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Surface-active spiders (Araneae) in ley and field margins

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Surface-active spiders were sampled from a ley and two adjacent field margins on a dairy farm in western Norway, using pitfall traps from April to June 2001. Altogether, 1153 specimens, representing 33 species, were found. In total, 10 species were found in the ley, 16 species in the edge of the ley, 22 species in the field margin "ley/forest" and 16 species in the field margin "ley/stream". *Erigone atra, Bathyphantes gracilis*, *Savignia frontata* and *Collinsia inerrans* were the most abundant species in the ley. *C. inerrans* was not found in the field margins. This species is previously recorded only a few times in Norway. *Diplocephalus latifrons, Tapinocyba insecta, Dicymbium tibiale, Bathyphantes nigrinus* and *Diplostyla concolor* were most abundant in the field margin "ley/forest". *D. latifrons, D. tibiale* and *Pardosa amentata* were most abundant in the field margin "ley/stream", followed by *E. atra* and *B. gracilis*. The present results were compared to results from ley and pasture on another farm in the region, recorded in 2000. A Detrended Correspondence Analyses (DCA) of the data sets showed that the spider fauna from the leys were more similar, independent of location, than the fauna in ley and field margins on the same locality. The interactions between cultivated fields and field margins according to spider species composition, dominance pattern and habitat preferences are discussed.

Key words: Araneae, biodiversity, organic farming.

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INTRODUCTION

In cultivated areas, a mosaic landscape of small-sized cultivated fields and semi-natural habitats increases and maintains a higher arthropod diversity as compared to larger cultivated fields with less areas for field margins (Duelli et al. 1990, Dennis et al. 2000). Species richness has also been shown to decrease with increased intensity of land use, such as numbers and types of grass cuttings, grazing intensity, tillage intensity and pesticide use (Downie et al. 1998, Marc et al. 1999). Increased spider diversity was found in cultivated fields by use of non-cropped stripes, intercropping, undergrowth, partial weediness, mulching and reduced tillage in various studies, reviewed by Sunderland & Samu (2000).

Small pioneer species that have good ability of dispersal, are characteristic for frequently disturbed areas like ley and cereal fields, and have been called agrobiont species (Luczak 1979). The most important disturbances in cultivated fields influencing the spider fauna are soil tillage, use of pesticides, harvesting and grazing. Differences in the spider fauna between cultivated fields and adjacent field margins or other habitats have been studied in various systems (Bishop & Riechert 1990, Kromp & Steinberger 1992, Sunderland & Samu 2000). When the spider fauna in the cultivated fields is disturbed, e.g. because of soil tillage, a re-establishment of the fauna may occur by species and individuals surviving in the field margins. Hence, the field margins serve as a source of re-invading species. Both for insects and spi-

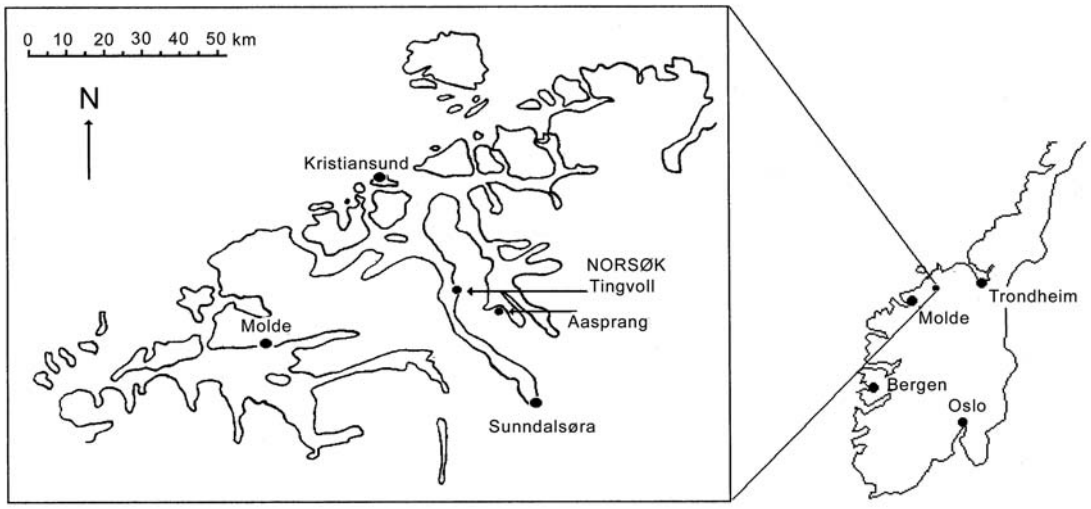

Figure 1: The location of the study area at Aasprang (2001 data set) and at Tingvoll (2000 data set), western Norway.

