Macrolepidoptera in South-eastern Lithuanian raised bogs

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The research of nocturnal Macrolepidoptera was carried out in 5 south-eastern Lithuanian raised bogs in 2000. A total of 11683 Macrolepidoptera specimens belonging to 372 species have been registered. The biggest number of individuals and species was found in a successional bog (3578:212). Meanwhile, the abundance of specific bog species was lowest there (5.95%). The open bog contained the smallest number of stenotopic species (10), but their abundance was high (<50%). Natural and semi-natural pine bogs contained a specific complex of relict cold adapted Macrolepidoptera species. The comparison of species has revealed that the most similar compositions were within samples of each raised bog sites, and there were no marked differences in specific species composition between the edge and the central part of the same raised bog, nor between the dense part and the open part of the same bog. The abundance of tyrphobiontic species was similar within each bog site, while the abundance of tyrphophilous species varied. A positive correlation between the raised bogs' size and the abundance of stenotopic bog species was revealed.

Key words: Macrolepidoptera, raised bogs, tyrphobiontic and tyrphophilous species, Lithuania

INTRODUCTION

Peat bogs are very sensitive and endangered habitats in Europe. Their protection became very important nowadays, as many bogs were drained and became highly fragmented and isolated, or naturally got overgrown with forests. Many wetlands are only temporary features of the landscape and will be expected to change and eventually disappear [1]. Therefore many specific species of plants and animals living in unique isolated peat bogs became threatened as they do not occur in other habitats. Changes in the local environment of a peat bog can cause the extinction of local relict species [12].

The Lepidoptera species living in European peat bogs are known [3, 8–11], while there is few data on Lepidoptera communities living in peat bogs [2, 6, 7, 13]. The present study outlines the research of Macrolepidoptera communities in successional and natural raised bog habitats.

MATERIALS AND METHODS

Nocturnal Macrolepidoptera were investigated in 5 raised bogs in 2000 (Table 1, Fig. 1). The studies were carried out from April till November. Each site was visited once per month. Lepidoptera species were attracted into Jalas model automatic light traps, using 160 W blended lamp bulbs. Two traps were operated in homogeneous habitats at each research site. In most cases they were placed at a distance of 100 m and there was no direct visibility between them. Captured Lepidoptera specimens were identified till species level. Only species belonging to the superfamilies Cossoidea, Lasiocampoidea,

Table 1. **Raised bogs of South-eastern Lithuania studied in 2000**

Site	Co-ordinates	District	Area (ha)	Bog type
Baloša 1/ Baloša 2	$54^0$53' N, $25^0$48' E	Švenčionys	58	pine bog
Palios 1/ Palios 2	$54^0$35' N, $23^0$42' E	Prienai	120	open bog
Giedraitiškės 1/Giedraitiškės 2	$54^0$51' N, $25^0$10' E	Vilnius	66	pine bog
Pakamūnis 1/ Pakamūnis 2	$54^0$04' N, $24^0$24' E	Varėna	25	pine bog
Kazimieravas 1/Kazimieravas 2	$54^0$11' N, $25^0$00' E	Ukmergė	25/50	pine bog/recovered bog

