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STUDIES ON GROUND DWELLING SPIDERS (ARANEAE) OF AGRARIAN HABITAT TYPES IN NORTHEAST GERMANY: ECOLOGICAL AND NATURE CONSERVATION ASPECTS

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Abstract

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The impacts of agrarian habitat types representative of the Northeast German Lowland (cereal fields, fallows, meadows) on the structure of the spider assemblage have been investigated on 16 study sites in the biosphere reserve Schorfheide-Chorin (Brandenburg, Germany). During 3 years (1995-1997) epigeal spiders were collected by pitfall traps (PT: n=8/10) and ground photo-eclectors (GPE: n=6).

Altogether 40536 specimens belonging to 179 species were recorded, among them several taxa (18%) listed in the Red Data Book of Germany (n=29) and of Brandenburg (n=21). The highest biodiversity was recorded for pastures with 108/97 species (according to PT/GPE catches), followed by fallows (101/89) and fields (78/69). Within arable land most species were recorded on a biodynamic cereal field cultivated after a four-year period of fallow. Using estimates of niche width, *Porrhomma microphthalmum, Erigone atra, Erigone dentipalpis, Savignia frontata* and *Meioneta rurestris* were identified as characteristic species of cereal fields. *Pelecopsis parallela, Oedothorax retusus, Trochosa ruricola* and *Alopecosa barbipes* were characteristic of fallows and *Thanatus arenarius, Trichopterna cito* and *Zelotes electus* were typical of pastures. Only four species (*Erigone atra, Meioneta rurestris, Pachygnatha degeeri, Pardosa palustris*) were recorded on all study sites. Generally, most specimens and the highest activity biomass of spiders were manifested on grasslands and long-term fallows; the lowest levels were recorded for cereal fields. Fallowing of cereal fields seemed to promote the relative abundance and activity biomass of the spider assemblage immediately after taking the fields out of cultivation, whereas species diversity took longer to build up. A similar effect was obvious in cereal fields with a cultivation cycle that was interrupted by a one-year period of set aside. The dominance structure of the spider assemblage was clearly affected by the agrarian habitat types: While the relative abundance of linyphiid spiders increased from meadows to cereal fields, the dominance position of lycosids decreased in the same sequence of agrarian habitat types. As expected, diversity indices using estimates of α (log series) were lowest on cereal fields, and highest on extensively used pastures as well as long-term fallows, independent of the sampling method.

Introduction

Spiders are considered to be among the most frequent epigeal predators. Besides parasitic wasps and flies as well as zoophagous beetles they play an important role in the regulation of insect pests in agroecosystems (e.g. SUNDERLAND, 1987; NYFFELER et al., 1994 a, b). In addition, spiders are acknowledged indicators of the hemerobiotic degree of terrestrial ecosystems (e.g. PLATEN, 1992, 1995; PLATEN et al. 1995; RATSCHKER, ROTH, 1999; RIECKEN, 1991) because: (1) the taxon comprises numerous species, e.g. in Germany at least 956 (PLATEN et al., 1995), (2) spiders occur in a variety of habitat types, mostly in high numbers of individuals, (3) most species react sensitively to alterations of environmental conditions (e.g. microclimatic and structural parameters (HÄNGGI, 1987)).

The cultural landscape of Central Europe is characterised by a long history of coevolutionary processes between humans and nature (ELLENBERG, 1996). Although, since the beginning of agriculture, human impact resulted in a localised degradation of ecosystem integrity, it is unambiguous that historical forms of land use promoted the diversity of species and habitat types (PLACHTER, 1996). Nevertheless, modern agricultural land use accounts for an ongoing loss of species and natural areas on a global scale, caused by the intensification of agricultural production in the last few decades.

Although many investigations refer to the impacts of agricultural practices on spider communities (SUNDERLAND, 1987; NYFFELER et al., 1994 a, b), a comprehensive study of the effects of the basic land use types dominating the cultural landscape of Central Europe is still missing. Thus, the present study focuses on the influence of the agrarian habitat types field, fallow and grassland (pasture, meadow) on species diversity and other structural parameters of spider assemblages in a landscape representative of the Northeast German Lowland.

Study area

From 1995 to 1997 the investigations were carried out in the agrarian dominated developmental zone of the biosphere reserve Schorfheide-Chorin, located about 60 km northeast of Berlin (Germany, Brandenburg). The study area is situated 60 m to 139 m above sea level. The climate with low precipitation (annual average: 572 mm; January: 39.2 mm; July: 62.5 mm) and a mean annual air temperature of 8.4°C (January: -1,3°C; July: 17,5°C) is almost continental. The influence of the Pommeranian Stage of the Vistula Glaciation on the landscape is manifested in a mosaic of loamy and sandy soil textures.

