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Spatial distribution of epigeic beetles (Insecta, Coleoptera) in the "Yelnia" peat bog

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Epigeic beetles were sampled from different habitats in the raised bog Yelnia, the largest in Central Europe. We found 83 species from 5 families. Peat bogs in the temperate zone form isolated and discrete patches of "tundra" and so are azonal or extrazonal ecosystems relative to the surroundings. A specific complex of species, which strongly differs from the beetle assemblages on nearby mineral soils, was found in the bog. All habitats on the Yelnia bog are characterised by low species diversity and the dominance of only a few carabid and staphylinid species. The beetle assemblages of the different habitats included 20-31 species. On a burned bog only 10 species were recorded. The numbers of *Agonum ericeti, Pterostichus diligens* and *Drusila canaliculata* were high in all habitats. Among these species, the main peat bog specialist is *Agonum ericeti*. Moreover such rare peat bog species as *Carabus nitens*, *Dicheirotrichus cognatus*, *Bradycellus ruficollis*, *Gymnusa brevicornis*, *Ischnosoma bergrothi, Euaesthetus laeviusculus* and *Atheta arctica* were also recorded. It can be stated that Yelnia is a huge European reserve of the tyrphobiontic and tyrphophilous beetle species. It is necessary to strengthen the international conservation status of this territory.

Key words: Cluster analysis, Diversity, Evenness, Ordination, Peat bog Raised bog, Tyrphobiont, Tyrphophilic.

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INTRODUCTION

Peat bogs play an important role in the biosphere. Their biomass accumulation involves the sequestration and storage of carbon from the atmosphere. Peatlands often constitute major components of local or regional hydrological systems. Peat bogs have the capacity to store and purify water by removing pollutants, and can prevent soil erosion. Peat bogs are important sources of biological material and genetic diversity, as they contain specialized organisms which contribute significantly to the global gene pool (Bragg et al. 2003). Unfortunately, peat bogs and other wetlands are very sensitive and endangered ecosystems in Central Europe (Succow 2000). Only five countries of Central Europe, including Belarus, have maintained more than 50% of their peatlands in a relatively natural condition. Most other countries have lost between 70% and 99% of their natural peatland systems (Bragg et al. 2003, Joosten 1994, Paavilainen & Päivanen 1995, Foss 1998).

Today, Central European peatlands play an important role in global and international species conservation. They harbour viable breeding populations and play a central role as migration and wintering sites for many bird species of global conservation concern. These areas have a special responsibility for the conservation of rare insect species (Bragg et al. 2003), as there are a number of species that can only live on ðeat bogs. Such species are the first to be threatened. They include the following: *Clossiana frigga* (Beclin in Thunberg, 1791), *Oeneis jutta* Hübner, 1806, *Ñolias palaeno* Linnaeus, 1761 (Lepidoptera), *Formica forsslundi* Lohmander, 1949, *F. uralensis* Ruzsky, 1895 (Hymenoptera), *Aeshna subarctica* Walker, 1908 (Odonata) and others (Spitzer & Danks 2006). Among the Coleoptera, the most susceptible are – *Carabus nitens* Linnaeus, 1758, *C. clathratus* Linnaeus, 1761, *A. ericeti* (Panzer, 1809), *Dicheirotrichus cognatus* (Gyllenhal, 1827), *Bembidion humerale* Sturm, 1825, *Gymnusa brevicornis* (Paykull, 1800) and *Ischnosoma bergrothi* Hellen, 1925 (Mossakowski et al. 2003, Dapkus & Tamutis 2008, Spitzer et al. 1999, Heikal 1990, Sushko 2006).

Many bog inhabitants have specific habitat requirements, such as acidic and nutrient-poor conditions, specific cold-adapted or bog-restricted food plants, and aquatic habitats. As a result, peat bogs in the southern boreal and temperate zones form isolated and discrete patches of "edaphic forest tundra" and so are azonal or extrazonal ecosystems relative to the surroundings.
Some such habitat islands are ancient and have persisted since the early Holocene periglacial periods, about 12,000 to 13,000 years ago, when conditions were much cooler. Such cold, isolated habitats can be classified as paleorefugia (Spitzer & Danks 2006). The peat bogs are important environments for the survival of subarctic and boreal biota, including cold-adapted insects far from the north, in more southern latitudes (Spitzer & Danks 2006, Sushko 2014).

