Acta Entomol. Bohemoslov., **86** : 459–475 1989
ISSN 0001 – 5601

Epigaeic arthropods across an arable land and grassland interface

LEOŠ KLIMEŠ[1] and EVA SECHTEROVÁ[2]

[1] Institute of Botany, Czechoslovak Academy of Sciences, 379 82 Třeboň, Czechoslovakia
[2] Špálova 8, 796 01 Prostějov, Czechoslovakia

Ecology of ecotone, pitfall traps, ground beetles, spiders, harvestmen, millipedes, ants, epigaeon, species-richness

Abstract. Across a field-meadow interface, communities of epigaeic spiders, carabids, millipedes, harvestmen, ants and isopods were sampled by pitfall traps. The changes in activity abundance from the edges towards the field and meadow central parts or vice versa simultaneously were not significant in any species tested. In old-field plots, 10–20 m^2 in size, situated within a cultivated field, activity abundance of carabid beetles corresponded to half that in the meadow, in contrast to spiders where the activity was six times lower. Some species were found to exploit the old-field islands as refuges enabling them to withstand periods infavourable for their survival in the neighbouring field, e.g. the carabid beetle *Trechus quadristriatus*, the spider *Pardosa pullata* and the harvestman *Oligolophus tridens*.

Recent development of the central European landscape is strongly affected by human activities. Anthropogenic impacts result in a fragmentation of natural ecosystems, including an increased size of corresponding transition zones. Consequently, more attention is currently given to the assessment of ecological significance of these gradients, frequently called ecotones (see DI CASTRI et al., 1988 for the recent progress).

An ecotone may be defined as a transition zone between two neighbouring ecosystems or habitats. Such a gradient is distinguished partly by its transitive quantitative changes, partly by distinctive specific features (ODUM, 1971 : 157). In general, the greater the difference between two ecosystems, the more distinct is the ecotone between them. Therefore, contrasting habitats have often been examined, such as pond and marsh, arable land and woodland, grassland and forest, forest and alpine tundra (ASPEY, 1976; BOGACH & POSPISHIL, 1984; CAMERON, 1917; DABROWSKA-PROT & ŁUCZAK, 1968; DABROWSKA-PROT et al., 1973; DLUSKIĬ, 1965; GÓRNY, 1968a, b; HEUBLEIN, 1983; JENNINGS et al., 1986; KLIMEŠ & ŠPIČÁKOVÁ, 1984; SIMBERLOFF & GOTELLI, 1984; TERRELL-NIELD, 1986; TISCHER, 1958; TURČEK, 1966 and many others). This study concerns an ecotone

Dedicated to the 80th anniversary of Academician Josef Kratochvíl between a field and an adjacent meadow, i.e. between two habitats profoundly transformed by frequent man-induced disturbances.

We aimed at estimating the distinctness and diversity of the epigaeic fauna prior to the first harvest, i.e. at a time when neither habitat was being disturbed by direct human activities.

LOCALITY AND METHODS

The study area is situated 200 m northwest of Strašnice, a village near Rokycany town, in western Bohemia (Fig. 1), at an altitude of 490 m. The quadrat code of the square grid after BUCHAR (1982) is 6248. Geographically the locality is in the Hořovická brázda depression which divides the Brdská vrchovina hills into two parts, each rising over 700 to 800 m. According to KONČEK (in VESECKÝ et al., 1958), the area belongs to the Moderately Warm and Moderately Moist B_5 Upland District, see climate diagram (Fig. 1).

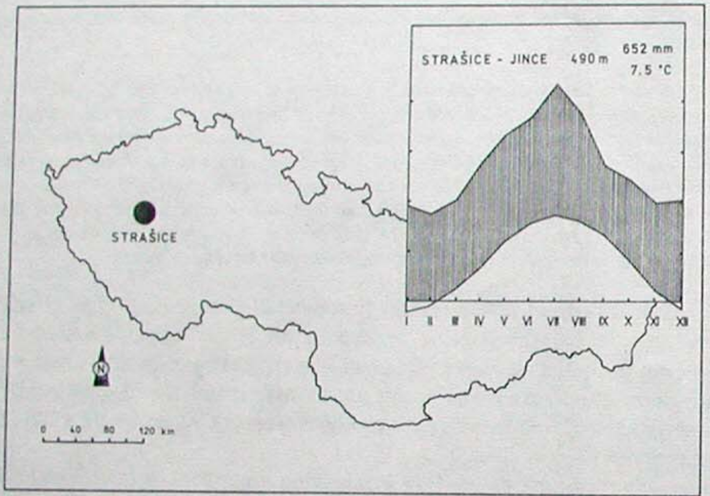


Fig. 1. Situation of the study area in Czechoslovakia, with respective climate diagram.

Three habitats were distinguished in the study area:

(i) Meadow. Managed grassland covering about 70 ha; the plot slopes at an angle of 3° down to a stream flowing parallel with and 100 m from the meadow-field boundary; the meadow is fertilized and regularly mown twice a year.

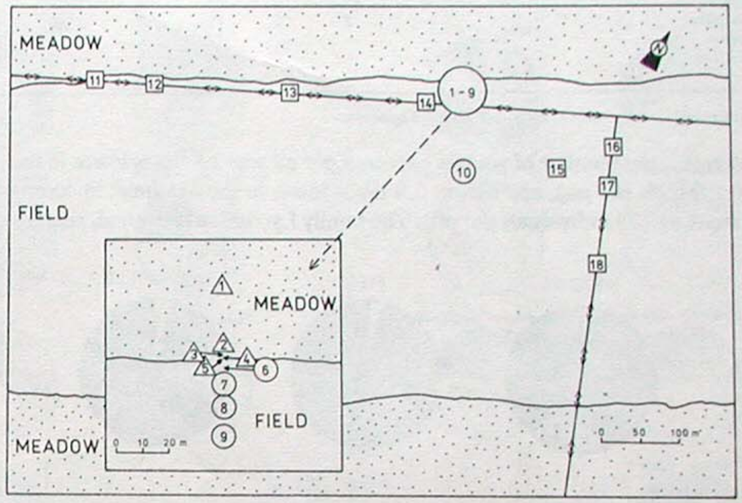
(ii) Field. Arable-land about 60 ha, gently sloping towards the meadow; during our observations in 1983–1984, a variety of winter wheat was cultivated there.

