European Arachnology 2000 (S. Toft & N. Scharff eds.), pp. 229-236.
 ISBN 87 7934 001 6
(Proceedings of the 19th European Colloquium of Arachnology, Århus 17-22 July 2000)

The spider fauna of balks

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Abstract
Results of studies of the spider fauna of three balks and a rye field adjacent to one of them in a mosaic of agrocoenoses in Eastern Poland are presented. Spiders were collected by pitfall trapping and sweep netting in the years 1998 and 1999. In total, 7589 specimens representing 94 species were collected. Spider diversity depended on width and age of the balk and on vegetation structure. More spider species occurred in the older balk, which had fewer plant species but a denser vegetation cover than in the younger one, which was covered with more diverse but less compact vegetation. Seasonal activity of the dominant spider species *Pachygnatha degeeri* was different in the balk and adjacent field. Balks, as important components of mosaic landscapes, play a significant role in enriching spider diversity in arable areas.

Key words: agricultural areas, Araneae, balks, biodiversity, refugial habitats

INTRODUCTION

Agricultural practices decrease the abundance of beneficial arthropods. The role of landscape diversification is to provide reservoirs that are strategically placed and which act as safe havens and sources of immigrants to the crop fields (Sunderland & Samu 2000).

In Eastern Poland the agricultural landscape has maintained its diverse character. It forms a mosaic of small fields (usually between 5 ha and 1 ha), separated by balks and small woods. Balks are narrow (less than 1 m) strips covered with herbs and grasses, slightly raised above the field level. A balk separates two fields and is unmanaged, although it may be affected by the agrotechnical treatments carried out in the adjacent fields. Because of their structural stability and vegetational composition balks might play a similar role for invertebrate animals as waste lands or meadows. Although balks are characteristic components of the Polish agricultural landscape, their importance as refugial habitats is not known.

Many investigations in other European countries have focused on the importance of unmanaged areas within arable lands. According to Barthel & Platcher (1995) a more diverse spider fauna in the agricultural landscape requires: larger field margins, fallow lands as sources of colonization, connectedness of uncultivated areas, and a stable vegetation structure of the margins. Bergthaler (1996) found that already during the first year of succession hedgerows functioned as an important refuge for the invertebrate fauna. Tóth & Kiss (1999) noticed that the presence of margins increased species richness of epigeic spiders in winter wheat fields. Kemp & Barrett (1989) found that predators were more abundant in uncultivated areas, especially successional corridors, than in soybean fields. The establishment of uncropped areas within the agricultural landscape might provide net ecological and economic benefits. Thomas et al. (1991) proposed the creation of 'island' habitats in the farmland. They noticed that during the first year of establishment the new habitats provided overwintering refuge sites for many species of Araneae, Carabidae and Staphylinidae. Experiments with the introduction of sown weed strips into crop fields were undertaken in Switzerland with positive results for the diversity of spiders and other arthropods (Lys & Nentwig 1994; Frank & Nentwig 1995).

Spiders and other invertebrates of balks have not previously been studied in Poland. The aim of this study was to determine the characteristics of balks which influence spider biodiversity. The role of balks as refugial habitats is considered.

MATERIAL AND METHODS

Study area

The spider fauna in three balks and the rye field adjoining one of them in the years 1998-99 was studied. The study area was situated in the village of Zbuczyn, Eastern Poland. Balk I separated a conventionally grown strawberry field and an organically grown wheat field. Balk II separated the strawberry field and organic potato fields. The width of the strawberry field between the two balks was about 6 m. Balks I and II were about 30 years old and about 40 cm wide. Both were covered with diverse vegetation composed of 33 plant species. Vegetation cover in balk I was not very dense. Apart from grass, some high and branched plants (e.g. *Artemisia vulgaris*) were present there. The vegetation in balk II was not as dense as in balk I and was composed mainly of low herbs. Balk III was situated at another farm, about 2 km from balks I and II, and separated two rye fields. Areas of cultivated fields were about 1 ha. The balk was about 80 years old and 70 cm wide. The flora of this habitat was composed of 13 plant species. Grass was a main component of the vegetation. Its long and bent blades formed a compact green mass.

