

## Spider species and communities in bog and forest habitats in Geitaknottane Nature Reserve, Western Norway

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### Abstract

Species and communities of epigeic spiders in different bogs and forests in Western Norway were investigated. Fifty different sites were sampled using pitfall traps in 1997. Five groups of spider communities could be classified: spider communities of wet, open areas; communities of open forests; communities of shady pine forests; spider communities of humid deciduous forests, and spider communities of dry deciduous forests. There was a good correlation between spider communities and vegetation on the site demonstrated by DCA and DCCA. Environmental variables like productivity of wood, soil humidity, tree cover, bush cover as well as heat index turned out to be significant, explaining the gradient of communities and species of spiders found in the investigated vegetation types. The number of species per site varied from 21 to 51. *Gonatium rubens* was typical for the open areas (bogs and *Calluna*-pine forests), and *Gonatium rubellum* was typically found in the bilberry-pine and deciduous forests. *Pirata hygrophilus* and *Notioscopus sarcinatus* were typically found on the bogs. New species to Norway were *Euophrys frontalis*, *Maro lepidus* and *Porrhomma oblitum*.

**Key words:** Spiders, diversity, community, bogs, forests, DCA, DCCA, Norway

### INTRODUCTION

Most of the research on spider diversity and faunistics in Norway is from the southern part of the country (Hauge & Wiger 1980; Hauge & Kvamme 1983; Tveit & Hauge 1983; Ellefsen & Hauge 1986; Hauge et al. 1991). Diversity and habitat preferences of spiders may differ in different geographical regions due to different climate, altitude or due to other abiotic factors. Hänggi et al. (1995) have worked out a synopsis on habitat preferences of spiders of Central Europe. Many of the Norwegian species are represented in this work, but it does not include many large Norwegian surveys. In the present paper, information on spider species and communities in bogs and forests typical for Western Norway is presented. The most abun-

dant and frequent spider species and species typical of the main spider community assemblages and vegetation types are discussed, and the relationship between spider communities and environmental factors are pointed out.

### MATERIAL AND METHODS

#### Description of the sites

The study area was in the Geitaknottane Nature Reserve, in Kvam south-east of Bergen, Western Norway (60°07' N, 5°52' E). It is situated 120-300 m above sea level and consists of a mosaic of exposed bedrock, bogs, pine- and deciduous forests. Fifty sites representing the main vegetation types in the area were chosen for study:

- Bogs (7 sites): Treeless bogs dominated by

*Calluna vulgaris*, *Molinia caerulea* and different *Sphagnum* spp.

- Open *Calluna*-pine forests (15 sites): The field layer was dominated by *Calluna vulgaris* and *Molinia caerulea*. A few pines (*Pinus sylvestris*) were scattered over the area.

- Bilberry-pine forests (12 sites): Tree cover of *Pinus sylvestris* mixed with birches (*Betula* spp.). The field layer dominated by *Vaccinium myrtillus*, some *Vaccinium vitis-idaea* and *Deschampsia flexuosa*.

- The deciduous forests (15 sites) consisted of five different vegetation types: Two bilberry-oak forests dominated by oak (*Quercus robur*, *Q. petraea*), with some pines (*Pinus sylvestris*). The field layer was similar to that of the bilberry-pine forests. Three humid grey alder-bird cherry forests consisted of grey alder (*Alnus incana*), some birches (*Betula* spp.) and bird cherry (*Prunus padus*). These forests had a dense field layer of grasses and herbs. Three humid grey alder-ash forests composed of birches (*Betula* spp.), grey alder (*Alnus incana*) and hazel (*Corylus avellana*) were sampled. The field layer consisted of *Ranunculus ficaria* and *Anemone nemorosa* in spring, later in the season various herbs and grasses. Six localities of dry Elm-lime forests had elm (*Ulmus glabra*) and ash (*Fraxinus excelsior*) in the canopy. A rich field layer consisted of *Matteuccia struthiopteris*, *Carex sylvatica* and various herbs. One locality was a hazel (*Corylus avellana*) shrub in a scree, with some bilberry and herbs.

- Spruce plantation (1 site): Dark, dense spruce plantation (*Picea abies*) with sparse vegetation and a thick layer of spruce needles. The vegetation on the different localities was classified according to Fremstad (1997).