Material and methods

The studies were carried out on 16 agricultural sites (Table 1) differing in habitat type (cereal fields (C), fallow (F), grassland (G): pasture, meadow) and land use intensity (cereal fields: conventional or biological dynamic management; pastures: intensive, extensive or sporadic grazing by cattle or sheep, respectively;

T a b l e 1. Characteristics of the study sites: Size [ha] in the year of investigation, type of farming: conventional or biodynamic, crop/mode of utilisation in the respective year: WW- winter wheat, WB- winter barley, WR- winter rye, WB* and WiRa*- to fallow after frost damage, fallow (duration since ploughing in years), SB- summer barley, spor.-grazing- semi-dry meadow, sporadic grazing by sheep, WiRa- winter rape; trapping period (TP): TP 95 (27 March to 19 June 1995), TP 96 (26 March – 18 June 1996), TP (22 May – 18 June 1996).

study site	Size [ha]	Soil character.	Type of farming	crop 1994	crop 1995	crop 1996	crop 1997	investigation period
0	10	loamy	conv.	WW	Silage corn	WW	WB	TP 96/97
1	20	loamy	conv.	WR	WR	WB*	Fallow (1)	TP 95/96/97
2	36	loamy	conv.	WW	WB	SB	WW	TP 95
3	4	sandy	–	spor. grazing	spor. grazing	spor. grazing	spor. grazing	TP 95/96
4	17	loamy	conv.	WR	Fallow (1)	Fallow (1)	-	TP 95
6	15	loamy	conv.	WB	WR	Fallow (1)	-	TP 95
7	32	loamy	conv.	Grazing by cattle	Grazing by cattle	Grazing by cattle	Grazing by cattle	TP 95
8	32	loamy-sandy	biodynamic	Fallow (1)	Fallow (2)	Hay meadow	Hay meadow	TP 95/96/97
9	45	sandy	biodynamic	Fallow (4)	WR	Oats	Lupin	TP 95
10	28	loamy-sandy	conv.	Fallow (4)	Fallow (5)	Fallow (6)	–	TP 95
11	11	sandy	conv.	Fallow (9)	Fallow (10)	Fallow (11)	Fallow (12)	TP 95/96/97
12	27	sandy	conv.	Sugar beet	Fallow (1)	Fallow (2)	Fallow (3)	FP 95/96
19	20	loamy-sandy	biodynamic	Oats	Fallow (1)	Triticale	Forage peas	TP 96
25	10	loamy	conv.	WW	Silage corn	WW	WB	TP 96/97
50	10	loamy	conv.	WW	Silage corn	WW	WB	TP 96/97
100	10	loamy	conv.	WW	Silage corn	WW	WB	TP 96/97

meadow: mown once a year). Study plots were either square (1, 2, 4, 6, 7, 9-19) or rectangular (0, 3, 8, 25, 50, 100), all of one hectare and with a minimum distance of 30 m to the field edge to minimise side effects of adjacent habitats.

Ground dwelling spiders were collected by pitfall traps (PT: n = 8 or 10 on study plot: 0, 25, 50, 100, respectively, but only data from trap 1-8 were included in this survey), and ground photo-eclectors (GPE: n = 6; Funke (1971)). Glass jars with an opening diameter of 7 cm and a volume of 370 ml served as pitfall traps. To prevent rain flooding the traps they were covered with a Perspex disc (15x15 cm) about 10 cm above ground. Four pitfall traps were dug into the soil at the corners of the one-hectare study plots. The others were placed at the corners of a concentric square of 50 m side length within the study plots or – on the rectangular study sites – 10 m apart along a transect parallel to the long side in the centre of the plots. A solution of picric acid (250 ml) (Roth, 1985) served as a preservative in pitfalls and ground photo-eclectors (pitfall trap and light trap). Ground photo-eclectors or emergence traps catch the imagines of various insect taxa (e.g. Hymenoptera, Diptera, Coleoptera) after emergence or hibernation in the soil or litter. Inside the eclector there was an additional pitfall trap to reduce epigeic predators. The type of eclector used in this survey was made of a square plastic frame (side 1 m, height 0,5 m) and a pyramid-shaped tent (white polyester cloth) which is fixed to four metal poles and ends in a short plastic pipe. Exactly fitting to this pipe a transparent polystyrene box (filled with a preservative – see above) at the top of the eclector serves as a kind of light trap for all positive phototactic (and negatively geotactic) invertebrates (e.g. juvenile Araneae, Diptera, Hymenoptera). The eclectors were dug into the soil to a depth of 15-20 cm and so the catch results can be attributed exactly to the enclosed area of 1 m_2. All traps were emptied at intervals of 4 weeks. After each sampling period ground photo-eclectors were moved to new, randomly-selected sites within the study plots. In every year the sampling period was restricted to the time span between the beginning of the vegetation period and the harvest time of the crops (3 sampling intervals): 27.03.-19.06.95, 26.03.-18.06.96, 25.03.-17.06.97.

