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Assemblages of beetles (Coleoptera) in a peatbog and surrounding pine forest

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Assemblages of beetles of an open raised bog, a pine bog and surrounding dry pine forest were studied in the Čepkeliai State Strict Nature Reserve (southern Lithuania) in 1999. The research was carried out by the means of pitfall traps. A total of 80 species of beetles (Coleoptera) was registered. Of these, 33 species (565 specimens) were registered in the open bog, 41 species (450 specimens) in the pine bog, and 42 species (946 specimens) in the dry pine forest. The results revealed that pine bog and open bog had the most similar assemblages of beetles (P=64.8). The similarity between pine forest and pine bog was lower (P=8.7), while the lowest similarity was registered between pine forest and open bog (P=5.4). The results showed that the number of species registered in the studied habitats was quite similar, while the number of individuals was twice bigger in the pine forest in comparison to the pine bog or open bog˙s site. *Agonum ericeti* and *Drusilla canaliculata* were the most abundant species making up 67% of all individuals registered at the open bog˙s site and 50% in the pine bog, while *Carabus arcensis* was the most abundant in the pine forest (60%).

Key words: Coleoptera, assemblage, peatbog, pine forest, Lithuania

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INTRODUCTION

Peatbogs and other wetlands are very sensitive and endangered ecosystems in Central Europe (Raeymaekers 1999, Succow 2000). The same situation exists in Lithuania where 6685 peatlands have been recorded (Janukonis 1995). Minerotrophic fens make up the largest part of Lithuanian peatland area (71%), oligotrophic bogs about 22% and mesotrophic bogs 7%. Some peatbogs have remained in a natural state, but most of them have been drained and became highly fragmented, isolated, or naturally overgrown by forest. Some small, undisturbed peatbog fragments exist on the edges of large excavated peatlands.

Conservation of all relict biodiversity of peatbogs is a basic priority for insect conservation in Europe (Spitzer et al. 1999). The fauna of beetles living in European peatbogs is known, but there is little information regarding the relationship between beetle assemblages living in peatbogs and surrounding areas (Mossakowski et al. 2003, Browarski 2005, Bezdģk et al. 2006). Moreover, the increasing fragmentation and uniformity of peatbog fragments following anthropogenic influence on the landscape make these questions urgent.

The fauna of beetles of Čepkeliai Strict Nature Reserve was studied since 1974 and the list of 788 species was compiled (Monsevičius 1997). Some species found on the bog were listed, e.g. *Agonum ericeti*, *Pterostichus diligens*, and *P. nigrita* (Ivinskis et al. 1984), while there were no data concerning species abundances.

At present, peatbogs and other wetland fragments are mainly surrounded by drier habitats such as forests or meadows. This paper deals with the relationship between beetle assemblages in a peatbog and the surrounding forest in the largest and the most natural mire complex of Lithuania.

MATERIAL AND METHODS

The research of beetles was carried out in the northwestern part of the Čepkeliai State Strict Nature Reserve (54°00' N, 24°30' E). It is located in southern Lithuania, near the Belarus border. Čepkelių Raistas (5858 ha) is the largest mire complex in Lithuania. More than 50% is covered by large open *Sphagnum* raised bogs, while the rest of the territory consists of fens, transitional bogs, small lakes and forested islands. Mires occur on sandy fluvioglacial lowland. The bog is surrounded by large dry pine forests.

Three study sites were chosen: dry pine forest dominated by *Vaccinio-Piceteea* Br.-Bl. 39 communities bordering the bog (high *Pinus sylvestris* trees and a dense layer of *Vaccinium myrtillus* predominating), pine bog (*Ledo-Pinetum* Tx. 55 community; the site is covered with *Pinus sylvestris* trees and dense *Ledum palustre* and *Vaccinium uliginosum* shrubs in the undergrowth), and open raised bog (*Sphagnetum magellanici* Kästner et Flössner 33 community characterized by a dense layer of *Andromeda polifolia, Oxycoccus palustris, Eriophorum vaginatum* with thick *Sphagnum magellanicum* mosses).

