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The epigeic spider fauna of single-row hedges in a Danish agricultural landscape

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Abstract
To characterise arthropod biodiversity supported by one type of non-cultivated habitat patches in a cultivated Danish landscape, ground-active arthropods were collected by pitfall traps in three single-row hedgerow types near Bjerringbro, central Jutland, Denmark. Three each of hawthorn (*Crategus monogyna*), rowan (*Sorbus intermedia*), or white spruce (*Picea glauca*) hedgerows were sampled twice yearly, in early (June) and late summer (late August) using 20 pitfall traps per habitat patch (10 in centre, 10 at edge). A total of 71 spider species were identified among 1422 individuals: 33 species (515 individuals) were found in hawthorn hedges, 52 species (653 individuals) in rowan, and 48 species (254 individuals) in spruce. Principal Component Analysis clearly separated the spider assemblages by tree species of the hedge. There was no difference between edge and central traps neither at the assemblage nor at the species level. Most species captured were characteristic of non-cultivated land (*Diplostyla concolor*, *Diplocephalus latifrons*, *Oxyptila praticola*, *Zelotes pusillus*), or associated with more permanent grassland rather than cultivated crops (*Pardosa prativaga*, *Pachygnatha degeeri*). Species typical of cultivated agricultural fields were infrequent (*Erigone atra*, *Bathyphantes gracilis*, *Meioneta rurestris*, *Oedothorax apicatus*) or missing altogether (eg. *Araeoncus humilis*). Thus, the narrow single-row hedges were faunistically very little influenced by the cultivated matrix habitat enclosing them.

Key words: biodiversity, hedgerows, spider assemblages, habitat affinity, rowan, hawthorn, spruce

INTRODUCTION

Biodiversity in the agricultural landscape has traditionally been associated with non-cultivated areas, even though a considerable number of species can be found on cultivated land (Meszaros 1984; regarding spiders: Toft 1989; Vangsgaard 1996). With the increasing human pressure on such habitats, the significance of biodiversity that can be supported by agricultural land is bound to increase. Little is known, however, of the level of biodiversity that can be supported, and how uncultivated areas interact with the cultivated land. An improved understanding of these is necessary for a more efficient management of biodiversity as well as of the ecosystem services they provide (Daly 1999). The study of predatory arthropods such as spiders is obviously relevant in this respect.

Because of methodological differences, studies of hedgerow spiders can be grouped into those considering the fauna of higher vegetation (see Nährig 1991; Ysnel & Canard 2000), and those considering the ground-active fauna (Blick 1989; Henatsch & Blick 1993; Møller-Nielsen 1990; Reinke & Irmler 1994; Bergthaler 1996). Hedgerows obviously add to the biodiversity of the arable landscape through the shrub and tree living species that would otherwise be absent. Hedges also add, however, to the fauna of ground-active spiders, especially woodland species. Earlier studies on the epigeic fauna indicated that: A) hedgerows are inhabited by an assemblage distinct from those of fields as well as woodlands (Blick 1989; Møller-Nielsen 1990; Reinke & Irmler 1994); B) they are often dominated by woodland or forest-edge species rather than by field species (Blick 1989); and C) the spider assemblages show high species richness because woodland and open-land species mix into a composite assemblage. Reinke & Irmler (1994) found only one type of hedge with dominance of the field species *Erigone atra* (Bl.): low hedges on sandy soil, poor in ground vegetation. Though some of the hedges studied previously were quite young, they were composed of at least three rows of trees or shrubs and thus of a considerable width (Blick 1989: 6-8 m; Møller-Nielsen 1990: 4.5 - 5 m; Bergthaler 1996: 3.5 m). As soon as the canopy closes, a 'forest floor' habitat is created in the centre of the hedge, the ground being covered by leaf litter rather than grasses or herb vegetation. The spider fauna of old single-row hedges in which the woodland character of the habitat is not obvious, was expected to be more influenced by influx from surrounding fields, but has to our knowledge not previously been analysed.