(iii) Old-field. Isolated patches of uncultivated land surrounding electric pylons; the size of each island ranges between 10 and 20 m^2; herbs were present in all plots, shrubs were recorded only in the plot No. 12.

Between April 9 and June 17, 1984, the epigaeic fauna was sampled at 9- to 13-day intervals by means of glass pitfall traps with captive rims 14 cm long. The traps were partially filled with 4 % formaldehyde.

Three pits were placed at each sample site (altogether 54 pitfall traps) situated along a transect perpendicular to the meadow-field boundary, and in the core of each old-field plot (Fig. 2). The distance between the most remote set of pitfall traps and the meadow-field boundary was 29 m in the meadow and 115 m in the field. According to the expected range of an ecotone effect (compare DABROWSKA-PROT & ŁUCZAK, 1968; GERSDORF, 1965; GÓRNY, 1968b; THIELE, 1971) these sites may be considered as representing typical meadow and field habitats.

The relations between spider and carabid beetle communities were evaluated by Principal Component Analysis (GAUCH, 1982).



RESULTS

During 69 days of observation, altogether 3353 individuals of spiders belonging to 41 species of 9 families, 2993 individuals of carabids belonging to 33 species, 88 individuals of millipedes belonging to 5 species, 16 individuals of harvestmen belonging to 2 species, 15 individuals of ants belonging to 4 species, and 5 specimens of one species of terrestrial isopod were collected (see Table 1)

Spiders

The studied habitats differed from each other mainly by the numbers of individuals of various spider species and families, whereas their species numbers were similar in all habitats studied (see Fig. 3 and Table 1).

The meadow habitat supported the greatest number of individuals. During the sampling period, 2150 specimens of spiders were collected (143 individuals per pit,

Table 1

Survey of activity abundance of epigaeic arthropods.

Habitat Number of pitfall traps	Meadow 15		Field 15		Old-field 24		Total 54	
	N	S	N	S	N	S	N	S
Araneae	2150	23	607	25	596	30	3353	41
Carabidae	1036	19	1049	21	908	29	2993	33
Diplopoda	33	5	22	2	33	3	88	5
Formicoidea	—	—	3	1	12	4	15	4
Opiliones	—	—	—	—	16	2	16	2
Oniscoidea	—	—	—	—	5	1	5	1

N — number of specimens; S — number of species.

on average), the number of spiders captured per pit was 3.5 times lower in the field (40 individuals per pit), and almost 5.8 times lower in the old-field, in comparison with meadow (25 individuals per pit). The family Lycosidae prevailed, representing

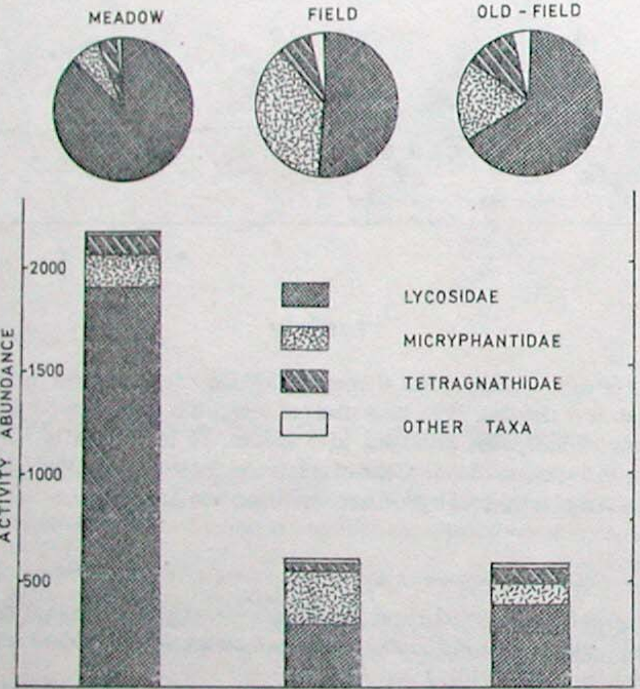


Fig. 3. Representation of the captured spider families; top — percentages, bottom, — absolute values.

88 % in the meadow samples (Fig. 3); *Alopecosa pulverulenta, Pardosa palustris* and *P. pullata*, its members preferring this habitat, were 3 to 10 times more abundant here, compared to the field or old-field (Fig. 4, Table 2). Other lycosids, particularly *Pardosa amentata*, were present in the meadow as well, but the occurrence of the above named species is not restricted to any habitat (Table 3). The meadow biotope was also suitable for *Xysticus cristatus* and *Pachygnatha degeeri* (Fig. 4, Table 2).

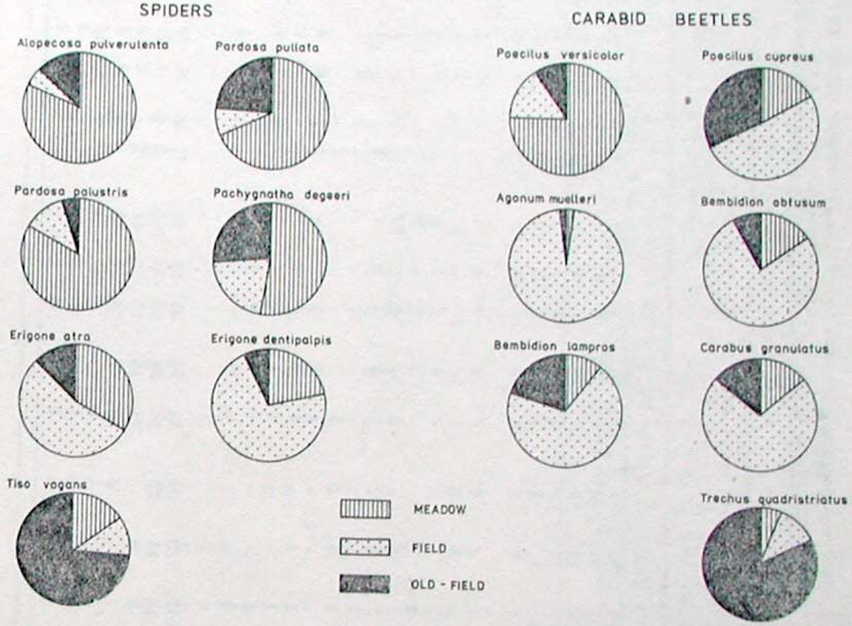


Fig. 4. Representation of spider and ground beetle species (%) in particular habitats.

