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Occurrence of grass-dwelling spiders in habitats of Lake Engure Nature Park

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Abstract

Ecological studies on spiders in the territory of Latvia have not been conducted recently. We describe grass-dwelling spider fauna in 12 different habitats within the area of Lake Engure Nature Park. Spiders were collected by three sweep-nettings per year during a 12-year period (1997 – 2008). More than 149 taxa from 19 families were identified. On the basis of similarity in spider fauna shown by cluster analysis, the habitats were divided into two groups. The first group included mostly dry habitats, such as dry wooded meadow, dry coastal meadow, moist coastal meadow, dry pine forests, wet deciduous forest and wet pine forest. The second group were characterised by wet habitats – marshlands and moist calcareous meadow. Dry pine forest was not included in any group due to a low species number and completely different fauna from the other habitats. Only three species were present in a particular habitat for nine or more years: *Linyphia triangularis* (in a dry pine forest on grey dunes and in a dry pine forest on mineral soil), *Tibellus maritimus* (in a calcareous fen) and *Evarcha falcata* (in a dry pine forest on mineral soil).

Key words: Aranea, distribution in habitats, sweep-net, long-term research.

Introduction

Spiders as predators play a significant role in regulating populations of various arthropod species. Spiders are distributed in a wide range of habitats (Foelix 1996). They have relatively high species diversity, and therefore they have been used as ecological indicators of habitat quality in several studies in Europe (Clausen 1986; Schultz, Finch 1996). However, these studies usually include only one habitat or a habitat group within a restricted area.

Spiders of dune grasslands were studied in Belgium, the Netherlands and the United Kingdom (Maelfait, Baert 1988; Rushton 1988; Maelfait et al. 1989). The impact of grazing on spiders in mesophytic calcareous dune grasslands and the effects of various factors on species richness in coastal grey dunes have been studied by Bonte et al. (2000; 2004). Buchholz (2009) investigated spider community structure in a coastal habitat of the Mediterranean delta region. Using long-term data since 1970, Bonte et al. (2002) identified indicator species for specific dune habitats in a heterogeneous coastal dune system in Belgium. In Poland, spider communities in natural and drained fen-mires in Biebrza River Valley have been studied since 1955 (Kajak et al. 2000).

In the Baltic region (including Latvia, Lithuania and Estonia), several studies of spiders have been conducted previously. In Estonia, the spider fauna of fens, raised bogs and transition mires (Vilbaste 1980; 1981) and various habitats of Matsalu State Nature Reserve (Vilbaste 1982; Meriste 2003) have been surveyed. In Lithuania, Biteniekytė and Relys (2006; 2008) presented data on the spider fauna of peat bogs. In Latvia, rather wide faunistic investigations of spiders, limited in ecological scope, have been conducted (Grube 1859; Šternbergs 1976; 1977; 1979a; 1979b; 1981; 1985; 1989). However, there are no studies on spider communities in coastal habitats in territory of Latvia.

This paper reports data on grass-dwelling spider collections made over 12 years (1997 – 2008) from a wide range of habitats in the Lake Engure Nature Park, one of the Ramsar Convention sites in Latvia (established in 1995). Lake Engure Nature Park was selected for the Long-term Ecological Research network, because of its many unique habitats inhabited by rare and endangered species (Melecis et al. 2005). Numerous long-term ecological studies have been conducted in this park, including studies of bird populations and plant communities in wetlands and terrestrial sites.

One of the main collection methods for identifying arthropod diversity within habitats is the sweep-net method. This method is commonly used for arthropod collection (Karpa 2000; Idris et al. 2001; Noyes 1989). The aim of this paper was (i) to evaluate the suitability of the sweep-net method for long-term research of spider communities and (ii) to describe grass-dwelling spider communities of a wide variety of terrestrial and wetland habitats of the Lake Engure Nature Park.

Materials and methods

Study site

The research was conducted in the Lake Engure Nature Park, Latvia (central coordinates 57°15' N; 23°07' E; Fig. 1; Table 1). Lake Engure is situated near the Eastern coast of the Kurzeme peninsula between the villages Engure and Mērsrags. The lake was formed as a lagoon 4000 years ago, when it was separated from Littorina Sea (historical stage of the formation of the Baltic Sea). Now the lake is situated 1 to 3 km from the Baltic Sea coast (Vīksne 1997).

Twelve sampling transects in 12 habitats were selected to cover the diversity of habitats of the park, including the most common habitats of the region, and also unique and protected habitats, such as calcareous fens (included in Annex 1 of the European Habitat Directive as a priority habitat type; EEC 1992). Locations of sample plots are shown in Fig. 1 and their numbering was made according to Melecis et al. (2000). Geographical coordinates of each transect and a short summary of the characteristic vegetation is given in Table 1. Vegetation of sample plots is described in Melecis et al. (2000).