Spiders were identified using the keys of WIEHLE (1956, 1960), ROBERTS (1985, 1987, 1995) and HEIMER, NENTWIG (1991). The nomenclature follows PLATNICK (1998). The activity biomass (dry weight) was calculated according to the algorithm of HENSCHEL et al. (1996), based on literature data of sex specific body lengths of spider species. Founded on pitfall trap sampling, Soerensen's index of similarity modified by BRAY, CURTIS (1957) was used to compare species composition between agrarian habitat types (standardised on 8 pitfall traps per plot). This version of the Soerensen's index (QS) uses quantitative data. The formula is $QS = 2_{jN}/(aN+bN)$ where aN/bN = number of individuals in site A/B, jN = the sum of the lower of the two abundances of species which occur in the two sites (MAGURRAN, 1988). For diversity statistics the α (log series) was used because the discriminant ability of α is good, the sensitivity to sample size is low and it is widely used. To identify characteristic species the niche width, which is a measure of the diversity of resources utilised, was calculated. The estimation of the specific niche width (MÜHLENBERG, 1993) is based on the formula of SIMPSON (1949):

$$sNB_i = \left[\frac{Y_i^2}{\sum_j N_{ij}^2} - 1 \right] \frac{1}{2}$$

sNB_i standardised specific niche width of species i
Y_i total of individuals of species i
N_{ij} frequency of species i in habitat type j

Species with specific niche width values < 0.3 were classified as being characteristic of the respective habitat type (RATSCHKER, ROTH, 1997). The nonparametric Mann-Whitney-U-Test (PC-software SPSS™ 8.0/Windows) was used for the statistical analysis of the data.

Results

During the investigation period from 1995 to 1997 a total of 30 175 individual spiders belonging to 146 species and 16 families were collected by pitfall traps. Using ground photo-eclectors 10 361 specimens (137 species, 16 families) were caught. Juveniles accounted for 13.6% of the catch of pitfall traps and 41.9% of the captures of ground photo-eclectors.

Species diversity, classified species, characteristic species

Regarding the species richness of the ground dwelling spider community, extensively used pastures and long-term fallows contributed (on a significance level of P<0.001) much more to the biodiversity level of the cultural landscape than cereal fields and one-year fallows (Table 2). Thus, based on the results from pitfall traps and ground photo-eclectors, 108/97 (PT/GPE) spider species were attributed to pastures, T a b l e 2. Species/individual numbers, activity biomass [mg dry weight], diversity index α (log series) and its variance of spider communities on agrarian study sites. Significance data of the comparisons of land utilisation types. Data basis: Total catch using pitfall traps (n=8) and ground photo-eclectors (n=6) of the years 1995, 1996, 1997. [1] study site 1 was ploughed up in autumn 1996 and set aside again.

Study sites (year)	Pitfall traps				Ground photo-eclectors			
	Species	Inds	Biomass	α (log series)	Species	Inds	Biomass	α (log series)
Cereal field								
C1 (1995)	28	490	501.1	6.7 ±1.6	24	249	389.9	7.4 ±2.3
C2 (1995)	28	698	474.7	6.1 ±1.3	24	260	233.1	6.8 ±1.9
C6 (1995)	29	297	295.6	8.7 ±2.6	15	73	70.5	8.3 ±4.6
C9 (1995)	33	694	12272	7.4 ±1.7	23	123	135.9	10.8 ± 5.1
C19** (1996)	28	867	3119.7	5.9 ±1.3	19	87	68.9	9.2 ± 4.5
C0** (1996)	30	847	1829.9	5.9 ±1.2	17	260	107.9	4.2 ± 1.1
C0*** (1997)	32	601	1577.1	6.9 ±1.5	17	221	660.0	4.5 ± 1.2
C25** (1996)	25	742	1407.9	4.7 ±0.9	11	159	64.1	2.8 ± 0.7
C25*** (1997)	24	743	1898.5	4.6 ±0.9	15	170	397.7	4.2 ± 1.2
C50** (1996)	22	616	953.2	4.3 ±0.9	27	496	283.6	6.7 ± 1.7
C50*** (1997)	23	764	1431.5	4.4 ±0.8	22	398	1119.3	5.4 ± 1.3
C100** (1996)	24	601	681.1	4.8 ±1.0	21	247	278.2	5.7 ± 1.5
C100*** (1997)	23	985	1254.5	4.1 ±0.7	28	362	677.5	7.6 ± 2.1
Long-term fallow								
F10 (1995)	44	1152	3840.5	9.6 ±2.1	32	356	710.4	11.1 ± 3.8
F11 (1995)	45	1238	4259.6	9.7 ±2.1	39	418	637.3	14.1 ± 5.1
F11** (1996)	46	1100	3594.4	10.4 ±2.3	34	277	346.5	13.9 ± 5.7
F11*** (1997)	62	1305	4064.7	14.1 ±3.2	38	451	430.5	13.9 ± 5.1
F12 (1995)	49	1702	4091.1	9.8 ±1.9	38	696	778.4	10.0 ± 2.6
F12** (1996)	48	1554	4970.4	9.8 ±2.0	37	668	274.5	12.6 ± 4.3
One-year fallow								
F1** (1996)	32	926	2414.2	6.7 ± 1.4	11	74	43.7	4.6 ± 2.0
F1*** (1997)[1]	20	112	205.4	8.1 ± 3.3	18	74	68.3	13.0 ± 9.3
F4 (1995)	35	1112	2668.9	7.0 ± 1.4	28	276	290.7	8.7 ± 2.7
Grassland								
G3 (1995)	61	949	3576.3	15.5 ± 3.9	51	1015	564.4	20.7 ± 8.4
G3** (1996)	49	495	1386.0	15.2 ± 4.7	40	778	548.3	13.7 ± 4.8
G7 (1995)	41	985	2636.4	9.0 ± 2.0	38	469	1018.8	11.0 ± 3.2
G8 (1995)	40	1378	3368.6	7.9 ± 1.6	27	254	412.9	8.5 ± 2.7
G8** (1996)	37	3300	11163.6	5.9 ± 1.0	25	811	784.8	5.6 ± 1.3
G8*** (1997)	36	2336	6648.3	6.1 ± 1.1	33	639	558.8	9.0 ± 2.4
Significance level								
Field – Fallow	***	***	***	***	***	**	ns	***
Field – Fallow (one-year)	ns	ns	ns	ns	ns	ns	ns	ns
Field – Grassland	***	*	**	*	**	**	*	*
Fallows long-term – one-year	*	*	*	*	*	*	*	ns
Fallow (long-term)-Grassland	ns	ns	ns	ns	ns	ns	ns	ns
Fallow (one-year) - Grassland	*	ns	ns	ns	ns	*	*	ns

