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The importance of semi-natural landscape structures in an agricultural landscape as habitats for stenotopic spiders

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Summary

Spatial distribution and habitat use of epigeic spiders have been investigated along two transects across valleys in an agricultural landscape near Bonn, Germany, ranging across semi-natural habitats (forests, river banks, wet fallows) and agricultural areas (pastures, arable land). The aim of the study was to analyse the function of different habitats and landscape features as guidelines or refuge zones for more or less stenotopic spiders. Some of the woodland species (e.g. *Histopona torpida* C. L. Koch, 1834) were recorded from larger beech–oak forests only. Other species, like *Coelotes terrestris* (Wider, 1834) and *Lepthyphantes flavipes* (Blackwall, 1854), are apparently also able to settle in semi-natural river banks with alder (*Alnus glutinosa*) and willows (*Salix* spp.) and may possibly use these as connecting lines between habitats. Additionally, a number of species (e.g. *Diplocephalus picinus* (Blackwall, 1841) and *Micrargus herbigradus* (Blackwall, 1854)) clearly prefer these stream banks. Wet fallows maintain a specific spider community. Typical representatives are *Oedothorax gibbosus* (Blackwall, 1841) and *Antistea elegans* (Blackwall, 1841). For these species wet fallows are clearly important refuges.

Introduction

The development of agricultural landscapes during the last decades has been characterized by an increase in management intensity, and a consequent decrease in the number and size of natural and semi-natural habitats. As a result, isolation of populations of stenotopic species of forests, shores, heathers, etc., has increased. This is a serious problem, especially for smaller invertebrates with low dispersal ranges like snails, wingless insects (Mader, 1979; Mader *et al.,* 1990) and spiders without ballooning behaviour. For these species linear or patchy natural and semi-natural landscape features may be important as guidelines or stepping-stones between habitats. Therefore the incorporation of habitat considerations within landscape planning and other nature conservation activities is considered very important in Germany. To this end, a large number of hedges and other linear or patchy landscape features have been introduced by a range of different organizations. However, little has been known until now about the ecological function of such landscape features as guidelines, stepping-stones or refuge zones within agricultural landscapes.

This study on spiders forms part of the long-term project "Habitat and species protection in the cultivated landscape", carried out by the Federal Agency for Nature Conservation. The main aim of this project is to analyse the function of different habitats and landscape features for more or less specialized animals belonging to different taxa (birds and mammals: Blab *et al*., 1989; amphibians and reptiles: Blab *et al*., 1991; Syrphidae: Ssymank, 1993). The results presented in this paper form part of a series of studies on epigeic arthropods (Carabidae: Riecken & Ries, 1993a,b; Riecken & Raths, 1996).

I have focused on the following questions: (1) which spider species inhabit the different biotopes and landscape features within an agricultural landscape; (2) are there any specialists (stenotopic) species; (3) to what extent are supposed eurytopic species eurytopic; and (4) which landscape features (e.g. semi-natural

no.	code	transect	investigation period	habitat
1	for1	I	3.90–3.92	beech–oak forest on acid soil with poor herb vegetation
22	for22	I	3.92–3.94	beech–oak forest on acid soil with poor herb vegetation mixed with *Pinus silvestris* and *Ilex* shrubs
24	for24	a	3.92–3.94	beech–oak forest on acid soil with poor herb vegetation
11	alf11	II	3.90–3.92	pastured red alder forest with springs
14	alf14	II	3.90–3.92	red alder forest with natural flood dynamic
5	rib5	I	3.90–3.92	shady river bank with red alder riparian forest, mixed with *Prunus padus*
13	rib13	II	3.90–3.92	river bank with red alder riparian forest partly mixed with *Urtica dioica* stands
26	rib26	a	3.92–3.94	muddy river bank with red alder riparian forest
27	rib27	a	3.92–3.94	bank top of river bank 26 with mesotrophic grassland Molinio-Arrhenatheretea community
25	pla25	a	3.92–3.94	young plantation of *Quercus petraea*, mixed with blackberry bushes and birch trees on acidic soil
18	fal18	a	3.90–3.92	mesophilic fallow surrounded by forest, partly covered with blackberry bushes and young trees (aspen)
4	rib4	I	3.90–3.92	linear red alder riparian forest close to the river bank exposed to the sun with rich tall herb vegetation
2	wfal2	I	3.90–3.92	wet fallow (Convolvuletalia), smaller parts with Filipendulion-community and Magnocaricion
17	wfal17	a	3.90–3.92	wet fallow with sedges, *Carex acutiformis* community, Magnocaricion
12	wpas12	II	3.90–3.92	wet pasture with *Juncus effusus*
7	pas7	I	3.90–3.92	intensively managed mesophilic pasture Lolio-Cynosuretum
15	pas15	II	3.90–3.92	intensively managed mesophilic pasture Lolio-Cynosuretum
19	pas19	a	3.90–3.92	intensively managed mesophilic pasture Lolio-Cynosuretum with apple trees, surrounded by forest
10	field10	II	3.90–3.92	extensively managed crop field with rich stands of weeds, Aphano-Matricarietum
8	field8	I	3.90–3.92	intensively managed crop field with few or no weeds