Spider collecting

Spiders and other grass-dwelling arthropods were collected using an entomological sweep-net on 50 m long transects. One sample, consisting of 100 sweeps, was taken from each of 12 transects (one transect for one habitat) three times yearly for 12 years (1997 – 2008). Arthropods were collected in a small nylon gauze bag attached to a metal ring fastened at the bottom edge of the entomological sweep-net. The bag was removed after sampling, closed, labelled, and placed in a plastic bag containing ethyl-acetate vapour (killing agent for arthropods). In the laboratory, the arthropods were sorted according to taxonomic groups. The spiders were placed in vials with 70% ethanol. Spider species were identified using identification keys (Locket, Millidge 1953; Heimer, Nentwig 1991; Nentwig et al. 2003; Almquist 2005; 2006). Taxonomy of spiders in this article follows Platnick (2010). Arthropod collection by sweep-netting was conducted by two people during the period 1997 – 2008.

All specimens collected in this study, including spiders, are kept in the collection of the Laboratory of Bioindication at the Institute of Biology of the University of Latvia.

Table 1. Characteristic vegetation and coordinates of the sample plots (numbering of the sample plots follows Melecis et al. 2000, see Fig. 1)

No.	Habitat of the sample plot and abbreviation used	Dominant plant species	Coordinates at the beginning of transect N, E	
1	dry wooded meadow – dwm	*Deschampsia flexuosa, Melampyrum pratense, Luzula pilosa, Trientalis europaea*	57°17'17.7"	23°08'30.3"
2	calcareous fen – cf	*Phragmites australis, Schoenus ferrugineus, Primula farinose, Epipactis palustris*	57°17'13.9"	23°08'57.8"
3	wet pine forest – wpf	*Molinia caerulea, Vaccinium myrtillus, V. vitis-idea, Equisetum variegatum, Carex nigra*	57°17'1.8"	23°09'01.9"
4	dry pine forest on poor soil – dpf	*Deschampsia flexuosa, Carex arenaria, Melampyrum pratense*	57°17'20.4"	23°09'13.2"
5	dry coastal meadow – dcm	*Elytrigia repens, Leymus arenarius, Honckenya peploides, Festuca arenaria*	57°17'19.3"	23°09'51.3"
6	moist coastal meadow – mcm	*Carex nigra, Trifolium pratense, Anthoxanthum odoratum, Hydrocotyle vulgaris, Angelica sylvestris*	57°17'28.8"	23°08'04.7"
7	wet deciduous forest – wdf	*Molinia caerulea, Filipendula ulmaria, Geum rivale, Pyrola rotundifolia*	57°18'08.0"	23°02'56.5"
8	flood-plain calcareous fen – fpcf	*Phragmites australis, Schoenus ferrugineus, Cladium mariscus, Mirica gale, Menyanthes trifoliata*	57°18'08.5"	23°03'14.5"
9	moist calcareous meadow – mcam	*Sesleria caerulea, Carex nigra, C. panacea, C. flava, Thalictrum simplex, Potentilla erecta, Peucedanum palustre*	57°17'03.8"	23°03'52.8"
10	marsh – m	*Carex nigra, Comarum palustre, Calamagrostis neglecta, Naumburgia thyrsiflora*	57°17'02.7"	23°03'54.6"
11	dry pine forest on grey dune – dpf1	*Vaccinium myrtillus, Festuca ovina, Fragaria vesca, Geranium sanguineum*	57°10'41.4"	23°13'16.5"
12	dry pine forest on mineral soil – dpf2	*Vaccinium myrtillus, V. vitis-idaea, Empetrum nigrum, Melampyrum pratense, Calluna vulgaris*	57°17'23.0"	23°09'41.3"

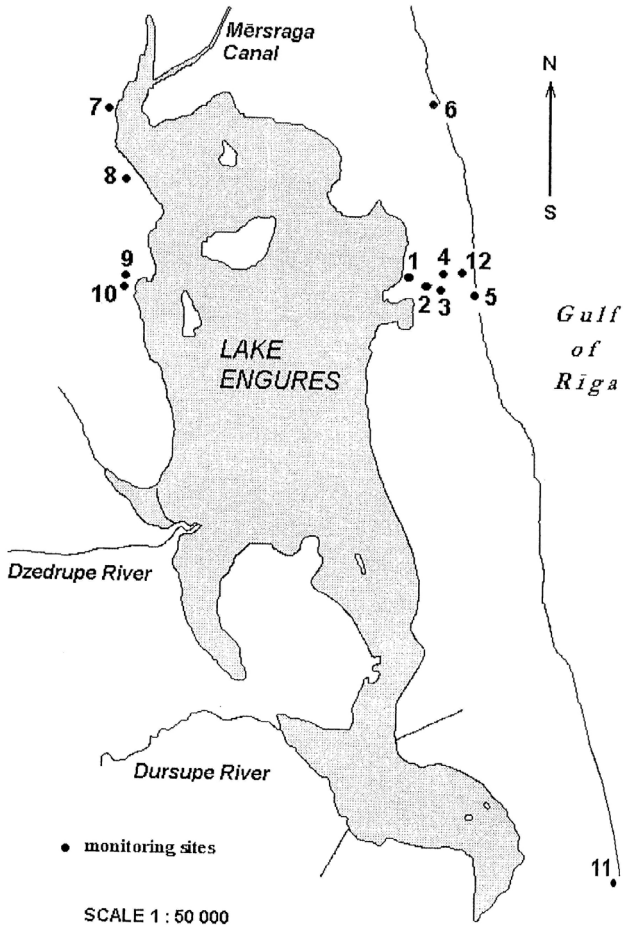

Fig. 1. Location of sample plots in the Engure Lake Nature Park.