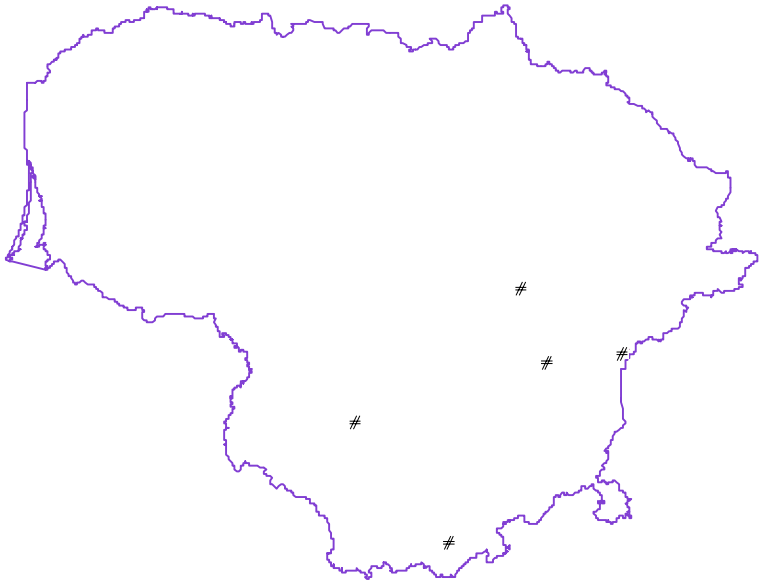

Fig. 1. Raised bogs of Lithuania studied in 2000

Bombycoidea, Drepanoidea, Geometroidea and Noctuoidea were used in the analysis. The nomenclature of Lepidoptera was used following O. Karsholt & J. Razowski [4]. Ecological terminology was that of K. Mikkola & K. Spitzer [9], K. Spitzer & J. Jaroš [11], K. Spitzer [12]: tyrphobiontic species are stenotopic and obligatorily associated with peat bogs, while tyrphophilous taxa are more abundant in bogs than in adjacent habitats. Tyrphoneutral species are eurytopic and have no association with peat bogs.

The Kruskal–Wallis non-parametric analysis of variance, with a-posteriori comparisons of mean ranks was used to test differences in the numbers of individuals in different raised bogs. The Spearman rank correlation was used to study the relationship between the abundance of stenotopic bog species in each community and the size of the bog. The similarity between each pair of sites has been counted using qualitative Soerensen's coefficient of similarity S_s [5]. Two sets of data have been analyzed: the whole species list and a set of specific species as accidental immigrants had an influence on the results. UPGMA method (unweighted pair-group method using arithmetic averages; [5]) was used to cluster the sites.

DESCRIPTION OF THE STUDY SITES

Baloša raised bog. A patch of untouched raised bog overgrown with wet pine forests of *Ledo–Pinetum* communities is left in the south-eastern part of the Baloša peatland. The first trap (Baloša 1) was in a dense pine bog with a thick layer of *Ledum palustre* shrubs, while the second (Baloša 2) was placed in a more open part of the same bog, with low and scarce *L. palustre* shrubs.

Palios raised bog. Only a fragment of a partly drained raised bog covered with *Ledo–Pinetum* communities remains in the north-eastern part of the peatland. The first trap (Palios 1) was operated in the part of the bog, overgrown with scarse pines and birches, while the second one (Palios 2) in the open part of the same bog, where hummocks were overgrown with *Eriophorum* sp., *Carex* spp. and dense *Calluna vulgaris* shrubs.

Giedraitiškės raised bog. One trap (Giedraitiškės 1) was operated at the edge of the bog overgrown with dense pines and thick *L. palustre* and *Vaccinium uliginosum* shrubs, while another (Giedraitiškės 2) was in the central part of the bog, covered with scarce low pines and a thick *Spagnum* spp. layer.

Pakamšis raised bog. The first trap (Pakamšis 1) was located at the edge of the dense pine bog overgrown with dense *L. palustre* and *V. uliginosum* shrubs, and the second one (Pakamšis 2) in the central, more open part of the bog.

Kazimieravas raised bog. One half of the raised bog is drained and clear-cut. One trap (Kazimieravas 1) was operated in the undisturbed raised bog overgrown with scarce low pines and *L. palustre* shrubs. The research was carried out at the edge of the bog (Kazimieravas 2) that recovered after clear-cut and overgrown with dense birches (up to 14 m high), scarce *L. palustre* and *Vaccinium myrtilus* shrubs, and a thick *Sphagnum* spp. layer. The trap was located at a distance of 130 m from Kazimieravas 1. A local gravel road and a spruce stand separated the sites.

