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Testing the origin of agrobiont spiders: spiders in agricultural and natural grassland habitats of the Körös-Maros National Park, Hungary

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Abstract
According to current hypothesis agrobiont spiders originate from spider communities of pioneer-like or regularly disturbed natural habitats, where they could pre-adapt to the periodic disturbances occurring in agricultural areas. The area of Körös-Maros National Park has a mosaic structure where natural grasslands (saltmarsh meadows and loess steppes) and agricultural areas (alfalfa, wheat) form habitat patches of various sizes. Out of the two predominant grassland habitat types loess steppe can be considered to be mature and stable, while saltmarsh meadows can be characterised by large open soil surfaces and periodic disturbances by flooding. This habitat structure is highly suitable for testing the question which is the natural habitat type where agrobionts come from. The results did not support entirely our starting hypothesis, namely that saltmarsh meadows would host the agrobionts and not the loess steppe. Instead we found a more complex picture: part of the agrobiont species (*Pardosa agrestis, Oedothorax apicatus, Syedra gracilis, Araeoncus humilis*) occurred predominantly in saltmarsh meadows, while others (*Meioneta rurestris, Pachygnatha degeeri*) could equally be found in both grassland types.

Key words: agricultural species, indicator species analysis, faunistics

INTRODUCTION

Regarding their biomass and species diversity spiders are one of the most important predatory group of arthropods both in agroecosystems and in natural habitats (Loksa 1968, 1979; Luczak 1980; Nyffeler & Benz 1987; Samu & Szinetár 2000). Different spider species have different habitat preferences and environmental tolerances. Therefore community structure, which essentially is a weighted list of uniquely adapted species, is a good indicator of habitat type and condition (Szita et al. 1998; Samu & Szinetár 2000). The species richness of agricultural areas may reach the diversity level of natural habitats as we can see from our present data and from Toft's surveys (1989). However, the number of dominant species in arable spider communities is limited (Samu et al. 1999, 2001). This regionally invariant set of dominant species of agricultural communities are called agrobiont species (Luczak 1975; Samu & Szinetár 2002).

Examination of the Central European habitat database of spiders (Hänggi et al. 1995) and Hungarian data (Szita et al. 1998; Samu et al. 2001, 2002) suggested that agrobiont spiders are typically native to wetland areas, such as saline grasslands, costal dunes, beaches. These habitats are characterised by frequent, regular perturbances of seasonal flooding, sand movements, tides etc. (Duffey 1978; Döbel et al. 1990).

A possible explanation for this phenomenon could be that agrobionts in these habitats preadapted to the periodic disturbances that also occur in agricultural areas (Wissinger 1997). On the other hand, species which are abundant in early successional habitats decline in numbers as the habitat becomes more stable and complex (Duffey 1978), likely because the two habitat types require different breeding and dispersal behaviour and ecological tolerance (Duffey 1978; Greenstone 1982; Hurd & Fagan 1992).

Our purpose in this study was to make a comparative study of agricultural habitats and two natural grassland habitats, out of which the saltmarsh meadow is periodically disturbed, while the loess steppe grassland patches are more stable. In replicated patches of the three habitat types we described spider communities and analysed the affinities of agrobionts.

MATERIALS AND METHODS

Study area

We collected spiders from the Körös-Maros National Park between 1998 and 2000. Agricultural fields were sampled only in 2000. The area of Blaskovics puszta in KMNP where our survey was carried out, has a mosaic structure where natural grassland habitats (saltmarsh meadows and loess steppes) and agricultural areas (mainly alfalfa and wheat) form habitat patches of various sizes. Out of the two predominant grassland habitats loess steppe patches are at a few ten centimeters higher elevation, therefore receive less of the seasonal floodings. Because of this, loess patches evolved deeper soil and a highly structured, species diverse plant community. Saltmarsh meadows, on the other hand are at somewhat lower elevation and are flooded regularly. During summer the soil has a negative water balance, and the soil water moves upwards, carrying Na^+ ions, resulting salt and clay colloid accumulating in the upper soil layer. The saltmarsh meadow and the arable vegetation is structurally simple (one stratum) and less diverse. Smaller or larger bare habitat patches often characterise the saltmarsh meadows.