Data analysis

Similarity of spider fauna among the studied habitats was determined by cluster analysis. The three samples per year were pooled together. Species represented by one or two individuals (n = 67 or 4.7% of total number of spiders) were excluded from the analysis (McCune, Grace 2002) to avoid outliers. All data were log-transformed [n = lg (n+1)] to achieve normality. All together 80 spider species (including some undetermined) were included. The cluster analysis was performed by PC-ORD 4 (McCune, Mefford 1999). Similarity was calculated as Sorensen's distance (Bray-Curtis) measure and the single linkage nearest neighbour method was used to form linkages.

Engelmann's classification (Engelmann 1978) was used to characterise the dominance structure.

Results

Spider fauna and dominance structure

We recorded 1783 adult specimens from 19 families representing more than 149 taxa (including undetermined species) (Appendix 1). The number of species differed between habitats (Appendix 1). The dominant families with the largest number of individuals were Tetragnathidae (32.5%) and Linyphiidae (20.3%), followed by Salticidae (10.4%), Theridiidae (9.7%), Araneidae (8.5%), and Philodromidae (7.1%) as subdominant. The other 13 spider families were considered recedent or subrecedent because they comprised less than 4% of the total. The highest number of species, more than 44, was recorded in the family Linyphiidae. The other 10 families were represented by less than 15 species and eight families had only one species. *Linyphia triangularis* (7.8%) was the most frequently recorded species, followed by *Metellina segmentata* (5.2%), *Enoplognatha ovata* (4.65%) and *Evarcha falcata* (4.6%) (all species were subdominant). The genus *Tetragnatha* sp. also dominated (23.4%) compared to other species, but specimens were not identified to species. The remaining species were recedent to subrecedent.

Each habitat contained dominant species (Table 2) excepting the dry pine forest due to small sample size.

Cluster analysis

Cluster analysis revealed two distinct groups of spider communities (Fig. 2). The first one included mostly dry habitats, such as dry wooded meadow (dwm), dry coastal meadow (dcm) and dry pine forests (dpf1, dpf2). Moist coastal meadow (mcm) and some forest habitats such as wet deciduous forest (wdf) and wet pine forest (wpf) were also associated with this cluster group. The second group of clusters included mainly marshlands (m, fcpf, cf) and wet calcareous meadow (mcam). The dry pine forest (dpf) was not associated with either of these clusters.

Species occurrence in habitats

During the 12-year investigation period, none of the species were found every year, except for *Tetragnatha* sp. in moist coastal meadows (Table 3). A species of *Tetragnatha* was found for 11 years in dry coastal meadows and 9 years in moist calcareous meadow. *Linyphia triangularis* was found 10 years in a dry pine forest on grey dunes and dry pine forest on mineral soil, and *Evarcha falcata* for 10 years in a dry pine forest on mineral soil.

Discussion

Critics on the sampling method

In our study, 149 spider taxa were found. Altogether 460 species have been found in Latvia (Relys, Spuņģis 2002; Cera 2008; Cera, Spuņģis 2008; Cera 2009). Sweep-netting is preferred for collecting insects which is why this method was chosen for the complex long-term study (Melecis et al. 2000). The method was not changed for 12 years because of its simplicity. Southwood and Henderson (2000) considered this method as the most frequently used for collecting grass-layer insects. Churchill and Arthur (1999) described also other methods, such as pitfall traps, litter sifting, suction sampling and visual search, as suitable for spider collecting. Lowrie (1971) used a sweep-net method for population estimation of Oxyopidae spiders. He analyzed

