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COMPARATIVE ANALYSES OF EPIGEIC SPIDER ASSEMBLAGES IN NORTHERN HUNGARIAN WINTER WHEAT FIELDS AND THEIR ADJACENT MARGINS

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ABSTRACT. Pitfall trapping was carried out in northern Hungarian winter wheat fields and their adjacent margins during the growing seasons of three consecutive years, 1992–1994. The dominant species of both habitats was the wolf spider *Pardosa agrestis* (Westring). A total of 8403 adult individuals of 19 families of 149 spider species was identified: 118 species from the winter wheat and 118 from the margins with fewer traps. The efficiency of detecting species by trapping was 90%, according to the Baule-Mitscherlich extrapolation model. Provided that the sampling effort is the same in both habitats, traps in the margin may catch higher number of individuals and species, than traps located within the field. Calculations, however, indicate that the field, with an area more than a hundred times larger than that of the margins, has a higher total number of species. Although the spider species spectrum of the field and of the margin had a considerable overlap, the Renkonen similarity index indicates that the spider fauna of the two types of habitats were different. Spider assemblages of the margins were more diverse (Rényi diversity), than those of the fields. The species richness of epigeic spiders in our Hungarian winter wheat fields was high, and it was increased by the presence of margins. Thus, for the purposes of the protection of our fauna and promotion of integrated pest management, establishment and maintenance of margins is strongly desirable.

Recent development of the Hungarian agriculture shows an increased attention to land use in general. Re-evaluation of former land use (share of field crops, reforestation of areas that are not suitable and economical for crop production), implementation of the basic principles of the ''National Strategy for Conservation of Biodiversity'' (Hungarian Academy of Sciences) reflects the importance of agrarian biotopes. Parallel to this, the present development of plant protection is focusing on the potential of natural enemies in integrated pest management (IPM), which involves maintaining their habitats and applying management practices that have minimal adverse effect.

Winter wheat and corn are the two most important crops grown in Hungary. Winter wheat covers about 25% of the arable land. Only a few data sets concerning the spider assemblages of arable lands in Hungary are available. Balogh & Loksa (1956), Samu et al. (1996) and Németh (1996) have examined the spider community in alfalfa fields. According to a recent bibliography of Hungarian arachnological studies (Szinetér & Samu 1995), the present research is the first to study the spider fauna of winter wheat in Hungary. Our preliminary surveys in winter wheat showed that spiders are among the dominant epigeic predators in winter wheat in Hungary (Kiss et al. 1993, 1994, 1998). Thus our study aimed to analyze the spider assemblages of winter wheat fields and their adjacent margins with respect to biotic diversity and the development of IPM.

METHODS

Description of study area and traps.—The study area was located in northern Hungary in the vicinity of the village Kartal (latitude 47°40′). Three winter wheat fields, Kartal 1 (K1), Kartal 2 (K2) and Józsefmajor (JM) and their adjacent margins less then 6 km apart were surveyed by pitfall traps in three consecutive years. Diameter of the pitfall traps was 10 cm. A 2% formalin solution with a drop of detergent was placed in traps as a preservative. The traps were run continuously and were emptied weekly, except in winter (in K2) when they were emptied monthly. Hereafter when we refer to a trap row we mean 5 traps placed in a row parallel to the closest field margin.

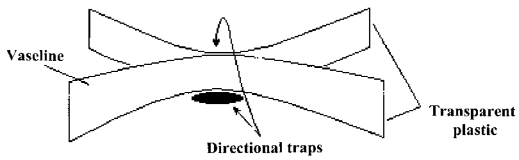

Figure 1.—A pair of directional pitfall traps in Józsefmajor field (JM) (1994).

Annual precipitation in the region is about 600–650 mm. Direction of the prevailing winds is highly variable. The topsoil is Luvic chernozem, developed on loess, mixed with weathered local andesitic material, that explains the more clayey texture than the loess origin would suggest. During the dry season in summer the topsoil in the fields opens 1–2 cm wide deep cracks. Field margins were abandoned, uncultivated and untreated strips at the edge of the fields, covered by an herbaceous undergrowth and containing a few separate trees (*Robinia pseudoacacia*) and shrubs (*Robinia pseudoacacia*, *Sambucus nigra, Rubus caesius*, *Prunus spinosa*). Coenological details are given in Kiss et al. (1997).