Table 1: List of the investigated sites; order corresponds to the results of a cluster analysis (UPGM linkage) based on the "percentage similarity" (RENKONEN index) (I = transect I, near the village of Pech; II = transect II, near the village of Zuellighoven; a = additional site).

river banks with alder galleries, wet fallows) work as refuge zones, stepping-stones or possibly as guidelines for typical species of (semi-) natural habitats?

Study area

The study area is a typical agricultural landscape south of Bonn (North-Rhine-Westphalia) (Fig. 1). The landscape is characterized by intensively used arable land, meadows and orchards and more or less patchy forests. Landscape features include smaller semi-natural river valleys with wet grasslands, smaller alder riparian forests, semi-natural river banks and small fallows, mostly former wet pastures (Table 1).

Spatial distribution and habitat use of epigeic spiders were investigated along two transects across two valleys (transect I near the village of Pech; transect II near the village of Zuellighoven) ranging from semi-natural to agricultural areas, and also in some additional habitats nearby, not covered by the two transects. Table 1 lists all 20 habitats investigated.

Methods

Spiders and carabid beetles (see Riecken & Raths, 1996) were collected by pitfall traps (350 ml honey-glasses, opening diameter 7 cm) filled with 125 ml formaldehyde solution (2%) and protected by a roof of acrylic glass

family	no. of species		abundance	
Agelenidae	4	2.4%	1166	2.31%
Amaurobiidae	4	2.4%	827	1.64%
Anyphaenidae	1	0.6%	6	0.01%
Clubionidae	9	5.4%	94	0.19%
Corinnidae	1	0.6%	1	0.00%
Dictynidae	1	0.6%	29	0.06%
Dysderidae	2	1.2%	12	0.02%
Gnaphosidae	5	3.0%	48	0.10%
Hahniidae	2	1.2%	172	0.34%
Liocranidae	2	1.2%	5	0.01%
Linyphiidae	96	57.1%	37,545	74.39%
Lycosidae	16	9.5%	9254	18.34%
Mimetidae	1	0.6%	3	0.01%
Philodromidae	3	1.8%	3	0.01%
Pisauridae	1	0.6%	33	0.07%
Salticidae	3	1.8%	12	0.02%
Segestridae	1	0.6%	2	0.01%
Tetragnathidae	3	1.8%	934	1.85%
Theridiidae	5	3.0%	115	0.23%
Thomisidae	7	4.2%	135	0.27%
Zoridae	1	0.6%	75	0.15%
Σ	**168**		**50,471**	

Table 2: Species numbers and abundance of the spider families.

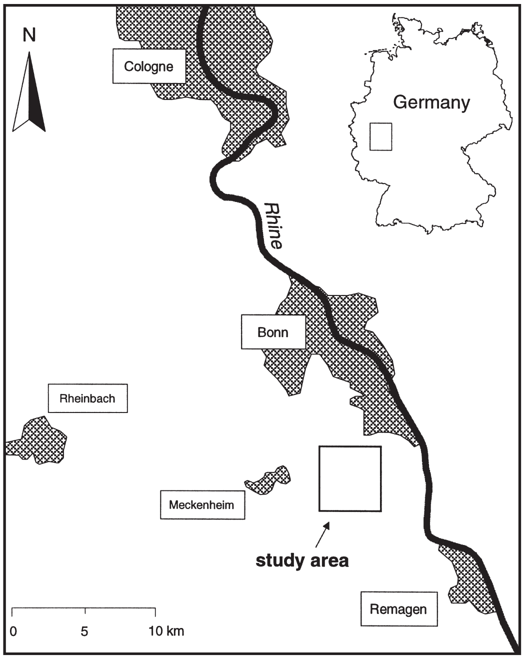

Fig. 1: Map of the study area.