Table 2. Dominance of grass-dwelling spider species in the studied habitats

No.	Habitat of the sample plot	Species	Dominance of spider species in respective habitat (%)
1	Dry wooded meadow	*Tetragnatha* sp.	19.61
		Tibellus oblongus	11.58
		Metellina segmentata	10.61
		Evarcga arcuata	8.36
		Evarcha falcata	8.04
		Enoplognatha ovata	6.11
2	Calcareous fen	*Tetragnatha* sp.	38.60
		Tibellus maritimus	14.04
		Evarcha arcuata	6.14
		Larinioides cornutus	5.26
3	Wet pine forest	*Tetragnatha* sp.	12.32
		Theridion varians	7.97
		Linyphia triangularis	6.52
		Metellina segmentata	6.52
		M. mengei	5.80
		Evarcha falcata	5.07
4	Dry pine forest on poor soil	–	–
5	Dry coastal meadow	*Tetragnatha* sp.	55.37
		Metellina segmentata	9.06
		M. mengei	4.70
		Larinioides cornutus	4.36
6	Moist coastal meadow	*Larinioides cornutus*	14.47
		Evarcha arcuata	5.66
		Enoplognatha ovata	4.40
7	Wet deciduous forest	*Enoplognatha ovata*	23.53
		Metellina mengei	13.97
		Tetragnatha sp.	13.24
		Neriene emphana	11.76
		Linyphia triangularis	9.56
		Metellina segmentata	8.82
8	Flood-plain calcareous fen	*Evarcha arcuata*	18.18
		Marpissa radiata	13.64
9	Moist calcareous meadow	*Tetragnatha* sp.	38.19
		Cheiracanthium virescens	4.17
10	Marsh	*Tetragnatha* sp.	42.05
		Larinioides cornutus	7.95
		Sitticus floricola	6.82
		Araneus quadratus	4.55
		Evarcha arcuata	4.55
11	Dry pine forest on grey dune	*Linyphia triangularis*	29.71
		Dismodiscus elevatus	6.52
		Hylyphantes graminicola	5.80
		Dismodiscus bifrons	5.07
		Metellina segmentata	5.07
		Dictyna arundinacea	5.07
12	Dry pine forest on mineral soil	*Linyphia triangularis*	27.46
		Evarcha falcata	21.24
		Metellina mengei	5.18
		Tetragnatha sp.	4.66
		Philodromus aureolus	4.66

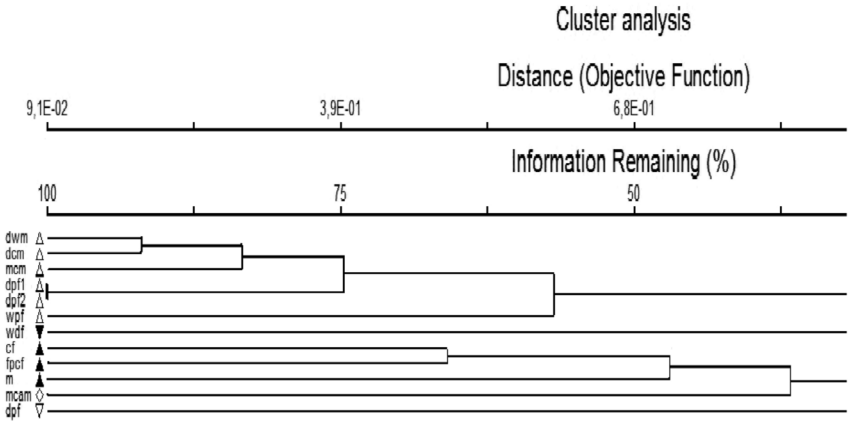

Fig. 2. Cluster analysis of 12 habitats at Lake Engure Nature Park based on pooled and reduced data of collected spider during 1997-2008, for abbreviations see Table 1.

factors affecting sample size (number of collected species) and found that species numbers were affected by collection time of day, cattle grazing, wetness of vegetation and air temperature. Norris (1999) recommended using sweep-netting (or pitfall traps, or litter samples) for habitat surveys, because these methods are least subjective to sampler bias. For collecting other arthropods, such as Hymenoptera, sweep-netting was found to be the most effective collection method (Noyes, 1989). There are other specific methods for collecting certain spider species. Duffey (1962; 1968), who studied grass-dwelling spiders in Great Britain, used collection by hand directly from vegetation or by help of a white paper sheet. This method might be more effective, but it is also less standardised. In long-term studies, sweep-netting and pitfall traps are easy to use, but the former is less time consuming. In the future, pitfall traps are also recommended for the study area to obtain a more complex overview of the spider fauna.

Cluster analysis and presence of species

Based on spider community composition in the studied habitats, the habitats were classified in two groups. The differences in number of species and specimens in various habitats can be explained by differences in vegetation, moisture, habitat preference of spider species or some other factors. Greenstone (1984) found a relation between spider species diversity in California and Costa Rica and micro-spatial heterogeneity of habitat (e.g. vegetation height), also observed by Duffey (1962).

Woodlands and meadows were relatively similar in species composition. This is probably because dry wooded meadow and dry coastal meadow are both to the same degree affected by pine *Pinus sylvestris*, either by invading trees or by forest edges. In heathlands, species diversity of spiders is influenced by presence of woodland (Webb et al. 1984). Also, moisture and shading affect spiders (Entling et al. 2007). The similarity of moist coastal meadow (mcm) communities to the woodland-meadow cluster group can be explained by similar species composition with dry coastal meadow (dcm).