The north-western part of Belarus is called Land O'Lakes, and this is the region where the majority of raised bogs are located (~166 000 ha). This area was formed after the Ice-Age, 10-11 thousand years ago and is characterized by specific soil types on moraine (including peat soils). Lakes occupy 10% of the territory in the Land O'Lakes. The climate here is moister and cooler than the regional climate in southern Belarus. As a result – a large area of raised bogs. (Yakushko 1971). The Yelnia peat bogs (19,984 hectares) are one of the largest in Central Europe. Today Yelnia remains one of the few bogs to be preserved in a natural condition. The national conservation status of the Yelnia peat bogs is national landscape reserve. The international conservation status IBA was established in 1998 (code BY 002, criteria A4, B1, B2) (Kozulin et al. 2005). It can be stated that Yelnia – is a model of European ðeat bogs. Fires are a major threat for Yelnia, which occur periodically in different parts of the ðeat bogs.

The present-day faunal composition of Belarus Land O'Lakes was formed during the post-glacial period. The postglacial Holocene histories and geographical positions of particular bogs are reflected in the specific composition of their insect assemblages. The specificity of peat bog insects is of interest in the context of zoogeography, island biology and ecology. These ancient and isolated bogs are among the least studied ones in Belarus. The uniqueness of the remaining bogs, their existence for hundreds or thousands of years, and their particular entomological interest make it essential that they should be conserved (Spitzer & Danks 2006). Beetles are a group containing many bog specialist species, some of which are of Red List status.

The aims of our investigation were to obtain specific information on the assemblages of beetles and its composition in various habitats in one of the largest natural peat bogs, the exposure of changes in assemblages on burned areas and to determine which species are in danger of becoming extinct.

MATERIALS AND METHODS

The peat bogs are located on the watershed of two river basins; coordinates 55°34 N 27°55 E.

Their central part is about 7 m higher than the peripheral parts. The peat layer can be as deep as 8.3 m, but is 3.8 m on average. Three rivers flow out of the mire, with no streams or rivers entering the complex. More than 100 lakes are located within the peat bogs (Kozulin et al. 2005).

For the collection of beetles, pitfall traps in the form of plastic cups (250 cm^3) with a fixation liquid (4 % formaldehyde solution) were used. The following seven habitats were sampled using 10 traps in each: forest bordering the bog, lag, pine forest, hummock, hollow, dome and burned bog. The traps were set out in a transect of about 100 m and placed at least 10 m apart. They were checked and emptied at 10-14 day intervals. Pitfall trapping was started in the first half of April and all traps were removed at the beginning of November in each year. The research was carried out between 1999 and 2011.

To calculate the diversity of the beetle assemblages, I used the Simpson (D) and Shannon-Wiener indices (H'). Evenness was estimated using Pielou's evenness (J). Hierarchical cluster analysis (UPGMA linking method) was employed in the analysis of habitat similarity. Similarity between sites was calculated by using the Sørensen similarity coefficient (Ss) (Krebs

Principal component analysis (PCA) was used to ordinate the relationship between species and their habitats (ter Braak 1995). Only species with abundances exceeding 1.0% in at least one assemblage were included in the analyses. The data were log_2 transformed. The PCA and cluster analysis were performed using the MVSP computer program (MVSP 2002). The nomenclature of beetles follows Lawrence & Newton (1995).

The ecological terminology is that of Spitzer & Danks (2006): tyrphobiontic species are stenotopic and obligatorily associated with peatbogs 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.

Description of the study sites (Fig. 1):

1) forest bordering the bog (BF), generally dry, but inundated for a long period during the spring (*Betula pubescens – Vaccinium vitis-idaea*); 2) lagg zone (LZ) at the bog margin, open and swampy (*Eriophorum vaginatum – Sphagnum angustifolium*); 3) bog slope (PB), pine forest, wet (*Pinus sylvestris – Eriophorum vaginatum – Ledum palustre – S. magellanicum + S. angustifolium*); 4) bog slope, hummock-hollow complex (HOL), open and swampy (*Rhynchospora alba – Sphagnum cuspidatum*); 5) bog slope, hummock-hollow complex (HUM), open and less wet (*Eriophorum vaginatum – Oxycoccus palustris + Andromeda polifolia + Ledum palustre – Sphagnum magellanicum + S. angustifolium + S. fuscum*); 6) dome (D), open, exposed and dry (*Eriophorum vaginatum – Calluna vulgaris + Ledum palustre – Sphagnum fuscum + S. magellanicum*); 7) dome (BB), open, burned bog, dry (*Eriophorum vaginatum – Calluna vulgaris – Polytrichum strictum*).