During our experiment 3 blocks of agricultural fields, 4 blocks of loess steppe and 4 blocks of saltmarsh meadows were examined (Fig. 1).

Collecting methods

Applying the standard methodology of our previous studies of the agricultural spider fauna in Hungary (Samu et al. 1996; Tóth et al. 1996) we used two different collecting methods in paralell. We sampled spiders by a hand-held suction sampler (10 samples - totalling 0.1 m² each - were taken from every habi-

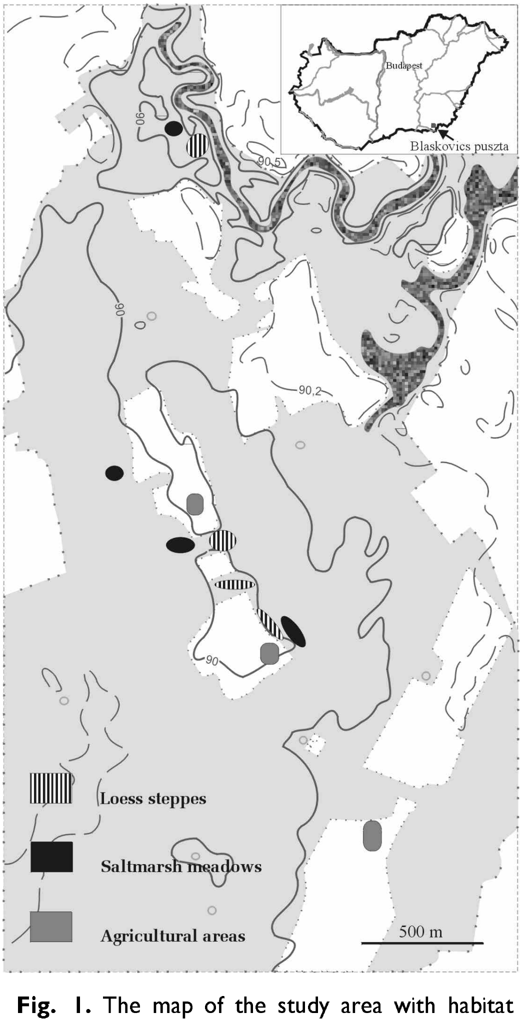

Fig. 1. The map of the study area with habitat type of sampled patches indicated – Blaskovics puszta on the Great Hungarian Plain.

tat patch, monthly between April and November) (Samu & Sárospataki 1995). This method is suitable mainly for collecting foliage dwelling and/or web building species. The other method was pitfall trapping (10 traps 5 m apart in each habitat patch, plastic cups, 7.5 cm upper diam., containing solution of ethylene glycol and detergent as preservative, emptied at fortnightly periods between April and November). This method is the most efficient in collecting adult specimens of the cursorial spider fauna (Sunderland et al. 1995).

Indicator Species Analysis

The main statistical method applied, Indicator Species Analysis (ISA) (Dufrene & Legendre 1997) reveals, which are the species that regularly occur in certain habitat types and not in others. The result of such an analysis is dependent on which habitat types were included in the analysis, and how the individual habitat patches were classified into habitat types.

To reach a robust result we made comparisons across all basic habitat types and also across all possible combinations. For instance, to answer the question which species are characteristic of agricultural habitat types (and not of natural habitat types) considering the habitats sampled in this study, we performed an ISA between arable vs. loess steppe + saltmarsh meadow habitats. For each ISA we calculated the indicator value for each species using the software PC-ORD4 (McCune & Mefford 1999). Using Monte-Carlo simulation this program also attaches a significance value to the indicator value. In Table 1 A-D we list species where the significance level was $P<0.1$. All analyses were performed separately for data-sets obtained by the two methods applied (pitfall and suction sampling) and for their joint data-sets, as well.

RESULTS AND DISCUSSION

Faunistical notes

During our survey in 2000 we collected 2523 adult spider individuals belonging to 113 species. Appendix contains the data of species that were collected on the area between 1998 and 2000 by pitfall trapping and handheld suction sampling. The faunistical results of years 1998 and 1999 were published earlier (Szita et al. 1998, 1999).