The K1 field measured 131 hectares. The margin was 2–3 m wide. Fifteen pitfall traps were operated in three parallel rows from late April until harvest in early July 1992. One row of traps was in the margin, parallel to the ecotone (5 m apart from each other), and two more were positioned into the field at increments of 30 and 250 m from the margin.

The area of the K2 field was 250 hectares. The margin was 2–3 m wide. Twenty pitfall traps were operated in four rows parallel to the ecotone from early November 1992 throughout winter until harvest in early July 1993. Five traps were placed in the margin (5 m apart from each other), and the other trap rows were in the field at increments of 20, 50 and 250 m from the margin.

The area of the JM field was 61 hectares and the margin was 4–5 m wide. Twenty pitfall traps were operated in four rows parallel to the ecotone from mid-March until harvest in mid-July 1994. Five traps were placed in the margin (10 m apart from each other) and the other trap lines were placed in the field at increments of 20, 50 and 250 m from the margin. Three pairs of directional pitfall traps, 20 m apart were placed in the JM field, 1m from the margin (Fig. 1). A pair of directional traps consisted of two pitfall traps, separated by two transparent U-shaped plastic plates. The plates were 1 meter long, 30 cm tall and were sunk into the ground to a depth of 10 cm. The upper edge of the plates was smeared with a thick layer of vaseline to inhibit climbing by arthropods. Traps facing the margin are called 'Dir. M', whereas traps facing the field are called 'Dir. F'. Directional traps enabled us to determine whether the spider assemblage of the immediate area of the margin (1 meter within the field) is similar to that of the margin or of the field.

Data analyses.—Since immature spiders are difficult to identify, only adults were taken into account in the analyses of extrapolation, similarity and diversity models, and all were identified to species level.

Extrapolation: The potential number of species caught in traps was estimated with the Baule-Mitscherlich function (Sváb 1981; Samu & Lövei 1995). The equation is:

$$y = T*(1-e^{a+bx})$$

where T means the potential number of species (saturation level), a and b are parameters, x (independent variable) is the cumulative number of individuals, and y (dependent variable) equals the cumulative number of species. Trapping results were randomly sorted and successively simulated an increase in sampling effort. Saturation level of the function best fitting the points was calculated using an iterative least squares grid searching method. Randomization of the trapping data and calculation of the saturation level (T) was repeated 50 times and the means were used in each case as the potential number of species. Potential number of species was calculated for both habitat types separately (field or margin), and combined (field + margin).

Similarity: Similarity of the spider assemblages of different trap rows was calculated with the Renkonen index (Renkonen 1938). The equation is:

$$R = \Sigma \min(p_i; q_i)$$

where p_i and q_i mean the relative frequency of species number i in habitats p and q. Since operating with relative frequencies, the captures are re-scaled between 0 and 1. So the Renkonen index enables us to compare results of different sampling efforts. In order to make the comparison of spider assemblages of the

Table 1.—Number of spider species and adult individuals captured in pitfall traps in three Hungarian winter wheat fields and in their adjacent margins (1992–94). Numbers in brackets imply that the results of directional pitfall traps has been added. (K1 = Kartal field 1; K2 = Kartal field 2; JM = Józsefmajor field. Distance of field traps from the margin is indicated.)

Field (year)	Margin	20(30) m	50 m	250 m	Wheat total	Total
Number of species						
K1 (1992)	57	38		31	54	77
K2 (1992–93)	72	34	35	37	55	91
JM (1994)	77	56	57	44	83 (97)	103 (111)
Total	118				107 (118)	145 (149)
Number of adult individuals						
K1 (1992)	1073	738		764	1502	2575
K2 (1992–93)	706	245	286	378	909	1615
JM (1994)	882	882	819	719	2420 (3331)	3302 (4213)
Total	2661				4831 (5742)	7492 (8403)

three different fields more reliable, autumn and winter catches in K2 were not included in this analysis. The similarities were also illustrated by a dendrogram, which shows the results of a hierarchical cluster-analysis using single linkage and the Renkonen index as distance measure data.