Pitfall traps were used for collecting the material. Six plastic jars (volume 300 ml, depth 10 cm, diameter 7 cm) filled with 100–120 ml of 5% formaldehyde solution mixed with detergent were used at each site. The distance between traps, disposed in a line, was ca. 5 m. The distance between the dry pine forest and the pine bog was 150 m, and the sites in the open bog and the pine bog were located at a distance of 120 m. The traps were in operation from 15 April to 26 October 1999. They were emptied once every three weeks.

The ecological terminology is that of Peus (1928) and Spitzer & Danks (2006): tyrphobiontic species are stenotopic and obligatory associated with peatbogs in temperate zone, tyrphophilous taxa are more abundant on bogs than in adjacent habitats, and tyrphoneutral species are eurytopic, widely distributed in different habitats.

The Sorensen coefficient of similarity (Ss) was used to compare species compositions registered at different sites (Krebs 1999). Relative abundances of species were compared using Percent Similarity index (P) (Krebs 1999). Principal components analysis (PCA) was used to study the relationship between species and their habitats (ter Braak 1995). Only species with the abundances exceeding 1.0% in at least one assemblage were included in the analyses. The data was $\log_2$ transformed. PCA and cluster analysis were performed using the MVSP computer program (MVSP 2002).

The nomenclature of beetles follows Lawrence & Newton (1995).

Table 1. The main parameters of beetle assemblages studied in Čepkeliai Reserve in 1999

Habitats	Number of species	Number of specimens	Species found only in one assemblage		Species represented by 1–2 specimens		Number of species with abundance >1%
			No.	%	No.	%	
Open bog	33	565	12	36.4	20	60.6	10
Pine bog	41	450	16	39.0	22	53.7	16
Pine forest	42	946	26	61.9	20	47.6	9

Table 2. The most abundant (relative abundance was more than 1.0% at least in one assemblage) species of beetles registered in 1999 in the Čepkeliai Reserve. N – number of specimens, % – relative abundance

Families and species (abbreviations in brackets) \ Habitats		Open bog		Pine bog		Pine forest	
		N	%	N	%	N	%
Carabidae							
Carabus arcensis L.	(*Cara arce*)	23	4.1	33	7.3	563	59.5
Carabus hortensis L.	(*Cara hort*)	0	0.0	0	0.0	11	1.2
Pterostichus nigrita Pk.	(*Pter nigr*)	10	1.8	2	0.4	0	0.0
Pterostichus niger Schall.	(*Pter nige*)	1	0.2	1	0.2	23	2.4
Pterostichus diligens Sturm	(*Pter dili*)	21	3.7	31	6.9	1	0.1
Pterostichus oblongopunctatus F.	(*Pter oblo*)	0	0.0	0	0.0	32	3.4
Calathus micropterus Duft.	(*Cala micr*)	0	0.0	0	0.0	39	4.1
Agonum ericeti Panz.	(*Agon eric*)	163	28.8	51	11.3	0	0.0
Leiodidae							
Agathidium atrum Pk.	(*Agat atru*)	13	2.3	8	1.8	4	0.4
Catopidae							
Sciodrepoides watsoni Spenc.	(*Scio wats*)	0	0.0	7	1.6	1	0.1
Silphidae							
Nicrophorus vespilloides Hbst.	(*Nicr vesp*)	0	0.0	27	6.0	5	0.5
Staphylinidae							
Acidota crenata F.	(*Acid cren*)	4	0.7	1	0.2	20	2.1
Drusilla canaliculata F.	(*Drus cana*)	215	38.1	174	38.7	0	0.0
Anotylus rugosus F.	(*Anot rugo*)	0	0.0	1	0.2	0	0.0
Platydracus fulvipes Scop.	(*Plat fulv*)	0	0.0	6	1.3	0	0.0
Ocypus fuscatus Grav.	(*Ocyp fusc*)	56	9.9	23	5.1	0	0.0
Quedius molochinus Grav.	(*Qued molo*)	6	1.1	7	1.6	2	0.2
Scarabaeidae							
Geotrupes stercorosus Scriba.	(*Geot ster*)	0	0.0	5	1.1	25	2.6
Cantharidae							
Cantharis pallida Goeze.	(*Cant pall*)	14	2.5	1	0.2	0	0.0
Cantharis rufa L.	(*Cant rufa*)	0	0.0	8	1.8	0	0.0
Scirtidae							
Cyphon variabilis Thunb.	(*Cyph vari*)	8	1.4	4	0.9	0	0.0
Cyphon padi L.	(*Cyph padi*)	5	0.9	8	1.8	2	0.2
Melyridae							
Dasytes niger L.	(*Dasy nige*)	2	0.4	7	1.6	0	0.0
Chrysomelidae							
Lochmaea caprea L.	(*Loch capr*)	0	0.0	10	2.2	0	0.0
Asiorestia sublaevis Motsh.	(*Asio subl*)	0	0.0	7	1.6	0	0.0
Curculionidae							
Strophosomus capitatum Deg.	(*Stro capi*)	0	0.0	0	0.0	126	13.3
Hylobius abietis L.	(*Hylo abie*)	0	0.0	2	0.4	20	2.1
Total		541	95.9	424	94.2	874	92.2