Species more common in woodlands (dpf1, dpf2, wpf) compared to meadows were *Hylyphantes graminicola, Linyphia triangularis, Evarcha falcata, Metellina mengei, M. segmentata, Theridion varians, Dismodicus bifrons, D. elevatus, Dictyna arundinacea, Philodromus aureolus* and *Xysticus cristatus*. Previously, *Hylyphantes graminicola* has been described as a common species in wet habitats in close proximity to water (Heimer, Nentwig 1991) where it

Table 3. Species present in various habitats of Lake Engure Nature Park nine years or more in the period 1997 – 2008

Species	Habitat and abbreviation	Number of years present	Years absent
Tetragnatha sp.	Calcareous fen (cf)	9	1997; 1998; 2004
Tibellus maritimus	Calcareous fen (cf)	9	2004; 2006; 2008
Tetragnatha sp.	Dry coastal meadow (dcm)	11	2007
Tetragnatha sp.	Moist coastal meadow (mcm)	12	–
Tetragnatha sp.	Moist calcareous meadow (mcam)	9	1998; 2001; 2004
Linyphia triangularis	Dry pine forest on grey dune (dpf1)	10	2000; 2008
Linyphia triangularis	Dry pine forest on mineral soil (dpf2)	10	2000; 2008
Evarcha falcata	Dry pine forest on mineral soil (dpf2)	10	1997; 2000

can be found on trees and bushes (Locket, Millidge 1953). *Linyphia triangularis* is very common in the shrub-layer and grass-layer of various woodland habitats (Robert 1995, Benjamin et al. 2002), while *Evarcha falcata* is typical for common heather (*Calluna vulgaris*) meadows (Almquist 2006). *C. vulgaris* is widely distributed in woodlands of the Lake Engure Nature Park. *Metellina mengei* and *M. segmentata* are typical for woodlands, particularly in fir (*Abies* sp.) and spruce (*Picea* sp.) stands (Almquist 2005). *Theridion varians* can be found in pine and young spruce forests (Almquist 2005), *Dismodicus bifrons* and *D. elevatus* in woody areas (Locket, Milledge 1953) on low vegetation or bushes (Roberts 1995), *Dictyna arundinacea* in the shrub-layer (Almquist 2006), *Philodromus aureolus* in dry pine forests, and juniper shrubs, and *Xysticus cristatus* is common in dry and damp meadows (Almquist 2006).

Meadow habitats (dwm, dcm, mcm) were characterised by the abundant species *Tibellus oblongus, Metellina mengei, M. segmentata, Evarcha arcuata, E. falcata, Enoplognatha ovata* and *Larinioides cornutus*. Of these species, *Tibellus oblongus* is typical for dune and damp meadows (Roberts 1995), *Evarcha arcuata* occurs in meadows, *Enoplognatha ovata* is found on shrubs, and *Larinioides cornutus* is common in dry meadows on vegetation or low shrubs (Almquist 2005; 2006). Šternbergs (unpublished data, collected by using entomological sweep-netting method) reported dominance (49%) of Thomisidae in coastal meadows of Latvia. Our results also recorded Thomisidae in meadow habitats (5%), but in 10 times lower abundance. Tetragnathidae (23%), Araneidae (21%) and Linyphiidae (14%) dominated in the moist meadow habitats. The sharp difference in family dominance in comparison with the previous study may be explained by characteristics of the studied habitats. Šternbergs mostly investigated hay meadows, a habitat not represented in our research. We found an almost identical number of species in moist coastal meadow (n = 54) as that observed at Lake Neuchâtel, Switzerland (n = 53), where the impact of mowing on spiders was studied in wet meadows (Cattin et al. 2003). In both studies, the following 12 species were common: *Theridion impressum, T. pictum, Bathyphantes gracilis, Silometopus elegans, Araneus diadematus, Larinioides cornutus, Neosconta adianta, Pardosa prativaga, Micrommata virescens, Tibellus maritimus, Evarcha arcuata* and *Sitticus caricis*. The frame method was used in the Swiss study (Cattin et al. 2003) instead of sweep-netting. This might explain why only some of species were found in both countries, but geographical differences between Latvia and Switzerland also have to be considered.

Wet deciduous forest (wdf) was characterised by the presence of *Enoplognatha ovata, Metellina mengei, M. segmentata, Tetragnatha spp., Neriene emphana* and *Linyphia triangularis,* which is similar with species composition of woodlands and meadows in the dry habitat cluster group. *Neriene emphana* has previously been reported to be more common in deciduous and coniferous forests (Hänggi et al. 1995).

Marshland habitats (cf, fpcf, m) at Lake Engure Nature Park were characterized by *Marpissa radiata*, which is known as typical for lake shores, especially covered by *Cladium mariscus* (Almquist 2006), Tibellus maritimus known for marshes with *Cladium mariscus, Sitticus floricola* – for *Carex*-swamps and moist meadows (Almquist 2006), *Araneus quadratus* – for bogs (Almquist 2005) and *Larinioides cornutus, Evarcha arcuata* – both for meadow habitats (Almquist 2005; 2006). We collected 51 species in the marshland habitats, considerably less than 130 species collected in similar habitats in Poland (Kajak et al. 2000). The difference can be explained by the different sampling methods (in Poland, the frame method was used instead of sweep-netting). We identified 16 species in marshland habitats, which were also common in natural and drained fens in Poland (Kajak et al. 2000): *Xysticus cristatus, X. ulmi, Sitticus floricola, Tibellus maritimus, Pardosa prativaga, P. sphagnicola, Batyphantes gracilis, Erigone atra, Gongylidiellum murcidum, Hypomma bituberculatum, Kaestneria pullata, Meioneta rurestris, Clubiona stagnatilis, C. subtilis, Araneus quadratus* and *Larinioides cornutus*. The genus *Tetragnatha* was the most common in half of the investigated habitats (dwm, cf, wpf, dcm, mcam, m). Identification was not made to species of this genus. Six species of the genus *Tetragnatha* are known for Latvia: *T. dearmata, T. extensa, T. montana, T. nigrita, T. obtusa* and *T. pinicola* (Relys, Spuņģis 2002). These species can be divided into two groups based on preferred habitats. *T. dearmata, T. extensa, T. montana* prefer moist places, while *T. nigrita, T. obtusa* (also dry meadow) and *T. pinicola* prefer habitats with trees (Almquist 2005). Robert (1995) described *T. extensa* and *T. montana* as the most common species in Britain and Northern Europe.