Methods

Samples were taken from April till October in 1998 (in balk II only from May), and from March till October in 1999. Epigeic spiders were collected by pitfall traps (plastic cups of 7 cm upper diameter, containing ethylene glycol and a few drops of detergent). Ten traps with a distance of 2 m between each one were installed at each site. The traps functioned for two weeks of every month. Spiders of the herbaceous layer were collected once a month by a sweep net of 40 cm diameter. One sampling consisted of 4 x 25 sweeps. The material was identified to species level or, in the case of young individuals, to genus level. For analysis Shannon-Weaver diversity index (H) and species similarity Sørensen index (So) were applied.

Table 1. Number of species, Shannon-Weaver and Equitability index for all study sites. B1 balk I, B2 balk II, B3 balk III, C rye field.

	1998			1999	
	B1	B2	B3	B3	C
Species richness	43	39	52	58	45
Shannon index	2.69	2.70	2.25	1.95	1.71
Equitability	0.72	0.74	0.57	0.47	0.45

RESULTS

In total, spiders of 15 families and 94 species represented by 7589 specimens were recorded. Numbers of spider species caught by pitfall traps and sweep net in all study areas, as well as Shannon index and equitability, are given in Table 1. An analysis of epigeic spiders showed differences between balks. In balks I and II similar numbers of species were found in pitfall traps (34 and 30, respectively) but the total number of individuals was much higher in balk I (748) than in balk II (293). As regards the number of specimens, *Pachygnatha degeeri* and *Pardosa palustris* were most abundant in balk I, while *Oedothorax apicatus* was most numerous in balk II. The spider fauna of balk III was more diverse and a larger number of species (46) and individuals (1761) was recorded than in the two other balks. *P. degeeri*, *Centromerita*