In samples from the field, besides the lycosids, a greater number of both species and individuals of the Micryphantidae spider family was present in higher numbers than in either the meadow or the old-field; they comprised 41 % of the total catch (Fig. 3). The field habitat, exposed to repeated ploughing, was densely occupied also by *Erigone atra* and *E. dentipalpis*. The proportion of the lycosids reached 48 % here, and was substantially lower here than in the meadow.

In ruderal old-filed islands, the smallest number of spider individuals was caught per pit. The higher species richness recorded here reflected the higher number of pitfall traps exposed. Only *Tiso vagans* prefered explicitly the ruderal old-field islands. An increased density was recorded in *Pardosa pullata* (Table 2) living here, in comparison with the field.

Eleven out of 16 important species, included in Table 3, differ in their distribution

TABLE 2

The number of specimens of epigaeic species caught in pitfall traps in the study area near Strašice; cumulative catches from three pitfall traps placed at each of sample sites (1 to 18) are indicated.

	Meadow					Field					Old-field							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Araneae																		
Pardosa palustris (L.)	500	172	274	235	263	55	27	85	32	22	13	10	39	18	10	16		38
Pardosa pullata (CL.)	78	55	65	57	80	8	4	7	.8	9	20	18	21	59	22	12	13	21
Erigone atra BL.	12	18	25	12	10	13	26	51	13	18	3	2	10	3	16	6	5	1
Pachygnatha degeeri SUND.	15	17	17	14	30	4	10	8	7	9	28	7	.	5	7	11	6	5
Alopecosa pulverulenta (CL.)	34	9	22	11	5	.	.	1	2	2	5	5	1	3	5	.	.	4
Oedothorax retusus (WESTR.) ♀ et *O. apicatus* (BL.) ♂	10	2	6	9	7	8	16	11	4	.	4	1	.	.	7	.	3	1
Pardosa amentata (CL.)	.	.	2	4	7	6	8	7	4	2	.	1	20	1	1	3	.	.
Erigone dentipalpis (WID.)	1	.	5	6	2	5	10	16	.	10	.	.	1	1	.	2	.	1
Trochosa ruricola (DEG.)	6	1	.	.	.	6	2	2	1	1	.	1	2	4	.	.	.	1
Araeoncus humilis (BL.)	1	1	3	7	.	.	.	3	3	2	3	.	.	2	.	1	.	.
Oedothorax apicatus (BL.)	.	.	.	5	.	2	.	4	.	10	.	.	.	1	2	.	1	.
Meioneta rurestris (C.L.K.)	.	.	.	3	1	2	3	4	3	1	1	.	.	1	.	.	.	1
Tiso vagans (BL.)	.	1	1	.	.	.	.	.	.	.	1	1	2	1	6	3	1	1
Xysticus cristatus (CL.)	3	3	1	5	2	1	.	.	.	.	2	.	.	.	.	.	.	.
Centromerita bicolor (BL.)	.	.	.	.	.	1	1	2	.	.	1	1	2	2	.	1	1	2
Pardosa agrestis (WESTR.)	.	.	1	1	.	1	3	1	1	.	.	.	.	.	1	1	.	1
Pachygnata clercki SUND.	1	.	1	.	.	1	.	2	.	.	1	3	2	.	.	.	.	.
Oedothorax retusus (WESTR.) ♂	.	2	1	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.
Panamomops sulcifrons (WID.)	.	.	1	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.
Carabidae																		
Poecilus versocolor (STURM)	229	122	201	122	98	28	16	38	16	66	41	24	21	25	7	10	20	6
Poecilus cupreus (L.)	7	21	36	31	36	34	38	84	53	190	3	5	4	86	20	101	100	82
Agonum muelleri (HERBST)	.	.	4	3	.	15	16	98	56	41	2	.	2	2	1	.	1	3
Bembidion obtusum SERVILLE	12	4	1	.	4	12	16	26	19	28	1	1	5	1	4	3	1	2
Trechus quadristriatus (SCHRANK)	1	.	1	1	1	2	1	.	3	4	6	7	35	13	14	12	7	25
Harpalus aeneus (FABR.)	1	1	14	2	2	6	4	5	5	14	.	.	.	2	3	11	7	4
Pterostichus melanarius (ILLIGER)	3	6	8	4	4	3	.	8	2	1	5	4	12	4	.	8	1	1

Table 2 continued

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bembidion lampros (HERBST)	3	1	1	.	1	12	5	11	1	5	1	1	1	.	1	2	7	2
Pterostichus diligens (STURM)	.	.	.	.	.	.	.	.	.	.	8	4	21	1	2	1	.	12
Carabus granulatus L.	2	1	2	.	1	3	4	10	1	8	3	1	.	3	.	.	.	1
Calathus melanocephalus (L.)	.	.	.	.	.	.	.	.	.	.	9	6	.	.	.	4	.	3
Bembidion guttula (FABR.)	.	.	2	.	.	.	1	1	1	2	5	3	.	.	2	.	.	2
Clivina fossor (L.)	.	1	.	.	1	1	.	2	1	1	3	4	.	.	.	.	.	1
Amara nitida STRM.	.	2	5	3	1	.	.	.	.	.	.	2	1	.	.	.	.	.
Amara communis PANZER	3	.	5	1	.	1	.	.	.	.	.	.	1	.	1	.	.	2
Harpalus rufipes (DE GEER)	.	2	3	2	2	1	1	1	.	.	.	.	1	.	.	.	.	.
Loricera pilicornis (FABR.)	.	.	1	.	.	.	4	4	1	.	.	.	.	.	.	.	.	1
Calathus fuscipes (GOEZE)	1	.	4	.	2	.	.	.	.	.	.	1	.	1	.	.	.	.
Carabus cancellatus ILLIGER	.	.	.	.	.	1	.	2	.	1	1	.	.	.	.	1	.	.
Bembidion quadrimaculatum (L.)	.	.	.	.	.	1	2	2	.	1	.	.	.	.	.	.	.	.
Diplopoda																		
Unciger foetidus (C.L.K.)	3	6	1	5	.	6	3	2	1	.	7	1	7	11	.	.	1	1
Polydesmus complanatus (L.)	1	3	1	5	4	2	3	3	2	.	1	1	1	1	.	.	.	.
Formicoidea																		
Lasius niger L.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	7	.	.	.
Opiliones																		
Oligolophus tridens (C.L.K.)	.	.	.	.	.	.	.	.	.	.	1	.	1	4	1	2	.	.
Rilaena triangularis (HERBST)	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	1