The species composition in dry pine forest (dpf) on poor soil was not similar to any other habitats. The habitat supported the lowest number of species in comparison to the other habitats (Appendix 1). The low number of species can be explained by scarce vegetation as well as by limited space for web building. Šternbergs (unpublished data) collected eight species by hand on mosses and lichens. Three species found by Šternbergs (unpublished data) were shared with these in this study: *Gonatium rubens, Crustulina guttata* and *Euophrys frontalis*. Šternbergs collected also *Tapinocyba pallens, Minyriolus pusillus, Diplocentria bidentata, Gonatium rubellum* and *Trochosa ruricola*. He also considered that pine forest had a poor spider fauna.

Bonte et al. (2002) considered as true indicator species only those, which are found in the respective habitat every year independently of their abundance. In this study we did not find any species every year in the same habitat. There were only three species that were present ≥ 9 years – *Linyphia triangularis, Tibellus maritimus* and *Evarcha*

falcata. *Tetragnatha* spp. were found in all years but were not identified to species.

Due to the used method, our results represent only grass-dwelling spider fauna in 12 habitats. More studies using other collection methods are required to assess complete fauna of all respective microhabitats (e.g. sampling by pitfall traps, frame method and collecting by hands).

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Appendix 1. Presence (×), number of individuals (Sum) and dominance (Dom. %) of spider species collected by sweep-netting at different habitats of Lake Engure Nature Park in 1997 – 2008 (see Table 1 for habitat abbreviations).

Family/ Species	dwm	cf	wf	dpf	wd	cm	wdf	fpgf	mcm	m	dpf1	dpf2	Sum	Dom.%
Mimetidae													1	0.05
Ero furcata (Villers, 1789)			×										1	0.05
Uloboridae													1	0.05
Hyptiotes paradoxus (C.L. Koch, 1834)			×										1	0.05
Theridiidae													182	9.67
Achaearanae lunata (Clerck, 1757)			×		×		×						4	0.22
Crustulina guttata (Wider, 1834)											×		1	0.05
Enoplognata sp.	×										×		2	0.11
Enoplognatha ovata (Clerck, 1757)	×		×		×	×	×		×		×	×	83	4.65
Episinus angulatus (Blackwall, 1836)	×										×		2	0.11
Episinus truncatus Latreille, 1809											×		1	0.05
Lasaeola tristis (Hahn, 183)			×										1	0.05
Neottiura bimaculata (Linnaeus, 1767)	×												3	0.16
Paidiscura pallens (Blackwall, 1834)	×			×							×		4	0.22
Robertus sp.						×							1	0.05
Simitidion simile (C.L. Koch, 1836)						×							1	0.05
Theridion imperssum L. Koch, 1881		×	×		×	×		×	×	×			24	1.34
Theridion pictum (Walckenaer, 1802)	×	×	×						×				11	0.61
Theridion sisyphium (Clerck, 1757)	×		×		×	×			×			×	10	0.56
Theridion sp.	×	×	×		×	×			×	×	×	×	11	0.61
Theridion tinctum (Walckeanaer, 1802)	×		×					×			×	×	6	034
Theridion varians Hahn, 1833			×			×			×				14	0.28
Theridiidae gen. spp.		×	×										3	0.16
Linyphiidae													374	20.28
Bathyphantes gracilis (Blackwall, 1841)	×					×				×		×	10	0.56
Bathyphantes nigrinus (Westring, 1851)								×					1	0.05
Bathyphantes sp.									×				1	0.05
Bolyphantes alticeps (Sundevall, 1833)						×							1	0.05
Centromerus dilutus (O.P.-Cambridge, 1875)					×								1	0.05
Dicymbium tibiale (Blackwall, 1836)				×									2	0.11
Dismodiscus bifrons (Blackwall, 1841)					×						×		8	0.45
Dismodiscus elevatus (C.L. Koch, 1838)	×		×	×				×			×	×	17	0.56
Entelecara flavipes (Wider, 1834)				×					×				3	0.16
Erigone atra Blackwall, 1833	×	×			×				×			×	5	0.28
Erigone sp.									×				2	0.11
Erigonella ingobilis (O.P.-cambridge, 1871)										×			1	0.05
Floronia buculenta (Clerck, 1757)			×										3	0.16
Gnathonarium dentatum (Wider, 1834)	×												1	0.05
Gonatium rubens (Blackwall, 1841)	×											×	4	0.22
Gongyilidiellum murcidum Simon, 1884	×	×					×	×			×		5	0.28
Gongylidiellum rufipes (Linnaeus, 1758)	×		×							×			4	0.22
Hylyphantes graminicola (Sundevall, 1830)	×	×	×	×	×	×			×		×	×	36	2.01
Hypomma bituberculatum (Wider, 1834)		×		×									3	0.16
Hypomma cornutum (Blackwall, 1833)	×			×	×	×			×		×		15	0.84
Kaestneria dorsalis (Wider, 1834)									×				1	0.05
Kaestneria pullata (O.P.-Cambridge, 1863)		×			×	×							3	0.16
Linyphia sp.					×				×				4	0.22
Linyphia triangularis (Clerk, 1757)	×		×		×	×	×				×	×	140	7.84
Maso sundevalli (Westring, 1851)	×					×	×						4	0.22
Meioneta rurestris (C.L. Koch, 1836)	×	×							×				5	0.28
Micrargus herbigradus (Blackwall, 1854)							×						1	0.11
Microlinyphia pusilla (Blackwall, 1844)						×							1	0.05
Minicia marginella (Wider, 1834)								×					1	0.05
Neriene clathrata (Sundevall, 1830)			×										1	0.05
Neriene emphana (Walckenaer, 1841)	×		×				×	×					23	1.28
Neriene montana (Clerck, 1757)			×						×			×	5	0.28