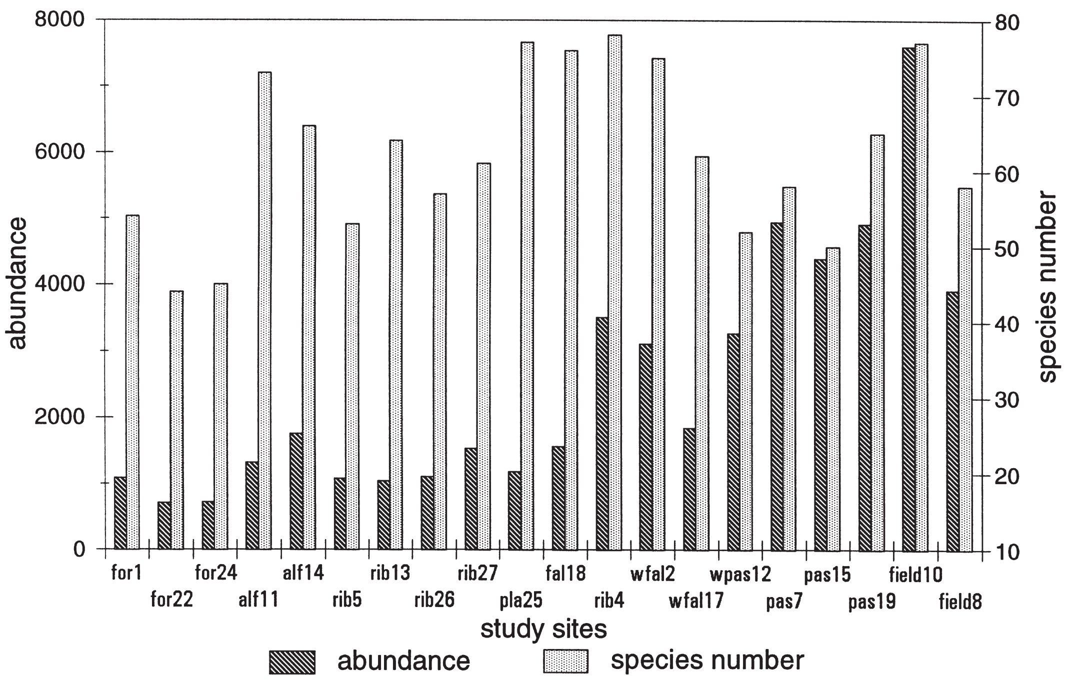

Fig. 2: Species number and abundance, based on catches over two years with four pitfall traps per site.