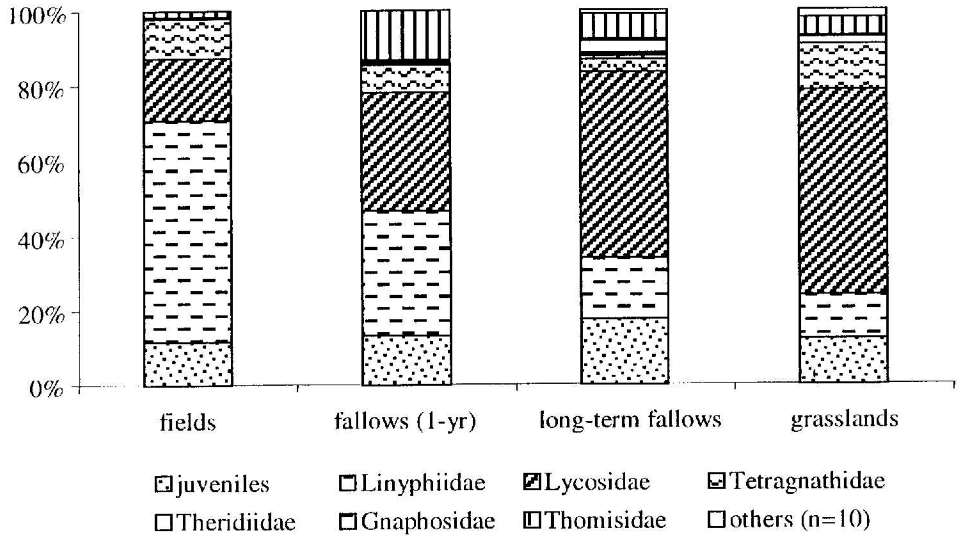

Fig. 1. Dominance structure of spider assemblages at family level in agrarian habitat types: field (n = 13), fallow (one-year/long term; n=3/6), grassland (n=6) – based on catch results of pitfall traps (1995-1997).

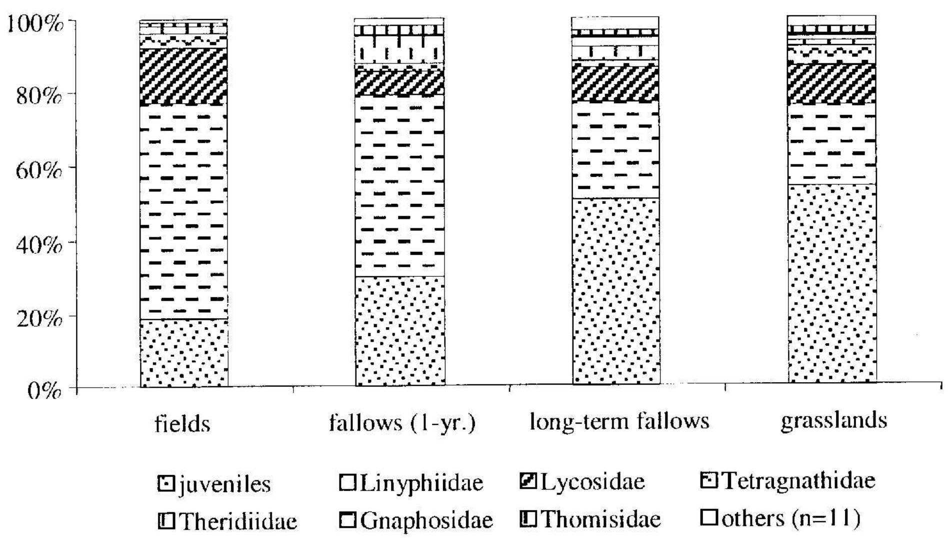

Fig. 2. Dominance structure of spider assemblages at family level in agrarian habitat types: field (n=13), fallow (one-year/long-term; n=3/6), grassland (n=6) – based on catch results of ground photo-eclectors (1995-1997).