We studied the assemblages of ground-active spiders in three types of single-row hedges in central Jutland, Denmark, and from the analysis of one year's results, we describe a fairly high degree of species richness. Moreover, the fauna was not highly influenced by that of the fields. Apart from an unpublished thesis (Møller-Nielsen 1990) on three 13 year old 3-rowed hedges, this is the first account of hedgerow spiders in Denmark.

STUDY AREA AND METHODS

Our study took place in the area of Bjerringbro, central Jutland, Denmark. Nine hedgerows were selected for study; three of hawthorn (*Crategus monogyna*) (localities: Lådnehøje, Aidt1, Aidt2), three of rowan (*Sorbus intermedia*) (Sahl, Gerning, Aldrup), and three of spruce (two of white spruce *Picea glauca*, one of sitka spruce *Picea sitchensis*) (Sahl1, Sahl2, Lådnehøje). They were old, well established hedges of the single-row type. The total width was variable as some hedges had a wide grass covered base (total hedge width, range of means at the three locations: hawthorn, 2.4 – 4.0 m; rowan, 2.6 – 5.0 m; spruce, 3.0 – 3.3 m). One hedge differed in some of these respects: the sitka hedge was planted alternately in two rows, it was rather dense with branches to the ground, thus creating a vegetation-free centre. Other peculiarities of single hedges will be mentioned along with the results. The nine sample locations were at a distance of 200 m – 10 km from each other, within a 4 km x 10 km area. Individual hedgerows were sampled twice yearly, in early (June 1999) and late summer (early September 1999), using 20 pitfalls per habitat patch. Ten of the traps were set at the edge, and ten in the centre of the hedgerow, at a distance of 10 m between individual traps. Neighbouring traps alternated with respect to position. Edge traps were situated only 10-20 cm from the adjacent cultivated field.

Individual pitfall traps were plastic cups of 10 cm diameter, filled with about 200 ml of 70% ethylene glycol solution and a drop of detergent. Traps were sunk into the ground so that their rim was level with the soil surface. Every trap was covered with a galvanised metal square cover to protect the trap contents from rain and disturbance by frogs, birds or small mammals. Traps were set for one week at a time. Trap catches were sieved in the field and transferred into glass vials containing 70% ethyl alcohol. Trap catches with small mammals or frogs as well as displaced or raised traps (33 of a total of 360) were not included in the evaluation. In the laboratory, the samples were sorted under a microscope, and ground beetles and spiders were put into separate vials and stored in 70% ethyl alcohol until identification.

Identification was made by ST. Spider tax-

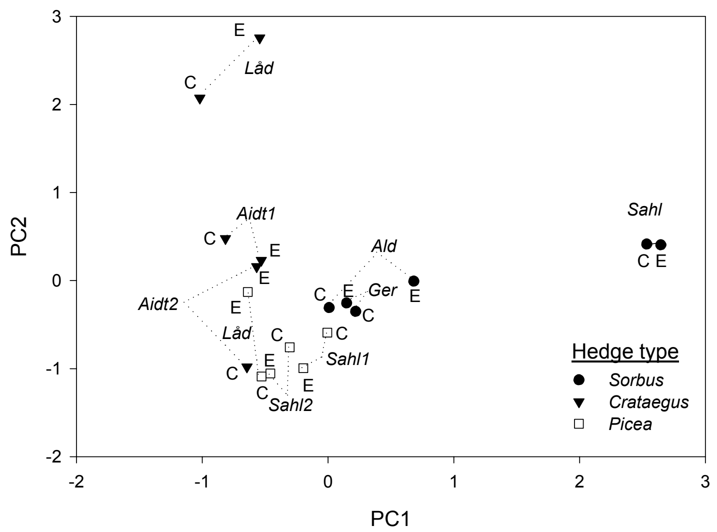

Fig. 1. The results of Principal Component Analysis on untransformed spider capture data in nine hedgerows near Bjerringbro, Jutland, Denmark. E: edge traps, C: centre traps. Aidt1, Aidt2, Ald, Ger, Låd, Sahl1, Sahl2 are abbreviations for sites (see text).