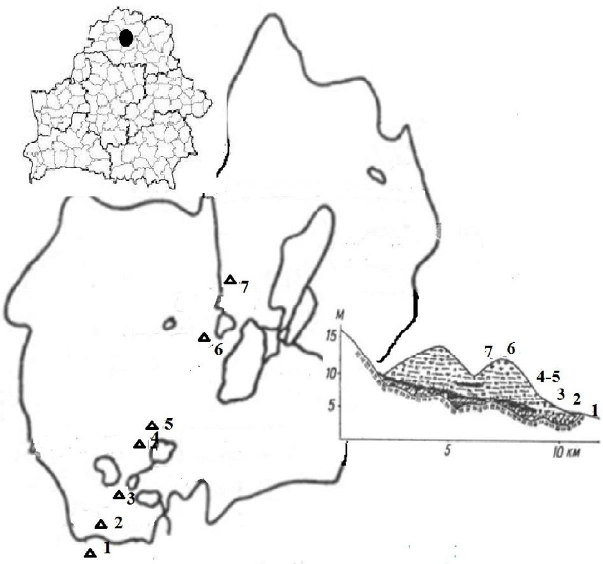

Fig.1. Location of the sampling sites in the peat bog Yelnia

RESULTS

I recorded 83 species of epigeic beetles from 5 families (Carabidae, Leiodidae, Staphylinidae, Byrrhidae and Curculionidae) on the Yelnia raised bog. In the forest bordering the bog (PB), I recorded 44 species of beetles from the same 5 families (Appendix, Table1). The assemblages of beetles in the bog habitats comprised from 20 to 31 species. The lowest number of species was recorded on the burned bog (BB) (10). The highest number of species was captured in the birch forest (BF) near the bog (44) (Table1). Thirty four carabid species were recorded and Staphylinidae were represented by 36 species. Other families were represented by even smaller numbers of species: *Leiodidae* – 3, *Curculionidae* – 2 and *Byrrhidae* – 1.

More than half of the species (50 -75%) caught in the peat bog were represented by 1-2 individuals. Only five species were recorded with an abundance of greater than 5%. These ranged from 69.80 to 94.90% of all collected specimens. In all natural bog habitats *A. ericeti* (20.75%-71.51%) and *Drusila canaliculata* (5.10%-27.36%) were distinctly more abundant than the other species. Such species as *Pterostichus diligens, P. rhaeticus* and *Ocypus fuscatus* were also quite abundant in some habitats (Appendix). In contrast, in the birch forest the dominant group is more diverse than that of the raised bog. It included species such as *Calathus micropterus* (18.40 %), *P. oblongopunctatus* (14.06 %), *P. niger* (10.27 %) and *Carabus arvensis* (7.03 %). Among the known bog species, only *Drusila canaliculata* was recorded in greater numbers (7.27 %). The abundance of these species was lower than those of the peat bog dwellers (Appendix). In this assemblage, such forest species as *P. oblongopunctatus, C. micropterus, Cychrus caraboides* and many others occurred. Stenobiont hygrophilous peat bog species, such as *A. ericeti* and the tyrphophilous beetles *P. diligens* and *P. rhaeticus*, were not found in this assemblage.

The beetle assemblage of the *Sphagnum* mat of the pine forest also included species associated with forests (*C. caraboides, P. niger, Platynus assimilis, Carabus glabratus, Oxypselaphus obscurus, Hylobius abietis*), though their numbers were not high. Consequently the beetle assemblages of raised bogs are characterized by the domination of several stenotopic bog species. The results of the burned bogs (BB) showed that eight years after the fire, the species diversity in the burned areas was lower than in the unburned habitats. It was dominated by only one species (*A. ericeti*), the dominance of which was 94.90 %.