ders, the adjacent field margins have been shown to contribute to a higher biodiversity in the field, with the diversity declining from the field margins into the cereal fields (Dennis et al. 2000). Habitats in which the vegetation cover is structurally comparable to the cultivated fields, are often better sources of spider species abundant in the main fields, than habitats that are structurally more different (Stevenson & Dindal 1980, Duelli et al. 1990). A study of the importance of long-distance (aerial dispersal by ballooning) versus short-distance (walking on the ground) dispersal of spiders re-colonising the cultivated fields, indicated that ballooning was the main mode of dispersal (Bishop & Riechert 1990). In organically managed leys in western Norway, *Bathyphantes gracilis, Erigone atra, Oedothorax fuscus* and *Savignia frontata* were the most abundant species (Pommeresche 2002), whereas *E. atra*, *E. dentipalpis* and *O. apicatus* were the most abundant in conventionally grown barley fields from different parts of Norway (Andersen 1990). All these species mainly disperse by ballooning.

Spiders are an important part of the fauna in cultivated areas, especially because they prey on other arthropods. Organic farming systems are dependent on the local conditions to a much larger extent than conventional systems. As a consequence, basic biological knowledge is of large importance in organic farming, which aims at a high biodiversity and well balanced self-regulating agroecosystems. Organic farming has been shown to have positive effects on floral and faunal diversity, as reviewed by Stoltze et al. (2000). In general, the knowledge of spiders in Norwegian cultivated areas is scarce, and only one study of spiders in organically managed ley and pasture has been conducted (Pommeresche 2002).

The present study presents spider species found in a ley and two adjacent field margins during one season. Spider species composition, dominance patterns and habitat preferences are discussed to reveal possible interactions between the spider fauna in field margins and in the cultivated field. The study is one of a series of investigations into the spider fauna in Norwegian agricultural fields, adjacent field margins and semi-natural habitats.

METHODS AND MATERIAL

Site description

The study area was located on the dairy farm Aasprang at Meisingset, western Norway, EIS 85, MRY, Tingvoll (Figure 1). Since 2000, the farm is under conversion to organic management. In 2001 spiders were collected in a 4 year old ley, and in two of the adjacent field margins. The ley was a mixture of timothy (*Phelum pratense* L.), fescue grass (*Festuca pratensis* Huds.) and white clover (*Trifolium repens* L.). In the year of establishment, 1998, herbicide was used once, but no pesticides have been used later. Both animal manure and mineral fertiliser have been used on the ley. Twice a year the ley is harvested for silage, and in the autumn grazed by cows. Total precipitation in 2001 was 1320 mm, and the yearly mean temperature was 5.6 ^{O}C (max + 25.5 ^{O}C, min –17.5 ^{O}C).

The site called "ley middle" (**LM)** was located in the central part of the ley, and the site called "ley edge" (**LE)** was in the edge of the ley, 3 m from the field margin along a stream. The two field margins are called "field margin forest" (**FMF**) and "field margin stream" (**FMS**). It is a small stream, about 1.5 m wide, with high and dense vegetation along the stream banks. The water flow is very low during the summer. Both field margins were 3-5 m wide and located along opposite sides of the ley. The vegetation in both field margins consisted of stinging nettle (*Urtica dioica* L.), raspberry (*Rubus idaeus* L.), meadowsweet (*Filipendula ulmaria* (L.) Maxim.), cow-parsley (*Anthriscus sylvestris* (L.) Hoffm.) and high grasses like reed canarygrass (*Phalaris arundinacea* L.) and couch grass (*Elytrigia repens* (L.) Nevski). On FMF also tussock-grass (*Deschamsia caespitosa* (L.) PB.) was found, and on FMS cocksfoot (*Dactylis glomerata* L.) and timothy. FMF borders a row of large larch trees (*Larix* sp) undergrown with buckthorn (*Prunus padus* L.), and is more shady than FMS. Another field margin, and another ley are located on the other side of both field margins. Pesticides have never been used in the field margins.