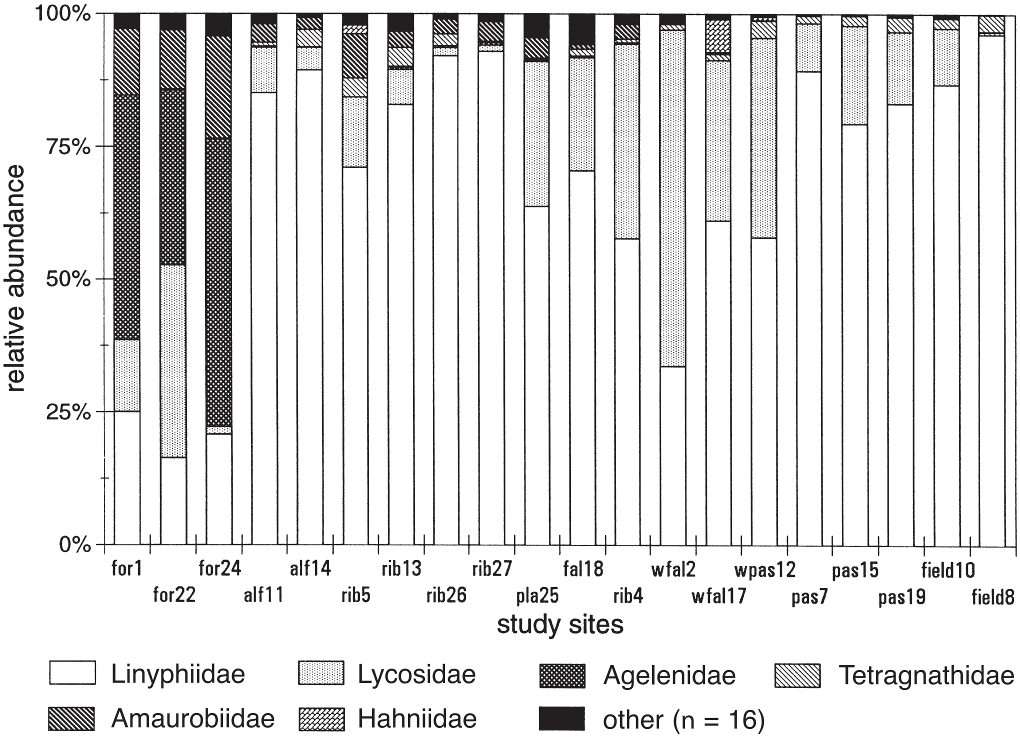

Fig. 3: Composition of the spider communities at family level.

(20 × 20 cm). Four traps were laid, in a line 5 m apart, in each habitat for two different periods over two years : March 1990 to March 1992 and March 1992 to March 1994 (Table 1).

Results

Altogether, 50,471 adult spiders belonging to 168 species were caught. The most important families were the Linyphiidae (74.4% of the total catch), Lycosidae (18.3%), Agelenidae (2.3%), Tetragnathidae (1.9%) and Amaurobiidae (1.64%). The remaining 17 families cover only 1.5% of the total abundance but 27% of the recorded species (Table 2).

There are large differences between the sites both in species number and in activity. The largest numbers of species were recorded from one of the river bank habitats (rib4: 78 species), one alder forest (alf11: 72), one wet fallow (wfal2: 72) and field10 (75); the lowest numbers from the forest sites (44–54 species), the wet pasture (wpas12: 52) and one pasture (pas15: 50) (Fig. 2). Activity was generally higher in all open habitats (wet fallows, pastures, fields) than in the forests and river banks (see Fig. 2).

The spider communities also differ at family level (Fig. 3). Lycosidae played a dominant role in all open habitats with no to extensive agricultural use (30.1–63.3%); Agelenidae dominated the larger forest sites (32.9–54.4%). The Linyphiidae covered more then 50% of the total abundance (maximum: 96.2% in field8) in most open and river bank habitats with the exception of one wet fallow (wfal2).

Based on the "percentage similarity" (RENKONEN index: Renkonen, 1938) a cluster analysis (UPGM linkage: Sneath & Sokal, 1973; Legendre & Legendre, 1987) was carried out comparing the habitat use of all species representing each more than 0.1% of the total catch (n = 55). The results (Fig. 4) show that the nearest related species had a similarity of 89% (*Oedothorax apicatus* (Blackwall, 1850) and *Meioneta rurestris* (C. L. Koch, 1836)); 88%