Table 1. The main parameters of beetle assemblages studied in the Yelnia raised bog

Parameters	**Habitats**						
	BF	LZ	PB	HOL	HUM	D	BB
Number of species	44	28	27	20	31	20	10
Number of families	4	3	5	3	4	4	2
Number of species represented by 1–2 specimens	24	21	17	13	20	10	6
% of species represented by 1–2 specimens	54.54	75.0	62.96	65.0	64.51	50.0	60.0
Number of species with abundance >5%	5	5	5	3	2	2	1
% of specimens of species with abundance >5%	57.03	69.80	77.84	84.40	83.00	84.60	94.90
Shannon-Wiener index (H’)	1.336	1.095	0.904	0.568	0.607	0.513	0.286
Simpson index (D)	0.099	0.476	0.514	0.740	0.567	0.861	0.920
Pielou index (J)	0.813	0.756	0.632	0.437	0.407	0.394	0.124

Habitat symbols: forest bordering the bog (BF); lagg zone (LZ); pine forest (PB); hollow (HOL); hummock (HUM); dome (D); burned bog (BB).

The described features of the species composition and abundance are reflected by the diversity indices. The Shannon-Wiener diversity index (1.336) and the interrelated Pielou evenness index (0.813) reached their maxima in the birch forest. The Simpson index (0.920), corresponding to the degree of dominance, attained the highest value in heather on the burned bog. On the other hand, the diversity (0.286) and evenness (0.124) were recorded in the post-fire habitats. In the remaining natural habitats of the peat bog, the species diversity is not rich (H'= 0.513-1.095). These assemblages have low evenness (0.756-0.394) and high dominance (0.861-0.476) (Table1). The Simpson's diversity index was much higher in the central part of the bog than in the lagg zone, and the Shannon-Wiener index decreased.

The cluster analysis (Fig. 2) showed that the beetle assemblages of the open habitat of the lagg zone (LZ) and the hollow (HOL) were the most similar (Ss=0.583). It also revealed high similarity of beetle assemblages of hummocks and dome (Ss=0.549). The assemblage of lagg zone and slope (PB, HUM, HOL) and the central part of the bog were less similar (Ss=0.375-0.400).

The principal components analysis revealed the groups of species associated with particular habitats (Fig. 3). The first two axes of the PCA ordination explained 58.58 % and 17.72 % of the variation. The cumulative percentage of variance explained by the two first axes was 76.30 %. From the left to the right side of the PCA diagram, there is a gradient through swampy hollow (HOL), less wet hummock (HUM), wet pine forest on the bog (PB) to dry birch forest on the mineral soil (BF). This gradient seems to correspond to a moisture gradient from wet open bog habitats at the left (HOL, HUM, LZ) through the less wet pine bog (in the center) to the dry mineral soil at the right-hand side. The vertical axis seems to constitute a gradient from the edge of the bog to the dome, with the slope habitats at the centre.

Many species showed clear preferences for certain habitats. The tyrphobiontic species *A. ericeti* seemed to be more strongly associated with the open treeless dome, though it was also recorded in other adjacent habitats as well. The pine bog assemblage was composed of *Drusilla canaliculata*, *Ocypus fuscatus* and *P. niger*. Preference for the hummocks was shown by *Carabus*

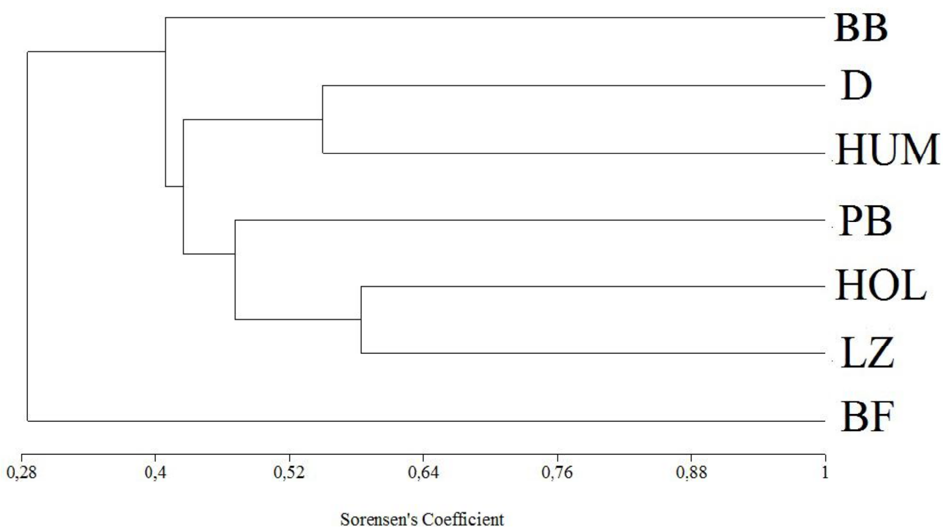

Fig. 2. Comparison of species compositions of beetles recorded in different habitats in the Yelnia peat bog (Sørensen coefficient of similarity (the scale on the horizontal axis), UPGMA linking method). Habitat symbols: forest bordering the bog (BF); lagg zone (LZ); pine forest (PB); hollow (HOL); hummock (HUM); dome (D); burned bog (BB)