#### Environmental factors

The following environmental factors were measured at each locality: Slope of the locality (degrees), exposure (0-360°) of the site, stratification (vegetation layers), tree cover (canopy cover (%)), forest productivity class (Fitje 1984), stand basal area (estimated using a relascope (m<sup>2</sup>/ha)), bush cover (%), soil humidity score

(defined by the vegetation type (Fremstad 1997)), heat index (Parkers index (Parker 1988, Økland & Eilertsen 1993)).

#### Sampling procedures

Eight pitfall traps (glassjars 11 cm high and 6.5 cm in diam., one-third filled with a 4% formalin solution) were used at each site to collect the spiders. The traps were emptied four times during the study period (April - November 1997).

#### Statistical analysis

Based on the number of specimens per spider species per locality, a two-way indicator species analysis, TWINSpan (Hill 1979), was used to group the 50 spider communities. Ordination of communities and species was carried out using detrended correspondence analysis (DCA), while the ordination of the spiders in relation to environmental variables was carried out using detrended canonical correspondence analysis (DCCA) (Jongman et al. 1995). DCA and DCCA were run in CANOCO 3.12 (ter Braak 1991), based on number of specimens per spider species per locality. Rare species (low frequency) were downweighted. Forward selection of environmental variables and a Monte Carlo permutation test (999 permutations) were used to find the statistically significant ( $p < 0.05$ ) environmental variables in DCCA.

## RESULTS

#### Groups of species and communities

TWINSpan split the spider species into five distinct community groups (Fig. 1). TWINSpan-group 1 (TWIN 1) consisted of spider species and communities in wet, open areas (the bogs), TWIN 2 of 13 open *Calluna*-pine forests. TWIN 3 grouped spider species and communities of 12 bilberry pine forests, two *Calluna*-pine forests, two bilberry-oak forests and one hazel shrub. TWIN 4 comprised spider species and communities of humid deciduous forests (three grey alder-bird cherry forests, three grey alder-ash forests, one elm-lime forest and one spruce plantation). TWIN 5 comprised spi-

der species and communities of dry deciduous forests (five elm-lime forests).

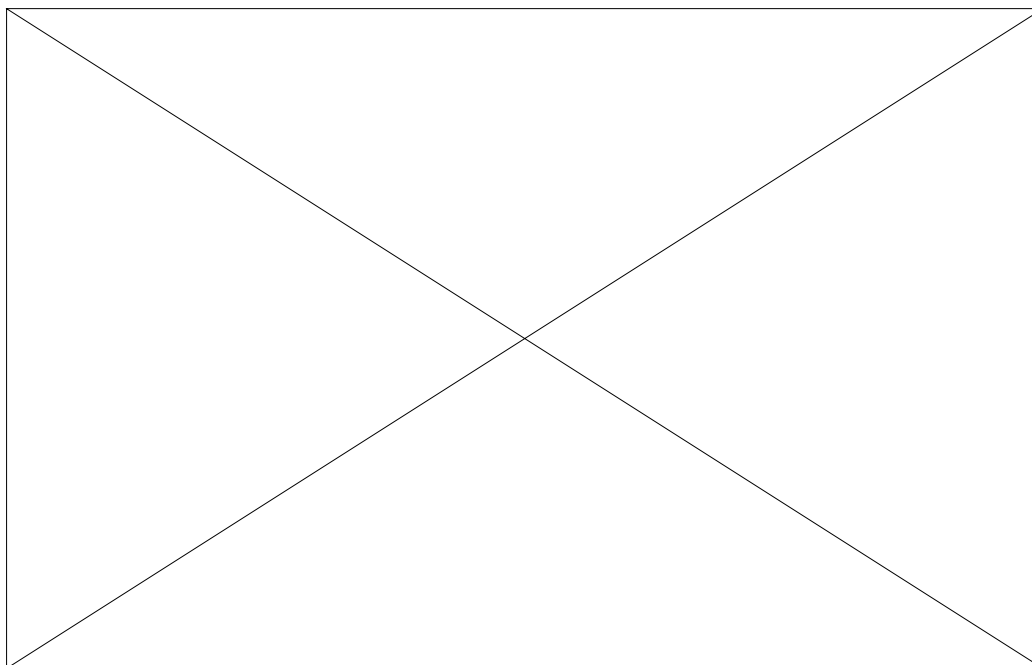
Fig. 1 indicates that spider communities on the bogs (TWIN 1) had more species in common with the open *Calluna*-pine forests (TWIN 2) than with the other forests. Indicator species of the community groups, separated by means of TWINSpan, were *Trochosa terricola*, *Gonatium rubens* and *Pardosa pullata*, all typical for open areas (TWIN 1 and 2). Species typical for the forests (TWIN 3-5) were *Lepthyphantes alacris* and *Gonatium rubellum*, for the bogs (TWIN 1) *Pirata hygrophilus* and for the deciduous forests (TWIN 4, 5) *Helophora insignis*.