The results are compared to a study from an organic dairy farm located 15 km away, at Tingvoll, conducted in 2000 (Figure 1). At Tingvoll a young ley (**YL**), established in 1999 and an old ley (**OL**) established in 1997 were studied, in addition to a permanent pasture (**PA**). YL, OL and PA were all sampled for spiders in the middle (**M**) and in the edge (**E**). More details about this study are found in Pommeresche (2002).

Sampling and identification

Spiders were collected in pitfall traps consisting of plastic jars 6.5 cm ø , 1/3 filled with 50 % propylene glycol and 1-3 droplets of soap as detergent. On each site, seven traps were placed 2 m apart in a row. In the sampling period, lasting from 30 April to 18 June 2001, the traps were emptied twice. Catches from each site were accumulated and treated as one sample. Only few juveniles (1.5 %) were found, and only adult spiders were identified to species and discussed in this paper. Pitfall trapping is the most commonly used sampling method for spiders (Hänggi et al. 1995). The method samples mostly surface-active spiders and is a measure of the activity-density of spiders, rather than of the total density (Tretzel 1955, Uetz & Unzicker 1976). The identification keys of Roberts (1993a; 1993b) and Nentwig et al. (2003) were used, and nomenclature and taxonomy are in accordance with Platnick (2003). The author names of the spider species are found in Table 1.

Data analysis

To detect patterns in the spider fauna from different sites, an ordination technique of multivariate analysis was used (ter Braak 1995). This "Detrended Correspondence Analysis" (DCA) was run by CANOCO 4.5 software. The analysis arranges the data so that sites close together in the plots are similar in species composition, while those that are further apart are less similar. The analysis is based on the spider species and the number of specimens within each species found on each site.

Table 1. Spider species and number of individuals from ley and field margins: ley middle (LM), ley edge (LE), field margin ley/forest (FMF) and field margin ley/stream (FMS). Spiders sampled in pitfall traps from April to June 2001 at Aasprang Farm.

Family/species	Ley middle LM	Ley edge LE	Fieldm. forest FMF	Fieldm. stream FMS
Linyphiidae				
Erigone atra (Blackwall)	158	217	1	25
Bathyphantes gracilis (Blackwall)	45	19	11	13
Savignia frontata Blackwall	34	30	5	2
Collinsia inerrans (O.P.-Cambridge)	15	21		1
Diplocephalus latifrons (O.P.-Cambr.)	6	11	156	81
Dicymbium tibiale (Blackwall)	1	2	42	49
Tapinocyba insecta (L.Koch)			45	
Batyhphantes nigrinus (Westring)		1	23	2
Diplostyla concolor (Wider)			17	
Erigone dentipalpis (Wider)	3	7		
Centromerus arcanus (O.P.-Cambr.)			6	1
Ceratinella brevipes (Westring)			7	1
Astenargus paganus (Simon)			2	
Jacksonella falconeri (Jacson)			2	
Tapinocyba pallens (O.P.-Cambridge)			2	1
Tenuiphantes cristatus (Menge)			2	1
Gonatium rubellum (Blackwall)			1	
Tenuiphantes alacris (Blackwall)			1	
Tenuiphantes zimmermanni (Bertkau)			1	
Micrargus herbigradus (Blackwall)	1	2		
Oedothorax fuscus (Blackwall)	1	4		
Meioneta affinis (Kulczynski)		1		
Meioneta saxatilis (Blackwall)		1		
Erigonella hiemalis (Blackwall)				1
Tenuiphantes mengei (Kulczynski)				3
Lycosidae				
Pardosa amentata (Clerck)	6	6		40
Pardosa nigriceps (Thorell)		1		5
Pardosa pullata (Clerk)		2		1
Pardosa lugubris (Walckenaer)			1	
Other families				
Cryphoeca silvicola (C.L.Koch)		2	1	
Tetragnatha sp			1	
Xysticus audax ((Schrank)			1	
Zora spinimana (Sundevall)			1	
number of specimens	**270**	**327**	**329**	**227**
number of species	**10**	**16**	**22**	**16**

