Diversity and species composition of beetles in the herb-shrub layer of a large isolated raised bog in Belarus

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SUMMARY

Temperate zone peat bogs form isolated ecosystems relative to their surroundings. The aim of the work reported was to investigate the species composition and diversity of the field layer beetles of an undisturbed natural bog in Belarus. In total, 99 beetle species belonging to 13 families were sampled along transects, using a sweep-net. A specific complex of Coleoptera species was found. The results showed a low diversity and species richness of beetle assemblages and a high abundance of a small number of species. Among these species, the primary peat bog specialists were *Cyphon kongsbergensis* Munster, 1924, *Cantharis quadripunctata* (Müller, 1764), *Plateumaris discolor* (Herbst, 1795), *Aphthona erichsoni* (Zetterstedt, 1838) and *Altica longicollis* (Allard 1860), which are rare in central Europe. Both the abundance and the species richness of Coleoptera were highest in shrub habitat. General linear modelling results (GLM) indicated that vegetation characteristics strongly influenced beetle abundance and species richness in peat bogs, which is interpreted as a measure of heterogeneity.

KEY WORDS: assemblages, Coleoptera, peat bog, tyrphobiont, tyrphophilous

INTRODUCTION

Today, peat bogs present some of the best examples of highly specific and relict habitats (palaeorefugia) and are of great importance for global and international species conservation (Joosten & Clarke 2002, Spitzer & Danks 2006, Wieder & Vitt 2006). The raised bogs of Central Europe, in particular, are island-like ecosystems with very specific environmental conditions and biota. *Sphagnum* moss with scattered or clumped ericaceous shrubs dominate these bogs, their mineralisation level is low, and their peat growth rate is high (Pidoplichko 1961, Geltman 1982, Bragg & Lindsay 2003, Yelovicheva *et al*. 2008). The conditions strongly influence the structure of their invertebrate communities including their insect inhabitants (Spitzer & Danks 2006, Dapkus & Tamutis 2008, Sushko & Borodin 2009, Sushko & Lukashuk 2011). Because 62 % of European mires and peatlands have been destroyed due to human activities (Joosten 1999, Bragg & Lindsay 2003), there is insufficient information on the fauna of pristine bogs in general and on their insect species in particular.

We know from literature that Central European bogs harbour a unique diversity of cold-adapted plants and insects, which have survived since the Late Glacial and early Holocene periods. Many bog inhabitants have specific habitat requirements, such as acidic and nutrient-poor conditions, specific cold-adapted or bog-confined food plants, and aquatic or aquatic-edge habitats (Spitzer & Danks 2006). The vegetation of ombrotrophic mires is isolated from the influence of mineral-rich groundwater and is fed almost exclusively by precipitation water. For that reason bog ecosystems are especially sensitive to climate change and also serve as valuable archives of detailed information for reconstructing past environments (Barber *et al*. 1994, Blackford 2000).

For bird species, bogs offer viable breeding habitats and also play a central role as migration and wintering sites. Bogs are especially important for the conservation of rare tyrphobiontic and tyrphophilous insects (Bragg & Lindsay 2003). Tyrphobiontic insect species are obligatorily restricted to bog habitats (bog dependent) and can be host-specialists and/or host-generalists (Mikkola & Spitzer 1983, Spitzer & Danks 2006, Swengel & Swengel 2011). Tyrphophilous insect species are generally associated with bog habitats but are not restricted to these habitats (facultative bog species). At present the fractions of tyrphobiontic species amongst the insect assemblages of most bogs are quite low. In the past, however, their representation may have been higher in pristine bogs. When we look at descriptions of the invertebrate fauna of European peatlands from the first decades of the twentieth century (Dampf 1924, Peus 1928, Skwarra 1929, Roubal 1934) we find that the authors mentioned a large number of invertebrate species that appeared to be restricted to peatlands, at least in the southern parts of their geographical ranges (Peus 1928, Roubal 1934, Spitzer & Jaroš

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1993, Rampazzi & Dethier 1997).

The Coleoptera (beetles) make up the most diverse order of insects. Cursory examination of their basic structure may do little to suggest why the group should be so successful, yet they have come to occupy an amazing variety of habitats. About 75 % of beetle species are phytophagous in both larval and adult stages, living in or on plants, wood and fungi and playing an important role in the ecosystem (Gillott 2005).

The Coleoptera represent one of the most abundant animal groups in peatlands. They are important members of food webs, providing protein for species at higher trophic levels (Maavara 1955, Spungis 2008, Sushko 2012). Previously, the species richness of beetles was estimated mainly in the *Sphagnum* carpet (Främbs *et al*. 2002, Mossakowski *et al*. 2003, Dapkus & Tamutis 2008), so it was not possible to build a full understanding of the composition of the beetle fauna in different (sub-) habitats and different layers of the vegetation. Very few papers have been dedicated to the chamebionts and chortobionts (shrub- and herb-dwellers) of peat bogs, and knowledge about beetle species composition in the shrub and herb layers is consequently sparse. Moreover, information on the sub-habitats of beetles (e.g. hummocks, hollows, lagg) is almost lacking (Peus 1928, Roubal 1934, Maavara 1957, Spungis 2008).

The present study aims, firstly, to describe the species composition and diversity of shrub-and-herb-layer beetle assemblages (including tyrphophilous species) associated with seven main sub-habitats in an undisturbed natural peat bog in Belarus. The second aim is to examine environmental factors affecting the species richness and abundance of beetles in this peatland. Particular emphasis is given to specialised bog species that may be valuable as biological indicators and are, thus, potential primary protection targets for peatland management.