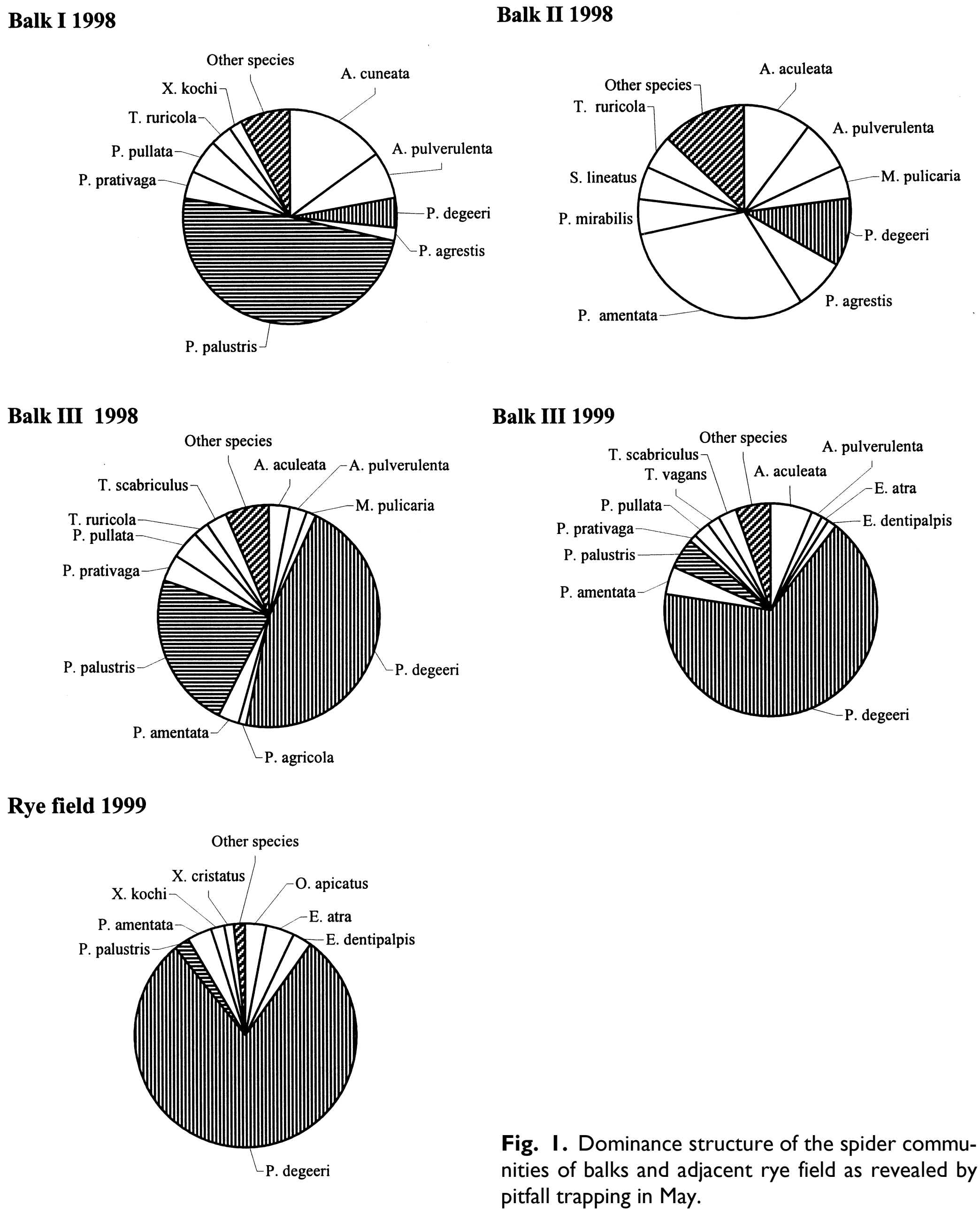

Fig. 1. Dominance structure of the spider communities of balks and adjacent rye field as revealed by pitfall trapping in May.

bicolor, Centromerus sylvaticus, Pardosa palustris and *O. apicatus* were the most abundant species. In the herbaceous layer, *Mangora acalypha* was the most numerous in all studied balks. The number of individuals was twofold higher (50) in balk I than in balk II (25).

A comparison of balk III in 1998 and 1999 revealed only small differences in epigeic spider composition but the number of individuals was much higher (2469) in the second year of the study. Foliage-dwelling spider communities were different in the two years studied. In

1999 twice the number of species was recorded. In the rye field agrobiont species were most numerous (*P. degeeri, O. apicatus, Erigone dentipalpis* and *E. atra*). The field and the adjacent balk had 21 species in common.

The dominance structure of epigeic spiders recorded in May (Fig. 1) revealed that the spider fauna of balk III was quite different from that of balks I and II. Moreover, there were differences between balk I and II, in spite of their closeness. In balk III, *P. degeeri* dominated in both years (47% and 67% respectively). In 1998 the second dominating species was *P. palustris* (23%), whereas in the next year of study this spider accounted for only 5%. In the rye field the dominant spider species was also *P. degeeri* (79%).

The Sørensen similarity index between balk I and balk II was high (0.72). Lower values were recorded for balk I and III (0.65), and for balk II and III (0.66). Only small changes of spider communities in balk III in 1998 and 1999 were noted (So = 0.70). The value of this index for the rye field and balk III was low (0.48).

The number of individuals of the dominant spider species *P. degeeri* during the 1999 study season showed two peaks in the balk but only one peak in the adjacent rye field (Fig. 2); the species disappeared completely after harvest of the field.

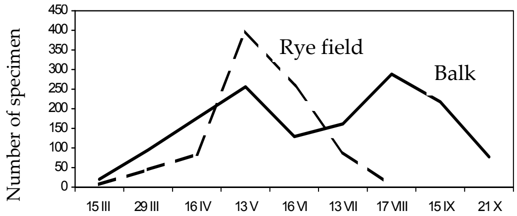

Fig. 2. Seasonal activity of *Pachygnatha degeeri* in balk III and adjacent rye field in 1999.