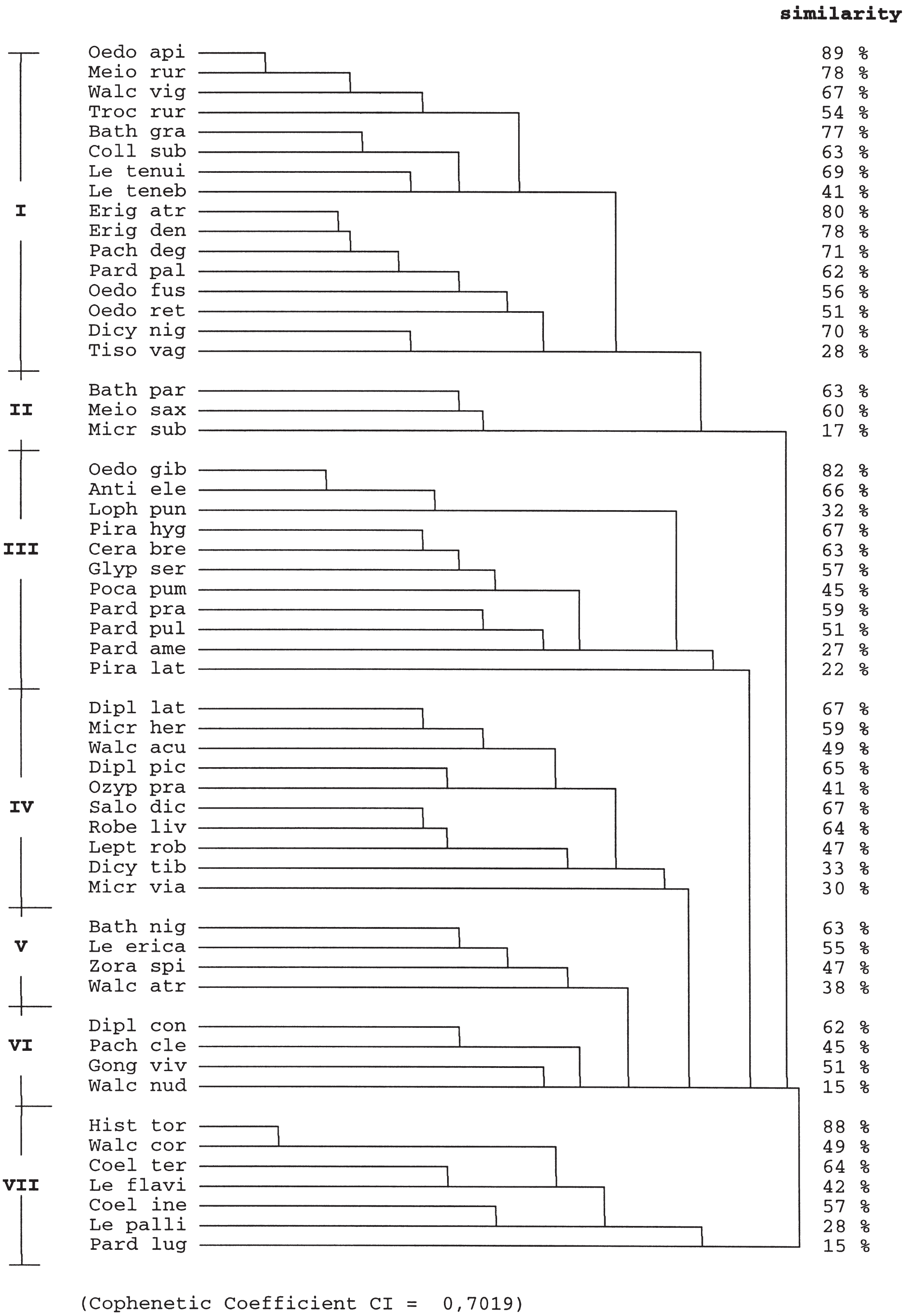

Fig. 4: Cluster analysis (UPGM linkage) on the similarity of the most frequent species ($n = 55$; minimum: 0.1% of the total catches) based on the "percentage similarity" (Renkonen index).