Rare species:

Araneae. *Alopecosa cuneata* (CL.) 4: 2, 11 : 1; *Alopecosa trabalis* (CL.) 5 : 1; *Cornicularia vigilax* (BL.) 16 : 1, 17 : 1, 18 : 1; *Dicymbium nigrum* (BL.) 13 : 1; *Diplocephalus latifrons* (O. P. CBR.) 15 : 3; *Diplostyla concolor* (WIDER.) 13 : 1, 16 : 1; *Enoplognatha thoracica* (HAHN.) 9 : 1; *Haplodrassus signifer* (C.L.K.) 7 : 1, 12 : 1, 17 : 1; *Leptyphantes pallidus* (O.P. CBR.) 14 : 1; *Leptyphantes tenuis* (BL.) 6 : 1, 14 : 1; *Micrargus herbigradus* (BL.) 15 : 1, 18 : 1; *Oedothorax agrestis* (BL.) 6 : 1; *Phrurolithus festivus* (C.L.K.) 6 : 1; *Robertus lividus* (BL.) 14 : 1; *Silometopus elegans* (O. P. CBR.) 8 : 1; *Tetragnatha extensa* (L.) 4 : 1; *Thanatus striatus* C. L. K. 3 : 1; *Trochosa terricola* (THOR.) 8 : 1, 12 : 2; *Xysticus kochi* THOR. 8 : 1; *Zelotes lutetianus* (L. K.) 1 : 1, 6 : 1; *Zelotes pedestris* (C. L. K.) 15 : 1; *Zelotes praeficus* (L. K.) 1 : 1; *Zora spinimana* (SUND.) 15 : 1.

Carabidae. *Amara curta* DEJEAN 15 : 1, 17 : 1; *Amara familiaris* (DFTSCHMID) 15 : 1; *Amara similata* (GYLLENHAL) 10 : 2, 18 : 1; *Amara* sp. 15 : 1, 17 : 1; *Bembidion tetracolum* SAY 5 : 1, 6 : 1, 7 : 1; *Dyschirius globosus* (HERBST) 11 : 1; *Harpalus luteicornis* (DUFTSCHMID) 1 : 1, 11 : 1, 18 : 1; *Harpalus* sp. 15 : 1, 17 : 1; *Nebria brevicollis* (FABR.) 2 : 1, 7 : 1, 13 : 1; *Notiophilus palustris* (DUFTSCHMID) 11 : 1; *Platynus assimilis* (PAYKULL) 12 : 1, 13 : 1; *Platynus dorsalis* (PONTOPPIDAN) 8 : 1, 9 : 1, 17 : 1; *Pterostichus strenuus* (PANZER) 10 : 1.

Diplopoda. Julidae jv. 4 : 1, 5 : 1, 13 : 1; *Polydesmus denticulatus* C. L. K. 2 : 1; *Polydesmus superus* (LATZEL) 1 : 1.

Formicoidea. *Myrmica laevinodis* NYLANDER 12 : 3; *Myrmica scabrinodis* NYLANDER 14 : 1; *Myrmica schencki* EMERY 15 : 1.

Oniscoidea. *Porcellio scaber* LATR. 14 : 2, 15 : 2, 16 : 1.

TABLE 3

Distribution of important species between habitats.

	Differences in abundance between habitats				Abundance vs. distance from the meadow/field boundary			Sex vs. distribution between habitats							
	M-F-O	M-F	F-O	M-O	M	F	O	M ♂	M ♀	F ♂	F ♀	O ♂	O ♀	χ^2	
Araneae															
Pardosa palustris	+++	+++	+++	+++	0.206	−0.359	−0.104	1233	211	167	54	119	25	13.942	+++
Pardosa pullata	+++	+++	+++	+++	−0.070	0.254	−0.134	296	39	31	5	161	25	0.454	NS
Erigone atra	+++	NS	+++	+++	0.199	0.078	−0.050	76	1	115	6	46	0	3.936	NS
Pachygnatha degeeri	+++	+++	NS	+++	−0.322	0.300	−0.140	39	54	13	25	26	43	0.754	NS
Alopecosa pulverulenta	+++	+++	NS	+++	0.549*		−0.109	76	5	4	1	18	5	5.351	NS
Pardosa amentata	NS				−0.678**	−0.121	0.010	10	3	27	0	15	11	14.220	+++
Erigone dentipalpis	+++	+	+++	++	−0.459	−0.015		14	0	40	1	5	0	0.471	NS
Trochosa ruricola	NS					−0.442		6	1	8	4	8	0	3.647	NS
Araeoncus humilis	+++	NS	+++	+++	−0.215	0.405									
Meioneta rurestris	+	NS	+++	NS		−0.142									
Tiso vagans	++	NS	+++	+			0.161								
Xysticus cristatus	+	++	NS	+++	−0.261										
Centromerita bicolor	+	+	NS	+++											
Carabidae															
Poecilus versicolor	+++	+++	+	+++	0.479	0.433	−0.450*	348	424	67	97	71	83	0.978	NS
Poecilus cupreus	+++	+++	+	NS	−0.580*	0.715**	0.723**	58	73	180	219	149	252	5.671	NS
Agonum muelleri	+++	+++	+++	NS	−0.336	0.613*	0.247	1	6	75	151	4	7	1.167	NS
Bembidion obtusum	+++	+++	+++	NS	0.398	0.455	0.127	5	16	31	70	3	15	1.697	NS
Trechus quadristriatus	+++	NS	+++	+++			0.099	1	3	5	5	54	65	0.753	NS
Harpalus aeneus	NS				−0.214	0.451	0.624**	14	6	19	15	15	12	0.683	NS
Pterostichus melanarius	NS				−0.081	0.024	−0.245	12	13	9	5	19	16	0.960	NS
Bembidion lampros	+	+	+	NS	0.105	−0.218	0.358	0	6	15	19	4	11	4.381	NS
Pterostichus diligens	+++	NS	+++	+++			−0.209								