RESULTS

Altogether 1153 specimens, representing 33 species, were found at Aasprang (Table 1). Most of the species (76 %) and individuals (94 %) belonged to the Linyphiidae family. The diversity of spiders increased from the middle of the ley towards the margins. Ten different species were found in the LM, 16 in LE, 16 in FMS and 22 species in FMF. The number of specimens was 270 in LM, 327 in LE, 227 in FMS and 329 in FMF. LM was dominated by *Erigone atra* (59 % of the individuals), followed by *Bathyphantes gracilis* (17 %), *Savignia frontata* (13 %) and *Collinsia inerrans* (3 %). The same species dominated in LE, but with *B. gracilis* less dominant (6 %). In both the field margins, *Diplocephalus latifrons* was the most abundant species, represented by 47 % of the individuals in FMF and by 36 % in FMS. In FMS the other dominating species were *Dicymbium tibiale* (22 %), *Pardosa amentata* (18 %) and *E. atra* (11 %), and in FMF *Tapinocyba insecta* (14 %), *D. tibiale* (13 %) and *Bathyphantes nigrinus* (7 %).

Five species were found in all the four sites, *E. atra, B. gracilis, S. frontata, D. latifrons* and *D. tibiale*, but very unevenly distributed. *E. atra, B. gracilis* and *S. frontata* were most dominant in the ley and *D. latifrons* and *D. tibiale* most dominant in the field margins. The various dominance pattern of these main species, as well as the differences in the total species composition between the sites, caused a clear difference in the spider fauna found in LM and LE as compared to the ones found in FMS and FMF (Table 1, Figure 2). These results demonstrate the importance of field margins for the total biodiversity in an agricultural system.

The results of the DCA are shown in Figure 3. The first ordination axes explained 74 % and the second another 4 % of the total variability. The first DCA-axis indicates difference between spider communities in the ley sites and the field margins. There is a gradient in the similarity of the fauna from LE and LM, via FMS to FMF. The distribution along the second axis cannot be attributed to any obvious gradient.

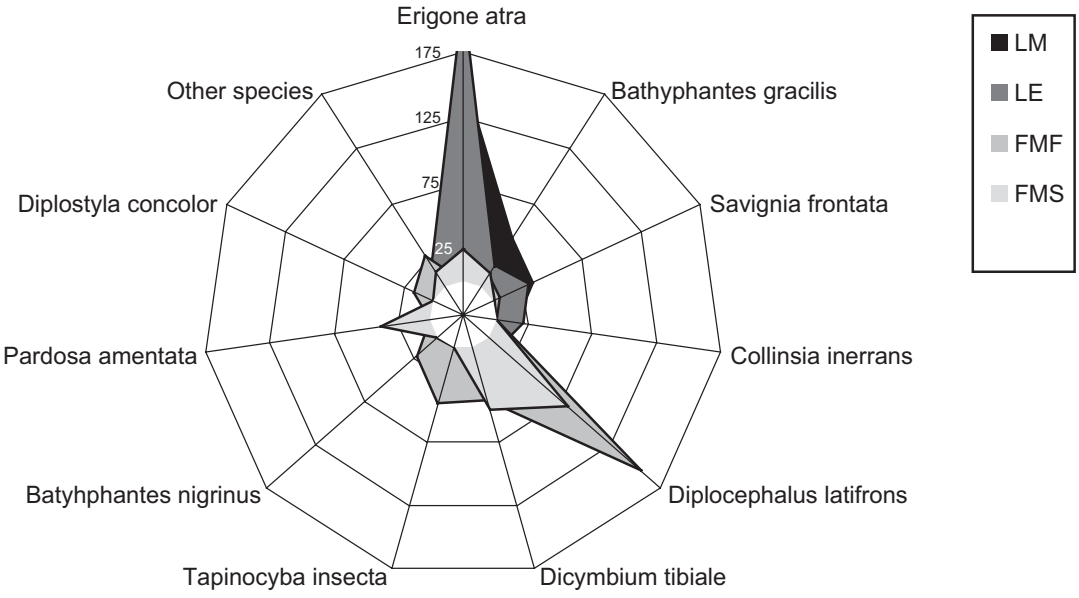

Figure 2: The dominance pattern of the spider fauna found in ley and field margins at Aasprang. Values along the radials are the number of individuals of each spider species. The area of the spider fauna at the different sites overlap, especially on LM and LE. For details and further details use Table 1.