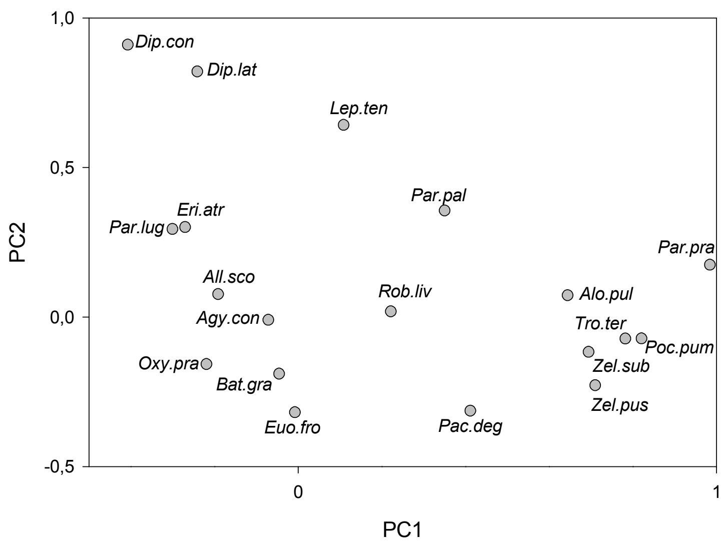

Fig. 2. Habitat affinity relations of the 19 most common spider species according to PCA (Cf. Fig. 1.). For abbreviations of species names: see appendix 1.

onomy follows Platnick (1993). The total (early + late summer) catches of 10 traps (centre or edge) of each hedgerow were summed, giving 18 sites. The species/sites matrix was analysed with a Principal Component Analysis (PCA) on untransformed numbers using the CANOCO 4 program (ter Braak & Smilauer 1998; cf. Jongman et al. 1987). All species were included in the analysis, but only the more abundant ones (≥ 10 individuals) are shown in the species plot.

RESULTS

In the captures from the nine hedgerows, a total of 72 spider species were identified among 1563 individuals (Appendix 1). In *Sorbus* hedgerows, 722 individuals of 52 species were captured, followed by *Crataegus* (548 individuals of 33 species). *Picea* hedgerows had the smallest number of individuals (293 spiders) but not the lowest species richness (49 species). The Principal Component Analysis gave a clear separation of hedges according to tree species (Fig. 1): *Sorbus* hedges were distinguished from the other two types along the first axis; *Crataegus* and *Picea* hedges separated along the second axis.

Fig. 2 shows which species were responsible for the separations of hedge types: *Pardosa prativaga*, *Trochosa terrestris*, and *Pocadicnemis pumila* were especially abundant in the *Sorbus* hedges. *Diplostyla concolor*, *Diplocephalus latifrons* were particularly abundant in the *Crataegus* hedges. The dominant species of the *Picea* hedges were more abundant elsewhere (notice that the origin of the graph is at the lower left); *Euophrys frontalis* were mostly found here.

Centre and edge positions of the same hedge had a high similarity in their spider faunas (Fig. 1). For the two most abundant species, *Pardosa prativaga* and *Diplostyla concolor*, centre and edge catches were tested against each other (Kruskal-Wallis ANOVA) for single hedges where they occurred in high numbers (spring period only). No significant differences were found (*P. prativaga* in *Sorbus* hedges: Aldrup, $H = 1.93$, $P = 0.17$; Sahl, $H = 0.13$, $P = 0.72$; Gerning, $H = 0.03$, $P = 0.87$. D. *concolor* in *Crataegus* hedge, Lådnehøje, $H = 0.44$, $P = 0.51$).

One each of the *Sorbus* and *Crataegus* hedges deviated in their spider fauna from the other two of their kind (Fig. 1). In both cases the hedgerow trees had low hanging branches that shaded the central part of the hedge, which was more or less devoid of ground vegetation. On top of that the *Sorbus* hedge at Sahl was bordered to one side by a permanent meadow. The two-rowed sitka hedge at Lådnehøje did not differ from the other spruce hedges.