Diversity: The Rényi-function (Tóthmérész 1993) was used to characterize species diversity of different trap rows. Rényi-diversity:

$$H_\alpha = (\ln\Sigma\ (N_i/N_T)^\alpha)/(1-\alpha)$$

where $0 < \alpha$, $\alpha \neq 1$, N_i means the number of individuals of the species number i, T means the total number of species, N_T means the total number of individuals, and α is a scale parameter. Where the scale parameter is low, the function is more sensitive to rare species, whereas high values of the scale parameter suggests that the function is more sensitive to the dominant species. If $\alpha \rightarrow 1$, then $H_\alpha \rightarrow H_S$ (H_S : Shannon diversity). If $\alpha = 0$, then $H_\alpha = \ln T$. Species richness was expressed by the Margalef-index (Margalef 1958). The equation is:

$$d = (S-1)/\ln N$$

where S means the number of species, N means the number of individuals.

RESULTS

The dominant spider species in our Hungarian winter wheat fields was *Pardosa agrestis* (Westring) (43% of wheat total), followed by *Oedothorax apicatus* (Blackwall) (16%), *Meioneta rurestris* (C.L. Koch) (11%), *Xysticus kochi* Thorell (3%), *Trichoncoides piscator* (Simon) (3%) and *Zelotes mundus* (Kulczynski) (3%). The dominant species of field margin spiders was also *Pardosa agrestis* (17% of margin total), followed by *Pardosa prativaga* (L. Koch) (7%), *Zelotes pedestris* (C.L. Koch) (6%), *Aulonia albimana* (Walckenaer) (5%), *Hahnia nava* (Blackwall) (5%) and *Xysticus kochi* Thorell (4%).

A total of 8403 adult individuals of 149 spider species was identified. From the winter wheat, 118 species were collected and similarly (with fewer traps), 118 species were collected from the margin. There were 87 species (58.4% of total) which occurred in both habitats. Margin trap rows collected larger number of individuals and species than field trap rows in the same field. Directional traps at JM collected 911 adults of 69 species. This increased the number of species in wheat total (K1 + K2 + JM) by 11 species. The directional trapping added only 4 species to the total (Table 1).

According to the Baule-Mitscherlich extrapolation model, the potential number of species caught with pitfall traps in these fields given the trap numbers and configuration was 164 ($r^2 = 0.981$) for the total area (field + margin), 135 ($r^2 = 0.979$) for the wheat, and 130 ($r^2 = 0.980$) species for the margin. The model suggests that 116 species is predicted to occur in both habitats. This means a 70.7% potential overlap between the species spectrum of field and margin, compared to the observed overlap of 58.4%.

In all the three fields, species composition of trap rows of the same field were highly

Table 2.—Renkonen similarity indices comparing adult ground spider assemblages captured in pitfall traps positioned in three Hungarian winter wheat fields and in their adjacent margins (1992–94). Indices were computed from relative frequency of species. (K1 = Kartal field 1; K2 = Kartal field 2; JM = Józsefmajor field. Distance of field traps from the margin is indicated. Dir. M./Dir. F. = directional traps facing the margin/field.)

	K1 Margin	K1 30 m	K1 250 m	K2 Margin	K2 20 m	K2 50 m	K2 250 m	JM Margin	JM Dir. M.	JM Dir. F.	JM 20 m	JM 50 m
K1 30 m	0.50											
K1 250 m	0.45	0.83										
K2 Margin	0.32	0.18	0.16									
K2 20 m	0.40	0.56	0.51	0.22								
K2 50 m	0.38	0.56	0.50	0.19	0.83							
K2 250 m	0.41	0.58	0.52	0.21	0.78	0.80						
JM Margin	0.40	0.25	0.23	0.44	0.32	0.27	0.30					
JM Dir. M.	0.53	0.58	0.57	0.29	0.65	0.59	0.65	0.43				
JM Dir. F.	0.49	0.52	0.50	0.27	0.55	0.49	0.55	0.46	0.79			
JM 20 m	0.44	0.62	0.59	0.20	0.66	0.60	0.65	0.34	0.79	0.79		
JM 50 m	0.43	0.60	0.57	0.18	0.67	0.61	0.69	0.31	0.75	0.75	0.89	
JM 250 m	0.42	0.57	0.56	0.18	0.54	0.47	0.55	0.30	0.72	0.78	0.80	0.79