Table 3 continued

	Differences in abundance between habitats				Abundance vs. distance from the meadow/field boundary			Sex vs. distribution between habitats							
	M-F-O	M-F	F-O	M-O	M	F	O	M ♂	M ♀	F ♂	F ♀	O ♂	O ♀	χ^2	
Carabus granulatus	++	+	+	NS	−0.046	0.096		6	0	18	8	5	3	2.816	NS
Calathus melanocephalus	++	NS	+	+			−0.213								
Amara nitida	+++	+	NS	+											
Harpalus rufipes	+	NS	NS	+											
Loricera pilicornis	+++	+	+++	NS											
Calathus fuscipes	+	+	NS	NS											
Carabus cancellatus	+	+	NS	NS											
Bembidion quadrimaculatum	+++	++	NS	+++											
Diplopoda															
Unciger foetidus	NS				−0.066	−0.522*	−0.325	12	3	9	3	18	10	1.294	NS
Polydesmus complanatus	+++	NS	++	+++	0.440	−0.221		9	4	6	4	1	2	1.343	NS
Opiliones															
Oligolophus tridens	++	NS	+	+											

Other species with non significant differences between M-F-O habitats: Areneae: *Pardosa agrestis*, *Pachygnatha clercki*, *Panamomops sulcifrons*; Carabidae: *Bembidion guttula*, *Clivina fossor*, *Amara communis*; Oniscoidea: *Porcellio scaber*.

M – meadow, F – field, O – old-field (Kruskal-Wallis test; Mann-Whitney test; Spearman rank correlation coefficient; χ^2 test; + – $P < 0.05$, ++ – $P < 0.01$, +++ – $P < 0.005$, NS – $P \geq 0.05$). Note differences in the number of pitfall traps placed at sample sites – M: 15, F: 15, O: 24.

among the habitats. The best sample site differentiation by species composition was found surprisingly between the meadow and old-field (Table 3). The islands within the field seem to be too small to support a typical meadow fauna. Only a few species hibernate there (e.g. *Pardosa pullata, Tiso vagans*). The other species have to migrate across the field to colonize the old-field islands every year.

The edge effect can be expressed by an either increasing or decreasing abundance of animals towards the meadow-field boundary. This assumption was confirmed for only two species, namely *Alopecosa pulverulenta* with a decreasing abundance along the transect from the meadow to the field, and, to some extent, in *Pardosa amentata* (see Table 3). The differences in sex distribution between the two habitats were found for two species, namely *Pardosa palustris* with males predominating conspicuously in the meadow and, to a lesser extent, in the old-field, and in *Pardosa amentata,* of which no females were caught in the field in contrast to the other two habitats (Table 3).

Ground beetles

The samples from the field and from the meadow were comparable in their numbers of both species and individuals. Almost all the species found in these two habitats occurred in the old-field as well, but in smaller numbers. High numbers of *Poecilus versicolor,* a common grassland species and a dominant species in the meadow, were recorded also in the core area of the field. In the field, the agrophilous *Poecilus cupreus* occurred together with *Agonum muelleri,* an inhabitant of cultivated land. Other species abundant in the field are generally regarded as grassland and/or field species (*Carabus granulatus, Bembidion lampros, B. obtusum* – see TIETZE, 1973). Only three out of 29 species present in the old-field plots are characteristic of this habitat: the eurytopic *Trechus quadrimaculatus,* grassland-bound *Calathus melanocephalus,* and hygrophilous *Pterostichus diligens.*

Out of the habitats studied, the field has the most characteristic species composition; that of the meadow resembles the fauna of the old-field (Table 3).

Four of the important species change their activity abundance along the transect, e.g., *Poecilus cupreus* with an increasing abundance from the meadow-field boundary towards the core of the field and towards the distal old-field patches, *P. versicolor* with decreasing numbers along the same gradient, but only in the old-field islands, *Harpalus aeneus* with an opposite trend, and *Agonum muelleri* with slightly decreasing numbers towards the core of the field. The distribution of sexes does not depend on the habitat in any carabid species (Table 3).

Other taxa

As the sampling period ended at the beginning of the summer, only juvenile specimens of the harvestmen *Oligolophus tridens* and *Rilaena triangularis* were

captured in low numbers, and exclusively in the old-field. Millipedes occurred in the meadow, adjacent field margin, and close old-field plots. Four species of ants as well as one terrestrial isopod species were recorded in the old-field, only *Lasius niger* was sampled in the core of the field as well.

The activity abundance of *Unciger foetidus* decreased along the gradient from the meadow-field boundary to the core of the field, but this species is distributed uniformly among the habitats. Among millipedes, the distribution of sexes does not depend on the habitat (Table 3).

DISCUSSION

The comparison of species composition in ground beetles, spiders, millipedes, ants and harvestmen, in the three habitats examined, implies several conclusions: (i) The distribution of species among the habitats is unequal in most instances – the variability of captured specimens is smaller within particular habitats than between different habitats (see principal component analysis – for spiders in Fig. 5, and for ground beetles in Fig. 6), whereas the distribution of the sexes among habitats and changes of activity abundance across particular habitats are equal in most instances; (ii) species richness of spiders and carabid beetles is nearly the same in all three habitats; (iii) the dominance of the first-order species in ground beetle and spider communities achieved the highest value in the meadow, caused by *Poecilus versicolor* among carabids and *Pardosa palustris* among spiders.

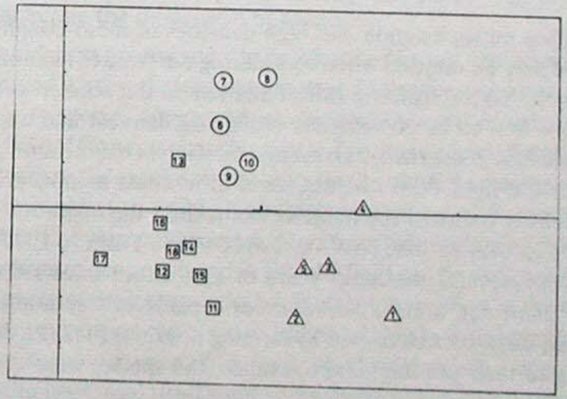


Fig. 5. Principal Component Analysis of Nos 1 to 18 sampling plots based on the spiders. Nos 1 to 5– meadow, 6 to 10 – field, 11 to 18 – old-field.