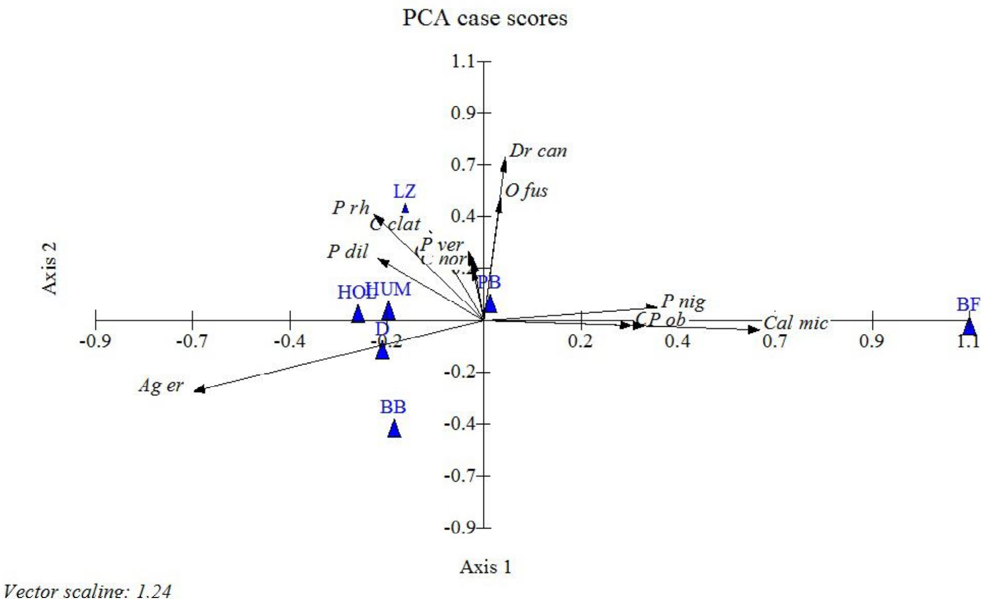

Fig. 3. PCA biplot for sites and for species. The species abbreviations are listed in the appendix

clathratus, *P. diligens*, *P. rhaeticus*. *Poecilus versicolor* and *C. hortensis* seemed to be more associated with the lagg zone and *P. oblongopunctatus*, *P. niger* and *C. micropterus* with the birch forest. Eurytopic species were mainly associated with the lagg zone, most tyrphophilous species were recorded on the slope, while the center of the peat bog was most suitable for tyrphobionts.

DISCUSSION

The results showed a low diversity of beetles and a high dominance of a small number of species in different habitats of the raised bog Yelnia. This distribution with a few highly abundant species and many species with low abundance is common on raised bogs in Europe. They are known as extreme habitats for plants and certain groups of animals (Främbs et al. 2002, Spitzer & Danks 2006, Dapkus & Tamutis 2008). In contrast, in the birch forest adjacent to the bog, there was a higher diversity and evenness of species. At the edges and on the slope of the bog, there were considerably more forest and eurytopic species, which came from adjacent habitats on mineral soils. However, with increasing distance from the boundary of the peat bog, their number and abundance decreased. The lowest number of beetle species was caught from the dome, which also had the highest abundance of the tyrphobiontic species *A. ericeti.* Higher abundance of tyrphobionts on the dome than in other parts of the bog places was also reported from a raised bog in the Czech Republic in a study of Lepidoptera assemblages (Spitzer et al. 1999, Spitzer & Danks 2006).

The principle components analysis revealed assemblages of beetles that were clearly separated by their habitat characterization. Swampy border sites, the wet slope and the almost dry dome hosted distinctive assemblages. The most important factor was probably the moisture regime. The number of species also depended on the distance from the edge of the peat bog. In total, 51 species (60.24%) were recorded in the slope habitats, 28 (33.73 %) in the habitat of the lagg zone, and 20 (24.09 %) in the habitats of the dome.