In 2000 we found two notable species: *Chalcoscirtus nigritus* (Thorell, 1875) and *Gnaphosa rufula* (L. Koch, 1866), both proved to be new to the Hungarian spider fauna. *C. nigritus* was previously found in Greece, Germany, Ukraine, Russia, Azerbaijan, and Kazakhstan in xerotherm sandy and stony steppes (Heimer & Nentwig 1991). Now we collected 5 specimens of this species from one of the saltmarsh meadows. *G. rufula* was previously recorded from Russia and Kazakhstan (Ovtsarenko et al. 1992). In KMNP this species was collected from every examined saltmarsh meadow, and it can be regarded as a dominant species of this habitat type in the Körös-Maros National Park.

Results of ISA

Table 1 contains the results of all comparisons by ISA. The three-way ISA shows that agricultural areas have their well defined set of indicator species (Table 1A). The two-way (agricultural vs. natural grassland) comparison gave a virtually identical list of agricultural indicators (Table 1D). These largely coincide with the most dominant species of the agricultural habitat type (Appendix), and the species are the same that were found to be agrobionts elsewhere in Hungary (Samu & Szinetár 2002). This highlights that agricultural communities have different dominant species from natural communities.

Searching for the affinities of the agrobiont species, the inspection of Appendix reveals that in general agrobionts do not solely occur in the agricultural habitat type, but also in natural grasslands, however, they cannot attain a dominant status in those communities. According to our initial hypothesis, agrobionts should be more likely to occur in the periodically disturbed saltmarsh meadows than in the more stable loess steppe patches. The ISA

Table 1. The results of Indicator Species Analysis. Total= Dvac + Pitfall together. Significance of indicator values P<0.1. (**A**) Three way ISA: comparison of the three types of habitats. (**B-C**) Two way ISA: combination of two habitat types compared with a third type of habitat. The names of species are abbreviated using four letter of the genus name and the four letter of the species name. Abbrevations of agrobiont species are in italic letterstyle.

A	agricultural field	loess steppe	saltmarsh meadow
Total	*pardagre, syedgrac, erigdent*	meiosimp, phrufest, agrocupr, argibrun, euopfron, aloppulv, hahnnava, zeloelec, enopthor, heliflav, trichack, argesubn,	gnaprufu, tricpisc, titavete
Dvac	*pardagre, syedgrac, erigdent, pachdege*	argibrun, heliflav, argesubn, phrufest	metodese
Pitfall	*araehumi, oedoapic, erigdent, pardagre*	meiosimp, phrufest, hahnnava, euopfron, zeloelec, aloppulv	gnaprufu, titavete, zelolong, zelograc, pellnigr, trocrobu, hognradi, drasprae

B	agricultural fielad+ saltmarsh meadow	loess steppe
Total	tricpisc, titavete, pellnigr	meiosimp, phrufest, phrufest, euopfron, hahnnava, argibrun, agrocupr, aloppulv, anopthor, trichack, phaebrac, heliflav, argesubn, meiorure, draspusi
Dvac	*syedgrac*	heliflav, argibrun, phrufest, argesubn, trichack, tetrexte, meiosimp
Pitfall	titavete, *pardagre*, micaross, pellnigr, *oedoapic*, gnaprufu, *araehumi*, pardcrib, tricpisc	meiosimp, phrufest, zeloelec, euopfron, pheabrac, xeromini, hahnnava, aloppulv

C	agricultural field+ loess steppe	altmatsh meadow
Total	*meiorure*, *pachdege*, meiosimp, hahnnava, agrocupr	gnaprufu, tricpisc, titavete, pellnigr
Dvac	-	metodese, tricpisc
Pitfall	-	gnaprufu, titavete, zelograc, pellnigr, drasprae, zelolong, hognradi, heliflav, tricpisc, zelodecl

D	agricultural field	loess steppe+ saltmarsh meadow
total	*syedgrac, pardagre, erigdent, oedoapic*	zelolong
Dvac	*erigdent, pardagre, syedgrac, pachdege*	-
Pitfall	*araehumi, oedoapic, erigdent, pardagre*	zelolong, trocrobu, thanaren

where agricultural + saltmarsh meadows were combined (Table 1B) revealed, that indeed (depending on sampling method) four of the agrobionts could be regarded as an indicator species for this habitat combination. On the other hand the loess steppe + agricultural vs. saltmarsh meadow ISA revealed that there were two agrobionts that were indicators of this opposing habitat combination (Table 1C), therefore we cannot say that all agrobionts would originate solely from the disturbed habitats.