Some species were most frequently found in particular TWINSpan groups, although not separated as indicator species. *Notioscopus sarcinatus*, *Pirata piraticus* and *Pocadicnemis pumila* were most frequent in the bogs (TWIN 1); *Gnaphosa bicolor*, *Zelotes clivicola* and *Hahnia ononidum* were most frequent in the open *Calluna*-pine forests (TWIN 2). The dominance of the different forest species *Lepthyphantes tenebricola* and *L. alacris* vary within the forest communi-

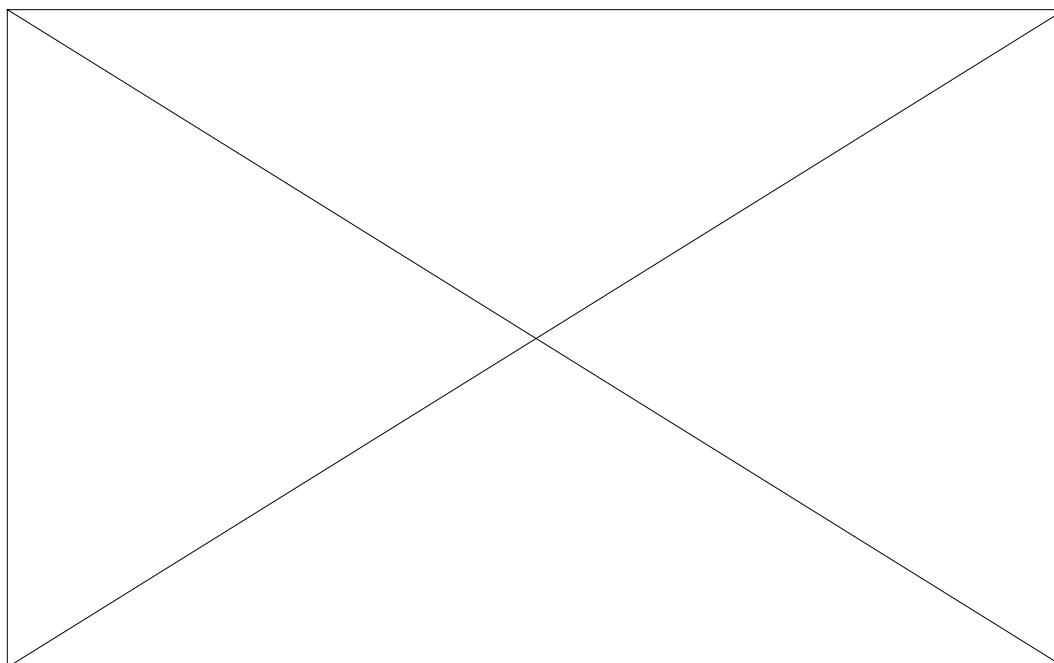
ties (TWIN 3, 4 and 5). *Diplostyla concolor* was found mainly in the deciduous forests (TWIN 4 and 5).

#### Ordination of species and communities

As a second step in the analysis of the spider data, DCA-analysis was used to detect major gradients of faunistic variation (Fig. 2). DCA-axis 1 is interpreted to represent the gradient of spider species and communities from bogs, via species and communities found in open *Calluna*-pine forests, bilberry pine forests to spider species and communities of different deciduous forests. DCA-axis 1 has a gradient length of 4.837 SD, an eigenvalue of 0.796 and explains 23.6% of the variation in the spider species/community data. The eigenvalue of DCA-axis 2 is 0.214, and it explains only 6.4% of the variation. Spider communities of the bogs and the *Calluna*-pine forests were more clearly separated as distinct groups in the ordinations than were the communities found in the bilberry-pine forests and the deciduous forests (Fig. 2).



**Fig. 1.** TWINSpan classification of the 50 sites (Geitaknottane, Western Norway) into five groups based on the spider data (1997), along with indicator species. N is the number of sites.



