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Epigeic spider assemblages of the sphagnum biotopes in Lake Ladoga region, north-west Russia

Комплексы наземных пауков в сфагновых биотопах Приладожья, северо-запад России

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ABSTRACT. The dynamic density, species richness, evenness and different biodiversity indices of spider assemblages in open peat moss bogs and bog moss pine forests were studied with regard to habitat structure. In total, 97 spider species were collected in these habitats, of which *Pardosa sphagnicola* was most abundant and almost ubiquitous. The Czekanowski-Sørensen's index of qualitative similarity was calculated for the bog and forest spider assemblages. The peatbog spider assemblage was compared with similar ones from Finland and Lithuania. Despite significant latitudinal differences of the studied sites in the Baltic region, there is a significant qualitative similarity between their spider faunas. This is particularly true for species from the families Lycosidae, Gnaphosidae and Liocranidae, which were most successfully caught by pitfall traps.

РЕЗЮМЕ. Определены структурные особенности комплексов пауков открытых болот и сфагновых сосняков: динамическая плотность, видовое богатство, выравненность и различные индексы биоразнообразия. Общий видовой список пауков для этих местообитаний представлен 97 видами. Всюду наиболее многочислен был *Pardosa sphagnicola*. Для списков пауков из болот и лесов найден показатель сходства по Чекановскому-Съеренсену. Список пауков сфагновых биотопов Приладожья сравнен с таковыми из Финляндии и Литвы. Несмотря на значительные широтные различия точек исследований Балтийского региона, между фаунами пауков в них имеется значительное качественное сходство. В особенности это касается видов из семейств Lycosidae, Gnaphosidae и Liocranidae, которые успешнее всего отлавливаются почвенными ловушками.

KEYWORDS: spider, peatbog, diversity, Lake Ladoga region, north-west Russia.
КЛЮЧЕВЫЕ СЛОВА: пауки, болота, разнообразие, Приладожье, Россия.

Introduction

Open peat moss bog and forest biotopes are typical for the northern taiga regions. Recently, particular attention has been given to studies on the spider assemblages of these habitats. In most cases these investigations comprised species lists, with indications of dominant species, but many of these are slightly out-of-date. In this respect, the epigeic spider fauna of the sphagnum sites of the north-eastern part of the Baltic region is better studied [Uzenbaev, 1987;

Oliger, 1999a,b, 2000, 2001; Koponen *et al*., 2001; Koponen, 2002; Relys *et al*., 2002].

The purpose of this paper is to compare different quantitative and qualitative characteristics of the spider assemblages using modern techniques for determination and comparison of the species diversities.

Material and methods

Data were collected by the author using pitfall traps in the open sphagnum bogs and bog moss pine forests in the south-east Lake Ladoga region, northwest Russia (60°35′N, 33°E) during 1986–2001.

The open peat moss bogs (*Eriophorum vaginatum–Oxycoccus–Carex–Sphagnum*) were surveyed in 1987–88, 91, 93–94, 96, 98–200l; a total of nine years. There are *Sphagnum* mosses, *Betula nana* on hillocks*, Andromeda, Oxycoccus, Eriophorum, Carex,* and in places *Menyanthes* and *Comarum*. The bog moss pine forests (*Pinus silvestris–Ledum palustre–Sphagnum*) are characterized by *Sphagnum* mosses, sparse low pine *Pinus silvestris,* and in places the shrubs *Chamaedaphne, Chamaerubus*, *Ledum, Empetrum; Oxycoccus, Gramineae* species and *Eriophorum*. These sites were surveyed in 1986–89, 93–96, 98, 2000–01; in total 11 years. Each of the two biotopes was sampled from eight different ground-sites.

Glass pots (0.5 litre, inner diameter *c*. 75 mm) were used as traps and were exposed for four to six days with an interval of approximately ten days during April–September of each season. The preservation liquid was water, thus the traps were emptied every one to three days. In a line of eight traps, the glass pots were placed about six metres apart. In total, 1 791 *td* (trap days) were conducted in the open peat moss bogs and 2 287 *td* in the bog moss pine forests. The material studied included 2 450 adult spiders: 97 species in 52 genera and 12 families (Table 1).

The dynamic density of species (in ind. per 100 trap-days) was calculated from the average for the entire study period.