The primary ecological indicator of raised bog habitats on Yelnia is the complex of the tyrphobiontic species *A. ericeti* and the tyrphophilous species *P. diligens* and also *D. canaliculata*. Their numbers were high in all bog habitats. A second set of tyrphophilous species with high number are – *P. rhaeticus* – *C. clathratus* –*O. fuscatus*. Specialized inhabitants of peat bogs also include species, the numbers of which were rather small. These included: *C. nitens*, *D. cognatus*, *Bradycellus ruficollis*, *G. brevicornis*, *I. bergrothi*, *E. laeviusculus* Mannerheim, 1844, *A. arctica* (Thomson, 1856). *Carabus nitens*, *D. cognatus* and *B. ruficollis* were recorded mainly in the central part of the bog in the heather. *Euaesthetus laeviusculus* and *Atheta arctica* were not collected in pitfall traps. They were caught by hand searching in the *Sphagnum* carpet on hummocks, though not from the study sites but from other parts of the bog. Thus, these species are not included in the overall species list or analyses. Most of these species are established on bogs in the Baltic region and Central Europe (Mossakowski et al. 2003, Dapkus & Tamutis 2008, Spitzer et al. 1999, Heikal 1990). Another probably tyrphobiontic species is *A. arctica*, which was exclusively found from peat bogs in Belarus.

The peat bog Yelnia has important environments for the survival of boreal species, including cold-adapted beetles far from the north in more southern latitudes. These include species with Euro-Siberian ranges, such as *A. ericeti*, *P. diligens*, *E. laeviusculus*, *A. arctica*, *I. bergrothi* (Sushko 2014). Some hygrophilous species, such as *Philonthus cognatus*, *Staphylinus erythropterus*, *Stenus similis*, *Tachyporus hypnorum*, *Carabus cancellatus* and *Byrrhus pilula* were present in almost all habitats. However, their numbers were not high. High abundances were only recorded for *A. ericeti*, *P. diligens*, *P. rhaeticus* and *Drusila canaliculata*, and the abundances of these species changed only slightly over the season. This suggests that such peat bog species assemblages are stable and highly specialized.

In burned habitats, the sphagnum carpet and most bog shrubs were lost and the vegetation is replaced by a heather monoculture. This abrupt change in the habitat structure affects the assemblage of bog beetles. The species diversity in burned habitats was considerably lower than in the undisturbed habitats. The abundances of typical bog species which dominated the unburnt site (*P. diligens*, *P. rhaeticus*, *Ocypus fuscatus*) was significantly reduced. Of the bog specialist species, only *A. ericeti* was recorded from the burnt site. Its abundance remained high and females prevailed in these populations (Sushko 2006).

The previously recorded species *Pterostichus macer* (Marsham, 1802) (Sushko 2006) is more interesting. One exemplar was found in June in the lagg zone. In Belarus, *P. macer* is generally a xerophilous field species (Aleksandrovich 1991). However, one can also encounter this species on bogs in the Baltic region (Mossakowski et al. 2003). The species *C. clathratus* is more usual on the bog Yelnia as well as on other bogs of this region, in contrast to the Baltic States and Czech Republic (Mossakowski et al. 2003, Dapkus & Tamutis 2008, Spitzer et al. 1999, Heikal 1990). The carabid *Platynus mannerheimii* is known from the Zehlau bog (Kaliningrad region of Russia) (Mossakowski et al. 2003). According to my previous studies, this species is established only in forest bordering the bog, on mineral soil (Sushko 2006).

CONCLUSIONS

Thus, on the raised bog Yelnia (one of the largest in central Europe) a specific complex of species which strongly differs from the species assemblages of nearby mineral soils, was determined. All habitats are characterised by low species diversity and the dominance of only a few carabid and staphylinid species. Among these species, the primary peat bog specialist is *A. ericeti*. Moreover such rare unique peat bog species as *C. nitens*, *D. cognatus*, *B. ruficollis*, *G. brevicornis*, *I. bergrothi*, *E. laeviusculus* and *A. arctica*, were also recorded. It can be stated that Yelnia is a large European reserve with an assemblage of bog beetle species. Stable populations of these species are present at the site. It is necessary to keep hydrological conditions stable in bogs and adjacent territories. So it is necessary to strengthen the international conservation status of this territory and to pay attention not only to protection of rare birds and plants, but insects as well.