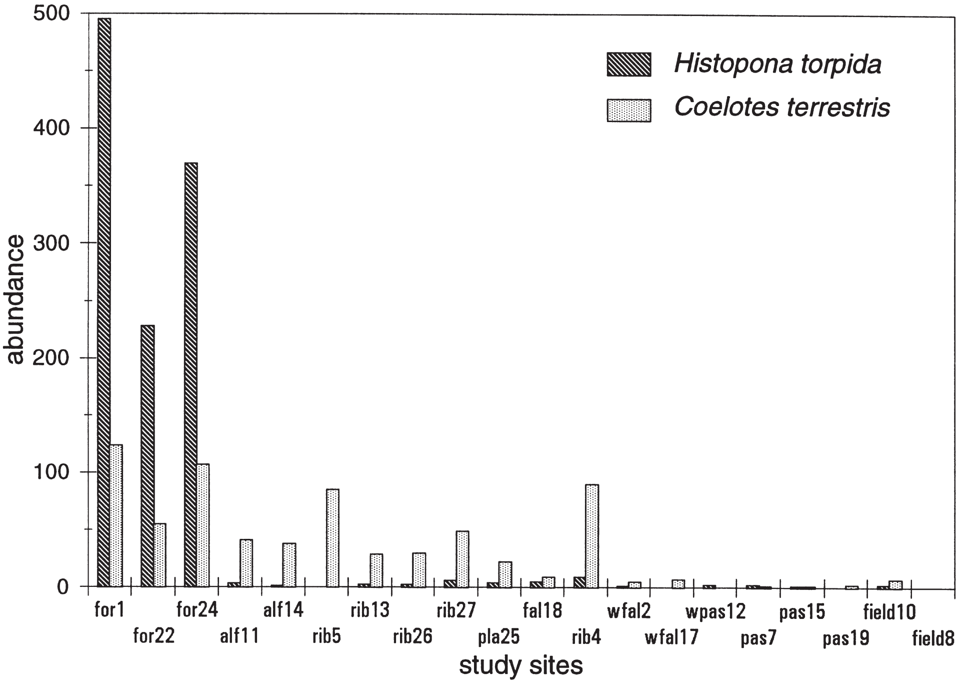

Fig. 5: Abundance of *Histopona torpida* and *Coelotes terrestris*, based on catches over two years with four pitfall traps per site.

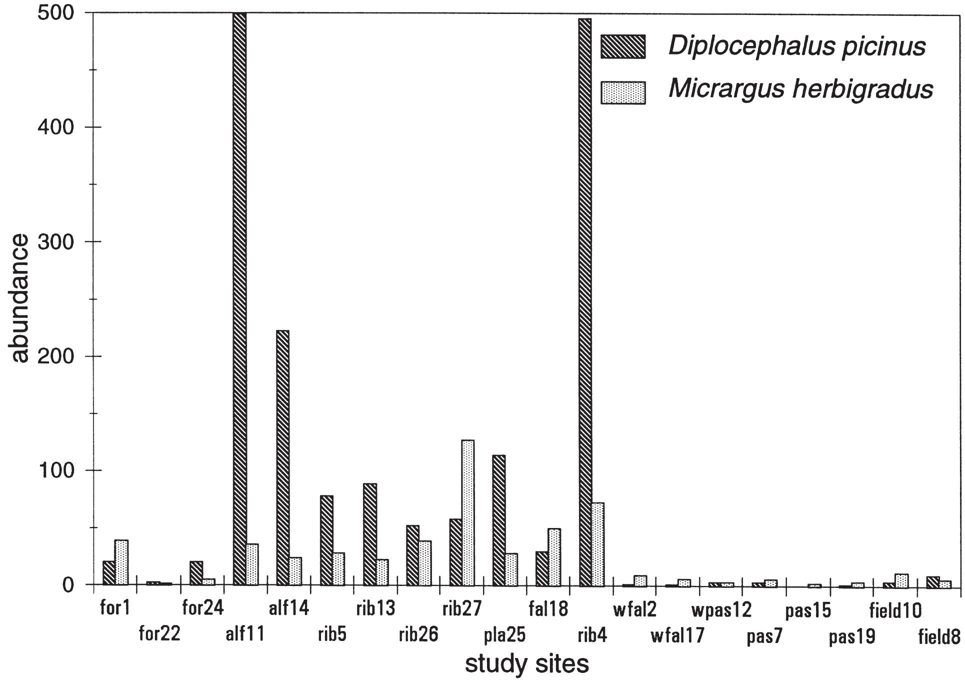

Fig. 6: Abundance of *Diplocephalus picinus* and *Micrargus herbigradus*, based on catches over two years with four pitfall traps per site.