Appendix 1. *continued*

Family/ Species	dwm	cf	wf	dpf	wd	cm	wdf	fpgf	mcm	m	dpf1	dpf2	Sum	Dom.%
Neriene peltata (Wider, 1834)	×		×				×						5	0.28
Nusoncus nasutus (Schenkel, 1925)									×				2	0.05
Obscuriphantes obscurus (Blackwall, 1841)			×									×	1	0.11
Oedothorax retusus (Westring, 1851)						×							1	0.05
Palludiphantes pallidus (O.P.-Cambridge, 1871)		×											1	0.05
Pelecopsis elongata (Wider, 1834)									×				1	0.05
Pelecopsis sp.	×												1	0.05
Pocadicnemis pumila (Blackwall, 1841)									×				1	0.05
Porrhomma pallidum Jackson, 1913			×										1	0.05
Porrhomma pygmaeum (Blackwall, 1834)	×					×							4	0.22
Savignia frontata (Blackwall, 1833)											×		2	0.11
Silometopus elegans (O.P.-Cambridge, 1872)									×				2	0.11
Tenuiphantes mengei Kulczynski, 1887	×						×				×	×	8	0.45
Tenuiphantes tenebricola (Wider, 1834)									×		×		1	0.05
Tiso vagans (Blackwall, 1834)	×												1	0.05
Troxochrus scabriculus (Westring, 1851)							×						1	0.05
Linyphiidae gen. spp.	×	×	×	×	×	×	×	×		×	×	×	23	1.28
Walckenaeria capito (Westring, 1861)							×						1	0.05
Walckenaeria obtusa Blackwall, 1836	×												1	0.05
Walckenaeria vigilax (Blackwall, 1853)					×								2	0.11
Tetragnathidae													580	32.48
Metellina mengei (Blackwall, 1869)	×		×		×	×	×				×	×	64	3.58
Metellina merianae (Scopoli, 1763)						×							2	0.11
Metellina segmentata (Clerck, 1757)	×		×		×	×	×		×		×	×	93	5.21
Metellina sp.					×								1	0.05
Pachygnatha clercki Sundevall, 1823	×					×							2	0.11
Pachygnatha listeri Sundevall, 1830							×						1	0.05
Tetragnatha sp.	×	×	×		×	×	×	×	×	×	×	×	417	23.37
Araneidae													153	8.53
Araneus diadematus Clerk, 1757	×	×	×	×	×	×	×		×		×	×	26	1.45
Araneus marmoreus Clerk, 1757	×	×				×	×						9	0.50
Araneus quadratus Clerck, 1757		×				×		×	×	×		×	12	0.67
Araneus sp.							×						1	0.05
Araneus sturmi (Hahn, 18310											×		1	0.05
Araniella cucrbitina (Clerck, 1757)			×			×	×				×	×	10	0.56
Araniella proxima (Kulczynski, 1885)	×					×			×		×		9	0.50
Hypsosinga pygmaea (Sundevall, 1832)		×				×			×	×			10	0.56
Lardinioides cornutus (Clerck, 1757)		×			×	×			×	×			52	2.91
Larinioides patagiatus (Clerck, 1757)	×				×	×	×		×			×	21	1.17
Neoscona adianta (Walckenaer, 1802)						×			×				2	0.11
Lycosidae													19	1.06
Pardosa prativaga (L. Koch, 1870)						×				×			3	0.16
Pardosa sphagnicola (Dahl, 1908)						×			×	×			8	0.45
Pardosa sp.						×			×	×			8	0.45
Pisauridae													5	0.28
Pisaura mirabilis (Clerck, 1757)					×					×		×	5	0.28
Agelenidae													1	0.05
Agelena labyrinthica (Clerck, 1757)					×								1	0.05
Hahniidae													1	0.05
Hahnia montana (Blackwall, 1841)												×	1	0.05
Dictynidae													42	2.32
Argenna subnigra (O.P.-Cambridge, 1872)	×			×	×								3	0.16
Dictyna arundinace (Linnaeus, 1758)	×			×		×			×		×	×	16	0.89
Dyctina pusilla Thorell, 1856	×			×	×				×		×	×	13	0.72
Dyctina sp.				×							×	×	7	0.39
Lathys humilis (Blackwall, 1855)												×	1	0.05
Dyctinidae gen. sp.											×	×	2	0.11

