BIOLOGIJA. 2006. Nr. 1. P. 77–82

Investigation of activity and vertical distribution of spiders in *Sphagnum* tussocks of peat bogs

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The spider fauna of European peat bogs is under active investigation, but data on the activity and distribution of spiders in the hummock layer is very sparse. The optimal setting of traps for gathering most representative data in peat bogs is not known. The activity of epigeic spiders in *Sphagnum* moss cover and the effectivity of pitfall traps was investigated in Lithuania in 2001. Eight sets of pitfall traps (5 traps each) differing in setting design were randomly set in *Sphagnum* moulds of a small peat bog area. The sets varied in the depth of placement, covering and conservation liquid. A total of 1484 adult specimens of 87 species belonging to 13 families were registered. The results show that only three species (*Centromerus arcanus, Lepthyphantes angulatus, Trochosa spinipalpis*) were equally distributed in various depths of the moss cover. The highest number of species (63) and individuals (690) was registered in the set of traps levelled with the surface of the moss cower (Set 1). The set of traps placed 2–3 cm below the surface (Set 2, Set 8) captured two times less individuals (277) and species (40), but the number of species found in more than three specimens was quite similar in both sets. The lowest number of individuals was registered in the sets of traps placed deep in moss cover (Set 7 – N = 30, Set 6 – N = 43). Only one species (*Micrargus apertus*) was registered as more abundant in deeper layers. A high activity of *Trochosa spinipalpis* in deep layers was registered too. No marked differences in species and individual numbers were registered between the sets with different conservation liquids (4% formalin and 10% sodium benzoate).

Key words: Araneae, peat bog, pitfall traps, Lithuania, *Sphagnum*

INTRODUCTION

Peatbogs and mires cover about 5% of the whole territory of Lithuania. A lot of investigations on spider and other arthropod communities in peat bogs have been performed using pitfall traps [1]. The effectiveness of this collecting method was widely discussed, and despite of the known weaknesses it remains the main collecting method used in peat bogs and is also widely used in other habitats. Various methodical issues regarding pitfall traps have been studied and discussed [2, 3]. The loose structure of *Sphagnum* cover raises some additional methodical questions regarding the usage of pitfall traps in peat bogs compared with investigations in habitats where no deep litter layer exists. The deep cover of *Sphagnum* allows placing traps at various depth, and the effect of this placement on the collected material still has not been studied. In the meantime, other methodical questions such as: trap size, distance between traps, preserving liquid and its concentration [3] have been studied in detail. Possible differences in catchabillity of unevenly placed traps may affect the material collected and conclusions made. On the other, hand pitfall traps seem to be suitable to gather data on the activity of spiders as well as of other arthropods inside the *Spahgnum* layer. The loose and deep *Sphagnum* cover provides living environment for a number of animals including spiders. The knowledge of the activity of spiders at a various depth of the *Sphagnum* cover is not sufficient and the abundance of some deep in *Sphagnum* living species might be estimated improperly if only surface data base is considered. Most of information about some spider species living in *Sphagnum* cover is known from personal observations, and printed information on this topic is very sparse [4–6]. Koponen [7] published data on the distribution of spiders on the surface of hollows and hummocks in Finland. We addressed both methodical and ecological questions in a one-

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year experimental study performed in a peat-bog in Lithuania in 2001. The current paper presents results on spider activity at a different depth of *Sphagnum* moulds evaluated by placing pitfall traps at a different depth into *Sphagnum*.

MATERIALS AND METHODS

The investigation was performed in a small peat bog (Tapeliai) 17 km southeast of Vilnius. It is a typical *Ledo-Pinetum* community with a well-expressed mould structure of *Sphagnum*. This type of habitat (Code: 91D0) has a status of protected area under European Habitat Clasification NATURA 2000 (10).

Eight sets of pitfall traps consisting of 5 traps each were placed randomly in the moulds of *Sphagnum* in the area of 50 × 50 m^2. Each set of five traps had a different design resulting in the depth of trap placement, cover or preserving liquid used (Fig. 1). A total of 40 traps were installed in the study area. Plastic jars (volume 300 ml, depth 12 cm, opening 7 cm) were used as traps. Traps were placed on the top of moulds no closer as 3 m to each other. Only traps belonging to the different trap sets were placed nearby. The cylinders used in two trap sets were made from clear plastic bottles by cutting off the bottom part at the height required. The bottom of the cylinder was glued to the wooden lid covering the entire trap system. The lids used were light square wooden plates (15 × 15 cm). The lids were fixed to the hummock using tiny 15 cm long wire strips stucked into the hummock through the holes in the corners of the lid. The traps were placed avoiding locating the traps of the same set nearby. Traps were operated from 20th April to 18th July and from 18th September to 11th November 2001. During this time the traps were emptied every 3 weeks. Six series of samples were taken. All adult and subadult (if possible) specimens of spiders were identified and included into analysis. The similarities of spider species in different trap sets were counted using the percentage similarity index. The Soerensen coefficient of species similarity was calculated for the whole set of species and for a set of species represented by four or more specimens in the community. More details and the formulas for calculating the aforementioned indices of similarity and diversity can be obtained from Krebs [8]. The nomenclature of spiders follows Platnick [9].