METHODS

Study site

This research was carried out during the period 2010–2015 on the 19,984 ha ‘Yelnia’ peat bog in Belarus (55° 34' N, 27° 55' E). This is the largest and least anthropically modified bog in the country and is currently protected as a landscape reserve. The international conservation status IBA (Important Bird Area) was established in 1998 (code BY 002, criteria A4, B1, B2) (Kozulin *et al*. 2005). It could be claimed that Yelnia is a pristine model for European bogs. Its centre is about 7 m higher than its periphery and the peat layer can be as deep as 8.3 m, but is 3.8 m thick on average. It includes more than 100 lakes (Kozulin *et al*. 2005, Yelovicheva *et al*. 2008) (Figures 1 and 2). There is a slope, a summit, and a plateau which is located at the edge of the border zone (lagg zone) and is periodically flooded due to its lower altitude (Figure 3). The water table level shows distinct patterns in different habitats. It was found that the water table was highest (relative to the ground surface) in the lagg, hollows and lakeshores, and deepest on the dome (Table 1).

Figure 1. An oblique aerial photograph of the Yelnia peat bog (photo: I. Borok).

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Vegetation

Vegetation surveys were conducted according to the method of Brown (1954) in seven of the most typical peat bog habitats (plant association types based on the dominant species in each layer of the vegetation canopy):

1) lagg zone (LZ) at the bog margin (plant association: *Eriophorum vaginatum* - *Sphagnum angustifolium*);

2) pine bog (PB) on the slope (plant association: *Pinus sylvestris* - *Eriophorum vaginatum/Ledum palustre* - *Sphagnum magellanicum*);

3) hollow (HOL) on the slope (plant association: *Rhynchospora alba* - *Sphagnum cuspidatum*);

4) hummock (HUM) on the slope (plant association: *Eriophorum vaginatum* - *Oxycoccus palustris* - *Andromeda polifolia* - *Ledum palustre* - *Sphagnum magellanicum* - *S. angustifolium*);

5) open bog space (OBS) on the slope (plant association: *Eriophorum vaginatum* - *Ledum palustre* - *Chamaedaphne calyculata* - *Empetrum nigrum* -*Calluna vulgaris* - *Oxycoccus palustris* - *Vaccinium uliginosum* - *Sphagnum magellanicum*);

6) lakeshore (L) on the slope (plant association: *Carex limosa* - *Sphagnum cuspidatum*);

7) dome (D) (plant association: *Eriophorum vaginatum* - *Calluna vulgaris* - *Sphagnum fuscum*) (Figure 3).

In each habitat three areas of 250 m^2 with homogeneous vegetation were sampled (21 sites in total) in July 2011. Four vegetation attributes were recorded in each site, namely: cover (%) of shrubs and herbs, the number of species of vascular plants, and the presence of trees (Table 1). Sites were situated more than 50 m from each other.

Coleoptera survey

Coleoptera were sampled with an entomological sweep-net (diameter 30 cm) along 50 m transects that were 5 m wide (250 m^2 per site). Exactly 50 net sweeps were done on each transect, twice a month. For statistical analysis, all data from each site were summed to obtain one value *per* habitat. Surveys were conducted during the main activity period of adult beetles between May and the end of September.

The nomenclature for Coleoptera follows Lawrence & Newton (1995). The ecological terminology is from Spitzer & Danks (2006): tyrphobiontic species are stenotopic and obligatorily associated with peat bogs in the temperate zone, tyrphophilous taxa are more abundant on bogs than in adjacent habitats, and tyrphoneutral species are eurytopic and widely distributed in various habitats.

Figure 2. An aerial photograph of the Yelnia peat bog (photo: V. Ivanovskij).

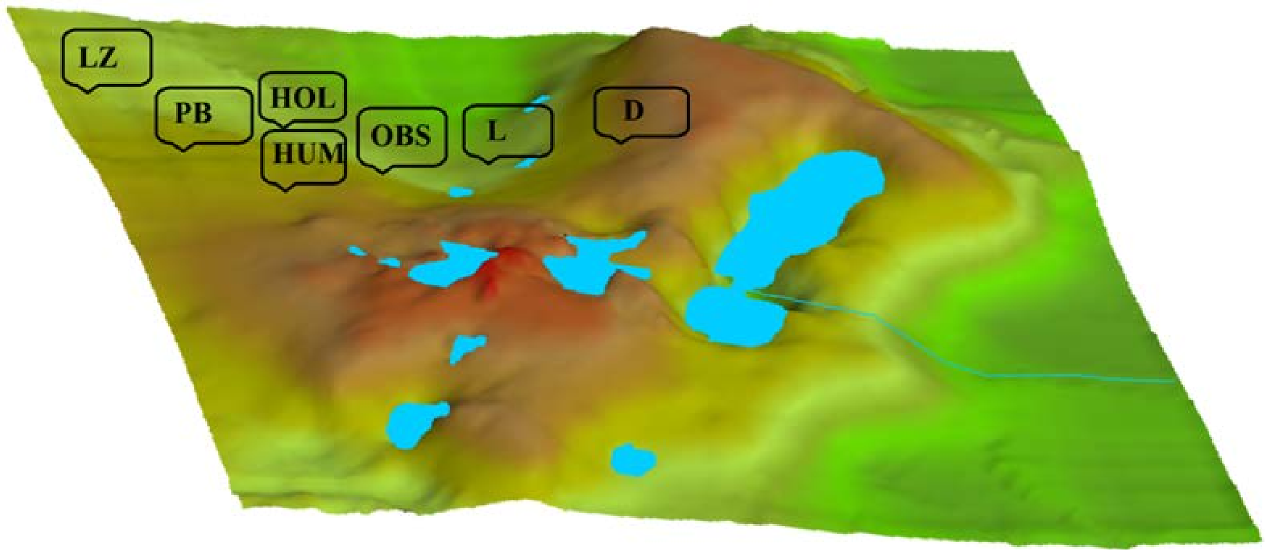

Figure 3. Locations of the sampling sites on the peat bog Yelnia, superposed on the 3-D landforms model from Grumo *et al*. (2010). Habitat symbols: lagg zone (LZ); pine bog (PB); hollow (HOL); hummock (HUM); open bog space (OBS), lakeshore (L); dome (D).