DISCUSSION

This study revealed that the richness of the spider fauna of balks depends on the width of the balk and on its vegetation structure. While width is important for the general abundance of spiders, vegetation structure may influence spider composition. In balk III, which was almost twice as wide as the other two, a far larger number of specimens was found. The size of the area itself seems to be important: the wider the balk, the more space to inhabit. Barthel & Platcher (1995, 1996) stated that the size of uncultivated margins is an important factor for spider composition. Narrower margins might be more affected by mechanical treatments of the neighbouring cultivated areas than wider margins, where an undisturbed central zone can be established. Stability of balks depends, among other things, on their age. More spider species were recorded in the 80-year-old-balk than in the 30-year-old ones. Similar relations were found by Frank & Nentwig (1995) in sown weed strips within cultivated fields and in field boundaries. Although strips were only one or two years old they were similar to balks in their width (1.5 m) and plant composition (25 weed species). The older strips contained significantly more spider species than the younger ones, and also the number of species in the ten-year-old boundary was significantly higher than in weed strips.

Vegetation structure is one of the essential factors for spiders. Dense and compact vegetation provides shade and humidity, appropriate conditions especially for small spiders of the families Linyphiidae and Theridiidae. These spiders, exposed to loss of water more than larger ones, find hiding places in numerous, tiny spaces of such habitats (Duffey 1975). Linyphiids were most abundant in balk III in which the vegetation provided good support for sheet webs. Apart from the Linyphiidae, spiders of five other families were registered here. According to Frank & Nentwig (1995) the dense grass cover reduces the mobility of spiders. In contrast, in balks I and II spiders representing 11 and 9 families respectively were found. It seems that less compact and more diverse vegetation provide better conditions for actively hunting and larger web-building spiders (more insolation and support for three-dimensional webs). Scheidler (1990) who studied the influence of habitat structure and vegetation architecture on spiders, found higher spider densities on broad plants with many branches than on plants with only few branches and a rather narrow architecture. He stated also that for some spiders the plant architecture may play the dominant role, while for other spider species special structures like leaves or buds are most important. Frank & Nentwig (1995) also recorded a more diverse spider fauna in areas covered with richly structured vegetation.

Although balk III was characterized by a lower Shannon diversity index than balks I and II, records of *Porrhomma errans*, *Allomengea vidua* and *Argiope bruennichi* in this site should be stressed. The two first species are known only from a few localities in Poland (Staręga 1983; Staręga & Stankiewicz 1996). *A. bruennichi*, although frequent in Western Europe (Nyffeler 1982; Barthel & Platcher 1995, 1996; Jmhasly & Nentwig 1995; Bergthaler 1996) and even in Western Poland (Radkiewicz & Jerzak 1991; Kuźniak 1998), is a relatively rare species in Eastern Poland and protected in the whole country.

Balks may serve as overwintering sites, especially for agrobiont spiders. Under a vegetation layer reduced temperature extremes can be recorded (Thomas et al. 1992) which might increase winter survival compared to open fields. This seems to be essential, especially for arthropods as spiders which are not able to dig well into the soil, and which showed the lowest overwintering abundance in cereal areas (Lys & Nentwig 1994). A pattern of seasonal activity of *Pachygnatha deggeeri* in balk III (Fig. 2) showed an increase in the number of individuals twice a year, in spring and in autumn. Similar data were obtained by Palmgren (1974). The second peak should not be related to the sexual activity of this species but rather to the migration to overwintering sites (Toft 1979). A number of individuals of this spider had only one peak in spring in the rye field and then it disappeared completely during harvest. The spiders might have migrated from the field to the balk, as this species is known as eurychronous and adult specimens overwinter (Schaefer 1977). Frank & Nentwig (1995) considered *P. degeeri* a species with distinct preference for the field boundary. They listed as agrobiont species *Erigone atra, E. dentipalpis, Oedothorax apicatus, Pardosa agrstis* and *P. palustris* showing dispersal from weed strips into fields (i.e. in spring more individuals were in weed strips, but as the season progressed more individuals were in the fields). This means that these spider species overwintered in the strips. Also Łuczak (1979) pointed out that densely vegetated biotopes provided particularly attractive sites for hibernation.