DISCUSSION

Species richness

Møller-Nielsen (1990) recorded 105 spider species (among c. 9000 individuals) in 70 pitfall traps catching continuously for four months (June - September) in three young hedges. This is equivalent to the 100 species found by Blick (1989) in Germany in an only slightly larger sample. We found 72 species among only 1423 individuals collected within two weeks. All together these results indicate a relatively high species richness of the hedgerow spider fauna. A study of newly planted hedgerows in Austria (Bergthaler 1996), even though longer in duration and collecting more spiders, found fewer species (44). Several of the dominant species in Bergthaler's (1996) study were associated with agricultural fields, but species characteristic of forests also started to appear.

Habitat relations

The habitat relations of the species have been evaluated from the data compiled by Hänggi et al. (1995) and other sources. The eight most abundant species on the dominance list can be characterized as follows: *Pardosa prativaga* is widespread in many types of open habitats, particularly in marshes and meadows; occurrence in cereal fields depending on adjacent permanent grassland. As a matter of fact, the high dominance of *P. prativaga* was mainly due to an extreme abundance of this species at the *Sorbus* hedge at Sahl; the adjacent permanent meadow was obviously the source habitat of the species. *Diplostyla concolor* occurs in both forested and open habitats, reaching highest abundance in forests, forest edges, and hedgerows. *Oxyptila praticola* is a species of forest edges, hedgerows and open shrubland. *Diplocephalus latifrons* is primarily a forest and forest-edge species, with no association to agricultural land. *Zelotes pusillus* is species of dry grassland and heaths. *Erigone atra* is a habitat generalist though most abundant in open habitats. It is often the most abundant species in Northern European agricultural fields (Sunderland 1987; Blick et al. 2000). *Pachygnatha degeeri* is widespread in meadows, grass fields and sometimes in agricultural fields. *Bathyphantes gracilis* is also a habitat generalist abundant in meadows, marshes and agricultural fields. Only *E. atra*, *B. gracilis* and sometimes *P. degeeri* may be among the dominant agricultural species (Sunderland 1987; Blick et al. 2000), which may owe their occurrence in the hedges to the adjacent agricultural habitats. Thus, the hedge fauna was dominated partly by species of permanent open habitats, partly by species characteristic of forest edges and even by true forest species. The most abundant agrobionts were rather low in dominance. Several species that are typical of Danish and European cereal fields (cf. Toft 1989; Vangsgaard 1996; Blick et al. 2000) were infrequent (e.g. *Meioneta rurestris*, *Oedothorax apicatus*, *Lepthyphantes tenuis*) or missing altogether (e.g. *Araeoncus humilis*).

In conclusion, we found that the spider fauna of single-row hedgerows depended on the tree species of the hedge, with *Sorbus* and *Picea* hedges (both with dense grassy herb layer) richest in species. Habitat structure is plausibly an important determinant of species richness, but we do not have data on that. Spruce hedgerows were the poorest habitat for ground beetles (Lövei, unpublished), but spruce hedgerows had a thick, grassy ground vegetation layer, and this could be the reason for a higher spider species richness in spruce vs. rowan hedges. Thus, Asteraki et al. (1992) found that herbicide-removal of hedgerow vegetation affected linyphiid spiders. The most unexpected finding was that in spite of their narrowness, the spider fauna of these hedgerows was dominated by species originating from permanent open-land habitats, forest or forest-edge species, and species characteristic of agricultural fields had low dominance, were rare or absent, even at the edge of the hedgerows.

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REFERENCES

Asteraki, E.J., Hanks, C.B. & Clements, R.O. 1992. The impact of the chemical removal of the hedge-base flora on the community structure of carabid beetles (Col., Carabidae) and spiders (Araneae) of the field and hedge bottom. *Journal of Applied Entomology* 113, 398-406.

Bergthaler, G.J. 1996. Preliminary results on the colonization of a newly planted hedgerow by epigeic spiders (Araneae) under the influence of adjacent cereal fields. *Revue Suisse de Zoologie* vol. hors serie, 61-70.

Blick, T. 1989. Die Beziehungen der epigäischen Spinnenfauna von Hecken zum Umland. *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie* 7, 84-89.

Blick, T., Pfiffner, L. & Luka, H. 2000. Epigäische Spinnen auf Ackern der Nordwest-Schweiz im mitteleuropäischen Vergleich (Arachnida: Araneae). *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie* 12, 267-276.