**Fig. 2.** DCA-ordination of the spider communities found in 50 different sites (Geitaknottane, Western Norway), based on activity abundance of spider species in 1997. The dotted lines indicate the different TWINSPAN-groups (cf. Fig. 1).

These interpretations of the DCA were largely confirmed by the results of the DCCA (Fig 3). Environmental variables like increasing forest productivity, decreasing soil humidity score, increasing bush cover, increasing tree cover and increasing slope of the site, turned out to be the significant ones, explaining the gradient of communities of spiders along DCCA-axis 1. A strong species-environment correlation (0.945) of DCCA-axis 1 support the importance of these factors. Increasing heat index was the only significant explanatory variable for DCCA-axis 2. The eigenvalue of DCCA-axis 1 is 0.697 and this axis explains 20.7% of the variation in the spider data. The eigenvalue of DCCA-axis 2 (0.139) explains considerably less (4.1%) and should be used with caution.

#### Diversity and habitat preference

In all, 16628 adult spiders were found, representing 154 species from 19 families. The number of species ranged from 21 to 51. On aver-

age, 27 (min 21; max 37) species were recorded in the deciduous forests (TWIN 4 and 5), 33 (30-38) in the bogs (TWIN 1), 32 (23-42) species in the bilberry-pine forests (TWIN 3) and 43 (32-50) species from the *Calluna*-pine forests (TWIN 2). Species new to Norway were *Euophrys frontalis*, *Maro lepidus* and *Porrhomma oblitum*.

Considering the ten most abundant species in the different TWINSPAN-groups, a complete change in species composition is indicated along the gradient from bogs (TWIN 1) to deciduous forests (TWIN 4 and 5). A change in species composition is also indicated by the gradient length of DCA-axis 1 (4.837 SD). The cursorial spiders (Lycosidae, Liocranidae, Tetragnathidae) dominated in the bogs and in the *Calluna* pine forests, while the linyphiids dominated in the bilberry-pine and deciduous forests. In the bogs (TWIN 1), *Pirata hygrophilus* showed the highest activity abundance (49.2%) followed by *Pardosa pullata* (17.2%), *Notioscopus sarcinatus* (3.9%), *Pardosa amentata* (3.3%) and *Trochosa terricola* (3.3%). In the *Calluna*-pine for-

ests (TWIN 2) *P. pullata* (15.8%) dominated followed by *Alopecosa taeniata* (7.4%), *T. terricola* (6.4%), *Lepthyphantes menzei* (5.8%) and *Agyneta cauta* (4.2%). In the bilberry-pine forests (TWIN 3) *Lepthyphantes alacris* (24.2%) was the most abundant species, followed by *L. tenebricola* (10.2%), *Centromerus arcanus* (8.0%), *Agyneta cauta* (6.1%), *A. conigera* (5.8%) and *Dicymbium tibiale* (5.5%). The humid grey alder forests (TWIN 4) and the drier elm-lime forests (TWIN 5) were both dominated by *Lepthyphantes tenebricola* (30.3% and 20.6% respectively). In TWIN 4 the second most abundant species was *L. alacris* (13.4%), followed by *D. tibiale* (12.4%), *C. arcanus* (7.7%) and *Helophora insignis* (5.8%). For the elm-lime forests (TWIN 5) the second most abundant species was *Pardosa lugubris* (17.2%), followed by *Diplocephalus latifrons* (11.7%), *L. alacris* (7.5%) and *L. zimmermanni* (7.3%).