Table 1. Site characteristics shown as means (± SE) of the vegetation structure and water level.

Environmental variables	**Habitats**						
	LZ	PB	HOL	HUM	OBS	L	D
presence of trees (-,+)	-	+	-	-	-	-	-
shrub cover (%)	7.4 ± 4	64.8 ± 5	7.2 ± 2	58.1 ± 4	62.4 ± 12	0	59.3 ± 5
herb cover (%)	85.5 ± 3	10.4 ± 9	67.3 ± 3	14.3 ± 2	24.4 ± 8	89.5 ± 1	22.7 ± 2
number of species of vascular plants	3	10	2	8	9	2	7
water table depth, cm	2 ± 0.13	12 ± 4.4	1 ± 0.7	15 ± 1.2	7 ± 0.5	3 ± 0.5	35 ± 3.3
total number of sites per habitat type	3	3	3	3	3	3	3

Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

Data analysis

Simpson (D) and Shannon-Wiener indices (H′) were used to calculate Coleoptera alpha diversity. Evenness was estimated using Pielou's evenness (J). Beta diversity was evaluated through similarity among beetle assemblages, with the Bray-Curtis similarity index (Sorensen's index; Magurran 2004) which considers quantitative data (relative abundance). After calculation of the indices, the single linking method for hierarchical clustering was used to analyse the values obtained. Analyses were performed using Past® software (Hammer *et al*. 2001).

Principal component analysis (PCA) was used to ordinate the relationship among species and their habitats (Jongman *et al*. 1995). This analysis was conducted using MVSP (Multi-Variate Statistical Package (2002), Kovach Computing Services, Anglesey, Wales, UK). The data were $\log_2$ transformed. The acronyms for scientific species names used in the ordination were formed from the first three letters of the genus and species (see Appendix). Species represented by only one individual, either in the entire study or within a site, were omitted from the ordination analysis. Post hoc Tukey HSD tests were used to examine pairwise differences between Axis 1 and Axis 2 of the PCA ordinations.

The relationships of species diversity and total Coleoptera abundance to environmental variables were tested with generalised linear models (GLM) to meet model assumptions (Zuur *et al.* 2009, Zuur *et al*. 2010). The statistical analyses were done in R 2.12.2 (R Development Core Team 2011).

RESULTS

Vegetation

Open and swampy lagg zones, hollows and lakeshores had a high percentage of herb cover and low plant species richness (Table 1). The most common vascular plant species of these sites were *Eriophorum vaginatum*, *Carex limosa* and *Rhynchospora alba*. The vegetation characteristics of pine bogs, hummocks and open bog were similar. These sites had high cover of ericaceous dwarf shrubs and high plant species richness. The hummocks, which could vary in diameter from 20–30 centimetres to several metres, were mainly composed of *Eriophorum vaginatum*, *Oxycoccus palustris*, *Vaccinium uliginosum*, *Ledum palustre*, *Empetrum nigrum* and *Chamaedaphne calyculata*. These plants were typical for pine bog and open bog, while the dome showed a higher percentage of heather in the shrub cover and a slight decrease of plant species richness. Trees occurred predominantly in the pine bog habitat. They were very sparse.

Coleoptera species richness, abundance and diversity

In total, 99 beetle species from 16 families (Scarabaeidae, Scirtidae, Buprestidae, Elateridae, Cantharidae, Dasytidae, Nitidulidae, Phalacridae, Coccinellidae, Latridiidae, Bruchidae, Oedemeridae, Lagriidae, Chrysomelidae, Apionidae and Curculionidae) were found. Curculionidae were represented by 24 species, while 18 Chrysomelidae, 14 Cantharidae and 13 Coccinellidae species were recorded. Other families were represented by fewer than ten species.

The assemblages of beetles *per* habitat comprised 29–65 species. The lowest number of species (20) was recorded in hollows. The highest species richness (65) was captured in pine bog (Table 2, Figure 4). Coleoptera abundance was highest in pine bog and on the dome (Figure 5).

Lochmaea suturalis (1.62–26.61 %), *Plateumaris discolor* (0.37–12.44 %), *Cyphon padi* (2.91–21.24 %) and *C. kongsbergensis* (3.51–10.37 %) were the most abundant species (see Appendix).

More than half of the species (51.72–63.41 %) caught in four of the seven habitats were represented by only 1–2 individuals. Only nine species were recorded with abundance higher than 5 %.

Cyphon kongsbergensis, *Cantharis quadripunctata*, *Plateumaris discolor* and *Altica longicollis* were the most abundant specialised peat bog species. Other peat bog dwellers included *Aphthona erichsoni* (tyrphobiontic), *Absidia schoenherri*, *Coccinella hieroglyphica*, *Cryptocephalus labiatus*, *Lochmaea suturalis*, *Chaetocnema sahlbergii* and *Micrelus ericae* (tyrphophilous).

Thirteen beetle species (*Cyphon kongsbergensis*, *C. padi*, *C. pubescens*, *Actenicerus sjaelandicus*, *Cantharis quadripunctata*, *Absidia schoenherri*, *Dasytes niger*, *Lochmaea suturalis*, *Aphthona erichsoni*, *A. euphorbiae*, *Chaetocnema mannerheimi*, *Ch. sahlbergii* and *Apion fulvipes*) occurred in all habitats.

Table 2. The main attributes of the beetle assemblages.