The discussed differences reflect the diversification of environmental factors in the examined habitats. Introducing a rather simplified generalization, we may consider moisture, light and food availability as the crucial factors controlling the occurrence of epigaeic fauna (see HAACKER, 1968; MARTENS, 1978; RIECHERT, 1974;

THIELE, 1977; WARBURG et al., 1984). Amplitudes of these factors are constrained by certain specific limits, necessary to maintain a balanced community, and by a certain frequency of their extreme values. Disturbances are accompanied by a certain factor surpassing its tolerated range (SOUSA, 1984). If the marginal values are grossly exceeded, the structure of the biotic community is disrupted.

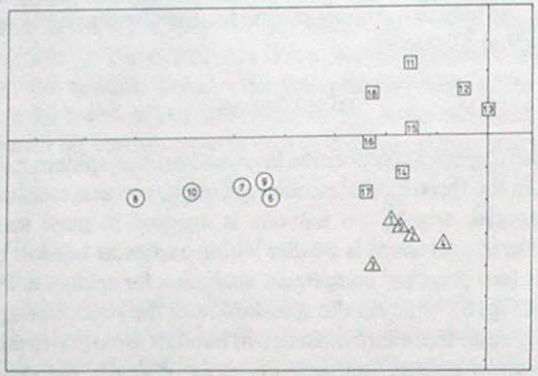


Fig. 6. Principal Component Analysis of Nos 1 to 18 sampling plots based on ground beetles. Nos 1 to 5 – meadow, 6 to 10 – field, 11 to 18 – old-field.

Because of intense eutrophication and high densities of meso-edaphon (mainly Collembola), food may be omitted when considering differences in limiting factors. Searching for crucial factors causing differentiation in the studied communities, regular disturbance had to be considered; ploughing, harvest and application of fertilizers and pesticides in the field, harvest and mowing in the meadow, and effects of pesticides in the old-field. Nevertheless, slight differences in moisture, temperature and light intensity between the habitats can restrict the migration of epigaeic species (compare GÓRNY, 1968b; NOVÁK, 1967; 1968; THIELE, 1977).

In central Europe several thousand years of agriculture have resulted in the establishment of plant and animal communities capable of tolerating successive, sometimes varying, disturbances caused by farming activities (TIETZE & GROSSER, 1985). According to their predominant tolerance, the species were classified into groups adapted to diverse patterns of agricultural management (compare BUCHAR, 1983a, b; LINDROTH, 1945): arable land species (e.g. *Oedothorax apicatus* and *Harpalus aeneus*), grassland species (e.g. *Alopecosa pulverulenta* and *Calathus melanocephalus*), woodland species (e.g. *Platynus assimilis* and partly *Micrargus herbigradus*). Among the ground beetles most of the recorded species appeared in all three habitats, but a number of them predominated conspicuously in the field (there are two exceptions: *Poecilus versicolor* dominating in the meadow, and *Trechus quadristriatus* prevailing in the old-field). This distribution contrasts with

that of spiders: five out of 16 important species given in Table 3 prefer the meadow, and only one of them, *Erigone dentipalpis*, prefers the field.

Communities of spiders in annual crops establish themselves anew each year from the populations dispersing from the surroundings (summarized in ŁUCZAK, 1975, but see DUFFEY, 1978), whereas ground beetles survive there, being adapted to the regular management of arable land. This pattern results in relati ely low numbers of spiders in the field/meadow if compared with that of carabid beetles (1 : 3.5 in spiders and 1 : 1 in carabids). Later, in summer and autumn, we can expect quite different results because of a high concentration of pest insect supporting the immigrating spiders in the field (see THALER et al., 1987).

The density of available food in spring seems to be very high in the ruderalized meadow. Sexually active spiders rapidly increase their activity abundance in the core of this habitat. The activity abundance data on catches from pitfall traps can be very approximately compared by means of the "number of individuals per metre of captive rim per day" index according to HEYDEMANN (1957) and RŮŽIČKA (1987). In our case, the maximum value for *Pardosa palustris* is 175 ind. m^{-1} d^{-1}. In more natural ecosystems, the corresponding values are often substantially lower, e.g. 20 to 30 for all species present in a wet meadow near Třeboň (RŮŽIČKA, 1987), 28 for *Pardosa palustris* in a mesic meadow in central Moravia (ŠPIČÁKOVÁ, 1985); nearly the same value was obtained for *Pardosa lugubris* in a forest ecotone in northern Moravia (KLIMEŠ & ŠPIČÁKOVÁ, 1984). According to ADIS (1979) and GREENSLADE (1964), these differences can be caused partly by different density of vegetation affecting the movement of animals.

The old-field plots are too small to be inhabited by self-maintaining populations of all the examined species throughout the year. However, even among ground beetles some migratory species appear, which regularly search for suitable winter refuges outside the fields (*Platynus dorsalis*, partly *Trechus quadristriatus* – THIELE, 1977). The distinctness of the species composition in the old-field may be regarded from this viewpoint. In contrast to arable land, higher numbers of *Pardosa pullata*, *Trechus quadristriatus*, *Calathus melanocephalus*, *Pterostichus diligens*, *Rilaena triangularis* and *Oligolophus tridens* captured in the old-field can be explained by a temporarily increased density of their populations left after hibernation at the start of the season (before their expansion into surrounding stands). This explanation is further supported by the occurrence of (i) juvenile, slowly mobile stages of harvestmen in the old-field habitat, and (ii) *Trechus quadristriatus*, a species sensitive to autumn frosts (MITCHELL, 1963), whose adults hibernate mostly outside the field (WEBER, 1965). However, an alternative explanation might be offered as well, considering the vernal absence of species in the fields as a result of their destruction either by agrotechnical measures or by an unfavourable march or winter weather. In both cases, the tiny old-field islands are important for the preservation, reinforcement, or re-establishment of populations in the open field (c.f. HIEBSCH, 1964; THIELE, 1964).

Pardosa pullata, a hygrophilous species, sensitive to drying-out and reaching higher densities in the old-field than on arable land, is strongly dependent on high air humidity (HALLANDER, 1970). The undisturbed, more luxuriant vegetation of the old-field environment undoubtedly provides a shelter during droughts for a part of the field population of this species.