One potential adaptation to the disturbance regime of agricultural habitats is the life history strategy of agrobionts. In this respect, we have studied *Pardosa agrestis*, the chief Hungarian agrobiont in more detail (Samu et al. 1998). We found, that unlike any other *Pardosa* spp., in agricultural areas *P. agrestis* has two phenological peaks during a season. The saltmarsh meadows of the KMNP were the first natural area, where we collected data in sufficient detail about *P. agrestis*. Our results revealed that the species shows the same type of life cycle both in natural and in agricultural habitat (Fig. 2).

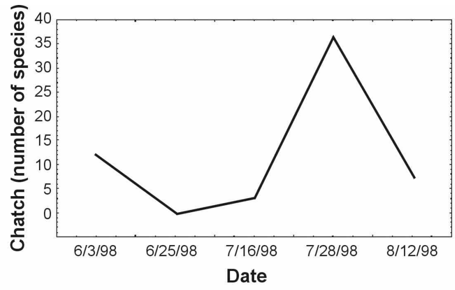

Fig. 2. Capture data of male *Pardosa agrestis* from the alkaline grassland blocks in 1998. The peaks of two generations can be seen clearly (the first peak, we suppose, is already descending).

Results from the present study give partial support to the "cyclic colonisation" hypothesis by Wissinger (1997). The hypothesis states that annual crop systems are predictably ephemer habitats that present a selective environment that is different from irregularly disturbed or early successional habitats. He describes the life histories of arthropods that thrive in these types of environments as " cyclic colonizers". Cyclic colonisers are not necessarily " r-selected", but rather have generations that alternate between relatively r- and K- selected life history strategies.

The presented data firstly shows, that many of the agrobionts are likely to originate from a natural habitat type (saltmarsh meadow), which has a disturbance regime that is similarly periodical as that in agricultural areas. Secondly, the life cycle of *P. agrestis* populations inhabiting natural grasslands shows a double peaked life cycle, which can be regarded as a pre-adaptation to the autumn and early spring disturbances of agricultural areas, because it ensures that there are dispersive life-stages (juveniles) are present during and soon after the disturbances. On the other hand, the present data also shows that species from more stable habitat types (loess steppe) can also became agrobionts, thus other species characteristics (e.g. foraging strategy, competitive ability) can potentially contribute the success of species in agricultural habitats.

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Appendix. The species list and number of catches in the three types of habitats on Blaskovics puszta in 1998-2000.