Attributes	Habitats						
	LZ	PB	HOL	HUM	OBS	L	D
Number of families	12	12	10	14	14	9	11
Number of species	41	65	29	58	57	30	44
Number of specimens	386	684	272	544	550	370	752
Number of species represented by 1–2 specimens	26	36	17	30	28	14	14
% of species represented by 1–2 specimens	63.41	55.38	58.62	51.72	49.12	46.67	31.81
Number of species with abundance > 5 %	4	2	5	2	3	2	4
% of specimens of species with abundance > 5 %	48.70	32.16	58.09	22.79	30.91	63.24	47.07
Shannon-Wiener index (H’)	1.269	1.432	1.204	1.519	1.498	1.150	1.349
Simpson index (D)	0.085	0.080	0.083	0.043	0.047	0.114	0.071
Pielou index (J)	0.792	0.790	0.832	0.865	0.853	0.779	0.821

Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

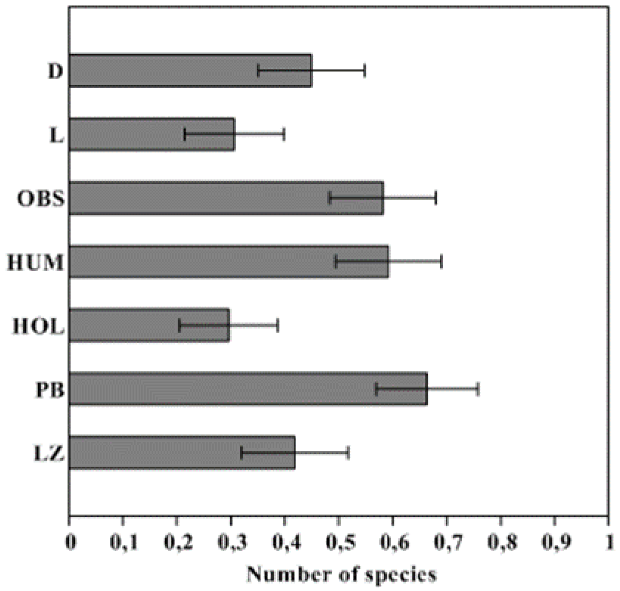

Figure 4. Differences in the species richness (log transformed ± SE) of Coleoptera assemblages. Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

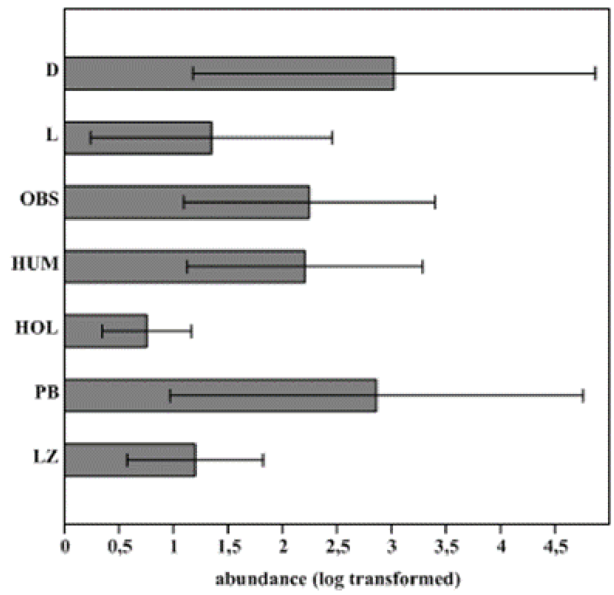

Figure 5. Differences in total abundance (log-transformed ± SE) of Coleoptera assemblages. Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

The open bog sites showed the highest average Shannon-Wiener index (H' = 1.498), whereas the lowest value was recorded from lakeshores (H' = 1.150). The diversity index was slightly lower in other assemblages (H' = 1.204–1.432). The Pielou evenness index (J = 0.779) was also lowest on the lakeshores. In contrast, dominance peaked on lakeshores (D = 0.114). The lowest dominance was on hummocks (D = 0.043).

The cluster analysis showed similarities in beetle assemblages between open bog spaces (OBS) and hummocks (HUM), and between open bog spaces (OBS) and pine bog (PB). The assemblages of hollows (HOL) and lakeshores (L) were also similar. The assemblages of the lagg zone were least similar to those of the other habitats (Figure 6).

Coleoptera species composition and response to environmental variables

PCA analysis revealed groups of species associated with particular habitats (Figure 7). The first two axes of the PCA ordination explained 75.27 % and 8.42 % of the variation. The cumulative percentage of variance explained by the two first axes was 83.70 %. *Cyphon padi*, *Oxythyrea funesta*, *Aphthona erichsoni*, *Actenicerus sjaelandicus* and *Cantharis quadripunctata* were associated with the lagg zone. *Altica longicollis* and *Strophosoma capitatum* seemed to be associated with open treeless bog spaces on the slope. *Cryptocephalus labiatus* correlated with hummocks. Correlation for the pine bog was shown by *Lochmaea suturalis*, *Absidia schoenherri*, *Dasytes niger*, *Hippodamia tredecimpunctata* and *Ampedus balteatus*. *Plateumaris discolor* and *Chaetocnema sahlbergii* were associated with hollows. *Limnobaris t-album* seemed to be more associated with lakeshores. *Micrelus ericae* and *Coccinella hieroglyphica* appeared to be associated with open (treeless) bog spaces on the dome.

The significant predictor variables in the GLM model for both Coleoptera species richness and beetle abundance were herb cover, shrub cover and number of plant species (Table 3).

The majority of species (43.75–79.41 %) captured in lagg zone, hollows and lakeshores preferred *Eriophorum vaginatum* and other sedges such as *Rhynchospora alba* and *Carex* spp. Among them, the most abundant species were *Actenicerus sjaelandicus, Plateumaris discolor, Aphthona euphorbiae* and *Limnobaris t-album.* On the other hand, the majority of species (68.67–77.54 %) collected from pine bog, hummocks, open bog spaces and dome were trophically associated with dwarf shrubs - predominantly *Calluna vulgaris*, *Vaccinium uliginosum*, *Empetrum nigrum* and *Ledum palustre* (BRC 2016). Other species feed on pollen, on birch and pine, or don't have clear trophic connections. Most of these species were in the border lagg zone (36.25 %) (Table 4).