Daily, G. C. 1999. Developing a scientific basis for managing Earth's life support systems. *Conservation Ecology* 3(2): 14. [online] URL: http://www.consecol.org/vol3/iss2/art14

Hänggi, A., Stöckli, E. & Nentwig, W. 1995. *Lebensräume Mitteleuropäischer Spinnen.* CSCF/SZKF, Neuchâtel, Switzerland.

Henatsch, B. & Blick, T. 1993. Zur Tageszeitlischen Laufaktivität der Laufkäfer, Kurzpflügelkäfer und Spinnen in einer Hecke und einer angrenzenden Brachfläche (Carabidae, Staphylinidae, Araneae). *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie*. 8, 529-536.

Jongman, R.H.G., ter Braak, C.J.F. & van Tongeren, O.F.R. 1987. *Data analysis in community and landscape ecology.* Pudoc, Wageningen.

Meszaros, Z. (ed.) 1984. Results of faunistical studies in Hungarian maize stands. *Acta Phytopathologica Academiae Scientiarum Hungariae* 19, 65-90.

Møller-Nielsen, L. 1990. En undersøgelse af løbebille- (Carabidae) og eddekoppefaunaen (Araneae) i trerækkede løvtræshegn. Unpublished MSc Thesis, University of Aarhus.

Nährig, D. 1991. Charakterisierung und Bewertung von Hecken mit Hilfe der Spinnenfauna. *Zoologische Beiträge* N.F. 33, 253-263.

Platnick, N.I. 1993. *Advances in spider taxonomy 1988-1991*. New York Entomological Society.

Reinke, H.-D. & Irmler, U. 1994. Die Spinnenfauna (Araneae) Schlegswig-Holsteins am Boden und in der bodennahen Vegetation. *Faunistisch-Ökologische Mitteilungen* Suppl. 17, 1-148.

Sunderland, K.D. 1987. Spiders and cereal aphids in Europe. *Bulletin SROP/WPRS* 10 (1), 82-102.

ter Braak, C.J.F. & Smilauer, P. 1998. *CANOCO 4*. Centre for Biometry, Wageningen.

Toft, S. 1989. Aspects of the ground-living spider fauna of two barley fields in Denmark: species richness and phenological synchronization. *Entomologiske Meddelelser* 57, 157-168.

Vangsgaard, C. 1996. Spatial distribution and dispersal of spiders in a Danish barley field. *Revue Suisse de Zoologie* hors serie 2, 671-682.

Appendix 1. List of spiders captured in three different hedgerow types near Bjerringbro, central Jutland, Denmark. The captures from three locations per hedgerow type were combined. Numbers in parentheses indicate dominance rank of species in hedgerow type (only species with ≥ 10 individuals). Underlining marks the abbreviations used on Fig. 2.

	Hedgerow type			
Species	Sorbus	Crataegus	Picea	Total
Gnaphosidae				
Haplodrassus signifer (C.L.K.)	1	0	2	3
Zelotes latreillei (Simon)	2	1	1	4
Zelotes longipes (L.K.)	0	1	0	1
Zelotes pusillus (C.L.K.)	(3) 28	3	(3) 21	52
Zelotes subterraneus (C.L.K.)	(9.5) 10	1	5	16
Zelotes sp. juv.	4	0	6	10
Micariidae				
Micaria pulicaria (Sund.)	1	1	1	3
Clubionidae				
Clubiona terrestris Westr.	0	1	0	1
Clubiona sp. juv.	2	0	1	3
Liocranidae				
Agroeca proxima (O.P.-C.)	0	0	3	3
Zoridae				
Zora spinimana (Sund.)	0	0	3	3
Thomisidae				
Oxyptila praticola (C.L.K.)	(4) 25	(2) 74	4	103
Thomisidae sp. juv.	1	1	2	4
Salticidae				
Euophrys frontalis (Walck.)	2	0	8	10
Lycosidae				
Pardosa agrestis (Westr.)	0	0	2	2
Pardosa palustris (L.)	7	4	1	12
Pardosa pullata (Cl.)	2	2	1	5
Pardosa prativaga (L.K.)	(1) 353	(4) 41	(1) 44	438
Pardosa amentata (Cl.)	0	1	1	2
Pardosa lugubris (Walck.)	3	6	2	11
Pardosa nigriceps (Thor.)	1	0	0	1
Alopecosa pulverulenta (Cl.)	8	4	6	18
Trochrosa ruricola (Deg.)	1	0	0	1
Trochosa terricola Thor.	8	1	5	14
Lycosidae sp. juv.	18	8	8	34
Agelenidae				
Tegenaria atrica C.L.K.	0	1	0	1
Agelenidae sp. juv.	0	1	0	1
Hahniidae				
Hahnia nava (Bl.)	0	0	4	4
Theridiidae				
Crustulina guttata (Wider)	1	0	0	1
Robertus lividus (Bl.)	7	3	9	19
Robertus neglectus (O.P.-C.)	1	0	0	1
Tetragnathidae				
Pachygnatha degeeri Sund.	(8) 11	3	(4) 17	31
Pachygnatha clercki Sund.	0	1	0	1