In the first seven sets sodium benzoate was used as a preserving liquid.

Sets with open jars: *Set 1* – traps were levelled with the top of the moss cover, *Set 2* – traps were dapped 2–3 cm below the upper level of the moss cover. This is the most common way of placing traps during investigations in peat bogs. *Set 3* – traps were dapped 15 cm into the moss cover. These three sets were supposed to catch all spiders from the surface and from a particular moss cover situated above the upper edge of a trap.

Sets with lids: *Set 4* – the same as Set 2, only a thin wooden cover (15 × 15 cm) was placed on the moss cover disturbing the entrance of surface-active spiders. *Set 5* – the same as Set 3, only a thin wooden cover was placed on the moss cover disturbing entrance of surface-active spiders.

These two sets were meant to catch spiders actively moving inside of a particular part of the moss determined by the distance between the wooden cover and the upper edge of a trap.

Sets with lids and cylinders: *Set 6* – traps were dapped 10 cm into hummock. A cylinder, 3 cm in height and fixed to the covering wooden lid, was placed in the upper part of the moss cover. The trap system exposed a 7 cm gap between the bottom rim of the cylinder and the upper rim of the trap.

Set 7 – traps were dapped 15 cm into the hummock. A cylinder 10 cm in height was placed in the upper part of the moss cover. The trap system was also covered with a thin wooden cover.

The last two sets were meant to be suitable for a selective catching of spiders active in a selected depth of the moss cover. Set 6 and Set 7 were supposed to catch spiders active in the depths of 3–10 cm and 10–15 cm, respectively.

Set 8 – the same as Set 2, only 4% formaldehyde solution was used as a preserving liquid instead of 10% sodium benzoate used in Set 2 and in all other sets of traps.

RESULTS AND DISCUSSION

A total of 1484 adult spider specimens were found during the investigation. They belonged to 87 species and 13 families. The highest numbers of species and specimens were found in sets located close to the surface (Set 1, Set 2 and Set 8), the lowest numbers being found in the sets operating in the deep layers of *Sphagnum* (Set 6, Set 7) (Table 1).

Numerous species (up to 68.0% from the all species in a particular set) were not abundant and were represented by 3 or less specimens. Their occurrence can be considered as accidental and they were not included in calculations of the significance of the differences among the materials from different sets.

The activity of spiders is concentrated in the surface of the *Sphagnum* cover. Only three from 87 species of spiders were equally distributed in all trap sets (*Trochosa spinipalpis*, *Lepthyphantes angulatus* and *Centromerus arcanus*) (Table 2), indicating that these species have a similar activity at a various depth of the *Sphagnum* cover. The other species showed a higher activity in one trap or in a group of trap sets. The main differences among the sets were caused by much higher numbers of specimens and species

Table 1. **General data on the spider material collected in various sets of pitfall traps**

Placement of traps	Sharp with surface	Open traps		Covered traps				
		Dapped 2–3 cm		Dapped 15 cm	Without cylinder		With cylinder	
					Dapped 2–3 cm	Dapped 15 cm	Cylinder height 10 cm	Cylinder height 3 cm
Sets	Set 1	Set 2	Set 8	Set 3	Set 4	Set 5	Set 7	Set 6
No. of species (S)	63	40	48	27	25	14	9	11
No. of specimens (N)	690	277	258	73	68	45	30	43
No. of spec. > 3 specm. (N > 3)	28	17	17	5	8	9	3	4

caught in a trap set where traps were on the level of the moss surface. The abundance of 12 species from 34 was significantly different ($p < 0.001$) in this set if compared to the rest of sets. Already 15 species showed no significant differences in abundance among sets if the material from Set 1 was excluded. This data show that the activity of about 30% of the abundant species is restricted to the surface of the *Sphagnum* cover.

The covered traps earned much less material, than the traps of the open sets. Six species were found being active in the upper part (2–3 cm) of the *Sphagnum* cover after comparing Set 2 and Set 4.