The following basic assemblage structural characteristics were calculated: a parameter of species richness, $d = S/vN$ [see Pesenko, 1982]; a relative entropy, $h = H/logS \times 100$ %, where H is Shannon's index (in part) and $logS = H_{max}$ is the maximum level of the entropy; a species diversity (expressed by species' quantity) was calculated as $V = 2^H$ [see Hill

Table 1.

A list of the species found in the open sphagnum bogs and the bog moss pine forests in Lake Ladoga region. For abbreviations see 'Material and methods'.

Таблица 1.

Список видов, найденных на открытых сфагновых болотах и в сфагновых сосняках Приладожья. Обозначения в 'Материлах и методах'.

Taxa	Bogs		Forests	
	N	%	N	%
ARANEIDAE				
Araneus diadematus Clerck, 1758			1	0.07
Cercidia prominens (Westring, 1851)			1	0.07
CLUBIONIDAE				
Clubiona norvegica Strand, 1900	1	0.10		
C. trivialis C.L. Koch, 1843			1	0.07
GNAPHOSIDAE				
Drassyllus lutetianus (L. Koch, 1866)			7	0.47
D. pusillus (C.L. Koch, 1833)	1	0.10	2	0.13
Gnaphosa badia (L. Koch, 1866)			3	0.20
G. bicolor (Hahn, 1833)	2	0.21	5	0.34
G. lapponum (L. Koch,1866)	12	1.25	4	0.27
G. nigerrima (L. Koch, 1878)	29	3.01	4	0.27
Haplodrassus signifer (C.L. Koch, 1839)			2	0.13
H. soerenseni (Strand, 1900)	1	0.10	3	0.20
Micaria pulicaria (Sundevall, 1831)			6	0.40
M. tripunctata Holm, 1978			1	0.07
Zelotes clivicola (L. Koch, 1870)	1	0.10	5	0.34
Z. latreillei (Simon, 1878)			1	0.07
HAHNIIDAE				
Antistea elegans (Blackwall, 1841)	49	5.09	29	1.95
LINYPHIIDAE				
Agyneta beata (O. Pickard-Cambridge, 1906)			4	0.27
A. conigera (O. Pickard-Cambridge, 1863)			2	0.13
A. decora (O. Pickard-Cambridge, 1870)	1	0.10	14	0.94

Table 1 (continued).
Таблица 1 (продолжение).