101/89 to long-term fallows, 78/69 to cereal fields and 78/69 to one-year fallows. In all years of investigation, according to pitfall traps, most spider species inhabited a long-term fallow (F11: 45 – 62 species) and a semi-dry pasture extensively grazed by sheep (P3: 49 – 61 species). In cereal fields most species were caught in the pitfall traps of a biodynamically managed crop (C9: 33 species) that was grown after a four-year fallow period (Table 1). In addition, the effects of fallowing on species diversity became obvious on a hay meadow (G8). Most spider species were caught in pitfall traps in the first year of investigation (Table 2). However, as documented for fallows developed from cereal fields (F1**, F1***, F4), set aside had little effect on species richness in the first year of land use management.

Among the 179 species and 40 536 individuals of spiders collected during the study by pitfall traps and ground photo-eclectors on agrarian habitat types, 18% of the species and 1% of the individuals are listed in the Red-Data-Book of Germany (29 species/413 individuals) or Brandenburg (21 species/257 individuals) according to PLATEN et al. (1998, 1999), respectively.

The greatest number of classified species (n = 21) and individuals (n = 344) was sampled (PT and GPE) on the habitat type „grassland". However, it has to be mentioned that 12 species and more than half of the individuals were restricted to a semi-dry sporadically-grazed sheep-pasture (G3). On this study site the lycosid *Alopecosa schmidti* (HAHN) as well as the linyphiids *Mecynargus foveatus* (DAHL) and *Trichopterna cito* (O. P.-CAMBRIDGE) belonged to the most frequent classified species of national importance. A similar range of classified species (n = 20) and individuals (n = 65) were sampled on fallows and here above all on long-term set asides. Thus, compared to young fallows (9 species), 15 species of the Red Data Books were recorded on long-term fallows (e.g. *Cheiracanthium campestre* LOHMANDER; *Gongylidiellum murcidum* SIMON; *Zelotes longipes* (L. KOCH)). The lowest number of classified species (n = 7) and individuals (n = 16) was found on the habitat type „cereal field", among them *Ero cambridgei* KULCZYŃSKI, a species feeding on other Araneae and characterised by an extraordinary prey capture strategy (BELLMANN, 1997). Four species, classified as „endangered" (category 2) in the Red-Data-Book of Germany (Theridiidae: *Enoplognatha oelandica* (THORELL); Clubionidae: *Cheiracanthium campestre* LOHMANDER; Philodromidae: *Thanatus arenarius* THORELL and *Thanatus striatus* C. L. KOCH) were collected on all agrarian habitat types, however mainly on fallows and pastures.

According to the calculation of the niche width the linyphiids *Porrhomma microphthalmum* (O. P.-CAMBRIDGE), *Erigone atra* BLACKWALL, *Erigone dentipalpis* (WIDER), *Savignia frontata* BLACKWALL and *Meioneta rurestris* (C. L. KOCH) were classified as characteristic species for the habitat type „cereal field". With respect to fallows, the same was valid for *Pelecopsis parallela* (WIDER), *Oedothorax retusus* (WESTRING) (Linyphiidae) as well as *Trochosa ruricola* (DE GEER) and *Alopecosa barbipes* (SUNDEVALL) (Lycosidae). *Thanatus arenarius* THORELL (Philodromidae), *Trichopterna cito* (O. P.-CAMBRIDGE) (Linyphiidae) and *Zelotes electus* (C. L. KOCH) (Gnaphosidae) belonged to the species which were characteristic of the habitat type „grassland".

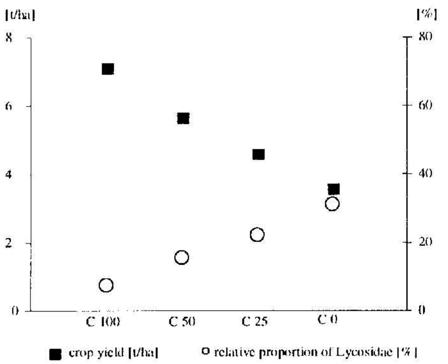

Fig. 3. Dominance level [%] of Lycosidae and the crop yield (t/ha) on winter wheat fields using pitfall traps (3rd trapping period 1996: 22.05.-18.06.96).

Presence-absence analysis of pitfall trap data showed that only four species (*Erigone atra* BLACKWALL; *Meioneta rurestris* (C. L. KOCH); *Pachygnatha degeeri* SUNDEVALL; *Pardosa palustris* (LINNAEUS)) were recorded on all study sites in all years of investigation.