RESULTS

The material collected comprised specimens of beetles representing 80 species belonging to 11 families (Carabidae, Leiodidae, Silphidae, Catopidae, Staphylinidae, Scarabaeidae, Cantharidae, Scirtidae, Melyridae, Chrysomelidae, and Curculionidae). Of these, 33 species (565 specimens) were registered in the open bog, 41 species (450 specimens) in the pine bog, and 42 species (946 specimens) in the dry pine forest (Table 1). The lowest number of specific species (12) was registered at the open bog˙s site, while the highest – at the pine forest (26), that made up from 36% to 62% of all registered species, respectively. Eight species of beetles (*Carabus arcensis, Pterostichus niger, P. diligens, Acidota crenata, Staphylinus erythropterus, Quedius molochinus, Agathidium atrum*, and *Cyphon padi*) occurred in all habitats making up 10.0% of all the species registered at the three sites. Four of these species had their highest abundance only in one assemblage. The core of each assemblage was composed from nine to 16 species of beetles with the abundance higher than 1.0% of all individuals (Table 2). Their total abundances ranged from 88 to 95% of all individuals of each assemblage. Only *Carabus arcensis* was represented by more than 20 specimens in all three habitats. This species was the most abundant in the assemblage of beetles at the dry pine forest site making up 59.5% of all individuals. Other abundant species were *Strophosomus capitatus* (13.3%), *Calathus micropterus* (4.1%), and *Pterostichus oblongopunctatus* (3.4%) at the latter site. The most abundant species at the pine bog˙s site were *Drusilla canaliculata* (38.7%), *Agonum ericeti* (11.3%), *Carabus arcensis* (7.3%), *Pterostichus diligens* (6.9%), *Nicrophorus vespilloides* (6.0%), *Ocypus fuscatus* (5.1%), *Lochmaea capreae* (2.2%) and others. *Drusilla canaliculata* (38.1%), *Agonum ericeti* (28.8%), *Ocypus fuscatus* (9.9%), *Carabus arcensis* (4.1%), *Pterostichus diligens* (3.7%), *Cantharis pallida* (2.5%), and *Agathidium atrum* (2.3%) were the most abundant species of beetles at the open bog˙s site. 48% of all species were represented in singletons in each assemblage.

The comparison of species compositions showed that pine bog and open bog˙s assemblages of beetles were the most similar (Ss=0.541, Fig. 1). These assemblages shared 19 common species (47 species were registered at the both sites). Pine bog and pine forest˙s assemblages were less similar (Ss=0.337, there were 14 common species out of 56), while species compositions were the most dissimilar between pine forest and open bog (Ss=0.267, 10