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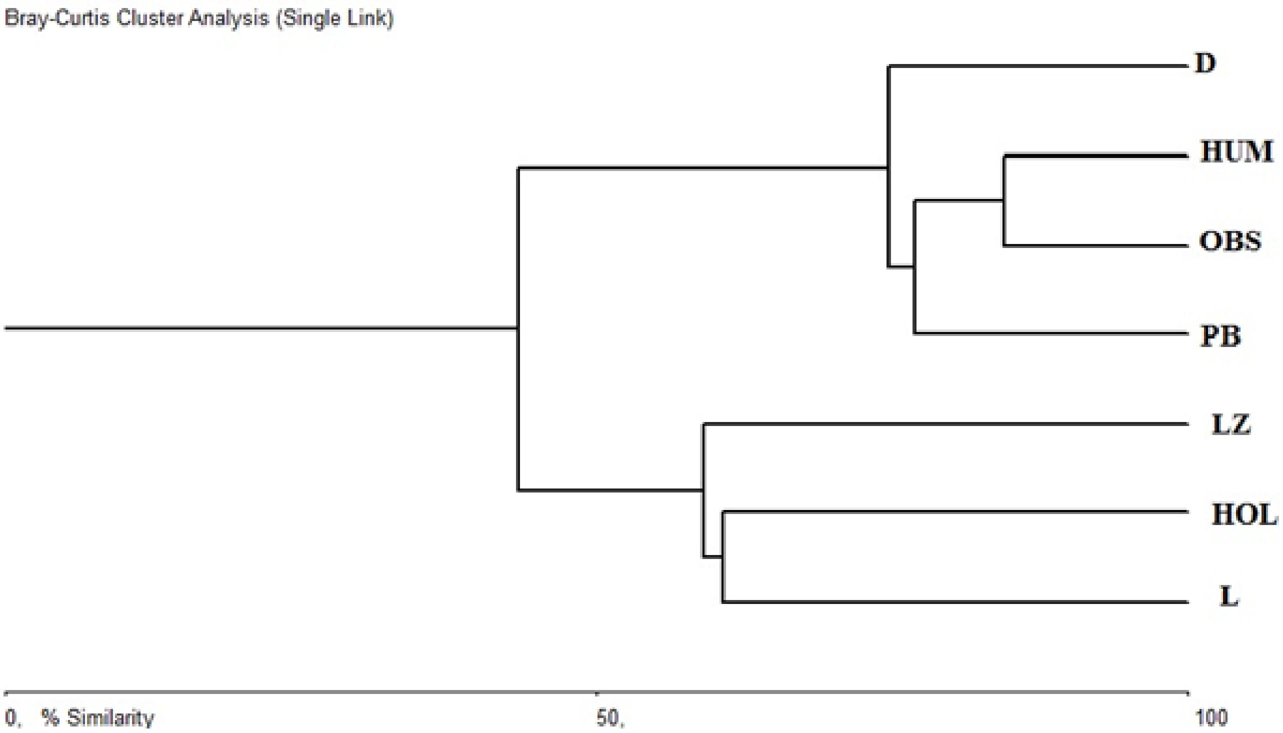

Figure 6. Relative similarity of species composition of beetle assemblages recorded in different habitats on the Yelnia peat bog. The scale on the horizontal axis is the Bray-Curtis coefficient of similarity (single linking method). Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

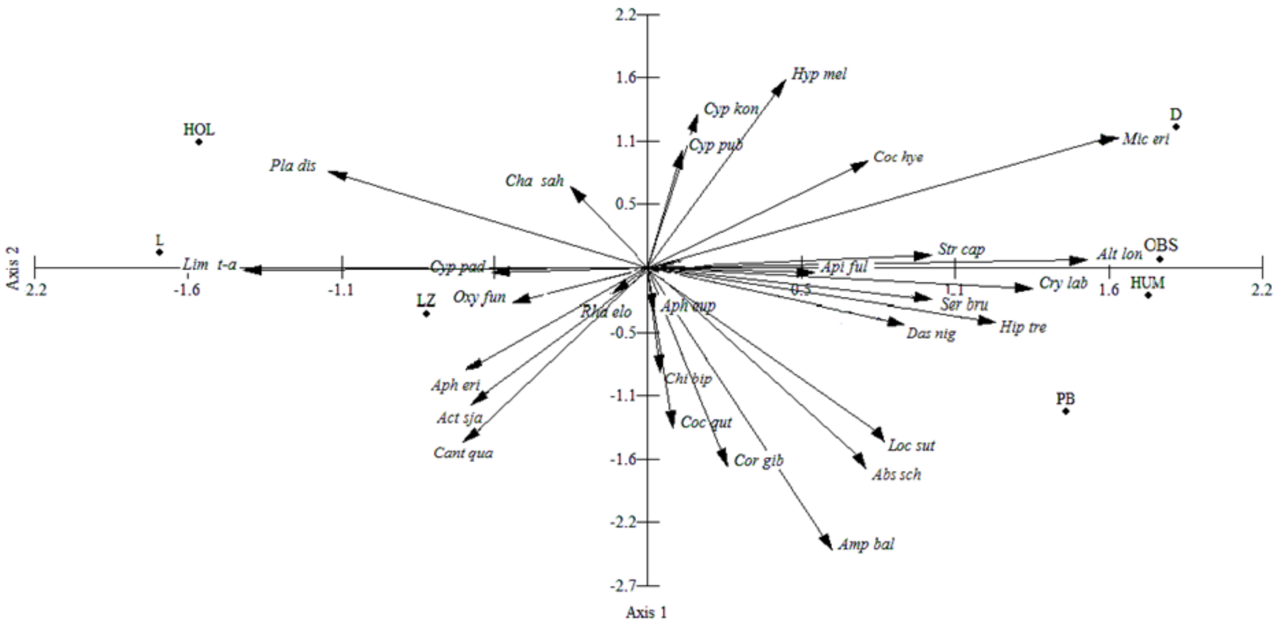

Figure 7. Odination diagram of the principal component analysis (PCA) for assemblages of Coleoptera in the habitats investigated. Species abbreviations are given in Table 3. The first two axes of the PCA ordination explained 75.27 % and 8.42 % of the variation. The cumulative percentage of variance explained by the two first axes was 83.70 %.