Slight differences in micro-climate and man-made disturbances of the meadow and arable land strictly determined the increased or decreased abundance of various populations, e.g. *Pardosa pullata* and *Poecilus versicolor* at the meadow-field boundary. The ecotone effect was expressed by a decreasing number of several populations toward the boundary between these habitats (e.g. *Agonum muelleri* in the field, *Alopecosa pulverulenta* in the meadow). In other species, some individuals move from the field to the meadow or vice versa (*Erigone dentipalpis, Pardosa agrestis, Meioneta rurestris*). Among ground beetles, no species was found to prefer simultaneously the meadow and the old-field, while among spiders only the above mentioned *Pardosa pullata* behaved in this way. None of the epigaeic species was found in increased numbers within the ecotone near the meadow-field boundary contrary to the plants, particularly weeds, that showed higher densities due to the accumulation of their seeds and nutrient transport by erosion.

SUMMARY

1. Patches of non-cultivated land approx. 10 to 20 m^2 in area can provide important refuges for arthropods lacking the ability to withstand unfavourable periods on arable land.
2. A gradient between the meadow-field boundary and the man-impacted core areas of the field and of the meadow, respectively, was manifested by an decrease or increase in activity abundance in a few species, whereas the differences in species composition between the habitats were more remarkable in the epigaeic arthropods studied.

Acknowledgements. I thank Dr F. Petruška and Dr J. Jeník for valuable comments and Dr L. Papáčková for translation of the manuscript into English.

REFERENCES

ADIS J. 1979: Problems of interpreting arthropod sampling with pitfall traps. *Zool. Anz.*, **202** : 177–184.

ASPEY W. P. 1976: Behavioral ecology of the "edge effect" in Schizocosa crassipes (Araneae: Lycosidae). *Psyche*, **83** : 42–50.

BOGACH YA. & POSPISHIL YA. 1984: Zhuzhelitsy (Coleoptera, Carabidae) i stafilinidy (Coleoptera, Staphylinidae) pshenichnogo i kukuruznogo polei vo vzaimosvyazi s okruzhayushchimi biotopami (Carabids and staphylinids in wheat and corn fields with relations to the surrounding biotopes). *Ekologiya, (SSSR)*, **1984** (3) : 22–34 (in Russian).

BUCHAR J. 1982: Způsob publikace lokalit z území Československa (Publication of faunistic data from Czechoslovakia). *Věst. Čsl. Spol. Zool.*, **46** : 317–318 (in Czech; Engl. abstr.).

BUCHAR J. 1983a: Bioindikační využití pavouků (Exploitation of spiders in bioindication). *Nika*, **4** (1) : 11–14 (in Czech).

BUCHAR J. 1983b: Die Klassifikation der Spinnenarten Böhmens als ein Hilfsmittel für die Bioindikation der Umwelt. *Fauna Boh. Sept.*, **8** : 119–135.

CAMERON A. E. 1917: The insect association of a local environmental complex in the district of Holmes Chapel, Cheshire. *Trans. Roy. Soc. Edinburg*, **52** : 37–78.

DI CASTRI F., HANSEN A. J. & HOLLAND M. M. (eds) 1988: A New Look at Ecotones: Emerging International Projects on Landscape Boundaries. 163 pp., Intern. Un. Biol. Sci., Paris.

DABROVSKA-PROT E. & ŁUCZAK J. 1968: Spiders and mosquitoes of the ecotone of alder forest (Carici elongatae – Alnetum) and oak-pine forest (Pino – Quercetum). *Ekol. Pol.*, A **16** : 461–483.

DABROWSKA-PROT E., ŁUCZAK J. & WÓJCIK Z. 1973: Ecological analysis of two invertebrate groups in the wet alder wood and meadow ecotone. *Ekol. Pol.*, **21** : 753–812.

DLUSKIJ G. M. 1965: Okhranyaemaya territoriya u muravev (Hymenoptera: Formicidae) (Territoriality in ants). *Zh. Obshch. Biol.*, **26** : 479–489 (in Russian).

DUFFEY E. 1978: Ecological strategies in spiders including some characteristics of species in pioneer and mature habitats. *Symp. Zool. Soc. Lond.*, **42** : 109–123.

GAUCH H. G. 1982: Multivariate Analysis in Community Ecology. 298 pp., Cambridge University Press, Cambridge.

GERSDORF E. 1965: Die Carabidenfauna einer Moorweide und der umgebenden Hecke. *Z. Angew. Entomol.*, **52** : 475–489.

GÓRNY M. 1968a: Synecological studies of the soil macroentomofauna in two different agricultural biotopes. *Ekol. Pol.*, A **16** : 411–443.

GÓRNY M. 1968b: Faunal and zoocenological analysis of the soil insect communities in the ecosystem of shelterbelt and field, *Ekol. Pol.*, A **16** : 297–324.

GREENSLADE P. J. M. 1964: Pitfall trapping as a method for a studying populations of Carabidae (Coleoptera). *J. Anim. Ecol.*, **23** : 301–310.

HAACKER U. 1968: Deskriptive, experimentelle und vergleichende Untersuchungen zu Autökologie rhein-mainischer Diplopoden. *Oecologia* (Berlin), **1** : 87–129.

HALLANDER H. 1970: Environments of the wolfspider Pardosa chelata (O. F. Müller) and Pardosa pullata (Clerck). *Ekol. Pol.*, **18** : 41–72.

HEUBLEIN D. 1983: Räumliche Verteilung, Biotoppräferenzen und kleinräumige Wanderungen der epigäischen Spinnenfauna eines Wald-Wiesen-Ökotons; ein Beitrag zum Thema "Randeffekt". *Zool. Jb. Syst.*, **110** : 473–519.

HEYDEMANN B. 1957: Die Biotopstruktur als Raumwiderstand und Raumfülle für die Tierwelt. *Verh. Deutsch. Zool. Ges. Hamburg*, **1956** : 332–347.

HIEBSCH H. 1964: Faunistisch-ökologische Untersuchungen in Steinrücken, Windschutzhecken und den angrenzenden Wiesen und Feldflächen. *Tag.-Ber. Deutsch. Akad. Landw. Wiss. Berlin*, **60** : 25–35.