Some spider species probably originating from the adjoining balk were found in the field, so one can speculate that spiders migrate from balks to the fields and vice versa. Because of the small width of the balks, the extent of this migration need not be large. Jmhasly & Nentwig (1995) observed that in many cases the spider density and web cover were larger close to the strips, so they supposed that weed strips might increase the spider population in the adjacent winter wheat.

The conclusion of this study is that balks, in spite of their small width, are important habitats for the spider fauna within Polish agricultural areas. Their presence might increase biodiversity in arable areas, because their spider fauna is much more diverse than in the cultivated fields. It is highly recommended to maintain or restore the Polish type of agricultural landscape with plenty of balks, woods, water bodies and small fields. Sustainable agriculture promotes diversified agroecosystems and extensive production in small-area farms so that it could be profitable. Gravesen & Toft (1987) mentioned the creation of grass strips along field margins and hedges as one way of 'manipulating' predator populations for productive and environmental benefits.

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Appendix. List of spider species and numbers collected on study habitats using pitfall traps (PF) and sweeping net (SN).

Spider species	1998						1999			
	Balk 1		Balk 2		Balk 3		Balk 3		Rye field	
	PF	SN	PF	SN	PF	SN	PF	SN	PF	SN
Mimetidae										
Ero furcata (Villers)			1							
Theridiidae										
Achaearanea lunata (Clerck)	1								1	
Enoplognatha ovata (Clerck)		2		2				1		
Neottiura bimaculata (Linnaeus)						1	2	7		
Robertus arundineti (O.P. Cambridge)	3		3		4		6			
Robertus lividus (Blackwall)		1			2		2		1	
Theridion impressum (L.Koch)		4						1		6
Theridion mystaceum (L. Koch)				3						
Theridion sp. (juv.)	1	5				4		7		13
Linyphiidae										
Allomengea vidua (L. Koch)					1					
Araeoncus humilis (Blackwall)	1		1		11				8	
Bathyphantes gracilis (Blackwall)	2				14		27		2	
Bathyphantes parvulus (Westring)							5			
Centromerita bicolor (Blackwall)	53		35		165		118		10	
Centromerus aequalis (Westring)									1	
Centromerus sylvaticus (Blackwall)	72		5		157		15			
Dicymbium brevisetosum (Locket)							8		2	
Diplocephalus latifrons (O.P. C.)									1	
Diplostyla concolor (Wider)							4			
Erigone atra (Blackwall)	5				17		69		154	1
Erigone dentipalpis (Wider)	9		1	1	57		97	1	161	
Erigone longipalpis (Sundevall)					1					
Gnathonarium dentatum (Wider)							1	1		
Lepthyphantes angulipalpis (Westring)					1		1			
Lepthyphantes pallidus (O.P. C.)							1			
Linyphia triangularis (Clerck)					1	1				
Macrargus rufus (Wider)							1		2	
Meioneta rurestris (C.L.Koch)			5		4		6		16	
Meioneta tenera (Menge)					1		2			
Micrargus herbigradus (Blackwall)									1	
Microlinyphia pusilla (Sundevall)				1			1			
Microlinyphia sp. (juv.)		2						2		
Microneta viaria (Blackwall)					1				1	
Neriene clathrata (Sundevall)							1	1		
Oedothorax apicatus (Blackwall)	44		66		137		169		634	
Oedothorax fuscus (Blackwall)					4		3		2	
Oedothorax gibbosus (Blackwall)							1			
Oedothorax retusus (Westring)					9		7		2	
Pocadicnemis pumilla (Blackwall)							1			
Porrhomma errans (Blackwall)							1			
Porrhomma pallidum (Jackson)							1			
Porrhomma pygmaeum (Blackwall)									1	
Silometopus reussi (Thorell)					3					
Stemonyphantes lineatus (Linnaeus)	24		40		3		15		7	
Tapinocyba insecta (L. Koch)					3		1			
Tiso vagans (Blackwall)			2		5		35		1	
Troxochrus scabriculus (Westring)	12		1		53		43		2	
Walckenaeria obtusa (Blackwall)							1			
Tetragnathidae										
Pachygnatha clercki (Sundevall)	3				19		12		5	
Pachygnatha degeeri (Sundevall)	177		37	1	747		1420	1	888	
Tetragnatha extensa (Linnaeus)				1		1		4		
Tetragnatha pinicola (L. Koch)		3				1		14		3
Araneidae										
Aculepeira ceropegia (Walckenaer)		2		4		3		1	1	1
Araneus diadematus (Clerck)				1						
Araneus marmoreus (Clerck)									1	
Araneus quadratus (Clerck)		4						2		
Araneus sp. (juv.)								1		
Araniella cucrbitina (Clerck)				1						1
Araniella opisthographa (Kulczyński)										1