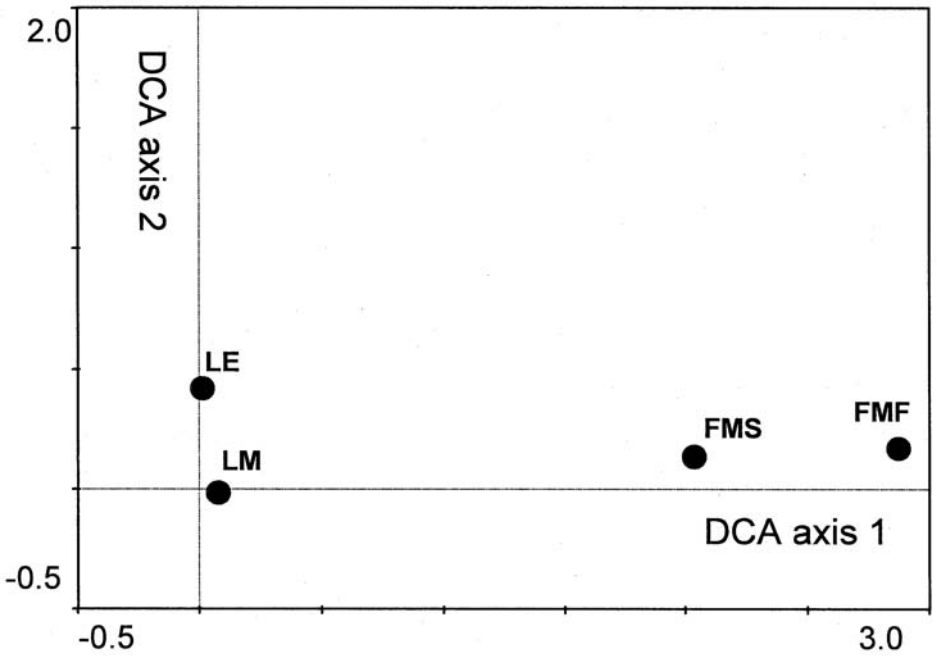

Figure 3: DCA ordination diagram of spider communities from ley and field margins at Aasprang. Spider species and numbers of specimens within each species are used as the basis of the analysis. For further details use Table 1.

A DCA comparing results from Aasprang with results from Tingvoll showed that the spider communities from leys at different locations (farms) were more similar than the communities in ley and field margins on the same farm (Figure 4). The spider communities in pasture (PAE, PAM) at Tingvoll differ much from the ones in the field margin (FMS, FMF) at Aasprang, as can be seen along the second DCA-axis. A high number of individuals of *Silometopus elegans*, only found in PAE and PAM, and a much higher number of *P. amentata* in the pasture sites as compared to the field margins, explain most of the difference. The first ordination axes explained 38 % and the second another 12 % of the total variability.

C. inerrans was found in the leys and in the edge of the leys both at Aasprang and Tingvoll, but only one individual was found in the field margins and none in the pasture. This species has previously only been recorded a few times from Norway, and was suggested as a Red-listed species by Aakra & Hauge (2000). However, it seems to bee less rare than expected.

DISCUSSION

The composition of the spider fauna was quite similar in the ley sites at Aasprang, but clearer differences were found between the ley and the field margins. Agrobiont and other pioneer species dominated in LM and LE. Most abundant were *E. atra*, *B. gracilis* and *S. frontata.* These species were also very frequent in the leys at Tingvoll. All these species perform aerial dispersal by ballooning (Duffey 1956, Weyman 1993, Weyman et al. 1995), something which explains the high numbers of these species in the ley. The similarity in species composition between the young ley at Tingvoll and the older leys at Tingvoll and Aasprang, may be explained by the yearly distur-