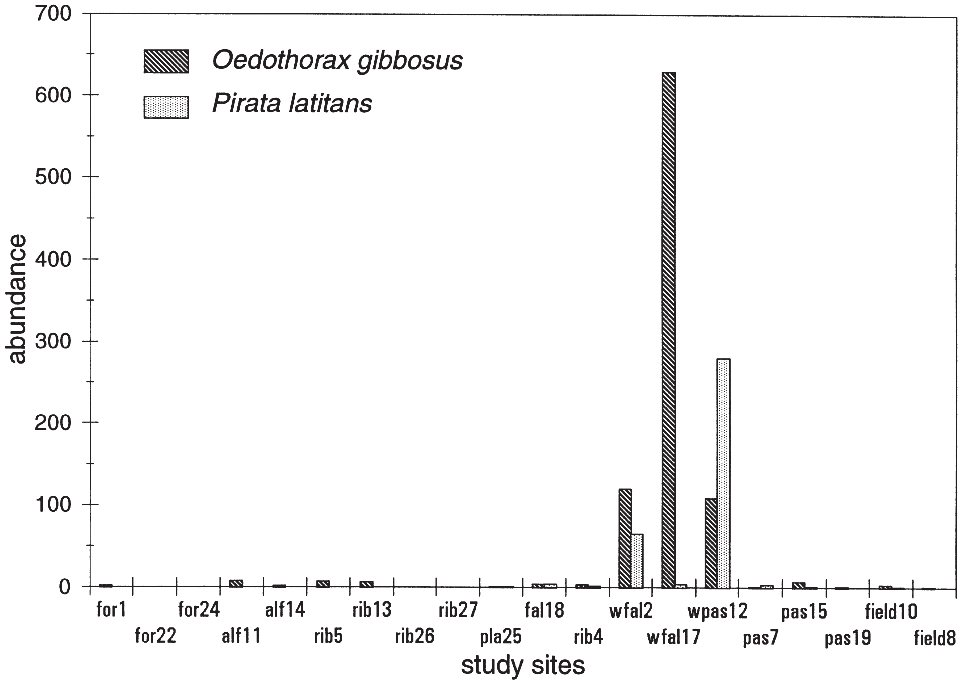

Fig. 7: Abundance of *Oedothorax gibbosus* and *Pirata latitans*, based on catches over two years with four pitfall traps per site.

(*Histopona torpida* C. L. Koch, 1834 and *Walckenaeria corniculans* (O. P.-Cambridge, 1875)); and 82% (*Antistea elegans* (Blackwall, 1841) and *Oedothorax gibbosus* (Blackwall, 1841)). That means that most species showed an individual kind of habitat use. Nevertheless, at least seven groups of species representing different types of habitat preference can be distinguished. Some of them were strictly restricted to the semi-natural habitats in the study area. *H. torpida* represents a group of species that could be recorded in larger forests only (Fig. 5). In contrast to that, other woodland species like *Coelotes terrestris* (Wider, 1834) could live in a broad range of forest habitats including the alder riparian forests at the river banks (Fig. 5).

A second group of typical woodland species, represented by *Diplocephalus picinus* (Blackwall, 1841) and *Micrargus herbigradus* (Blackwall, 1854), preferred wet alder riparian forests (Fig. 6) and avoided mesophilic forests. These habitats seem to be a suitable habitat for a typical spider fauna, different from the mesophilic forests, as well as a possible guideline for more or less eurytopic woodland species but not for more stenotopic ones.

Oedothorax gibbosus (Fig. 7) belongs to a relatively large group of species (including *Antistea elegans, Ceratinella brevipes* (Wider, 1834), *Lophomma punctatum* (Blackwall, 1841), *Pirata hygrophilus* (Thorell, 1872)) which prefer open and wet habitats. Nevertheless, each of them gives an individual picture of habitat use. In the study area only a few places were suitable for these species. Most important were wet fallows, but there were also species which were strictly tied to the wet pasture (wpas12: e.g. *Pirata latitans* (Blackwall, 1841), Fig. 7). These habitats obviously play an important role as refuge zones for stenotopic species of wetlands and fens. Other landscape structures, including the stream banks, were less important or completely unsuitable for them.

While more or less stenotopic woodland species were dominant in the beech–oak forests, eurytopic ones became more dominant in the river bank sites, alder forests and wet fallows. There was also a stock of species typical of wet