Relative abundance, activity biomass, dominance structure and diversity indices

Number of individuals and activity biomass of ground dwelling spider assemblages reflected in general the habitat type-specific relations as mentioned above for species richness. With few exceptions (C19, C50***, C100***, G3**) the highest levels of relative abundance and activity biomass were documented on long-term fallows and grasslands, independent of the sampling method (Table 2). By far the most specimens (n=3300) and activity biomass (11g dry weight) were captured during the investigation period of 1996 in the pitfalls of an extensively used hay meadow (G8**), which developed from a two-year fallow (Table 1). Contrary to species diversity, a one-year period of set aside (C19**) or fallowing of cereal fields (F1**, F4) seemed to promote immediately the relative abundance and activity biomass of spider the assemblage.

At family level the dominance structure of the spider assemblage was clearly affected by the agrarian habitat types. According to pitfall traps (Fig. 1) and ground photo-eclectors (Fig. 2) Linyphiidae dominated the ground- dwelling spider community of „cereal fields". On average this taxon comprised about 60% of the total catch in fields under cultivation. On the other types of agroecosytems the relative abundance of linyphiids decreased in the following sequence: one-year fallow (33.4%) > several-year fallow (16.4%) > meadows (11.8%). Based on pitfall traps, the opposite distribution pattern was documented for lycosid spiders (Fig. 1): cereal fields (16.4%) < one-year fallow (31.5%) < several-year fallows (49.7%) < grasslands (54.5%). For both taxa the differences in the dominance structure of the habitat types was in most cases statistically significant (Mann-Whitney-U-test, P<0.01). As shown for cereal fields cultivated with winter wheat, the relative abundance of lycosids decreased significantly (Spearman correlation coefficient, r=-1.0, P<0.01) with increasing stalk density and thus crop yield (Fig. 3).

In addition, the dominance level of Gnaphosidae (PT, GPE) and Thomisidae (PT) varied significantly in dependence on the habitat type. Pasture management as well as fallowing favoured both taxa (Fig. 1 and 2).