RESULTS

A total of 11683 Macrolepidoptera specimens belonging to 372 species were registered in the investigated bogs. The number of species ranged from 103 (Palios 2) to 212 (Kazimieravas 2) (Fig. 2). The largest number of individuals was found in the community with the biggest number of species (Kazimieravas 2, 3578 ind.). The lowest number of specimens was observed in Giedraitiškės 2 (348 ind.). Some tyrphoneutral species were captured in

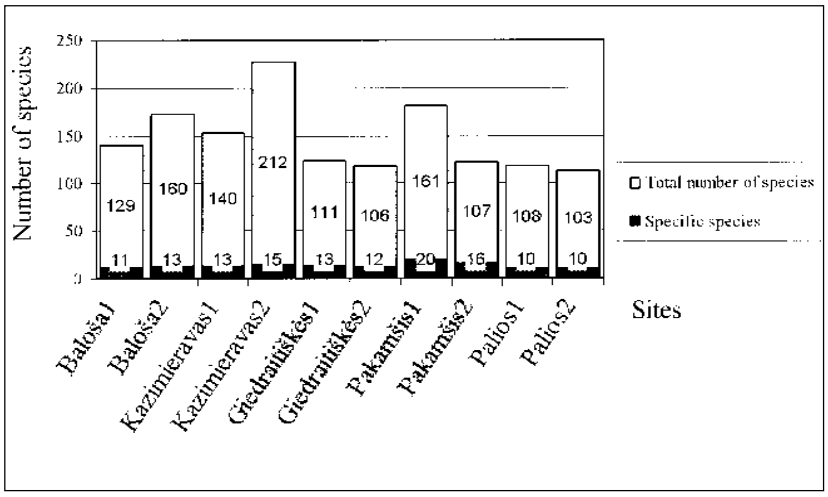

Fig. 2. Number of species registered in raised bogs studied in south-eastern Lithuania in 2000

huge numbers. *Eupithecia pussilata* was very abundant in Pakamšis 1 (835 ind.) and Pakamšis 2 (524 ind.), *Panolis flammea* in Pakamšis 1 (396 ind.), *Agrotis exclamationis* in Kazimieravas 1 (303 ind.) and Kazimieravas 2 (297 ind.), *Pelosia muscerda* (289 ind.) and *Hydrelia flammeolaria* (217) in Kazimieravas 1, while the largest part of species were immigrants from surrounding habitats and were presented as singletons and as doubletons. The Kruskal-Wallis ANOVA test showed some differences in the catches of individuals among the studied sites (H =

Table 2. **Distribution of tyrphobiontic and tyrphophilous species in south-eastern Lithuanian raised bogs in 2000. The abundance (%) of every species is presented**

Species/sites	Baloša 1	Baloša 2	Kazimieravas 1	Kazimieravas 2	Giedraitiškės 1	Giedraitiškės 2	Pakamšis 1	Pakamšis 2	Palios 1	Palios 2
Tyrphobiontic										
Amphipoea lucens	0.5	1.2	0	0.1	0.4	0	0.1	0.2	0	0
Acronicta menyanthidis	0.3	1.0	0.7	0.03	3.5	0.9	0.1	0.5	0	0
Celaena haworthii	0.3	0.7	0.8	0.1	0	0	0.4	1.0	0.9	0.8
Coenophila subrosea	0.1	0	0.1	0	0	0	0.1	0	0	0
Lithophane lamda	0.5	0.5	0	0	0	0	0	0	0	0
Lithomoia solidaginis	0.1	0	0.6	0.03	0.5	0.3	0.1	0	0.4	0.1
Chloroclysta infuscata	0	0	0	0.03	0	0	0	0	0	0
Carsia sororiata	0	0	0	0	0	0	0.2	0.4	0	0
Eupithecia gelidata	0	0.1	0.2	0	1.4	4.3	0.1	0	0	0
Tyrphophilous										
Arichanna melanaria	0.1	1.0	0	0.03	8.1	2.3	2.3	1.1	0	0
Jodis putata	0	0	0	0.7	0	0	0.1	0	0	0.1
Perconia strigillaria	0.3	0	0.1	0	0	0	0.2	0.3	1.3	0.4
Scopula ternata	0.4	0.1	2.4	2.5	11.6	6.9	2.7	1.5	0.2	0
Scopula virgulata	0	0	0	0	0	0	0.1	0	0.9	1.1
Thalera fimbrialis	0	0	0	0	0	0	0	0	9.6	17.3
Itame brunneata	0	0.2	0.8	1.8	12.1	2.0	2.0	1.4	0	0
Hypenodes humidalis	0	0	0.1	0.1	0	0.9	0.6	0.6	0	0
Lycophotia porphyrea	2.9	0.8	0.1	0	0.5	2.9	0.1	1.9	1.5	16.1
Papestra biren	0	0	0	0.03	0.1	4.9	0.3	1.5	0	0
Orthosia opima	0	0	1.2	0.3	0.3	0.6	0	0	0	0
Rhyparia purpurata	0	0.2	0	0	0	0	0	0	0.2	0.3
Coscinia cribraria	0	0	0	0	0	0	0	0.1	0.6	0.8
Nola aerugula	5.4	2.9	0.8	0.2	3.1	3.5	4.7	7.9	8.3	6.6
Total (%)	10.9	8.7	7.9	5.95	41.6	29.5	14.2	18.4	23.9	43.6