JENNINGS D., HOUSEWEART M. W. & FRANCOEUR A. 1986: Ants (Hymenoptera: Formicidae) associated with strip-clearcut and dense spruce – fir forests of Maire. *Can. Entomol.*, **118** : 43–50.

KLIMEŠ L. & ŠPIČÁKOVÁ E. 1984: Příspěvek k poznání dynamiky arachnofauny na lesním ekotonu (Beitrag zum Erkennen der Dynamik vom Arachnofauna an dem Waldökoton. *Acta Univ. Palack. Olomouc., Biol.*, **81** : 167–190 (in Czech; Germ. abstr.).

LINDROTH C. H. 1945: Die Fennokandischen Carabidae, 709 pp., *Göteb. Kungl. Vetensk. Vitter.-Samh. Handl.*, B **4**/1.

ŁUCZAK J. 1975: Spiders in agrocoenoses. *Pol. Ecol. Stud.*, **5** : 151–200.

MARTENS J. 1978: Weberknechte, Opiliones. 464 pp., Gustav Fischer Verlag, Jena.

MITCHELL B. 1963: Ecology of two Carabid beetles, Bembidion lampros (Hrbst.) and Trechus quadristriatus (Schrank). *J. Anim. Ecol.*, **32** : 289–299.

NOVÁK B. 1967: Vazba dospělců některých druhů polních střevlíkovitých na životní podmínky v porostu ječmene (Col. Carabidae) (Bindung der Imagines von manchen Feldcarabiden-Arten an die Lebens-

bedingungen in einem Gerstebestand (Col. Carabidae). *Acta Univ. Palack. Olomouc., Biol.*, **25** : 77–94.
NOVÁK B. 1968: Bindungsgrad der Imagines einiger Feldcarabiden-Arten an die Lebensbedingungen in einem Winterweizenbestand (Col. Carabidae). *Acta Univ. Palack. Olomouc., Biol.*, **28** : 99–131.
ODUM E. P. 1971: Fundamentals of Ecology. Third ed. W. B. Saunders Company, Philadelphia.
RIECHERT S. E. 1974: Thoughts on the ecological significance of spiders. *BioScience*, **24** : 352–356.
RŮŽIČKA V. 1987: An analysis of spider communities in the meadows of the Třeboň Basin. *Acta Sci. Nat. Brno*, **21** (5) : 1–39.
SIMBERLOFF D. & GOTELLI N. 1984: Effects of insularisation on plant species richness in the prairie – forest ecotone. *Biol. Conserv.*, **29** : 27–46.
SOUSA W. P. 1984: The role of disturbance in natural communities. *Ann. Rev. Ecol. Syst.*, **15** : 353–391.
ŠPIČÁKOVÁ E. 1985: Příspěvek k arachnofauně Státní přírodní rezervace Čubernice a jejího blízkého okolí (Ein Beitrag zur Arachnofauna des Naturschutzgebietes Čubernice und seiner näheren Umgebung). *Acta Univ. Palack. Olomouc., Biol.* **25** : 209–235 (in Czech; Germ. abstr.).
TERERRELL-NIELD C. E. 1986: Ecotones and community boundaries: analysis by pitfall trapping. *Field Stud.*. **6** : 407–428.
THALER K., AMANN H., AUSSERLECHNER J., FLATZ U. & SCHÖFFTHALER H. 1987: Epigäische Spinnen (Arachnida: Aranei) im Kulturland des Innsbrucker Mittelgebirges (900 m, Nordtirol, Österreich). *Ber. Naturw.-Med. Ver. Innsbruck*, **74** : 169–184.
THIELE H. U. 1964: Ökologische Untersuchungen an bodenbewohnenden Coleopteren einer Heckenlandschaft. *Z. Morphol. Oekol. Tiere*, **53** : 537–586.
THIELE H. U. 1971: Wie isoliert sind Populationen von Waldcarabiden in Feldhecken? *Misc. Pap. Landbouwhogesch. Wageningen*, **8** : 105–111.
THIELE H. U. 1977: Carabid beetles in their environments. 369 pp., Springer-Verlag, Berlin.
TIETZE F. 1973: Zur Ökologie, Soziologie und Phänologie der Laufkäfer (Coleoptera – Carabidae) des Grünlandes im Süden der DDR. II. *Hercynia N. F.*, **10** : 111–126.
TIETZE F. & GROSSER N. 1985: Zur Bedeutung von Habitatinseln in der Agrarlandschaft aus tierökologischen Sicht. *Hercynia N. F.*, **22** : 60–71.
TISCHLER W. 1958: Synökologische Untersuchungen an der Fauna der Felder und Feldgehölze. *Z. Morph. Oekol. Tiere*, **47** : 54–114.
TURČEK F. J. 1966: The zoological significance of ecological and geographical borderlands. *Acta Zool. Acad. Sci. Hung.*, **12** : 193–201.
VESECKÝ A., PETROVIČ Š., BRIEDOŇ V. & KARSKÝ, V. 1958: Atlas podnebí Československé republiky (Climatic atlas of Czechoslovakia). Ústř. správa geod. kartogr. Praha (in Czech).
WARBURG M. R., LINSENMAIR K. E. & BERCOVITZ, K. 1984: The effect of climate on the distribution and abundance of Isopods. *Symp. Zool. Soc. Lond.*, **53** : 339–367.
WEBER F. 1965: Feld- und Laboruntersuchungen zur Winteraktivität der Carabiden auf Kulturfeldern. *Z. Morph. Oekol. Tiere*, **54** : 551–565.

Наземные членистоногие на переходе между пахотной землей и луговой растительностью

Экология экотона, земляные ловушки, наземные жуки, пауки, сенокосцы, жужелицы, многоножки, муравьи, эпигеон, видовое разнообразие

Резюме. С помощью земляных ловушек отлавливали образцы сообществ наземных пауков, жужелиц, многоножек, сенокосцев, муравьев и равноногих ракообразных поперек переходной зоны между полем и лугом. Изменения абунданции активности от окраины по направлению к середине поля или луга, и наоборот, не были достоверны ни у одного из изучавшихся видов. На участках залежей размером в 10–20 квадратных метров, расположенных внутры обрабатываемого поля, абунданция активности жужелиц составляла лишь половину таковой на