Taxa	Bogs		Forests	
	N	%	N	%
A. subtilis (O. Pickard-Cambridge, 1863)	2	0.21	3	0.20
Aphileta misera (O. Pickard-Cambridge, 1882)	1	0.10		
Araeoncus crassiceps (Westring, 1861)	1	0.10		
Bathyphantes parvulus (Westring, 1851)			2	0.13
Bolyphantes alticeps (Sundevall, 1832)	1	0.10		
Centromerus arcanus (O. Pickard-Cambridge, 1873)			3	0.20
C. sylvaticus (Blackwall, 1841)	1	0.10	3	0.20
Cnephalocotes obscurus (Blackwall, 1834)	1	0.10		
Drepanotylus uncatus (O. Pickard-Cambridge, 1873)			1	0.07
Entelecara congenera (O. Pickard-Cambridge, 1879)			1	0.07
Hypselistes jacksoni (O. Pickard-Cambridge, 1902)	1	0.10		
Kaestneria pullata (O. Pickard-Cambridge, 1863)	1	0.10		
Tenuiphantes cristatus (Menge, 1866)	2	0.21	2	0.13
T. mengei Kulczyński, 1887			2	0.13
T. tenebricola (Wider, 1834)			1	0.07
Macrargus rufus (Wider, 1834)			5	0.34
Maso sundevalli (Westring, 1851)	1	0.10		
Metopobactrus prominulus (O. Pickard-Cambridge, 1872)	1	0.10	1	0.07
Notioscopus sarcinatus (O. Pickard-Cambridge, 1872)			9	0.60
Oedothorax retusus (Westring, 1851)	1	0.10		
Pocadicnemis pumila (Blackwall, 1841)	1	0.10	1	0.07
Silometopus elegans (O. Pickard-Cambridge, 1872)	1	0.10		
Stemonyphantes lineatus (Linnaeus, 1758)			2	0.13
Tallusia experta (O. Pickard-Cambridge, 1871)	5	0.52	1	0.07
Trichopterna thorelli (Westring, 1862)	2	0.21		
Walckenaeria antica (Wider, 1834)	1	0.10	3	0.20
W. atrotibialis (O. Pickard-Cambridge, 1878)			1	0.07
W. cucullata (C.L. Koch, 1836)			1	0.07
W. cuspidata Blackwall, 1833			1	0.07
W. dysderoides (Wider, 1834)			3	0.20
LIOCRANIDAE				
Agroeca brunnea (Blackwall, 1833)	4	0.42	32	2.15
A. lusatica (L. Koch, 1875)	5	0.52	2	0.13
A. proxima (O. Pickard-Cambridge, 1871)	1	0.10	19	1.28
Phrurolithus festivus (C.L. Koch, 1835)			4	0.27
Scotina palliardi (L. Koch, 1881)			6	0.40
LYCOSIDAE				
Alopecosa aculeata (Clerck, 1758)	15	1.56	20	1,34
A. pulverulenta (Clerck, 1758)	38	3.95	112	7.53
Arctosa figurata (Simon, 1876)	21	2.18	2	0.13
Hygrolycosa rubrofasciata (Ohlert, 1865)	18	1.87	61	4.10
Pardosa agrestis (Westring, 1861)	1	0.10		
P. amentata (Clerck, 1758)	1	0.10	2	0.13
P. atrata (Thorell, 1873)	149	15.49		
P. hyperborea (Thorell, 1872)	45	4.68	46	3.09
P. lugubris (Walckenaer, 1802)	1	0.10	30	2.02
P. paludicola (Clerck, 1758)			2	0.13
P. palustris (Linnaeus, 1758)	2	0.21		
P. prativaga (L. Koch, 1870)	2	0.21	3	0.20
P. pullata (Clerck, 1758)	4	0.42	2	0.13
P. riparia (C.L. Koch, 1847)			22	1.48
P. sphagnicola (F.Dahl, 1908)	237	24.64	346	23.25
Pirata hygrophilus Thorell, 1872	16	1.66	116	7.80
P. insularis Emerton, 1885	7	0.73	3	0.20
P. piraticus (Clerck, 1758)	23	2.39	2	0.13
P. piscatorius (Clerck, 1758)	33	3.43		
P. tenuitarsis Simon, 1876			1	0.07
P. uliginosus (Thorell, 1856)	142	14.76	266	17.88
Tricca alpigena (Doleschall, 1852)	28	2.91	3	0.20
Trochosa ruricola (De Geer, 1778)	18	1.87	2	0.13

Table 1 (continued).
Таблица 1 (продолжение).

Taxa	Bogs		Forests	
	N	%	N	%
T. spinipalpis (F.O. Pickard-Cambridge, 1895)	10	1.04	149	10.01
T. terricola Thorell, 1856	5	0.52	44	2.96
PISAURIDAE				
Dolomedes fimbriatus (Clerck, 1758)	3	0.31		
Pisaura mirabilis (Clerck, 1758)			1	0.07
SALTICIDAE				
Evarcha falcata (Clerck, 1758)	1	0.10	3	0.20
TETRAGNATHIDAE				
Pachygnatha clercki Sundevall, 1823	1	0.10	1	0.07
P. listeri Sundevall, 1830	3	0.31	16	1.08
Tetragnatha dearmata Thorell, 1873			1	0.07
THERIDIIDAE				
Euryopis flavomaculata (C.L. Koch, 1836)			1	0.07
Robertus arundineti (O. Pickard-Cambridge, 1871)			1	0.07
R. lividus (Blackwall, 1836)	2	0.21	6	0.40
THOMISIDAE				
Ozyptila atomaria (Panzer, 1801)	1	0.10	1	0.07
O. trux (Blackwall, 1846)	3	0.31	4	0.27
Xysticus cristatus (Clerck, 1758)			1	0.07
X. lineatus (Westring, 1851)			1	0.07
X. luctuosus (Blackwall, 1836)			5	0.34
X. ulmi (Hahn, 1831)			2	0.13
ZORIDAE				
Zora nemoralis (Blackwall, 1861)	1	0.10	2	0.13
Z. spinimana (Sundevall, 1832)			4	0.27
Total:	962	100.0	1488	100.0

1973]; a relative species diversity V–% = V/S (in %); a probability of interspecific encounter PIE = $1–\lambda$, where $\lambda = \Sigma p_i^2$ is Simpson's index; ά-diversity (i.e., quantity of dominant species) $S_\lambda = 1/\lambda$, percentage of dominant species S–% = S_λ/S (in %); an evenness index $E = (S_\lambda–1)/(V–1)$; the estimated species richness in view of insufficiency for information about rare species numbers $St = S + F_1^2/2F_2$, where F_1 = number of singletons, F_2 = number of doubletons [Colwell & Coddington, 1994]; an insufficiency of the received information $m = 1–h$; the Czekanowski-Sørensen's qualitative similarity index $Ics = 2a/(b+c)$.

