численность, количество видов, структура доминирования) указывают на зависимость упомянутых параметров от способа хозяйственного использования луга. Карабидофауна охарактеризована с зоогеографической и с экологической точки зрения. Анализируемый метариал (собранный в 1976—1977 и 1980—1984 гг.) содержит около 4000 имаго из 79 видов. Отлов производился, главным образом, в ловушки Барбера.