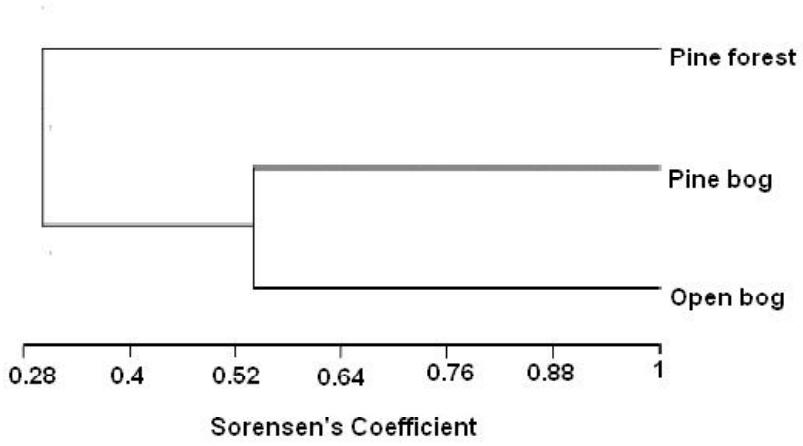

Fig. 1. Comparison of species compositions of beetles registered in different habitats in the Čepkeliai Reserve in 1999 (Sorensen coefficient of similarity, UPGMA linking method).

common species of beetles out of 48 registered at the both sites).

The comparison of relative abundances of species of beetles registered in the different habitats revealed a similar pattern (Fig. 2). Pine bog and open bog had the most similar assemblages of beetles (P=64.8). Relative abundances of seven species (*Agonum ericeti, Carabus arcensis, Pterostichus diligens, Drusilla canaliculata, Quedius molochinus, Ocypus fuscatus,* and *Agathidium atrum*) exceeded 1.0% of all individuals registered in each assemblage (Table 2). *Agonum ericeti* and *Drusilla canaliculata* were the most abundant species in the open bog and pine bog. The similarity between pine forest and pine bog was very low (P=8.7), as there were only two species (*Carabus arcensis* and *Geotrupes stercorosus*) which abundances were higher than 1.0% at these sites. The lowest similarity was registered between pine forest and open bog (P=5.4), where only *Carabus arcensis* reached the abundance of more than 1.0% of all individuals at the both sites (59.5% and 4.1%, respectively).

Principal components analysis revealed the groups of species of beetles associated with particular habitats (Fig. 3). *Agonum ericeti, Ocypus fuscatus, Cantharis pallida, Pterostichus nigrita, Cyphon variabilis,* and *Agathidium atrum* seemed to be more associated with open treeless raised bog in spite of that they were recorded in other adjacent habitats as well. Pine bog˙s assemblage of beetles was composed of *Drusilla canaliculata*, *Platydracus fulvipes*, *Pterostichus diligens*, *Dasytes niger*, *Lochmaea capreae*, *Asiorestia sublaevis, Sciodrepoides watsoni*, and some other species of beetles. Preference for the dry pine forest˙s habitat was shown by *Carabus arcensis, C. hortensis, Pterostichus oblongopunctatus, P. niger, Calathus micropterus, Strophosomus capitatus, Hylobius abietis,* and *Geotrupes stercorosus*.

DISCUSSION

The results showed that the number of species registered in the studied habitats was quite similar, while the number of individuals was twice as much in the pine forest in comparison to the pine bog or open bog˙s site. This was mainly influenced by *Carabus arcensis* that was very abundant in the pine forest and dispersed to the bog only in low numbers. *C. arcensis* was mainly found in forest bordering the Zehlau bog (Latvia) (Mossakowski et al. 2003). It is considered to be a real forest species penetrating to adjacent habitats in short distances (Sklodowski 2006).

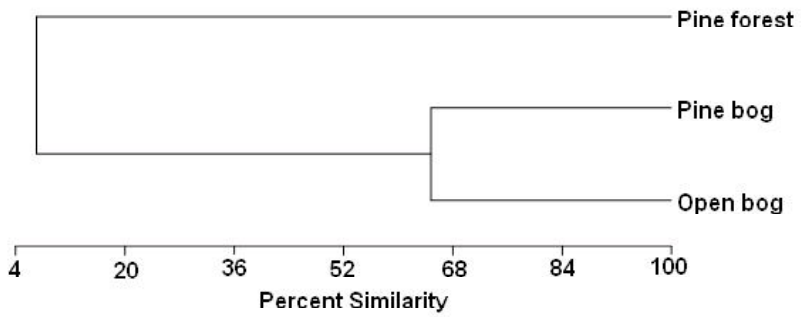

Fig. 2. Comparison of relative abundances of beetle species registered in different habitats in the Čepkeliai Reserve in 1999 (Percent Similarity index, UPGMA linking method).