similar (R = 0.72–0.89) (Table 2; Fig. 2). Species composition of margins differed more either from that of the other margins (R = 0.32–0.44) or from that of the field trap rows (R = 0.16–0.53). The lowest field-field similarity (R = 0.47) was higher than the highest margin-margin similarity (R = 0.44). Directional trap catches, oriented to capture spiders moving across the edge were highly similar to each other (R = 0.79) and to the field catches (R = 0.72–0.79).

The Rényi-diversity of margin trap rows were higher than those of the field trap rows of the same field, regardless of concentrating on rare (when scale parameter is low) or dominant (when scale parameter is high) species (Fig. 3). Species richness of the total capture is characterized by a Margalef-index of d = 16.4, whereas the index for wheat is d = 13.5, and d = 14.8 for margin.

DISCUSSION

Field margin seems to be a more dense and rich habitat than field, since traps in the margins usually catch higher number of individuals and species, than traps located within the fields (Kromp & Steinberger 1992; Al Hussein & Lübke-Al Hussein 1995; Samu et al. 1996). This experience, however, does not necessarily means that the total number of species is higher in the margins because the total area of the fields is much larger than that of the margins. Overlap between the number of spider species in the margin *vs.* field may be as high as 70%. The proportion of species occurring in both habitats is influenced by the sampling effort, so comparability is more reliable with the Renkonen index than with the species list overlap. Similarity between margin and field was found R = 0.18 (Kromp & Steinberger 1992), R = 0.21–0.53 (Al Hussein & Lübke-Al Hussein 1995), and R = 0.62 (Janssens & De Clercq 1986), whereas in-field similarity was R = 0.82–0.95 (Al Hussein & Lübke-Al Hussein 1995). These data and our findings suggest that margin-field or margin-margin similarity usually remains under 0.5, while field-field similarity values in most cases exceed this level. This is explained by that the fields are strongly and repeatedly disturbed every year by tillage, harvest, pesticide application and other field works, while occasional disturbance in the margins (mowing, pesticide drifting) does not destroy the habitat basically. As a consequence, pioneer spider species, such as *Oedothorax spp.*, *Meioneta spp.*, *Erigone spp.*, *Pardosa spp.*, *Trochosa spp.*, *Pachygnatha spp*. dominate the European arable fields, resulting in a relative uniformity. Most of these pioneer species are frequent in the margins as well, but spider assemblages of the margins are more diverse than those of the fields (Kromp & Steinberger