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Table 3. Relationship of total Coleoptera species richness and abundance to environmental factors (generalised linear model with log transformed data, multiple regression).

Factors	Estimate	SE	t	P
Species richness (R^2 = 0.777)				
shrub cover	0.41188	0.098674	4.1741	**0.00870**
herb cover	-0.3484	0.095597	-3.6445	**0.01483**
number of vascular plant species	3.9274	0.54823	7.1638	**0.00082**
presence of trees	21.833	13.584	1.6073	0.16891
Abundance (R^2 = 0.788)				
shrub cover	2.5037	0.57988	4.3176	**0.00758**
herb cover	-2.0509	0.61279	-3.3468	**0.02039**
number of vascular plant species	21.083	5.8635	3.5956	**0.01561**
presence of trees	104	89.597	1.1608	0.29814

Table 4. Differences (relative abundance, %) in the trophic preferences of herbivorous beetles occurring in different habitats on the Yelnia peat bog. Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome.

Host plants	**Habitats**						
	LZ	PB	HOL	HUM	OBS	L	D
Eriophorum vaginatum and other sedges	43.75	10.00	61.29	18.95	18.67	79.41	13.37
Ericales shrubs	20.00	77.50	12.90	66.01	68.67	15.69	77.54
Other	36.25	12.50	25.80	15.03	12.70	4.90	9.09

DISCUSSION

Our results from the almost-pristine bog complex Yelnia in Belarus showed low species richness and diversity of beetles in contrasting sub-habitats of the bog. We also found that a relatively small number of species showed high abundance, which is typical for bogs in other European countries as well (Peus 1928, Maavara 1955, Spungis 2008). Among the most abundant beetles were *Lochmaea suturalis*, *Plateumaris discolor*, *Cyphon padi* and *C. kongsbergensis*. This low species richness is in contrast to what has been found in forests, meadows and fens (Maavara 1955, Krogerus 1960, Kozulin *et al* 2005, Spitzer & Danks 2006, Wieder & Vitt 2006). The difference is probably related to better nutrient availability in forests, meadows and fens compared to bogs.

Despite the low species richness, many of the beetle species are real 'bog species' (bog-dependent or tyrphobiontic species), such as *Cyphon kongsbergensis*, *Cantharis quadripunctata*, *Plateumaris discolor*, *Aphthona erichsoni* and *Altica longicollis*. We also found several species that prefer bog habitats (tyrphophilous species), such as *Absidia schoenherri*, *Coccinella hieroglyphica*, *Cryptocephalus labiatus*, *Lochmaea suturalis*, *Chaetocnema sahlbergii* and *Micrelus ericae* (Peus 1928, Roubal 1934, Maavara 1955, Spitzer & Danks 2006). Most of these species are herbivorous and associated trophically with particular peat bog plants (mainly ericaceous shrubs) such as *Ledum palustre*, *Chamaedaphne calyculata*, *Oxycoccus palustris*, *Andromeda polifolia* and *Vaccinium uliginosum*. For instance, beetle species such as *Plateumaris discolor*, *Aphthona erichsoni* and *Chaetocnema sahlbergii* feed almost exclusively on cottongrass (Sushko 2006).

Compared to reports from old literature, a new finding was that we recorded the highest Coleoptera species richness, abundance and diversity in habitats

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covered with shrubs. This may be due to the sampling method applied. Whereas we used sweep-nets, most of the older studies used soil traps which underestimate species diversity in shrub habitats. In contrast to shrub-covered sites, habitats covered only by sedges showed much lower beetle diversity.

The modelling results (GLM) indicated that vegetation characteristics, such as herb and shrub cover and number of vascular plant species, strongly influenced beetle abundance and species richness in bog habitats. Several bog specialists that feed on *Eriophorum vaginatum* and *Carex* species - such as *Plateumaris discolour* (tyrphobiontic), *Aphthona erichsoni* (tyrphobiontic) and *Actenicerus sjaelandicus* (tyrphophilous) - seemed to be associated with lagg zones and hollows, while other bog specialists (both tyrphobiontic and tyrphophilous) e.g. *Altica longicollis*, *Cryptocephalus labiatus*, *Lochmaea suturalis* and *Micrelus ericae* correlated with open treeless bog spaces on the slopes and on the dome with pines.

The present study of beetles provides a basis for identifying centres of species richness and abundance within the protected areas of European wetlands. The bog reserve Yelnia, which is one of the largest protected mires in Europe, was found to be a repository of many of the specialised cold-adapted boreal bog beetles that occur in the temperate zone of Europe, and hence is an especially important site in the context of global warming. These results reveal that environmental stability is a key factor for the preservation of beetle diversity in bogs. In particular, it is necessary to keep the hydrological conditions stable in bogs and the adjacent areas, because most of the tyrphobiontic species are restricted to the wetter parts of the bogs (lagg, hollows and other bog slopes). Moreover, it is necessary to strengthen the international conservation status of this territory by considering not only rare and protected birds and plants, but also threatened insects.