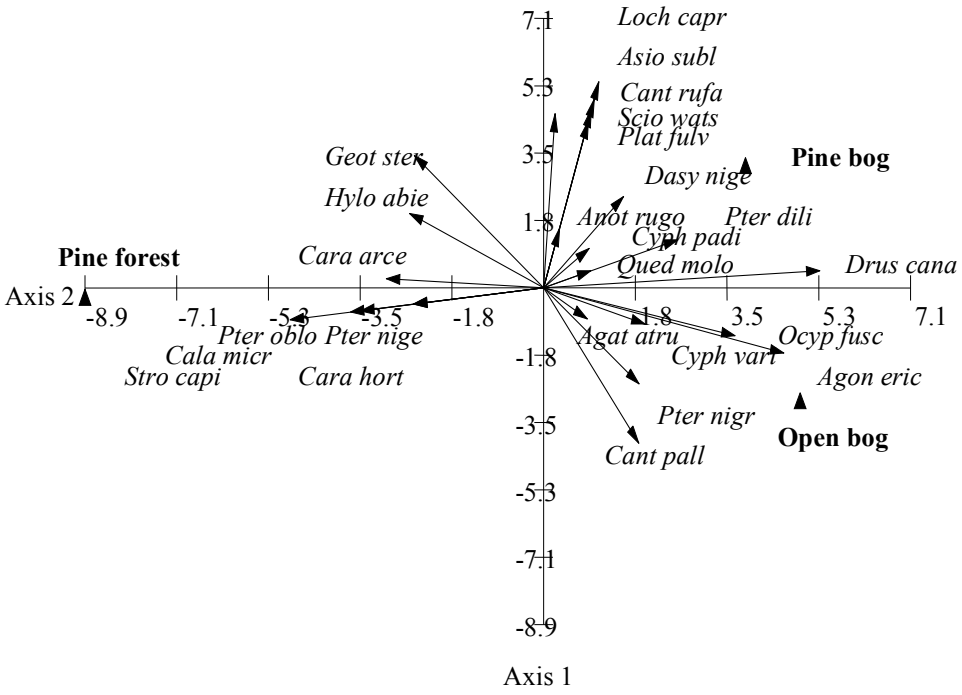

Fig. 3. PCA biplot for the sites and for the species of beetles. Eigenvalues of the first two axes were 118.153 and 19.158, respectively, explaining 86.1% and 13.9% of the variation in the species dataset. Abbreviations of species of beetles are listed in Table 2.

Agonum ericeti and *Drusilla canaliculata* were the most abundant species in the bogs, making up 67% of all individuals registered at the open bog˙s site and 50% in the pine bog. Bogs are usually inhabited by 2–3 species that are very abundant, while other species are found in low numbers (Främbs et al. 2002, Browarski 2005). Bogs are mainly inhabited by cold adapted species and microclimatic conditions are very important concerning local distribution of species (Mikkola, Spitzer 1983, Vepsäläinen et al. 2000).

High similarity of species composition between the assemblages of the open bog and pine bog was expected. The results showed that both sites shared the biggest amount of common species adapted to extreme microclimatic conditions. Some of them were not recorded in the dry pine forest at all (e.g. *Agonum ericeti, Drusilla canaliculata, Ocypus fuscatus, Cyphon variabilis, Cantharis pallida*). Of these, only *Agonum ericeti* is a real tyrphobiontic species living on bogs (Spitzer et al. 1999). It was found on both bogs sites, but showed a preference for the open bog with a thick *Sphagnum* layer. The majority of tyrphobiontic species obligatory associated with peatbogs are distributed within the habitat islands with high preference for the bog center (Främbs et al. 2002, Bezdģk et al. 2006). *Pterostichus diligens* is considered to be a tyrphophilous carabid species (Spitzer et al., 1999, Browarski 2005), and it showed a preference for the pine bog with very low dispersion to the adjacent dry forest. Similar trends were presented

by Browarski (2005), while it was found evenly distributed within the bog and the bordering linden forest showing broader ecological niche (Främbs et al. 2002). *Drusilla canaliculata* was recorded only from the bog and its abundance was high, while it is considered to belong to a large group of habitat unspecific species (Mossakowski et al. 2003). *Ocypus fuscatus* is a dominant species in wet oligothrophic places, while its abundance becomes lower in other habitats (Kuznecova 1999). Mossakowski et al. (2003) attributed *O. fuscatus* to eurytopic species. *Cyphon variabilis* seemed to be associated with peat bogs. It is usually found in raised bogs where *Calluna* shrubs are abundant (Forster 2001). The zoophagous solder beetle *Cantharis pallida* was more abundant in the open bog, but its is usually found in wet meadows at the edges of forests. It is considered to be a declining species in some European countries (Chobotov 2002).