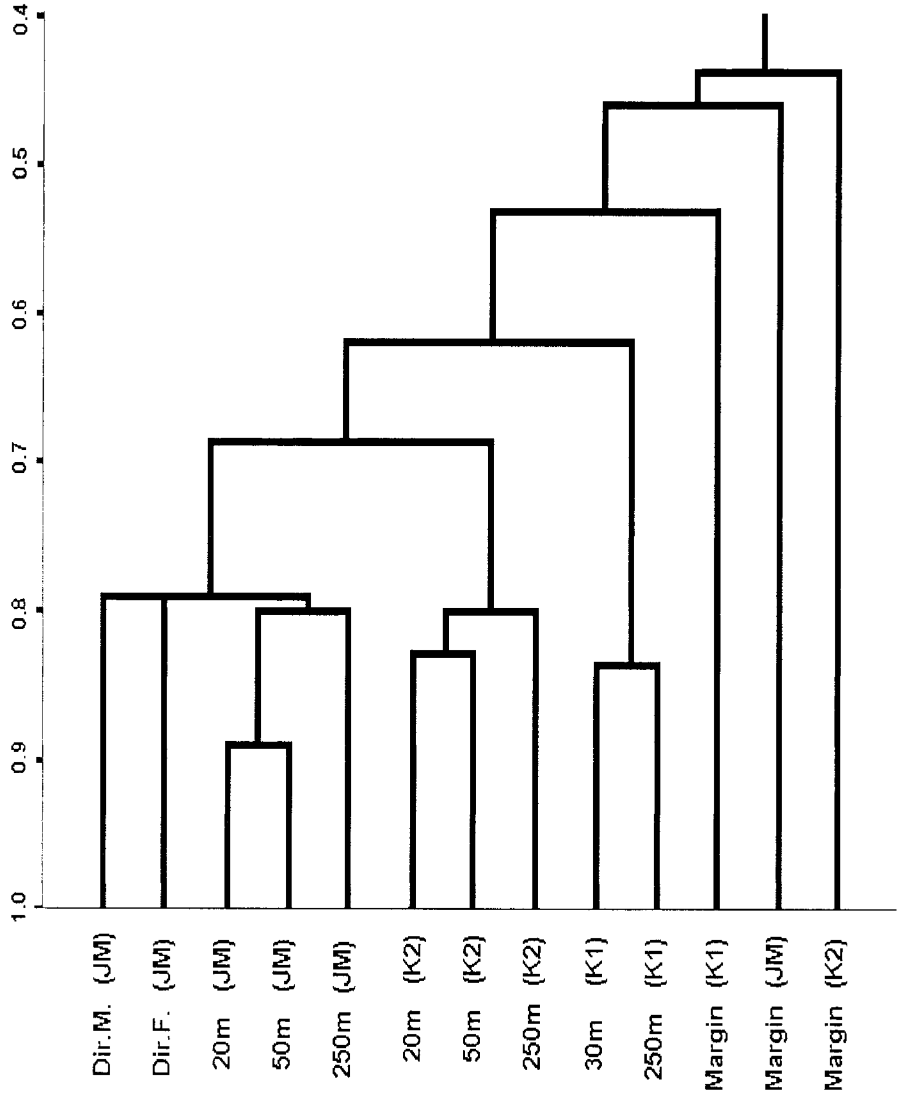

Figure 2.—Similarity of the spider assemblages of three Hungarian winter wheat fields and of their adjacent margins. The dendrogram illustrates the result of a hierarchical cluster analysis using single linkage and the Renkonen index, calculated from relative frequency data of species. (K1 = Kartal field 1; K2 = Kartal field 2; JM = Józsefmajor field. Distance of field traps from the margin is indicated. Dir. M./Dir. F. = directional traps facing the margin/field.)

1992; Al Hussein & Lübke-Al Hussein 1995; Samu et al. 1996). Ground spider species richness in these northern Hungarian winter wheat fields and their adjacent margins were higher than those found in other such surveys in European agricultural areas (Table 3). For the explanation of this phenomenon further investigations are needed.

According to the IOBC Technical Guidelines for arable crops (Boller et al. 1997) ecological compensation areas (reservoirs of pest antagonists, like flowering field margins, groups of trees, ponds, haystacks) have to cover at least 5% of the entire farm surface excluding forests. It means that calculating with a 5m wide field margin, the average field size should not exceed 1–2 ha. As a result of the large scale farming, that was characteristic of Hungary until 1989 (Kiss et al. 1997) we estimate that field margins cover around 1%