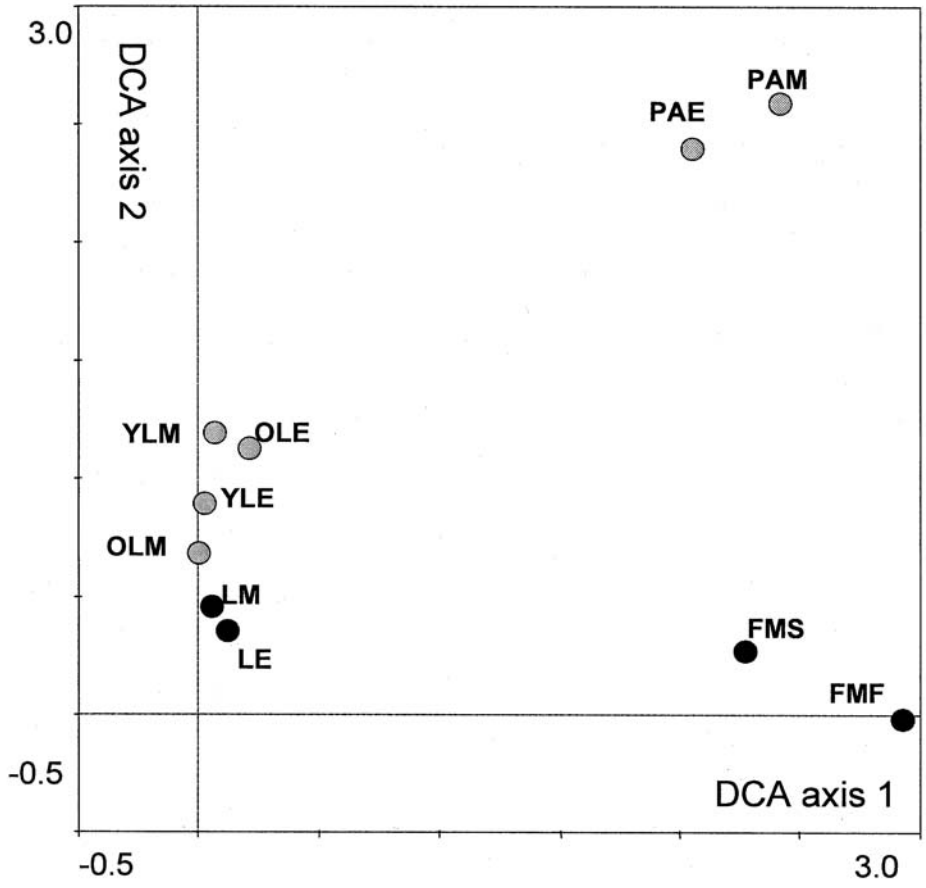

Figure 4: DCA ordination diagram of spider communities found in different agricultural sites and field margins on two dairy farms. Spiders from one ley (LM, LE), and two field margins, ley /forest (FMF) and ley /stream (FMS) at Aasprang 2001 (black dots). Spiders found in young ley (YL), old ley (OL) and permanent pasture (PA) at Tingvoll in 2000 (grey dots). One site is located in the middle (M) and one nearer the edge (E) of the leys and the pasture. Spider species and numbers of specimens within each species are used as the basis of the analysis.

bances of harvesting and grazing. These yearly disturbances seemed to influence the resident spider fauna so much, that a potential effect of age of the ley was not evident from the composition of spider fauna. The importance of vegetation structure, rather than the age of the plant species, explains these results.

Although the FMF only bordered a line of threes and no real forest, some species mainly preferring forest habitats were found there, like *D. latifrons*, *Diplostyla concolor* and *Gonatium rubellum*. This indicates that even small areas with forest-like vegetation may create suitable habitats for some forest species.

P. amentata was represented with 40 individuals in FMS and with 6 in both LM and LE, but none in FMF at Aasprang. This species is found in a very wide range of habitats both in Norway and Europe, including natural habitats like riverbanks, littoral areas and forest edges, but also cultivated

areas like pastures and cereal fields (Kjetil Aakra pers. comm. 2004, Hänggi et al. 1995). This species" preference for more open and wet habitats was also reflected in a very high number of individuals in the pasture (290 individuals in PAM, 185 individuals in PAE) at Tingvoll. There was less migration of *P. amentata* into the ley at Aasprang than could have been expected from the high abundance in FMS. This may be explained by the species preference for space and the lack of aerial dispersal behaviour (Richter 1970).