Abbreviations: bogs = open peat moss bogs; D = dynamic density in ind./100 trap-days; forests = bog moss pine forests; ind. = individual(s); LL = Lake Ladoga region; N = number of adult ind.; *S* = number of species; *td* = trap-day.

Results and discussion

Structural analysis

The species groups and structure of the spider assemblages were similar in both biotopes (Table 2). Total numbers of species and the adult specimens caught in the forests were, respectively, 1.4 and 1.5 times as high as those in the bogs. Singleton species constituted 44% of *S* in the bogs and 28% in the forests. The total level of dynamic density in the forests was also slightly higher.

Table 2.
Structure characteristics of the spider assemblages in the sphagnum biotops of the Lake Ladoga region. For abbreviations see 'Material and methods'.
Таблица 2.
Структурные характеристики комплексов пауков сфагновых биотопов Приладожья. Обозначения в 'Материалах и методах'.

Parameters	Bogs	Forests
N	962	1488
S	59	81
F_1	26	23
F_2	7	16
Total D	53.7	65.1
d	1.9	2.1
St	107	98
V	15.03	16.56
$S_ë$	8.4	8.8
E	0.527	0.501
h	66.5	63.9
V-%	25	21
S-%	14.3	10.9
PIE	0.88	0.89
Total (without *N*, F_1, F_2)	351.34	368.75

A parameter of species richness d specified that *S* approximately twice exceeded its theoretical dimension at the given level *N*. The estimated species richness *St* was higher than the number of species observed: by 1.8 times for the bogs, and 1.2 times for the forests.

A species diversity *V* almost twice exceeded the quantity of dominant species S_{λ} for *S* and *D* observed. It included the species for which the percentage was greater than 1.5% of N in the bogs and above 0.6% in the forests. The relative species diversity was 25% of *S* in the bogs and one-fifth of that in the forests. Percentage of dominant species from S was greater than 10%. However, the probability of interspecific encounter was very high, since the evenness *E* and level of the relative entropy *h* in the spider complexes for both biotopes were very high, exceeding 50%.

As a whole, the structure of the spider complexes in both biotopes were similar in the majority of parameters investigated. The representatives of the free living ground forms (Lycosidae and Gnaphosidae), which are both diurnal and nocturnal, were less sensitive to moisture surplus than spiders of the family Linyphiidae.

The richest families (in % of S; the bogs, the forests) were: Lycosidae = 37, 26; Linyphiidae = 30, 28; Gnaphosidae = 10, 15.

Insufficiency of information

The insufficiency of the information obtained (*m*) in both biotopes comprises up to approximately one-third of its common value. Most likely, it concerns the data on singleton species. Of these, *Aphileta misera, Pardosa agrestis, Clubiona norvegica, Hypselistes jacksoni, Metopobactrus prominulus, Ozyptila atomaria, Pisaura mirabilis, Xysticus lineatus* and *Micaria tripunctata* were very rare in the sampling area. Any information on them should be considered.

The capture of five hortobionts (grass dwellers) in the pitfall traps should be considered accidental. These were *Maso sundevalli* in the bogs and *Araneus diadematus, Cercidia prominens, Clubiona trivialis* and *Tetragnatha dearmata* in the forests.

The occurrence of *Agroeca proxima, Pardosa amentata, P. lugubris, Haplodrassus soerenseni, Zelotes clivicola, Walckenaeria antica* and *Zora nemoralis,* which are common in the neighbouring habitats, were not typical for the open bogs of the LL. For other species (11 from b and 14 from f) caught here as singletons, but which are common in other neighbouring biotopes, the information obtained is obviously insufficient.

In total, a clear sufficiency of the information obtained can be attributed to 20 rare species from the bogs and to 18 from the forests, comprising 34% and 22% of *S* respectively. For the bog data this is close to the value *m*, whereas in the forests it is 1.5 times lower than *m*. This means that the information deficiency for the forest data does not relate only to singletons. It is highly likely that due to the large variation in humidity levels, micro relief and vegetation structure in the moss bog pine forests, as well as their mosaic arrangements between other wooded habitats and the open peat moss bogs, the forest spider fauna constantly exchanges species with the neighbouring habitats. This is probably especially true for agile, large species from the families Lycosidae, Gnaphosidae and Liocranidae.