	cereal fields													fallows									grasslands					
study sites	C1	C2	C6	C9	C0**	C0***	C100**	C100***	C19**	C25**	C25***	C50**	C50***	F10	F11	F12	F11**	F11***	F12**	F4	F1**	F1***	G3	G7	G8	G3**	G8**	G8***
C1	XXX	XX	XXX	XX	XXX	XX	XX	XXX	X	X	X	XX	X	X	XXX	X	XX	XX	XX	XXX	XXX	XXX	XX	X	XX	X	XX	XXX
C2	0,83	XXX	XX	XXX	XX	XXX	XXX	X	XXX	XXX	XXX	XXX	XXX	XX	XXX	X	XXX	XXX	XXX	XX	XX	XX	XX	XXX	XX	X	X	XX
C6	0,67	0,53	XXX	XXX	X	XX	XX	XXX	XX	X	X	XX	X	XXX	XXX	XXX	XX	XXX	X	X	X	XX	X	X	XXX	XXX	XXX	X
C9	0,90	0,92	0,67	XXX	XXX	XX	XX	XXX	XX	XX	X	XXX	X	XX	X	XXX	XX	X	XXX	X	X	XX	XXX	XX	XXX	XX	XXX	X
C0**	0,69	0,88	0,43	0,70	XXX	XX	XX	XXX	XX	XXX	XXX	XX	XXX	XXX	XXX	X	XXX	XXX	XX	XX	XXX	X	XX	XXX	XX	XX	X	XX
C0***	0,88	0,92	0,60	0,87	0,81	XXX	XXX	X	XXX	XX	XX	XXX	XX	XX	XXX	XX	XX	X	XXX	XXX	XX	XX	XXX	XX	XXX	X	XXX	X
C100**	0,86	0,96	0,54	0,85	0,82	0,98	XXX	X	XXX	XX	XX	XXX	XX	XXX	XXX	XXX	XXX	XX	X	X	XXX	XX	XXX	XX	X	XX	XXX	X
C100***	0,62	0,78	0,37	0,68	0,91	0,73	0,74	XXX	XX	XX	XX	X	XX	XXX	XX	XX	XX	XXX	XXX	XXX	XXX	X	XXX	XX	XXX	X	XX	XXX
C19**	0,78	0,98	0,51	0,87	0,90	0,91	0,92	0,82	XXX	XXX	XXX	XX	XXX	XX	XX	XXX	XX	X	XXX	XX	XXX	XX	XX	XX	X	XX	XXX	X
C25**	0,75	0,94	0,48	0,82	0,94	0,87	0,88	0,85	0,96	XXX	XXX	XX	XXX	XXX	XXX	XXX	XXX	XXX	XX	X	XXX	XX	XXX	XXX	XX	XX	X	XX
C25***	0,76	0,96	0,50	0,75	0,92	0,88	0,90	0,84	0,98	0,99	XXX	XX	XXX	XXX	XXX	XXX	XXX	XXX	X	XX	XXX	XX	XX	XXX	XX	XX	XXX	XX
C50**	0,87	0,94	0,57	0,96	0,81	1,00	0,99	0,73	0,90	0,87	0,88	XXX	XX	XX	XX	XX	XX	X	X	XXX	XX	XX	XX	X	XXX	XXX	XXX	X
C50***	0,75	0,94	0,47	0,75	0,93	0,88	0,89	0,84	0,97	0,99	1,00	0,88	XXX	XXX	XXX	XXX	XXX	XX	XX	XXX	XXX	XX	X	XXX	XX	X	X	XX
F10	0,72	0,83	0,70	0,82	0,98	0,84	0,94	0,92	0,86	0,97	0,95	0,81	0,94	XXX	XXX	X	XXX	XXX	XX	XXX	XXX	XX	XX	XXX	XX	XX	X	XX
F11	0,66	0,70	0,91	0,79	0,93	0,94	1,00	0,88	0,87	0,94	0,95	0,88	0,94	0,97	XXX	XX	XXX	XXX	XX	XXX	XXX	XX	X	XXX	XX	X	X	XX
F12	0,46	0,71	0,34	0,62	0,72	0,57	0,61	0,81	0,64	0,67	0,65	0,56	0,68	0,77	0,83	XXX	XXX	XX	XXX	XX	X	X	XXX	X	XXX	XX	XXX	X
F11**	0,81	0,68	0,84	0,84	0,94	0,85	0,96	0,87	0,90	0,98	0,93	0,86	0,91	0,98	0,94	0,98	XXX	XX	XX	XXX	XXX	XX	XX	XXX	XX	XX	X	XX
F11***	0,60	0,93	0,69	0,73	0,96	0,74	0,81	0,95	0,78	0,91	0,93	0,78	0,89	0,92	0,93	0,86	0,88	XXX	XXX	XXX	XX	X	X	XX	XXX	X	XX	XXX
F12**	0,52	0,96	0,43	0,64	0,84	0,69	0,75	0,98	0,70	0,81	0,76	0,71	0,83	0,84	0,89	0,93	0,84	0,97	XXX	XXX	X	X	XX	XX	XXX	XX	XX	XXX
F4	0,61	0,83	0,42	0,76	0,85	0,70	0,77	0,98	0,80	0,78	0,82	0,68	0,91	0,95	1,00	0,83	0,95	0,95	0,93	XXX	XX	X	XXX	XXX	XXX	X	X	XXX
F1**	0,70	0,90	0,46	0,78	0,99	0,82	0,91	0,91	0,92	0,95	0,94	0,82	0,99	0,95	0,98	0,71	0,93	0,84	0,78	0,88	XXX	X	XXX	XXX	X	XX	X	XX
F1***	0,33	0,25	0,56	0,30	0,19	0,27	0,27	0,17	0,23	0,22	0,22	0,28	0,22	0,21	0,25	0,12	0,21	0,17	0,16	0,15	0,20	XXX	X	XX	X	X		
G3	0,88	0,81	0,72	0,99	0,52	0,70	0,35	0,69	0,55	0,68	0,52	0,89	0,20	0,81	0,76	0,94	0,85	0,73	0,85	0,92	0,92	0,71	XXX	XX	X	XXX	XX	XXX
G7	0,71	0,97	0,50	0,81	0,99	0,82	0,87	0,88	0,88	0,97	0,95	0,80	0,97	0,97	0,95	0,75	1,00	0,88	0,83	0,91	0,96	0,22	0,82	XXX	X	X	X	XX
G8	0,58	0,84	0,40	0,67	0,88	0,65	0,74	0,91	0,71	0,81	0,81	0,65	0,84	0,83	0,86	0,93	0,85	0,96	0,97	0,93	0,79	0,16	0,71	0,80	XXX	X	XX	X
G3**	0,50	0,47	0,69	0,57	0,29	0,42	0,27	0,19	0,90	0,30	0,23	0,38	0,18	0,52	0,47	0,59	0,55	0,45	0,54	0,48	0,55	0,71	0,66	0,48	0,43	XXX	X	X
G8**	0,27	0,79	0,39	0,35	0,45	0,33	0,36	0,51	0,37	0,41	0,40	0,33	0,42	0,47	0,49	0,65	0,44	0,51	0,58	0,50	0,42	0,06	0,29	0,45	0,60	0,15	XXX	XX
G8***	0,35	0,85	0,46	0,44	0,58	0,43	0,44	0,64	0,48	0,52	0,52	0,42	0,51	0,59	0,57	0,80	0,54	0,65	0,68	0,64	0,56	0,08	0,34	0,55	0,74	0,17	0,84	XXX

legend:

QS	0-0.1	>0.1-0.2	>0.2-0.3	>0.3-0.4	>0.4-0.5	>0.5-0.6	>0.6-0.7	>0.7-0.8	>0.8-0.9	>0.9-1.0
symbol		x	xx	xxx	x	xx	xxx	x	xx	xxx

Fig. 4. Similarity index according to Soerensen (QS) modified by *Bray & Curtis* (1957) based on pitfall traps.