Only a few species were found active in deep layers of *Sphagnum* humps. The species *Micrargus apertus* and *Trochosa spinipalpis* can be mentioned as active inhabitants of deep layers of *Sphagnum*, alongside the already mentioned species with equal distribution in all layers.

Micrargus apertus was less abundant on the moss surface than in deeper layers. It can be supposed that in previous studies the abundance of *M. apertus* could be underestimated if traps were set close to the surface.

Another species occurring in deep layers of *Sphagnum* are *Pocadicnemis pumila, Agyneta conigera, Theonoe minutissima, Phrurolithus minimus, Robertus lividus* and probably *Lepthyphantes cristatus*. In Table 2, the five main groups of spider species according to activity in the *Sphagnum* layer were separated.

The results of Set 1 and Set 2 show that much more material was captured in traps levelled with the surface than in traps dapped 2–3 cm into the moss cover. Fourteen species from 31 were equally active in both trap sets; 15 species were significantly more active on the surface of the moss ($p < 0.1$). Only two species (*W. atriotibialis, P. pullata*) were more abundant in the set where traps were dapped into the moss cover. The surface-levelled traps catched more specimens and species (Table 1). Also,

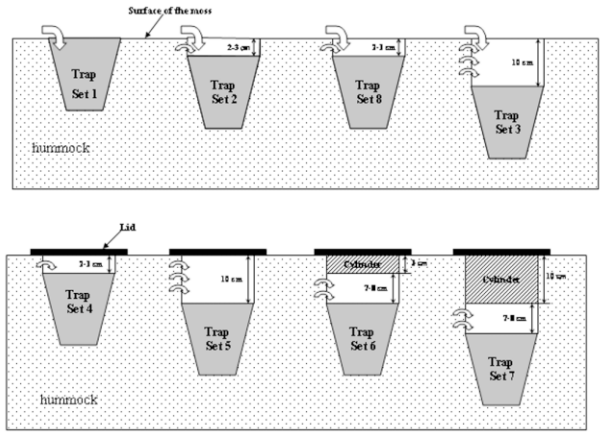

Fig. 1. Different trap placement in *Sphagnum* moulds – experimental design

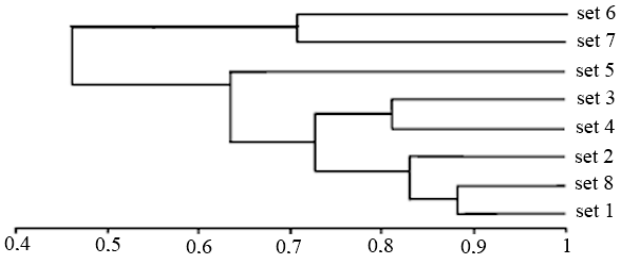

Fig. 2. Soerensen's coefficient of species similarity (all species) among different trap sets