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Appendix

Composition of beetle assemblages of different habitats of the Yelnia peat bog

Species	***abbreviations used in ordination figure***	**Habitats**						
		BF	LZ	PB	HOL	HUM	D	BB
		relative abundance, %						
Cicindela campestris Linnaeus, 1758		0	0	0	0	0	0.35	0
Notiophilus palustris (Duftschmid, 1812)	***Not pal***	1.62	0	1.14	0	0	0	0
Carabus arvensis Herbst, 1784	***C arv***	7.03	0	0	0	0	0	0
C. cancellatus Illiger, 1798	***C can***	2.16	1.89	1.70	0	0.18	0	0.53
C. clathratus Linnaeus, 1761	***C clat***	0	3.77	0.57	2.87	1.28	0.71	0.18
C. glabratus Paykull, 1790		1.08	0	0.57	0	0	0	0
C. granulatus Linnaeus, I758		1.08	0.94	0.57	0.64	0.18	0	0
C. hortensis Linnaeus, 1758	***C hor***	1.62	1.89	0.57	0	0	0	0
C. menetriesi Hummel, 1827		0	0	0.57	0	0	0	0
C. nitens Linnaeus,1758		0	0	0	0	0.18	0.53	0
Cychrus caraboides (Linnaeus, 1758)	***Cych car***	1.62	0	2.27	0	0	0	0
Loricera pilicornis (Fabricius, 1775)		1.08	0	0	0	0	0	0
Dyschiriodes globosus Herbst, 1784		1.08	0.94	0	0	0	0	0
D. tristis (Stephens, 1827)		0	0	0	0.64	0	0	0
Asaphidion flavipes (Linnaeus, 1761)		1.62	0	0	0	0	0	0

Appendix (Continuation)

Poecilus cupreus (Linnaeus, 1758)		0	0	0.57	0.32	0.55	0	0
P. versicolor (Sturm, 1824)	***P ver***	0	2.83	0	0	0	0	0
Pterostichus diligens (Sturm, 1824)	***P dil***	0	8.49	5.68	4.78	2.38	2.13	2.64
P. niger (Schaller, 1783)	***P nig***	10.27	0.94	8.52	0.96	0	0	0
P. nigrita (Paykull, 1790)		1.08	0	0	0	0	0	0
P. oblongopunctatus (Fabricius, 1787)	***P ob***	14.06	0	0	0	0	0	0
P. rhaeticus Heer, 1838	***P rh***	0	6.60	1.70	10.83	2.93	3.53	0.35
Calathus melanocephalus (Linnaeus, 1758)	***Cal mel***	1.62	0	0	0	0	0	0
C. micropterus (Duftschmid, 1812)	***Cal mic***	18.40	0	0	0	0	0	0
Agonum ericeti (Panzer, 1809)	***Ag er***	0	20.75	48.30	68.47	62.16	71.51	94.90
A. sexpunctatum (Linnaeus, 1758)		0	0	0	0	0	0.18	0
Platynus assimilis (Paykull, 1790)		1.62	0	0.57	0	0	0	0
P. mannerheimii (Dejean, 1828)		0.54	0	0	0	0	0	0
Oxypselaphus obscurus (Herbst, 1784)		0	0	0.57	0	0	0	0
Amara brunnea (Gyllenhal, 1810)		0.54	0	0	0	0	0	0
A. communis (Panzer, 1797)		0.54	0	0.57	0	0.18	0	0
A. equestris (Duftschmid, 1812)		0.54	0	0	0	0.18	0	0
A. ovata (Fabricius, 1792)		0	0	0	0	0.18	0.35	0
A. plebeja (Gyllenhal, 1810)		0.54	0	0	0	0.18	0	0
Bradycellus ruficollis (Stephens, 1828)		0	0	0	0	0	0.35	
Dicheirotrichus cognatus (Gyllenhal, 1827)		0	0	0	0	0	0.35	0.18
Harpalus affinis (Schrank, 1781)		0	0.94	0	0	0	0	0
Ophonus rufibarbis (Fabricius, 1792)		0	0.94	0	0	0	0	0
Pseudoophonus rufipes (Degeer, 1774)	***Ps ruf***	1.62	0.94	0	0.32	0	0	0
Amphicyllis globus (Fabricius, 1792)		0	0	0	0	0.18	0.18	0
Agathidium atrum (Paykull, 1798)		0.54	0	0.57	0	0	0	0
A. laevigatum Erichson, 1845		0	0	0	0	0	0.18	0
Philonthus atratus (Gravenhorst, 1802)		0.54	0	0	0	0.18	0	0
Ph. cognatus Stephens, 1832		2.16	0.94	0	0.64	0.18	0.35	0
Ph. decorus (Gravenhorst, 1802)		0	0	0.57	0	0	0	0
Ph. furcifer Renkonen, 1937		0.54	0.94	0	0.32	0	0	0
Ph. laminatus (Creutzer, 1799)		1.08	0	0	0	0	0	0
Ph. marginatus (Strøm, 1768)		1.62	0	0	0	0	0	0
Ph. spinipes Sharp, 1867		2.16	0.94	0	0	0	0	0
Ph. varius (Gyllenhal, 1810)		0.54	0	0	0	0.18	0	0