As expected, α diversity was lowest on cereal fields, independent of the sampling method (Table 2). The relatively high α values of C6 (PT/GPE), C9 (GPE) and C19** (GPE) compared to the median (median ± median absolute deviation) of cereal fields (α_{PT}=5.9 ±1.2; α_{GPE}=6.7 ±1.8) may reflect the effects of adjacent non-managed habitat types (C6, see also below) or of a previous fallowing period (C9, C19).

Reaching maximum values on long-term set asides (maximum: α=14.1; median: α_{PT}=9.8 ±1.2; α_{GPE}=13.3 ±1.4), fallows generally were characterised by significantly higher diversity indices than cereal fields. Even most of the one-year fallows a values (average: α_{BF}=7.0 ±0.6 bzw. α_{BPE}=8.7 ±2.8) exceeded the average of fields (Table 2).

Within agrarian habitat types extensively used pastures (e.g. G3: α_{PT}=15.5, α_{GPE}=20.7) reached the highest levels of diversity. Diversity-index levels of an intensively used cattle pasture (G7) and an extensively used hay meadow (G8) approximately corresponded to the one-year fallows.

Success of reproduction

Ground photo-eclector sampling demonstrated very impressively the effects of agrarian habitat type on juvenile spiders (Fig. 2). Thus, the abundance of spiderlings differed significantly ($P<0.01$) between cereal fields, one-year fallows, long-term fallows and grasslands. On cereal fields juvenile spiders comprised only 20% of total catch results. Most juveniles were obtained on pastures ($P<0.05$) and long-term fallows ($P<0.05$).

Soerensen-index of similarity

With few exceptions (F1***, G8**), estimates of the Soerensen-index showed relatively high similarities between spider assemblages of different agrarian habitat types (Fig. 4). Even study plots, which are extremely variable in abiotic site conditions and agricultural practice, such as a semi-dry pasture with a sandy soil texture, grazed sporadically by sheep (G3) and a cereal field on loamy soil, managed biodynamically (C9), reached a similarity index of 0.99. Nevertheless, the highest congruency of spider community structure was manifested among the habitat type „cereal field". Especially the spider assemblage of C2, a conventionally managed field, cultivated with winter barley during the investigation period 1995 showed high similarity to other study plots of the habitat type „cereal field". Field size, combined with the characteristics of adjacent habitats, seemed to be an important parameter, determining similarity levels of spider assemblages on cereal fields. Thus C6, a relatively small-sized winter rye field, almost completely surrounded by forests and hedgerows, differed clearly from other cereal fields with respect to Soerensen index. On the other hand, the similarity index of 0.91 indicated that the species composition of the C6 spider community was more congruent with an old fallow (F11).

Discussion

Among agrarian habitat types representative of the cultural landscape of Northeast Germany, cereal fields were characterised by low numbers of spider species. In contrast to this, grasslands – especially extensively grazed pastures as well as long-term fallows – promoted the diversity of species, while one-year periods of set aside had little effect on species richness. Regarding species diversity itself as a common objective of nature conservation (CROZIER, 1997), extensive grazing as well as taking fields out of the cultivation cycle for several years seem to be convenient tools for the realisation of species protection in agrarian landscapes independent of abiotic site conditions (e.g. soil type) (KLINGE, 1993; STRÜVE-KUSENBERG, 1980).

Without ignoring the fact, that few classified species tolerate arable farming (RATSCHKER, ROTH, 1997; VOLKMAR, WETZEL, 1998), the distribution pattern of species recorded in the Red-Data-Book caught on agrarian habitat types showed the importance of extensively managed habitats, such as long-term fallows and semi-dry grasslands, for species diversity in general and for endangered species particularly.

Moreover, in agrarian landscapes pastures and fallowing over several years may function as source habitats for the recolonisation of agroecosystems. As has been demonstrated by ground photo-eclectors, pastures and long-term fallows were characterised by a high number of juvenile spiders. Due to the dispersal strategy (ballooning behaviour) of most spider species these habitat types may contribute to the maintenance of spider assemblages on adjacent cereal fields. With respect to the role of spiders as antagonists of insect pests (e.g. MARC, CANARD, 1997; WYSS et al., 1995), the occurrence of pastures and long-term fallows in the habitat mosaic of cultural landscapes, surely promotes biological pest control on arable land.

Assuming that the activity biomass of spiders is a suitable indicator of prey consumption (e.g. BISHOP, 1980), another mechanism to increase the antagonist potential of cereal fields is the interruption of the cultivation cycle by a one-year period of set aside.

The investigation confirmed the indicator qualities of spider assemblages. Also other authors (e.g. KLEINHENZ, BÜCHS, 1995; RATSCHKER, ROTH, 1999; RIECKEN, 1998; STIPPICH, KROOß, 1997) point to the outstanding indicative properties of the dominance level of wolf spiders (see Fig. 3), to characterise the types and intensities of land use. The predominance of the Linyphiidae, (e.g. VOLKMAR, SCHÜTZEL, 1997) is typical for arable land and of one-year fallows. The selection of the characteristic species for the various types of land use is corroborated at least partially by PLATEN (1996). The estimation of similarity indices has clearly shown the close interlinking between spider assemblages of different agrarian habitat types.

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