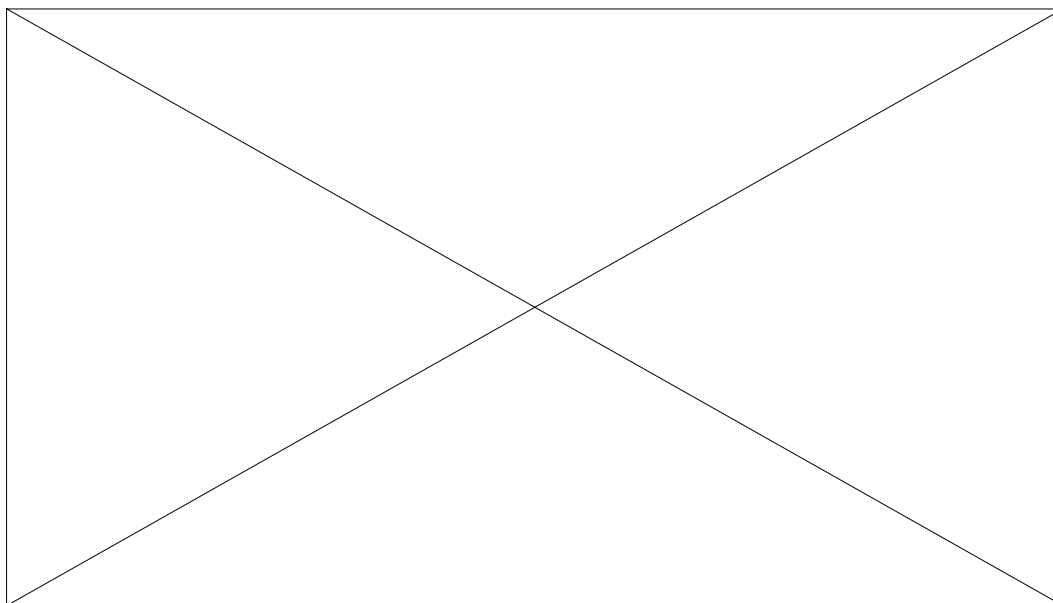
The correlation between the vegetation types and the spider fauna of the sites was quite high at the community level, but at the species level the pattern was more complex. Species found in many different vegetation types are *Centromerus arcanus* (found in 49 out

of 50 sites), *Agyneta conigera* (42/50), *Lepthyphantes menzei* (40/50) and *Walckenaeria cuspidata* (39/50). Species found only in particular vegetation types in the study area are *Pirata hygrophilus* and *Notioscopus sarcinatus*, both found only in the bogs.

### DISCUSSION

The DCA gradient of spider communities, from communities found in bogs, *Calluna*-pine forests, bilberry-pine forests to the communities of deciduous forests, was confirmed and partly explained by the environmental factors in DCCA. There was only a minor reduction in the biological variation being explained by the two first axes, from 30.0% (23.6 + 6.4) in DCA to 24.8% (20.7 + 4.1) in DCCA. The strong species-environment correlation (0.945) of DCCA-axis 1 also support this statement (ter Braak 1990).

According to the results of TWINSpan and DCA/DCCA, the correlation between vegetation types and the spider fauna on the site is quite high at the community level. Exceptions are the spider communities in three deciduous forests and two *Calluna*-pine forests, all



**Fig. 3.** DCCA-ordination of the spider communities found in 50 different sites (Geitaknottane, Western Norway), based on activity abundance of spider species in relation to 6 recorded environmental factors (1997). The dotted lines indicate the different TWINSpan-groups (cf. Fig. 1).

grouped together with the spider communities found in bilberry-pine forests (TWIN 3). This is most likely explained by similar structures of the vegetation in the field layer. The presence of a woody field vegetation (*Vaccinium myrtillus* and *Calluna vulgaris*), with similar structure, density, and shade conditions, may affect the spiders living there. The DCA-ordination of one bog spider community separated from the other bog spider communities (lower left part of Fig. 2) is primarily due to high abundance of *Pardosa amentata*, not found at the other bog localities.

TWIN 3, 4 and 5 were not separated clearly as distinct community groups along the DCA/DCCA-axis (Fig. 2 and 3). The fact that these three TWINS PAN groups have some dominant species in common and few abundant species typical for one TWINS PAN-group, can result in different grouping in the TWINS PAN, but do not separate them clearly in the ordination. Similar microclimate or shade conditions in the bilberry-pine forests and the deciduous forests may result in similarity in the spider composition of these small habitats. However, neither plant composition or structure of the field layer were similar on these sites.

Along the first DCCA-axis, the spider species and communities in the bogs were ordinated with high scores for humidity and low scores for tree cover and productivity. The spider communities found in the different deciduous forests were ordinated with higher scores for tree cover and productivity, and lower scores for humidity. Some spider communities from *Calluna*-pine forests have relatively high scores for the heat index. These patterns partly confirm the habitat preference of the spider species presented by Reinke & Irmeler (1994) and Hänggi et al. (1995). One exception is *Pirata hygrophilus*, which in the present study was most abundant and frequent in the bogs (treeless, open areas), while in Europe it is most frequently reported from humid forests (Maelfait et al. 1995; Thaler 1997).

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