= 59.14, p = 0.000). The a-posteriori comparisons of mean ranks revealed that only Kazimieravas 2 was significantly different from other raised bogs (Z = 3.26, p < 0.05), while open bog sites and pine bog sites were grouped together. There were no significant differences among catches of individuals when only specific bog species were analysed (Kruskal–Wallis ANOVA, H = 5.79, p = 0.76).

The number of tyrphobiontic and tyrphophilous species varied from 10 (Palios 1 and Palios 2) to 17 (Pakamšis 1) (Fig. 2). Other sites contained from 11 to 15 specific bog species. Tyrphobiontic *Lithophane lamda* was found only in both Baloša sites, *Carsia sororiata* in the Pakamšis raised bog, while *Chloroclysta infuscata* only in the Kazimieravas 2 site. Tyrphophilous *Nola aerugula* was found in all studied bogs. *Thalera fimbrialis* was registered only in the Palios sites, while *Lycophotia porphyrea* was not present only in Kazimieravas 2. *Nola aerugula* was one of the dominant species in all studied bogs. This species made less than 1% of all individuals in the communities of Kazimieravas 1 and Kazimieravas 2 (Table 2), while its abundance was from 2.9 to 8.3% in other sites. Palios 2 was characterised by *Thalera fimbrialis* (17.3% of all specimens in the community) and *Lycophotia porphyrea* (16.1%), but these species were less abundant in Palios 1 (9.6% and 1.5%). Giedraitiškės 1 could be characterised by *Itame brunneata* (12.1%), *Scopula ternata* (11.6%), and *Arichanna melanaria* (8.1%), while these species were less abundant in Giedraitiškės 2 (2.0%, 6.9% and 2.3% each). The abundance of tyrphobiontic species was low in all studied raised bogs (Table 2). Only some species can be singled out: *Eupithecia gelidata* made 4.3% of all individuals in Giedraitiškės 2 (1.4% in Giedraitiškės 1), *Acronicta menyanthidis* 3.5% in Giedraitiškės 1 (0.9% in Giedraitiškės 2) and 1.0% in Baloša 2 (0.3% in Baloša 1), and *Amphipoea lucens* 1.2% in Balo□a 2 (0.5% in Baloša 1). The abundance of other tyrphobiontic species was up to 1% of all individuals in every community.

Total abundance of specific bog species differed in the studied sites and was less than 10% of all individuals in the community (Kazimieravas 1, Kazimieravas 2 and Baloša 2), up to 20% (Baloša 1, Pakamšis 1 and Pakamšis 2), less than 30% (Palios 1 and Giedraitiškės 2), and up to 50% (Giedraitiškės 1 and Palios 2). There was a significant positive correlation between the raised bog size and the total abundance of specific bog species in each community (Spearman r_s = 0.73, p < 0.05; the successional bog Kazimieravas 2 was not included in the analysis).

In spite of different habitats studied at each raised bog (the edge and the central part, or dense and open part of the same bog, see Description of the study sites), comparison of the whole set of species showed that the species compositions were most similar within each bog (Table 3). The highest similarity of Macrolepidoptera species was found between the communities of Kazimieravas 1 and Kazimieravas 2 (S_s = 0.65), Baloša 1 and Baloša 2 (0.64), Pakamšis 1 and Pakamšis 2 (0.64), Pakamšis 1 and Kazimieravas 2 (0.62). The lowest similarity was between the Macrolepidoptera communities of Palios 2 and Giedraitiškės 1 (0.29), Palios 2 and Kazimieravas 2 (0.32), Palios 2 and Pakamšis 1 (0.34), Palios