B. gracilis was found at all sites, both at Aasprang and Tingvoll. This indicates that the field margins may serve as a site of survival for this species during disturbances in the ley. *B. gracilis*, and also *E. atra,* may originate from the field margins, but also from other fields in the surrounding areas, or more distant field margins, because they perform aerial dispersal (Duffey 1956, Weyman 1993, Weyman et al. 1995). Both these species have also been shown to survive soil cultivation (Duffey 1978). *B. gracilis* always anchor their web in the vegetation, whereas *E. atra* use small depressions in bare soil to anchor their webs, or hunt prey without using nets (Alderweireldt 1994). This may explain the high number of both these species in the leys. These different hunting strategies may also partly explain a higher frequency of *B. gracilis* than *E. atra* in the pasture and field margins. The FMF was obviously not attractive to *E. atra*, possibly because of few available places to anchor their webs.

C. inerrans has been suggested as a Red-listed species by Aakra & Hauge (2000), perhaps more because of lack of search for this species in agricultural areas in Norway than because of rarity. The species is not frequently reported in European studies, found in only ten out of 1382 species lists checked by Hänggi et al. (1995), there in reed beds (4 localities) and different cultivated areas (6 localities). *C. inerrans* seems to be connected with frequently disturbed areas in the present study. It is possible that this species invades cultivated fields from other cultivated areas, disturbed at another time, rather than from field margins or pastures. The connection of this species to agricultural areas, as found in this study, is supported by other studies (Andersen 1990, Rushton & Eyre 1992, Feber et al. 1998), and by closer study of the autecology of *C. inerrans* (Klapkarek & Riecken 1995).

Some of the most abundant species found in the leys, such as *E. atra*, *B. gracilis*, *Oedothorax* spp. and *E. dentipalpis*, have also been found in comparable grass and cereal fields in England and Denmark (Thomas & Jepson 1997, Feber et al. 1998). *Meioneta rurestris* and *Tenuiphantes tenuis* were abundant in English grass and cereals fields (Thomas & Jepson 1997, Feber et al. 1998), and *M. rurestris* and *O. apicatus* in Danish barley fields (Toft 1989). However, these were all absent in our leys, except for one specimen of *M. rurestris* found at Tingvoll. In contrast, *S. frontata* and *C. inerrans* were found in our leys in quite high numbers, but not in the English and Danish studies. In many studies *S. frontata* seems to have preference for moist habitats like moist meadows and litteral areas (Hänggi et al. 1995). Both Tingvoll and Aasprang are located close to the fjord (water) and this may partly explain the high element of this species in the leys. *M. rurestris* and *O. apicatus* are both more frequently reported in studies from the central parts of Europe than from Scandinavian studies (Hänggi et al. 1995) and there may be a biogeographical explanation to the lack of these species in the present study.

The DCA showed that the spider fauna from the leys was more similar, independent of locations, than the fauna in ley and field margins on the same locality (Figure 4). This is in accordance with Sunderland and Samu (2000), who found that the spider fauna in a cultivated field consists of some typical agrobiont species, similar in the same crop over a larger area, and additionally some species from the field margins, depending on the natural habitat types and mosaic of habitats in the area. The same species dominated the leys at both Tingvoll and Aasprang. This reflects the importance of the typical agrobiont species in the composition of the spider fauna in the leys. The high number of *Oedothorax fuscus* found in both OL and YL at Tingvoll, suggest that this species is an agrobiont and one of the dominant species in these leys. The very low frequency of this

species at Aasprang is difficult to explain other than a local patchyness. High numbers of this species have also been found in English studies of different grasslands and cereal fields (Rushton & Eyre 1992, Feber et al. 1998), while very few specimens were found in a study of 10 different cereal fields in Norway (Andersen 1990).

Better knowledge about the spider fauna in Norwegian agricultural areas may ensure a more sustainable management and conservation of biodiversity in agricultural areas, and may also serve as a basic for biological pest-control. With more knowledge about interactions of spiders between different habitats, the relative importance of field margins and different mosaic of the cultivated fields in regards to biodiversity in the cultivated fields and in the landscape, will be revealed.

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