Appendix 1. *continued*

Family/ Species	dwm	cf	wf	dpf	wd	cm	wdf	fpgf	mcm	m	dpf1	dpf2	Sum	Dom.%
Anyphaenidae													3	0.16
Anyphaena acaentuata (Walckenaer, 1802)			×									×	3	0.16
Miturgidae													21	1.17
Cheiracanthium erraticum (Walckenaer, 1892)					×	×			×				7	0.39
Cheiracanthium virescens (Sundevall, 1833)						×	×	×	×	×			14	0.78
Clubionidae													23	1.25
Clubiona frutetorum L. Koch, 1866			×										1	0.05
Clubiona lutescens Westring, 1851			×				×			×			5	0.28
Clubiona phragmitis C.L. Koch, 1843		×											1	0.05
Clubiona reclusa O.P.-Cambridge, 1863						×							4	0.22
Clubiona sp.		×							×			×	4	0.22
Clubiona stagnatilis Kulczynski, 1897										×			1	0.05
Clubiona subtilis L. Kock, 1876		×										×	4	0.22
Clubiona trivialis C.L. Koch, 1843		×										×	3	0.16
Zoridae													1	0.05
Zora silvestris Kulczynski, 1897												×	1	0.05
Sparassidae													10	0.56
Micrommata virescens (Clerk, 1757)		×				×		×	×				10	0.56
Philodromidae													127	7.09
Philodromus aureolus (Clerck, 1757)	×			×	×				×		×	×	20	1.12
Philodromus cespitum (Walckenaer, 1802)		×	×						×				3	0.16
Philodromus collinus C.L. Koch, 1835	×												1	0.05
Philodromu dispar Walckenaer, 1826			×								×		2	0.11
Philodromus sp.	×										×	×	5	0.28
Tibellus maritimus (Menge, 1875)	×	×	×		×			×	×	×	×		33	1.84
Tibellus oblongus (Walckenaer, 1802)	×	×	×		×	×		×	×		×		63	3.53
Thomisidae													53	2.99
Diae dorsata (Fabricius, 1777)											×		1	0.05
Misumena vatia (Clerck, 1757)						×			×				2	0.11
Ozyptila atomaria (Panzer, 1801)												×	1	0.05
Ozyptila trux (Blackwall, 1846)	×		×										2	0.11
Xysticus bifasciatus C.L. Koch, 1837						×		×				×	3	0.16
Xysticus cristatus (Clerck, 1757)	×		×		×	×				×	×	×	18	0.95
Xysticus erraticus (Blackwall, 1864)	×												2	0.22
Xysticus luctuosus (Blackwall, 1836)	×					×			×			×	6	0.34
Xysticus sp.						×							5	0.28
Xysticus ulmi (Hahn 1831)	×	×	×		×	×	×	×	×	×			13	0.72
Salticidae													186	10.40
Dendryphantes rudis (Sundevall, 1832)			×										2	0.11
Euophrys frontalis (Walckenaer, 1802)	×												2	0.11
Evarcha arcuata (Clerck, 1757)	×	×	×			×		×	×	×		×	61	3.41
Evarcha falcata (Clerck, 1757)	×		×	×	×	×					×	×	82	4.59
Heliophanus auratus C.L. Koch, 1835									×				1	0.05
Heliophanus cupreus (Walckenaer, 1802)										×			2	0.11
Heliophanus flavipes Hahn, 1832						×							1	0.05
Heliophanus sp.										×			1	0.05
Marpissa radiata (Grube, 1859)		×	×					×		×			11	0.61
Salticus sp.						×							1	0.05
Sitticus caricis (Westring, 1861)			×			×							2	0.11
Sitticus floricola (C.L. Koch, 1837)									×	×			9	0.50
Sitticus sp.					×	×							3	0.16
Synageles hilarius (C.L. Koch, 1846)								×					1	0.05
Synageles venator (C.L. Koch, 1846)			×					×					3	0.16
Salticidae gen. sp.		×	×			×		×		×			5	0.28
Number of individuals	341	114	138	22	298	159	136	44	139	88	138	193	1783	100%
Number of species	54	29	46	15	33	54	24	22	48	26	36	42	149	-