Family/ Species	Agricultural fields	Loes steppes	Saltmarsh meadows
Dysderidae			
Dysdera erythrina	0	1	0
Mimetidae			
Ero cambridgei	0	1	0
Theridiidae			
Enoplognatha thoracica	0	4	2
Robertus arundineti	0	0	1
Robertus lividus	0	0	1
Steatoda albomaculata	0	0	1
Steatoda phalerata	1	5	7
Theridion melanurum	0	0	2
Linyphiidae			
Araeoncus humilis	12	9	21
Bathyphantes gracilis	1	2	0
Bathyphantes similis	0	1	0
Ceratinella brevipes	0	0	1
Ceratinella brevis	0	11	0
Diplostyla concolor	11	8	6
Erigone dentipalpis	25	1	3
Erigonoplus globipes	0	0	2
Lepthyphantes tenuis	0	1	0
Linyphia triangularis	0	1	0
Meioneta mollis	1	11	4
Meioneta rurestris	14	40	23
Meioneta simplicitarsis	1	108	7
Metopobactrus deserticola	1	3	58
Microlinyphia pusilla	0	1	0
Oedothorax apicatus	42	6	54
Porrhomma microphthalmum	2	0	1
Silometopus reussi	2	0	0
Syedra gracilis	13	6	6
Tallusia vindobonensis	1	9	16
Trichoncoides piscator	2	0	16
Trichoncus hackmani	0	56	8
Trichopterna cito	0	1	40
Walckenaeria capito	1	3	1
Tetragnathidae			
Pachygnatha clercki	0	0	1
Pachygnatha degeeri	36	60	36
Tetragnatha extensa	0	1	8
Araneidae			
Argiope bruennichi	0	19	1
Hypsosinga albovittata	0	0	1
Hypsosinga pygmaea	0	3	1
Larinioides folium	0	0	1
Singa hamata	0	1	1
Lycosidae			
Alopecosa accentuata	0	4	0
Alopecosa mariae	0	1	0
Alopecosa pulverulenta	6	97	45
Alopecosa schmidti	1	0	0
Aulonia albimana	0	4	3
Hogna radiata	11	24	92
Lycosa singoriensis	1	0	0
Lycosa vultuosa	1	6	9
Pardosa agrestis	297	52	149
Pardosa cribrata	2	0	16
Pardosa prativaga	5	16	7
Pardosa proxima	0	4	3
Pardosa pullata	0	1	0
Trochosa robusta	21	111	170
Trochosa ruricola	0	1	0
Xerolycosa miniata	18	86	42
Pisauridae			
Pisaura mirabilis	0	2	0
Hahnidae			
Hahnia nava	1	17	3
Dictynidae			
Argenna subnigra	0	13	4
Cicurina cicur	0	0	0
Amaurobiidae			
Paracoelotes segestriformis	1	0	0
Titanoecidae			
Titanoeca veteranica	2	1	69
Liocranidae			
Agroeca brunnea	0	1	1
Agroeca cuprea	0	14	0
Phrurolithus festivus	0	50	6
Clubionidae			
Cheiracanthium campestre	0	0	1
Cheiracanthium montanum	0	0	1
Cheiracanthium pennyi	0	1	1
Clubiona diversa	4	9	7
Clubiona similis	0	2	2
Clubiona subtilis	0	2	0
Gnaphosidae			
Drassodes pubescens	0	1	0
Drassodes villosus	0	1	0
Drassyllus praeficus	1	4	52
Drassyllus pusillus	1	20	6
Gnaphosa lucifuga	3	2	1
Gnaphosa rufula	0	3	79

Family/ Species	Agricultural fields	Loes steppes	Saltmarsh meadows
Haplodrassus dalmatensis	2	0	6
Haplodrassus minor	3	1	2
Haplodrassus signifer	0	12	12
Micaria dives	0	2	1
Micaria rossica	14	4	108
Phaeocedus braccatus	0	3	0
Trachyzelotes pedestris	4	14	18
Zelotes atrocaeruleus	0	0	1
Zelotes declinans	1	0	17
Zelotes electus	0	31	5
Zelotes gracilis	0	4	13
Zelotes latreillei	0	2	1
Zelotes longipes	1	105	170
Zoridae			
Zora armillata	0	4	2
Philodromidae			
Thanatus arenarius	13	161	136
Thanatus striatus	0	0	0
Tibellus maritimus	1	0	0
Tibellus oblongus	2	1	0
Thomisidae			
Misumenops tricuspidatus	2	1	0
Ozyptila pullata	0	27	5
Xysticus acerbus	2	1	0
Xysticus cristatus	0	1	0
Xysticus kempeleni	1	0	1
Xysticus kochi	19	19	20
Salticidae			
Chalcoscirtus nigritus	0	0	6
Euophrys frontalis	0	19	2
Euophrys westringi	0	2	3
Evarcha arcuata	0	0	1
Evarcha falcata	0	0	1
Heliophanus auratus	1	1	1
Heliophanus flavipes	1	19	8
Pellenes nigrociliatus	1	0	5
Phlegra fasciata	0	15	14
Saitis tauricus	0	0	1
Talavera aequipes	0	4	1