Dominants

The dominants in the bogs include seven Lycosidae, one Gnaphosidae and one Hahniidae species, and those of the forests, eight Lycosidae and one Liocranidae species. In both biotopes, their percentage was approximately 78% of the total *D*. The dominant species common to both the bogs and the forests were the four lycosids: *Alopecosa pulverulenta, Pardosa sphagnicola, P. hyperborea* and *Pirata uliginosus*. In the bogs they made up 48% of the total *D*, and in the forests 52%. The total *D* of dominant species in the bogs was lower than in the forests: 41.8 and 51.2 ind. per 100 *td* respectively.

In all samples, *Pardosa sphagnicola* was most abundant (Table 3). In addition, the typical species for the bogs were *Pardosa atrata* and *Pirata piscatorius*, both of which were absent from the forests. *Antistea elegans*, *Gnaphosa nigerrima*, *Tricca alpigena* were numerous in the bogs, but rare in the forests.

On the contrary, *Trochosa spinipalpis*, *T. terricola*, *Pirata hygrophilus*, *Hygrolycosa rubrofasciata* and *Agroeca brunnea* were five to ten times less abundant in the bogs than in the forests, where they were among the dominant species.

Table 3.
Relative abundance of the commonest spider species in the open sphagnum bogs and the bog moss pine forests of the Lake Ladoga region. Asterisk (*) indicates a species belonging to the dominant group both of the bogs and of the forests, and (**) indicates a species typical only for the bogs. For abbreviations see 'Material and methods'.

Таблица 3.
Относительное обилие массовых видов пауков на открытых сфагновых болотах и в сфагновых сосняках Приладожья. Звездочкой (*) обозначены виды, общие для доминирующих групп в bogs и forests, двумя звездочками (**) — виды, типичные только для bogs. Сокращения как в 'Материалах и методах'.

Bogs	**D**	**%**	**Forests**	**D**	**%**
Pardosa sphagnicola *	13.2	24.6	*Pardosa sphagnicola* *	15.1	23.2
Pardosa atrata **	8.3	15.5	*Pirata uliginosus* *	11.6	17.9
Pirata uliginosus *	7.9	14.8	*Trochosa spinipalpis*	6.5	10.0
Antistea elegans	2.7	5.1	*Pirata hygrophilus*	5.1	7.8
Pardosa hyperborea *	2.5	4.7	*Alopecosa pulverulenta* *	4.9	7.5
Alopecosa pulverulenta *	2.1	3.9	*Hygrolycosa rubrofasciata*	2.7	4.1
Pirata piscatorius **	1.8	3.4	*Pardosa hyperborea* *	2.0	3.1
Gnaphosa nigerrima	1.6	3.0	*Trochosa terricola*	1.9	2.9
Tricca alpigena	1.6	2.9	*Agroeca brunnea*	1.4	2.1
Total:	41.7	78.0	**Total**:	51.2	78.8

Similarity

There were 43 species common to both LL's biotopes. The Czekanowski-Sørensen's index of qualitative similarity for the bogs and forests, *Ics* = 0.6. The *Ics* for the Lycosidae was 0.84, for the Gnaphosidae it was 0.67. The Linyphiidae were more selective of habitat types: *Ics* = 0.39.

A comparison of the LL's bog spider list with that from Finland [Koponen, 2002] has shown a high qualitative similarity between free living species: *Ics* 0.63 for the lycosids and 0.67 for the liocranids. The forest spider fauna and a similar one from Lithuania [Relys *et al*., 2002] proved to be even more similar: *Ics* 0.72 for the lycosids, 0.61 for the gnaphosids, with the overall level of similarity being 0.51. The same was true for Karelia [see Uzenbaev, 1987]: *Ics* 0.50 for the forest lycosids, and *Ics* 0.67 for the bog gnaphosids.

Despite the relative geographical remoteness and latitudinal differences of the study sites in the Baltic region, there is a significant qualitative similarity between their faunas. In particular, it concerns the spider families Lycosidae, Gnaphosidae and Liocranidae, which are most successfully caught in pitfall traps.

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