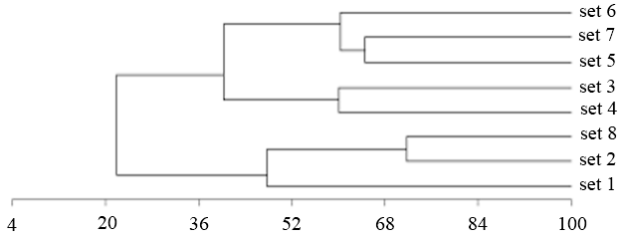

Fig. 3. Percentage similarity of species abundance among different trap sets

Table 2. **Activity (%) of specimens in different sets of traps**

	Set 1	Set 2	Set 8	Set 3	Set 4	Set 5	Set 7	Set 6
I *Agyneta decora*	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I *Pardosa hyperborea*	83.33	0.00	16.67	0.00	0.00	0.00	0.00	0.00
I *Xysticus bifaciatus*	83.33	16.67	0.00	0.00	0.00	0.00	0.00	0.00
I *Agroeca brunea*	80.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
I *Zora spinimana*	72.73	27.27	0.00	0.00	0.00	0.00	0.00	0.00
I *Drassodes pubescens*	83.33	0.00	16.67	0.00	0.00	0.00	0.00	0.00
I *Cnephalocotes obscurus*	66.67	0.00	33.33	0.00	0.00	0.00	0.00	0.00
I *Agroeca dentigera*	62.50	12.50	25.00	0.00	0.00	0.00	0.00	0.00
I? *Aulonia albimana*	52.81	18.18	15.70	3.31	0.00	0.00	0.00	0.00
I? *Gonatium rubens*	50.50	11.76	32.35	5.88	0.00	0.00	0.00	0.00
I? *Maro minutus*	19.23	15.38	61.54	3.85	0.00	0.00	0.00	0.00
II *Alopecosa pulverulenta*	53.85	11.54	30.77	0.00	3.85	0.00	0.00	0.00
II *Phrurolithus festivus*	76.92	0.00	15.38	0.00	7.69	0.00	0.00	0.00
II *Pirata uliginosus*	55.81	13.95	23.26	4.65	2.33	0.00	0.00	0.00
II *Agyneta cauta*	42.34	24.32	25.23	4.50	3.60	0.00	0.00	0.00
II? *Pardosa sphagnicola*	71.43	13.06	9.39	3.27	2.45	0.41	0.00	0.00
II? *Hygrolycosa rubrofasciata*	46.00	40.00	8.00	2.00	2.00	2.00	0.00	0.00
II? *Walcknaeria alticeps*	37.50	22.92	18.75	10.42	2.08	8.33	0.00	0.00
II? *Neon reticulates*	11.11	27.78	11.11	11.11	11.11	11.11	0.00	0.00
II? *Scotina palliardi*	68.75	12.50	12.50	0.00	0.00	6.25	0.00	0.00
II? *Notioscopus sarcinatus*	63.16	21.05	5.26	0.00	5.26	5.26	0.00	0.00
Lepthyphantes cristatus	11.11	0.00	11.11	66.67	11.11	0.00	0.00	0.00
Pardosa pullata	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
III *Theonoe minutissima*	0.00	0.00	91.67	0.00	0.00	0.00	8.33	0.00
III *Phrurolithus minimus*	56.25	0.00	0.00	6.25	31.25	0.00	6.25	0.00
III *Agyneta conigera*	0.00	9.09	45.45	9.09	9.09	0.00	0.00	27.27
IV *Micrargus apertus*	3.13	6.25	9.38	0.00	0.00	25.00	34.38	21.88
V *Trochosa spinipalpis*	36.45	13.08	13.08	3.74	8.41	6.54	5.61	13.08
V *Centromerus arcanus*	33.78	18.92	9.46	2.70	10.81	9.46	6.76	8.11
V *Lepthyphantes angulatus*	13.89	22.22	19.44	13.89	5.56	16.67	5.56	2.78
V? *Pirata insularis*	71.43	8.13	10.20	2.04	4.08	0.00	2.04	2.04
V? *Pocadicnemis pumila*	32.35	37.25	15.69	4.90	2.94	1.96	0.00	4.90
V? *Robertus lividus*	22.73	13.64	36.36	4.55	0.00	9.09	9.09	4.55
V? *Walcknaeria atriotibialis*	11.48	39.34	26.23	8.20	8.20	1.64	0.00	4.92

GROUP I – species active only on the surface of the moss and never entering deeper layers. GROUP II – species active on the surface and in the upper part of the moss cover.

GROUP III – species occurring in some sets and showing ability to move and be abundant in deep layers.

GROUP IV – species with the main activity in deep layers of the *Sphagnum*. Only one species – *Micrargus apertus.*

GROUP V – species showing equal activity in all layers of the moss, or being active also in deep layers.

Question mark (?) indicates that particular species also probably can belong to the appropriate group.

the number of abundant species (N > 3) was much higher here (28 *versus* 17). The open deep placement of traps (15 cm, Set 3) did not result in higher numbers either of surface-active deep-living species. Deepply placed traps earned mainly species active in all layers and *Micrargus apertus*, while the number of surface-active species remained low.

The similarity analyses based on various indices clearly separated groups of sets differing in spider material collected (Figs. 2, 3). According to Soerensen's coefficient there are three separated groups (Fig. 2). The first group is formed by open trap sets near the moss cover (Set 1, Set 2 and Set 8). The second group is formed by trap sets without cylinders (Set 4 and Set 5) (see Fig. 1), and the last group is formed by trap sets with cylinders (Set 7 and Set 6). Comparing sets using the percentage similarity index, the same three groups are distinguished (Fig. 3), but comparing the distribution of individuals in open traps placed close to the moss surface, differently from the similarity of specimens, most similar are species distributed in Set 2 and Set 8, though different preserving solutions were used (formaldehyde and sodium benzoate).

The present results show that even minor differences in the depth of placement can result in big differences in material collected. For the future publications describing results of the pitfall trapping of spiders in peat bogs seems to be important to add additional information on the depth of trap placement.