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Appendix. Composition (relative abundance, %) of the beetle assemblages found in different habitats on the Yelnia peat bog. Habitat symbols: LZ = lagg zone; PB = pine bog; HOL = hollow; HUM = hummock; OBS = open bog space; L = lakeshore; D = dome. *Tyrphophilous species, **Tyrphobiontic species.

Family	**Species**	***Abbreviation***	**Habitats**						
			LZ	PB	HOL	HUM	OBS	L	D
Scarabaeidae	*Oxythyrea funesta* (Poda, 1761)	*Oxy fun*	3.11		1.47	0.37			
Scirtidae	*Cyphon kongsbergensis* Munster, 1924**	*Cyp kon*	3.63	3.51	10.29	4.04	3.64	7.57	10.37
	C. ochraceus Stephens, 1830	*Cyp och*	1.55				0.36		
	C. padi (Linnaeus, 1758)	*Cyp pad*	21.24	4.97	19.85	2.94	2.91	15.14	3.99
	C. pubescens (Fabricius, 1792)	*Cyp pub*	2.07	2.34	11.76	3.68	3.27	3.24	3.19
	C. variabilis (Thunberg, 1787)	*Cyp var*			0.74	2.94	1.09		0.80
Buprestidae	*Trachys minutus* (Linnaeus, 1758)	*Tra min*				0.74	1.45		
Elateridae	*Athous haemorrhoidalis* (Fabricius, 1801)	*Ath hae*		0.29		0.37			
	Denticollis linearis (Linnaeus,1758)	*Den lin*		0.29				0.54	
	Actenicerus sjaelandicus (Müller, 1764)	*Act sja*	8.29	1.46	2.21	3.31	3.27	2.70	1.33
	Ampedus balteatus (Linnaeus, 1758)	*Amp bal*	0.52	2.63		2.21	2.18	0.54	
	A. sanguinolentus (Schrank, 1776)	*Amp san*		0.29					
	Sericus brunneus (Linnaeus, 1758)	*Ser bru*	0.52	2.92	1.47	1.84	3.64		2.13
	Agriotes lineatus (Linnaeus, 1767)	*Agr lin*	0.52						
	A. obscurus (Linnaeus, 1758)	*Agr obs*				0.37			
	Dalopius marginatus (Linnaeus, 1758)	*Dal mar*		0.58			0.73		
Cantharidae	*Cantharis fulvicollis* (Fabricius, 1792)	*Can ful*		0.29	0.74	0.37	0.36		
	C. fusca Linnaeus, 1758	*Can fus*	0.52						
	C. lateralis Linnaeus, 1758	*Can lat*		0.29		0.37	0.36		0.27
	C. pallida Goeze, 1777	*Can pal*	0.52						
	C. rufa Linnaeus, 1758	*Can ruf*		0.29					
	C. quadripunctata (Müller, 1764)**	*Can qua*	6.74	3.51	3.68	3.31	6.18	6.49	4.26
	Rhagonycha elongata (Fallen, 1807)	*Rha elo*		1.17	4.41	2.21	2.18	2.70	1.06
	Rh. lignosa (Müller, 1764)	*Rha lig*		0.29					
	Rh. limbata Thomson, 1864	*Rha lim*	1.04						
	Rh. testacea (Linnaeus, 1758)	*Rha tes*				0.37			
	Absidia schoenherri (Dejean, 1837)*	*Abs sch*	2.07	3.51	0.74	3.68	3.27	4.32	3.99
	Malthinus biguttatus (Linnaeus, 1758)	*Mal big*		2.05		1.10	1.09		1.86
	Malthodes crassicornis Maeklin, 1846	*Mal cra*		0.58		0.37	0.36		
	M. fuscus (Waltl, 1838)	*Mal fus*		0.58		0.37	0.36		
Dasytidae	*Dasytes niger* (Linnaeus, 1761)	*Das nig*	2.07	2.34	0.74	2.21	1.82	1.62	2.13