Appendix (Continuation)

Platydracus fulvipes (Scopoli, 1763)		0.54	0	0	0	0	0	0
Staphylinus dimidiaticornis Gemminger, 1851		0.54	0.94	0	0	0.18	0	0
S. erythropterus Linnaeus, 1758	***S eryt***	0	0.94	2.27	0	0.18	0.18	0
Ocypus fuscatus (Gravenhorst, 1802)	***O fus***	1.62	6.60	3.41	1.27	1.83	0.35	0.35
O. nero (Faldermann, 1835)		0	0	0.57	0	0	0	0
Quedius molochinus (Gravenhorst, 1806)		0	1.89	0	0	0	0	0.53
Gyrohypnus atratus (Heer, 1839)		0.54	0	0	0	0.18	0	0
Xantholinus linearis (Olivier, 1795)		0	0	0	0	0.18	0	0
X. tricolor (Fabricius, 1787)		0.54	0	0	0.32	0	0	0
Lathrobium brunnipes (Fabricius, 1792)		0	0	0	0.32	0	0	0
L. volgense Hochhuth, 1851.		2.16	0	0	0	0	0	0
Ochthephilum fracticorne (Paykull, 1800)		0.54	0	0	0	0	0	0
Stenus biguttatus (Linnaeus, 1758)		0	0.94	0	0	0	0	0
S. similis (Herbst, 1784)		0	0	0.57	0	0.18	0	0
Omalium caesum Gravenhorst,1806		0.54	0.94	0	0	0	0	0
Acidota crenata (Fabricius, 1792)		0	0	0	0	0	0	0.18
Anotylus rugosus (Fabricius, 1775)		0.54	0	0	0	0.18	0	0
Ischnosoma bergrothi Hellen, 1925		0	0.94	0	0	0	0	0
I. splendidum (Gravenhorst, 1806)		0	1.89	1.14	0.64	0.37	0	0
Bolitobius inclinans (Gravenhorst, 1806)		0	0	0	0	0	0.35	0
Conosoma pedicularius (Gravenhorst, 1802)		0.54	0	0	0.32	0	0	0
C.testaceus (Fabricius,1792)		0	0.94	0	0	0	0	0
Tachyporus chrysomelinus (Linnaeus, 1758)		0	0	0	0	0.55	0.88	0
T. hypnorum (Fabricius, 1775)	***T hyp***	2.16	0	0.57	0	1.83	2.83	0
T. nitidulus (Fabricius, 1781)		0	0	0	0	0.18	0	0
Tachinus laticollis Gravenhorst, 1802		0	0	0	0	0.18	0	0
T. rufipes (Linnaeus, 1758)		0.54	0	0	0	0.73	0	0
Drusila canaliculata (Fabricius, 1787)	***Dr can***	7.27	27.36	9.66	5.10	20.84	13.09	0.18
Zyras collaris (Paykull, 1800)		0	0	0	0.64	0	0	0
Gymnusa brevicornis (Paykull, 1800)		0	0.94	0	0.32	0	0	0
Byrrhus pilula (Linnaeus, 1758)	***B pil***	0	0.94	0.57	0.32	1.10	1.59	0
Otiorhynchus scaber (Linnaeus, 1758)	***Ot sc***	1.62	0	0	0	0	0	0
Hylobius abietis (Linnaeus, 1758)	***Hyl ab***	0	0	5.68	0	0	0	0

Habitat symbols: forest bordering the bog (BF); lagg zone (LZ); pine forest (PB); hollow (HOL); hummock (HUM); dome (D); burned bog (BB). * relative abundance was more than 1.0% at least in one assemblage.

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