No marked differences were found between Set 2 and Set 8 where different preserving solutions (4% formaldehyde and 10% sodium benzoate) were used. Sixteen from 21 abundant species found in both sets showed no differences in abundance between the sets. Only the abundances of five species were different. Three of them (*P. pumila, H. rubrofasciata, P. pullata*) were more abundant in a set with sodium benzoate and two (*Th. minutissima, M. minutus*) in a set with formaldehyde. The species numbers and the abundance of the abundant species (N > 3) show that the impact of the preserving solution is much smaller than the effect of trap placement. The differences in species numbers were caused mainly by different numbers of sporadic species (N < 3). In the set with sodium benzoate, 57.5% of all the species, while in the set with formaldehyde 64.6% belonged to sporadic species (N < 3).

Our results show that 72.4% of all species found during the present investigation were captured in the set where traps were leveled with the surface. In the sets of deeper placed traps (Set 2 and Set 8) less species were found (46.0% and 55.1% respectively).

The surface-levelled traps earned more abundant species which are mainly typical peat bog species and can be used as bioindicators. It seems that part of typical peat bog species cannot be captured if traps are even slightly dapped into moss. Also, the number of specimens belonging to common abundant species was much higher in the surface-levelled traps.

It can be recommended that traps should be placed as close as possible to the moss surface. There is no sense to try to place traps deep into the peat bog cover. It can be reasonable to place part of traps deeper to assess deep-living species. The most appropriate set can probably be 4 + 2, where 4 traps are set sharp with the surface and two are dapped to 5 cm.

Finally, we would like to emphasize that the activity of spiders in different layers of *Sphagnum* is different. Only a very small part of spider community is active in all layers of *Sphagnum*. The highest activity is on the surface of the *Sphagnum* cover. Setting traps 2–3 cm deeper into moss cover resulted in a much smaller number of specimens and species captured. Deeply (down to 15 cm) placed traps earned several times less material that the traps located close to or on the level with the moss surface. Only very few species are active in deep moss layers and seldom appear in the upper layers (*M. apertus*).

ACNOVLEDGEMENS

This work has been partially supported by the Norwegian Center for the International University Cooperation (grant CCP 03 / 02 : ENLINO. Master Program Network).

Both authors are very thankful to Ilona Vaščilo (Vilnius) for her help in performing has fieldwork.

Received 1 December 2005
Accepted 8 March 2006

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VORŲ AKTYVUMO IR VERTIKALAUS JŲ PASISKIRSTYMO TYRIMAI AUKŠTAPELKĖS KIMINŲ KUPSTUOSE

Santrauka

Europos aukštapelkių vorai yra aktyviai tiriami, tačiau yra tik pavienių duomenų apie vorų aktyvumą ir pasiskirstymą kiminų kupstuose. Taip pat nežinomas ir geriausias gaudyklių pastatymo būdas tiriant vorus aukštapelkėse. Tam tikslui 2001 m. buvo tirtas vorų aktyvumas *Sphagnum* dangoje, kartu buvo nustatytas optimalus gaudyklių pastatymo būdas šio tipo buveinėse. Tyrimai atlikti nedidelėje Tapelių aukštapelkėje, nuo Vilniaus miesto nutolusioje 14 km pietryčių kryptimi. *Sphagnum* kupstuose pastatyti 8 gaudyklių rinkiniai (kiekviename po 5 gaudykles), besiskiriantys gaudyklės pastatymo būdu. Rinkiniai tarpusavyje skyrėsi gaudyklių pastatymo gyliu, konservuojančiu skysčiu ir danga. Šių tyrimų metu buvo surinkti 1484 subrendę vorai, priklausantys 13 šeimų, 87 rūšims. Tik trys rūšys iš visų rastų 87 rūšių buvo vienodai pasiskirsčiusios visuose gaudyklių rinkiniuose (*Centromerus arcanus, Lepthyphanthes angulatus ir Trochosa spinipalpis*). Daugiausiai rūšių (63)

ir vorų (690) nustatyta arčiausiai paviršiaus esančiame gaudyklių rinkinyje (Set 1); 2–3 cm gylyje (Set 2, Set 8) rūšių įvairovė kur kas skurdesnė (40) ir individų mažiau (277), tačiau gausesnių rūšių skaičius (N > 3) panašus (atitinkamai 28 ir 17). Mažiausias gausumas pastebėtas tuose gaudyklių rinkiniuose, kurie buvo pastatyti gilesniuose kiminų sluoksniuose (Set 7 – N = 30, Set 6 – N = 43). Tik viena rūšis (*Micrargus apertus*) buvo gausesnė gilesniuose kiminų sluoksniuose. *Trochosa spinipalpis* gausi tiek gilesniuose, tiek paviršiniuose sluoksniuose. Patikimų skirtumų tarp gaudyklių rinkinių su skirtingu konservuojančiu skysčiu (4% formalino ir 10% natrio benzoato) nenustatyta.