	Hedgerow type			
Species	Sorbus	Crataegus	Picea	Total
Linyphiidae				
Walckenaeria acuminata Bl.	4	0	4	8
Walckenaeria antica (Wider)	0	0	1	1
Walckenaeria dysderoides (Wider)	2	0	6	8
Dicymbium brevisetosum Locket	2	1	0	3
Dismodicus bifrons (Bl.)	3	0	0	3
Oedothorax apicatus (Bl.)	3	1	1	5
Gonatium rubens (Bl.)	2	0	1	3
Pocadicnemis pumila (Bl.)	(5) 17	0	(5) 12	29
Minyriolus pusillus (Wider)	0	0	1	1
Troxochrus scabriculus (Westr.)	2	0	0	2
Tiso vagans (Bl.)	0	1	1	2
Micrargus herbigradus (Bl.)	2	0	0	2
Gongylidiellum vivum (O.P.-C.)	1	0	0	1
Tapinocyba praecox (O.P.-C.)	0	0	1	1
Tapinocyba insecta (L.K.)	1	0	1	2
Tapinocyba pallens (O.P.-C.)	4	2	1	7
Savignia frontata (Bl.)	2	0	0	2
Diplocephalus cristatus (Bl.)	0	0	1	1
Diplocephalus latifrons (O.P.-C.)	2	(3) 47	4	53
Diplocephalus picinus (Bl.)	1	0	0	1
Erigone atra (Bl.)	(6) 14	(5) 18	4	36
Erigone dentipalpis (Wider)	1	0	0	1
Agyneta conigera (O.P.-C.)	7	2	3	12
Agyneta subtilis (O.P.-C.)	3	0	1	4
Meioneta rurestris (C.L.K.)	0	0	1	1
Microneta viaria (Bl.)	4	0	0	4
Ostearius melanopygius (O.P.-C.)	0	0	1	1
Porrhomma microphthalmum (O.P.-C.)	1	0	0	1
Centromerus sylvaticus (Bl.)	3	0	4	7
Centromerus dilutus (O.P.-C.)	0	0	2	2
Centromerita bicolor (Bl.)	1	2	0	3
Poeciloneta globosa (Wider)	1	0	0	1
Stemonyphantes lineatus (L.)	0	1	0	1
Bathyphantes gracilis (Bl.)	8	(8) 10	(6) 12	30
Bathyphantes parvulus (Westr.)	3	0	1	4
Diplostyla concolor (Wider)	(2) 57	(1) 252	(2) 36	345
Bolyphantes alticeps (Sund.)	0	1	0	1
Lepthyphantes mengei Kulcz.	5	0	2	7
Lepthyphantes tenuis (Bl.)	(9.5) 10	(7) 13	2	25
Lepthyphantes insignis O.P.-C.	1	0	1	2
Lepthyphantes ericaeus (Bl.)	1	0	1	2
Lepthyphantes angulipalpis(Westr.)	1	0	0	1
Neriene clathrata (Sund.)	0	1	0	1
Allomengea scopigera (Grube)	(7) 12	(6) 14	2	28
Linyphiidae sp. juv.	44	23	21	88
Total	**722**	**548**	**293**	**1563**