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Family	Species	*Abbreviation*	Habitats						
			LZ	PB	HOL	HUM	OBS	L	D
Nitidulidae	*Meligethes aeneus* (Fabricius, 1775)	*Mel aen*	1.04	0.58		1.10	1.09		1.06
Phalacridae	*Olibrus aeneus* (Fabricius, 1792)	*Oli aen*	1.04	0.58	0.74	1.47	1.45		1.33
Coccinellidae	*Scimnus suturalis* Thunberg, 1795	*Sci sut*		0.29					
	Hyperaspis reppensis (Herbst, 1783)	*Hyp rep*					0.36		
	Chilocorus bipustulatus (Linnaeus, 1758)	*Chi bip*		2.05		3.31	2.91		1.06
	Ch. renipustulatus (Scriba, 1790)	*Chi ren*		0.29	1.47		0.36		
	Exohomus qudripustulata (Linnaeus,1758)	*Exo qud*		0.29			0.36		
	Coccinulla qutuordecimpustulata (Linnaeus,1758)	*Coc qut*	1.55	1.17		0.74	0.73	3.24	0.53
	Anisosticta novemdecimpunctata (Linnaeus,1758)	*Ani nov*			1.47			0.54	
	Calvia decemguttata (Linnaeus, 1767)	*Cal dec*		0.29					
	Halyzia sedecimguttata (Linnaeus,1758)	*Hal sed*			0.74			0.54	
	Anatis ocellata (Linnaeus, 1758)	*Ana oce*		0.29					
	Hippodamia tredecimpunctata (Linnaeus, 1758)	*Hip tre*	0.52	1.75		2.57	1.82	0.54	1.60
	Coccinella hieroglyphica Linnaeus, 1758*	*Coc hie*		3.80		5.15	4.36		6.91
	C. septempunctata Linnaeus, 1758	*Coc sep*		0.58	1.47	0.74	0.73	1.08	1.60
Latridiidae	*Corticarina fuscula* (Gyllenhal, 1827)	*Cor fus*				0.37			
	C. gibbosa (Herbst, 1793)	*Cor gib*	2.59	1.17		1.84	1.82	2.16	0.53
Oedemeridae	*Chrysanthia geniculata* Heyden, 1877	*Chr gen*		0.88		2.57	1.82		
	Oedemera lurida (Marsham, 1802)	*Oed lur*					0.36		
Lagriidae	*Lagria hirta* (Linnaeus, 1758)	*Lag hir*		0.88					
Bruchidae	*Bruchus affinis* Frolich, 1799	*Bru aff*					0.36		
Chrysomelidae	*Plateumaris discolor* (Herbst, 1795)**	*Pla dis*	12.44		11.03	0.37	1.82	5.95	0.80
	Oulema gallaeciana (Heyden, 1870)	*Oul gal*		0.29					
	Cryptocephalus decemmaculatus (Linnaeus, 1758)	*Cry dec*	0.52						
	C. labiatus (Linnaeus, I76I)*	*Cry lab*		2.63		3.68	2.91		1.86
	Lochmaea suturalis (Thomson, 1866)*	*Loc sut*	3.63	26.61	2.94	17.65	18.18	1.62	21.54
	Phyllotreta atra (Fabricius,1775)	*Phy atr*		0.29		0.37	0.36		
	Ph. nemorum (Linnaeus, 1758)	*Phy nem*	0.52	0.29		0.37	0.36	0.54	0.27
	Ph. vittula (Redtenbacher, 1849)	*Phy vit*		0.29	0.74	0.74	0.73	1.62	0.53
	Aphthona erichsoni (Zetterstedt, 1838)**	*Aph eri*	1.04	0.58	1.47	0.74	0.73	0.54	0.53
	A. euphorbiae (Schrank, 1781)	*Aph eup*	4.66	2.34	3.68	1.84	1.82	2.16	1.33
	Longitarsus luridis (Scopuli, 1763)	*Lon lur*		0.29					
	L. parvulus (Paykull, 1799)	*Lon par*				0.74			1.86

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Family	Species	*Abbreviation*	Habitats						
			LZ	PB	HOL	HUM	OBS	L	D
Chrysomelidae (continued)	*Altica longicollis* (Allard 1860)**	*Alt lon*		5.56		3.68	6.55		8.24
	Batophila rubi (Paykull, 1799)	*Bat rub*		0.88		0.37			0.27
	Crepidodera aurata (Marsham, 1802)	*Cre aur*	0.52	0.29					
	Chaetocnema mannerheimi (Gyllenhal, 1827)	*Cha man*	1.04	0.88	0.74	0.74	0.73	0.54	0.53
	Ch. sahlbergii (Gyllenhal,1827)*	*Cha sah*	2.59	0.29	4.41	1.84	1.09	2.70	1.33
	Cassida hemisphaerica Herbst, 1799	*Cas hem*	0.52	0.29			0.36		
Apionidae	*Apion apricans* Herbst, 1797	*Api apr*	0.52	0.88		0.37	0.73		0.53
	A. fulvipes (Geoffroy, 1785)	*Api ful*	1.04	1.46	0.74	2.21	1.09	0.54	1.60
	A. seniculus Kirby, 1808	*Api sen*	0.52	0.58	2.94	0.74			
Nanophydae	*Nanophyes marmoratus* (Goeze, 1777)	*Nan mar*				0.37			
Curculionidae	*Strophosoma capitatum* (DeGeer, 1775)	*Str cap*		1.75		1.10	1.09		1.33
	Sitona lineatus (Linnaeus, 1758)	*Sit lin*	1.04	0.88		0.37	0.36		1.86
	Hypera adspersa (Fabricius, 1792)	*Hyp ads*	0.52						
	H. arator (Linnaeus, 1758)	*Hyp ara*		0.29					
	H. denominanda (Capiomont, 1868)	*Hyp den*				0.37			
	H. meles (Fabricus, 1792)	*Hyp mel*					1.09		1.33
	H. nigrirostris (Fabricius, 1775)	*Hyp nig*	0.52	0.58		0.37	0.36		0.27
	Grypus equiseti (Fabricius, 1775)	*Gry equ*	0.52					0.54	
	Notaris bimaculatus (Fabricius, 1787)	*Not bim*			0.74			1.08	
	Ellescus scanicus (Fabricius, 1787)	*Ell sca*		0.29					
	Anthonomus phyllocola (Herbst, 1795)	*Ant phy*			1.47				
	Brachonyx pineti (Paykull, 1792)	*Bra pin*		0.88			0.36		
	Rhynchaenus iota (Fabricus, 1787)	*Rhy iot*				1.10			0.53
	Rh. lonicerae (Herbst, 1795)	*Rhy lon*		0.29		0.37	0.36		0.27
	Rh. pratensis (Germar, 1821)	*Rhy pra*	0.52					1.08	
	Anoplus plantaris (Naezen, 1794)	*Ano pla*		0.29					
	Acalles camelus (Fabricius, 1792)	*Aca cam*					0.36		
	Limnobaris t-album (Fabricius, 1777)	*Lim t-a*	0.52		5.15			28.11	
	Micrelus ericae (Gyllenhal, 1813)*	*Mic eri*		0.29		1.10	0.73		1.60
	Ceutorhynchus erysimi (Fabricius, 1787)	*Ceu ery*							0.53
	C. punctiger (Sahlberg, 1835)	*Ceu pun*		0.29		0.37	0.36		0.80
	Ceuthorhynchidius floralis (Paykull, 1792)	*Ceu flo*	0.52	0.29		0.74	0.36		0.27
	C. obstrictus (Marsham, 1802)	*Ceu obs*				0.37			
	Cidnorhinus quadrimaculatus (Linnaeus, 1758)	*Cid qua*	0.52					0.54	