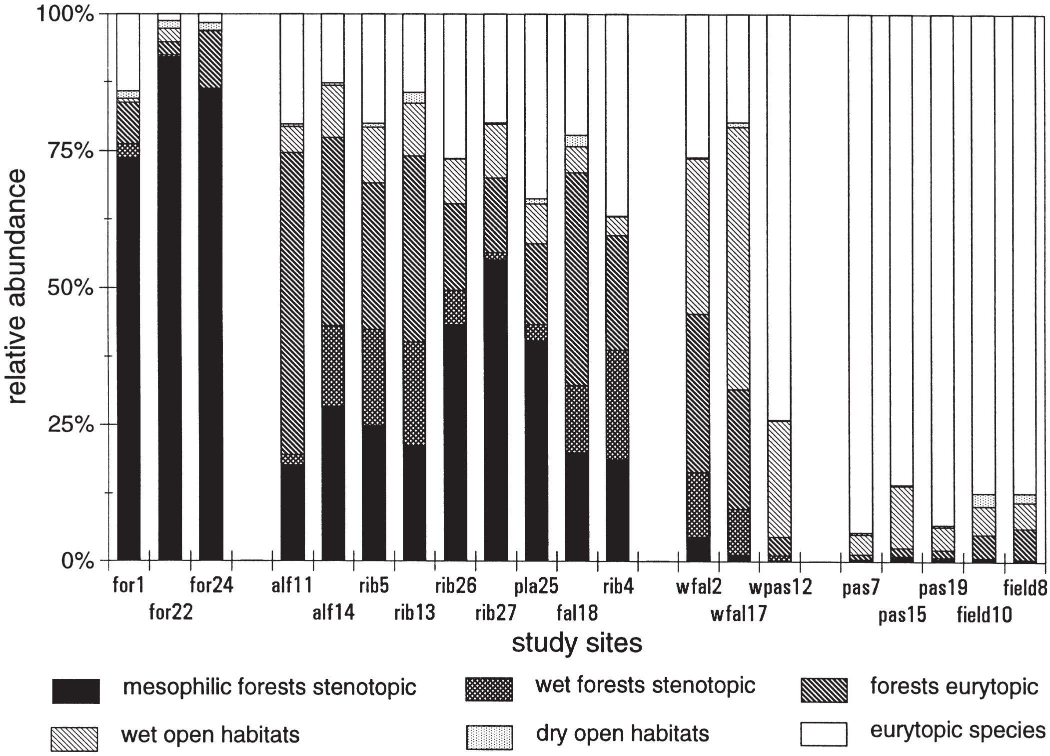

Fig. 8: Composition of the spider communities based on classification of ecological types (after Roberts, 1987, 1995; Platen *et al.*, 1991; Reinke & Irmler, 1994; Hänggi *et al.*, 1995).

forests in some of these habitats. As expected, in pastures and fields woodland species could be recorded only in low numbers. Hydrophilic species were dominant especially in wet fallows and the wet pasture but were also present both in the river bank habitats and in pastures and fields (Fig. 8).

At least four different types of spider communities can be distinguished and also separated by cluster analyses, based both on JACCARD and RENKONEN index. The first group, including all larger forests is characterized by stenotopic woodland species only (up to 90% of total abundance). The second group is heterogeneous and includes most of the river bank sites, the plantation (pla25) and the mesophilic fallow (fal18). These communities were dominated by woodland species (eurytopic and stenotopic) but also included hydrophilic and wet woodland species. The spider communities of the wet fallows and the wet pasture were dominated by hydrophilic species in combination with a small stock of different forest spiders. The last group includes all pastures and fields. Most individuals belonged to more or less eurytopic field species; hydrophilic species and woodland species had only low relative abundance (Fig. 8).

Discussion

In contrast to other studies on spider communities in agricultural landscapes which are focused on a single question or a limited number of different habitats (e.g. Mader, 1981; Baehr, 1983; Dumpert & Platen, 1985; Petto, 1991; Usher *et al.,* 1993; Dröschmeister, 1994; Schikora, 1994; Barthel & Plachter, 1995; Gruttke & Kornacker, 1995; Merkens, 1995; Volkmar, 1995; Hugenschütt, 1996), this study analyses and compares the spider communities of a broad range of different habitats typical of agricultural landscapes. The results make it possible to assess the different habitats from a nature conservation point of view. When doing this, the relative abundance of stenotopic species plays an important role because of the low number of endangered species which are usually recorded in agricultural landscapes (Blab, 1990). In this way it has been possible to identify guidelines and refuge zones for specialized species.

Another parameter that can be used for assessing the spider communities of open habitats is the relative abundance of Lycosidae. Several studies on spider communities of different grassland habitats (e.g. Schäfer, 1973; Sunderland, 1987; Maelfait & De Keer, 1990; Riecken, 1991; Hiebsch, 1992) have shown that there is an evident negative correlation between dominance of Lycosidae and agricultural land use intensity. In field8 and one pasture (pas7) relative abundance of Lycosidae was very low. Both habitats were managed rather intensively. In contrast, the fallows and the extensively managed wet pasture (wpas12) showed a high relative abundance of this spider family. My data therefore accord with these general results.

Finally, it can be pointed out that, on the one hand, natural habitats like forests and river banks are very valuable from a nature conservation point of view and, on the other, semi-natural landscape features, like wet fallows and even wet pastures, play a very important role as refuge zones for hydrophilic species. There are rather few of these habitats and most of them cover a small area. Furthermore, some of them (especially the wet fallows) are only a temporary stage within the development processes of vegetation. Nature conservation activities within agricultural landscapes should therefore focus on such landscape features.

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