Appendix, continued.

Spider species	1998						1999			
	Balk 1		**Balk 2**		**Balk 3**		**Balk 3**		**Rye field**	
	PF	SN	PF	SN	PF	SN	PF	SN	PF	SN
Araniella sp. (juv.)						3				
Argiope bruennichi (Scopoli)								1		
Cyclosa oculata (Walckenaer)	1		1							
Hypsosinga pygmea (Sundevall)								1		
Mangora acalypha (O. P. Cambridge)		16		5		6		26		10
Lycosidae										
Alopecosa aculeata (Clerck)	1		4		13		27		2	
Alopecosa cuneata (Clerck)	22		1		4		2			
Alopecosa pulverulenta (Clerck)	12		5		31		26			
Alopecosa sp. (juv.) Simon	31		12		6		4			
Pardosa agrestis (Westring)	16		3		4		29			
Pardosa agricola (Thorell)	1				3				6	
Pardosa amentata (Clerck)	40		20		32		34		31	
Pardosa lugubris (Walckenaer)					1				2	
Pardosa palustris (Linnaeus)	115		11		140		161		79	
Pardosa prativaga (L. Koch)	15		3		14		31		3	
Pardosa pullata (Clerck)	7				19		24		2	
Pardosa sp. (juv.)	8	1			13		6		3	
Pirata latitans (Blackwall)							2			
Pirata piraticus (Clerck)									1	
Pirata tenuitarsis (Simon)					1					
Trochosa ruricola (De Geer)	33		7		15		12		17	
Trochosa terricola (Thorell)	2									
Trochosa sp. (juv.)	6		3		8		3			
Xerolycosa nemoralis (Westring)			3							
Pisauridae										
Pisaura mirabilis (Clerck)	1	3	2			6		2	1	
Hahnidae										
Hahnia pusilla (C. L. Koch)	1									
Dictynidae										
Argenna subnigra (O.P. Cambridge)									1	
Cicurina cicur (Fabricius)	1									

Spider species	1998						1999			
	Balk 1		**Balk 2**		**Balk 3**		**Balk 3**		**Rye field**	
	PF	SN	PF	SN	PF	SN	PF	SN	PF	SN
Liocranidae										
Agroeca brunnea (Blackwall)			3							
Agroeca proxima (O.P. Cambridge)	1		1							
Phrurolithus festivus (C. L. Koch)			1		1					
Gnaphosidae										
Drassyllus lutetianus (L. Koch)	1		1							
Drassyllus pusillus (C. L. Koch)	1				1		1			
Haplodrassus sylvestris (Blackwall)			1		1					
Micaria pulicaria (Sundevall)	2		3		3		3			
Micaria sp. (juv.)			2				1			
Zelotes sp. (juv.)	2				2					
Zoridae										
Zora spinimana (Sundevall)							2			
Philodromidae										
Philodromus aureolus (Clerck)										1
Philodromus sp.(juv.)		1								
Thomisidae										
Ozyptila scabricula (Westring)	1									
Ozyptila trux (Blackwall)					2					
Ozyptila sp. (juv.)		1			1					
Xysticus cristatus (Clerck)	16		1		10		3		9	
Xysticus kochi (Thorell)	2		1		6		8		10	
Xysticus sp. (juv.)	3	4	7	4	8	3	13		12	14
Salticidae										
Euophrys frontalis (Walckenaer)							1			
Total of individuals	798		318		1790		2543		2140	
Total of species	43		39		52		58		45	