Table 3. **Soerensen's coefficient of similarity (S_s) between Macrolepidoptera communities in south-eastern Lithuanian raised bogs in 2000. The first number means S_s for the whole set of species and the second one for the specific bog species in each community**

	Baloša 1	Baloša 2	Kazimieravas 1	Kazimieravas 2	Giedraitiškės 1	Giedraitškės 2	Pakamšis 1	Pakamšis 2	Palios 1
Baloša 1	*								
Baloša 2	**0.64**/0.73	*							
Kazimieravas 1	0.52/0.70	0.52/0.61	*						
Kazimieravas 2	0.49/0.58	0.53/0.58	**0.65**/0.64	*					
Giedraitiškės 1	0.45/0.64	0.47/0.73	0.49/0.70	0.50/0.75	*				
Giedraitškės 2	0.39/0.55	0.49/0.64	0.47/0.78	0.49/0.75	0.53/**0.91**	*			
Pakamšis 1	0.48/0.71	0.54/0.64	0.59/0.76	**0.62**/0.73	0.51/0.71	0.49/0.71	*		
Pakamšis 2	0.41/0.67	0.47/0.67	0.49/0.64	0.47/0.69	0.46/0.67	0.44/0.67	**0.64**/**0.80**	*	
Palios 1	0.40/0.57	0.43/0.48	0.49/0.55	0.43/0.35	0.37/0.38	0.42/0.38	0.41/0.52	0.44/0.52	*
Palios 2	0.37/0.48	0.40/0.38	0.37/0.46	**0.32**/**0.34**	**0.29**/**0.29**	0.42/**0.29**	**0.34**/0.52	**0.34**/0.43	0.56/**0.90**

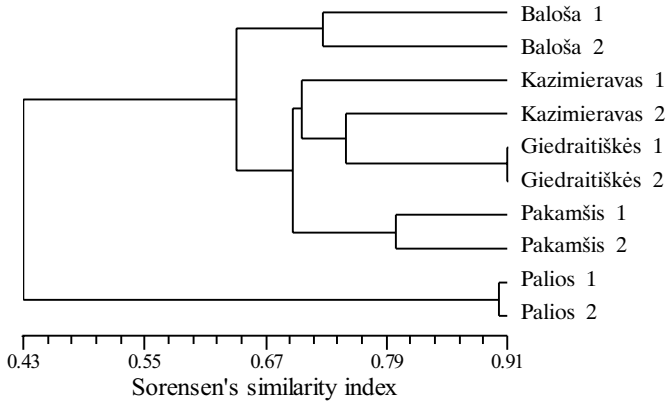

Fig. 3. Clustering of sites on the basis of specific bog species data

2 and Pakamšis 2 (0.34). Palios 1 and Palios 2 were most similar (S_s = 0.56). The site dendrogram (not presented in the article) based on the whole set of species revealed similar patterns: the samples taken from every site were most similar. Open bogs (Palios 1 and Palios 2) formed a different group, while other sites joined pine bogs.

Comparison of sites based on specific bog species showed that the most similar sites were Giedraitiškės 1 and Giedraitiškės 2 (S_s = 0.91), Palios 1 and Palios 2 (0.90), Pakamšis 1 and Pakamšis 2 (0.80), while the lowest similarity was observed between the communities of Palios 2 and Giedraitiškės 1 (0.29), Palios 2 and Pakamšis 1 (0.29), Palios 2 and Kazimieravas 2 (0.34). The similarity between Kazimieravas 1 and Kazimieravas 2 was 0.64, while Kazimieravas 1 was more similar to Giedraitiškės 2 (0.78), Pakamšis 1 (0.76) and Giedraitiškės 1 (0.70). Kazimieravas 2 was more similar to Giedraitiškės 1 and Giedraitiškės 2 (0.75), Pakamšis 1 (0.73) and Pakamšis 2 (0.69). The site dendrogram based on the specific bog species showed that open bogs (Palios 1 and Palios 2) formed a different cluster, and the pine bogs joined together (Fig. 3).