The eurytopic ground beetles *Poecilus versicolor*, *P. cupreus*, rove beetles *Tachyporus chrysomelinus*, and *T. hypnorum* were registered only in the open bog. They are usually found in open habitats (e.g. meadows, cultural fields, etc.) having different hydrological conditions (Kromp 1989, Tamutis 1999, Andersen & Eltun 2000, Tamutis et al. 2004). *Bolitobius analis, Pterostichus nigrita,* and *Agathidium atrum* were recorded only from the open bog as well. *B. analis* is a stenotopic species living in heathlands (Eyre et al. 2004). *P. nigrita* is found in different wet habitats (Hłrka 1996, Jędryczkowski & Kupryjanowicz 2005), while *A. atrum* is associated with fungi living in wet forests (Nunberg 1987, Wheeler & Miller 2005), so these species could disperse to bogs from the adjacent habitats.

Paederus riparius, *Platydracus fulvipes*, *Anotylus rugosus*, *Paederus litoralis*, and *Quedius picipes* were found only in the pine bog, but in low numbers. Staphylinid beetles usually occur only in low numbers on bogs (Mossakowski et al. 2003), so it is not easy to define their association to particular habitats. Only *Platydracus fulvipes* is found in raised bogs (Szujecki 1980). *Paederus riparius* and *Quedius picipes* are considered to be associated with open and wooded swamps (Szujecki 1980, Kuznecova 1999). A single individual of eurytopic *A. rugosus* was registered in Edla bog (Estonia), but it was hard to show its preference to bogs (Mossakowski et al. 2003) This species is mainly found in wet habitats, in the surface of detritus rich soil (Tichomirova 1973, Pileckis & Monsevičius 1995). *Paederus litoralis* is a rare and poorly studied species in Lithuania and there were no data about its finding places on bogs (Pileckis & Monsevičius 1995). It is usually found in open and warm places (Szujecki 1965, Jędrzejczak 2002, Markgraf & Basedow 2002).

Lochmaea capreae and *Neocrepidodera sublaevis* are phytophagous species and they are associated with different plants. They have no association with bogs (Warchałowski 1978, Lopatin 1986, Pileckis & Monsevičius 1997). *Dasytes niger* and *Sciodrepoides watsoni* are tyrphoneutral species distributed in the bog like opportunistic taxa.

The assemblage of beetles was quite different in the dry pine forest having some species that were not registered on the bog, e.g. *Pterostichus oblongopunctatus, P. strenuus, Nothiophilus palustris, Carabus hortensis, C. violaceus, Cychrus caraboides, Calathus micropterus, Amara brunnea, Stenus clavicornis*, *Xantholinus linearis, X. tricolor, Strophosomus capitatus*, etc. Some of these species were quite abundant (Table 2) and they influenced the results of the comparison of relative abundances with both bogs' sites. The majority of these species are considered to be associated with forest habitats and only sometimes penetrating to bogs (Främbs et al. 2002, Mossakowski et al. 2003, Browarski 2005). *Geotrupes stercorosus* is associated with a special microhabit and is usually found in forests (Stebnicka 1976). Some species (*Strophosomus capitatus* and *Hylobius abietis*) are considered to be pest insects (Pileckis, Monsevičius 1997) and were abundant in the pine forest, but did not disperse to the bog.

Bogs are unique ecosystems, so their protection is necessary (Spitzer & Danks 2006). The

results showed that bogs have specific assemblages of beetles. Overgrowth of bogs with pines and other trees leads to the decline of abundances of some stenotopic species, e.g. *Agonum ericeti*. It is necessary to keep hydrological conditions in bogs and adjacent territories stable in order to preseve the proportion of open and closed habitats within bogs. Otherwise, some management activities in bogs should be used.

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