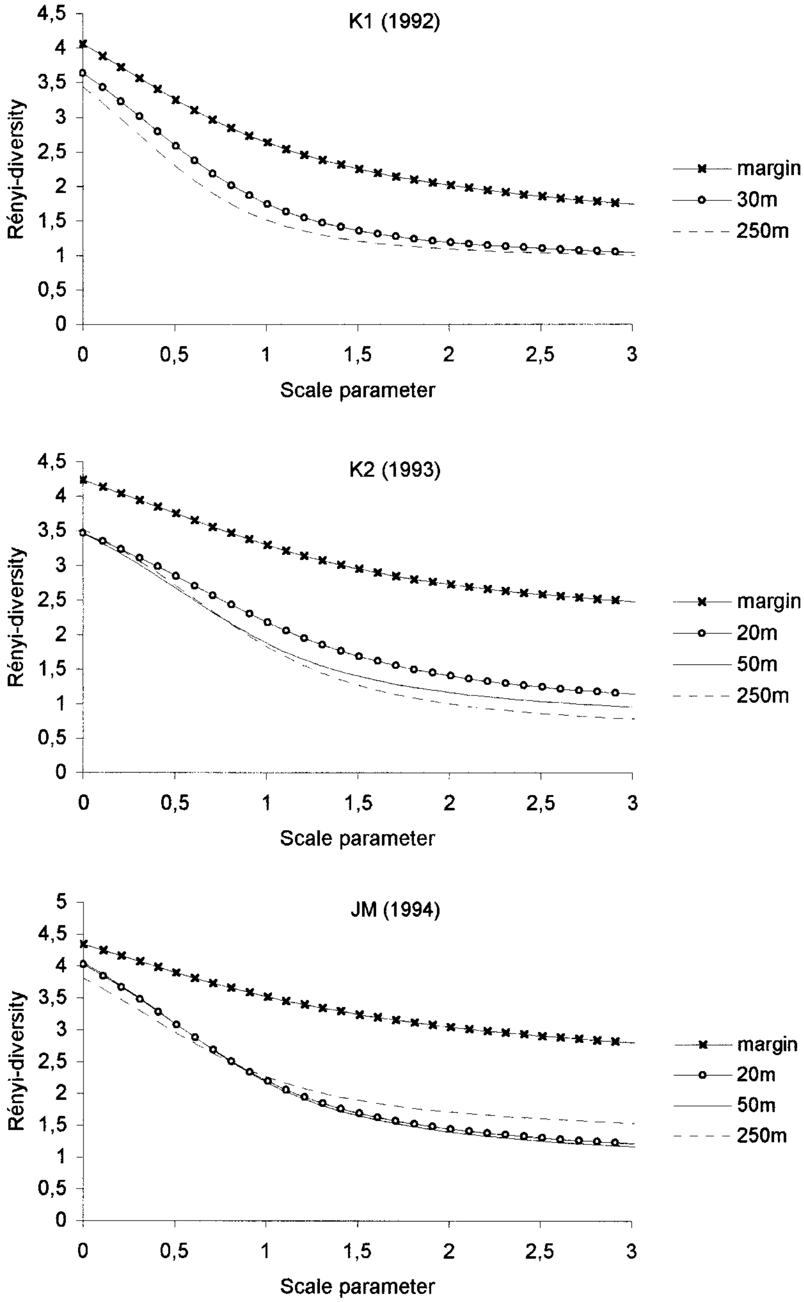

Figure. 3.—Rényi-diversity (H_α) in three Hungarian winter wheat fields and in their adjacent margins, calculated from relative frequency data of spider species. Where the scale parameter (α) is low, the function is sensitive to the rare species, whereas increasing the scale parameter results in a higher sensitivity to the dominant species. If $\alpha \rightarrow 1$, then $H_\alpha \rightarrow H_S$ (H_S : Shannon diversity). If $\alpha = 0$, then $H_\alpha = \ln T$ (T = number of species). (K1 = Kartal field 1; K2 = Kartal field 2; JM = Józsefmajor field. Distance of field traps from the margin is indicated.)

Table 3.—Spider species richness in different European pitfall trap studies, according to the Margalef-index (d), computed from the number of individuals (*n*) and species (S).

Habitat	*n*	S	d	Reference
Total catch	8403	149	16.4	Present study (Tóth & Kiss 1999)
Winter wheat	5742	118	13.5	
Margin	2661	118	14.8	
Winter wheat and sugar beet	101,213	122	10.5	Janssens & De Clercq (1986)
Maize	2018	19	2.4	Alderweireldt & Desender (1990)
Winter wheat, peas and maize	1235	47	6.5	Gajdos (1992)
Winter wheat	4460	80	9.4	Kromp & Steinberger (1992)
Winter wheat	5069	41	4.7	Topping & Sunderland (1992)
Potato and margin	5145	75	8.7	Steinberger & Kromp (1993)
Winter wheat, winter barley and margin	9510	82	8.8	Al Hussein & Lübke-Al Hussein (1995)

of our arable lands. Owing to the rich epigeic spider fauna, Hungarian agroecosystems have a considerable potential to enhance natural enemy populations and their diversity by increasing the number, width and quality of field margins.

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