DISCUSSION

The results showed that the former raised bog (Kazimieravas 2) contained the biggest number of species and individuals. That was due to successional changes after the drainage of one half of the raised bog. The vegetation had changed, and birches began to dominate instead of cut pines. That led to an increase of tyrphoneutral species in the studied bog. Similar results have been obtained during a research of successional stages of bogs: climax bog pine forest was found to be less diverse than successional habitats and composed mostly of abundant tyrphophilous and tyrphoneutral Lepidoptera taxa [11]. Kazimieravas 2 contained 13 tyrphobiontic and tyrphophilous species, but their abundance was low. They could immigrate from the adjacent semi-natural part of the raised bog. Some very abundant species increased the number of individuals in Macrolepidoptera communities. These were tyrphoneutral and widespread in other habitats species (e.g. *E. pussilata*, *P. flammea*, *A. exclamationis*, etc.), so they were excluded during some analysis, and only the set of tyrphobiontic and tyrphophilous species was used.

The abundance of tyrphobiontic species was similar within each bog. Tyrphobionts formed strong populations which spread throughout the whole raised bog. Only *A. menyanthidis* was more abundant at the edge of the site Giedraitiškės 1 than in the more open part of the same bog (Giedraitiškės 2), but it was slightly more abundant in the open part of Pakamšis 2 than at the edge of Pakamšis 1. *C. infuscata* was found only in the successional bog Kazimieravas 2. This species is very rare in Lithuania, and it is necessary to obtain some additional data to explain its habitat preference. It was found in open and pine bogs in Lithuania [2]. In Czech Republic, it prefers climax pine bog forests [13]. *L. lamda* was only found in both Baloša sites. It is a typical bog species which is usually found after adult hibernation [3, 11]. This species was registered in the Baloša raised bog in early spring, but the obtained results gave no explanation of its habitat preference. Tyrphophilous species showed a greater variety in abundance within each site, especially *A. melanaria*, *S. ternata* and *I. brunneata*, which were more abundant in dense parts of raised bogs, where the foodplant of larva (*V. uliginosum*) grew. Besides bogs, coniferous forests are important habitats for these species [11]. *Jodis putata* seems to be a species of successional bogs; it was most abundant in Kazimieravas 2. It is usually seen during a daytime on the edges of intermediate bogs (Dapkus, unpubl.). Thus, the abundance of tyrphophilous species depends on habitat patches overgrown with particular foodplants.

The number of specific species decreases with a succession from an intermediate bog, *Calluna* peat bog to a subcontinental open bog, but drastically increases in coniferous peat bog [6]. The lowest number of stenotopic bog species was found in the open bog sites (Palios 1 and Palios 2); they markedly differed from those in pine bogs. Meanwhile, the abundance of specific species in both Palios sites was

high. It is known that the tyrphobiontic and tyrphophilous species are host-specific and most of them feed on the dominant species [10, 11]. The tyrphophilous species *T. fimbrialis* and *Coscinia cribraria* were found only in the Palios bog. In comparison with other bogs, *L. porphyrea, Perconia strigillaria* and *Scopula virgulata* were most abundant there. These species are trophically associated with *Calluna vulgaris* or *Carex* spp. After the drainage and excavation of the biggest part of the raised bog, these plant species began dominating in the remaining part of the bog.

A low number of species and individuals was found in the raised bogs Giedraitiškės and Pakamšis, but they maintained strong populations of stenotopic species (*E. gelidata, A. menyanthidis, S. ternata*, *Papestra biren, A. melanaria,* etc.), and the abundance of specialises was up to 50% in the communities. The presence and survival of the tyrphobiontic and tyrphophilous insect species was found to be good evidence of the long-term constancy of the peatland, and relict species are the best bioindicators of successional change or stability of peat bogs [12, 13].

The recent studies have revealed that samples taken from every bog were most similar to each other, and no differences among catches of individuals of stenotopic bog species have been found. It means that raised bogs maintain specific and stable Macrolepidoptera communities, which depend on characteristic micro- and mesoclimatic conditions and specific vegetation of bogs. In spite of the short distance between Kazimieravas 1 and Kazimieravas 2 (130 meters), marked differences in the number of individuals were found between the sites. Kazimieravas 1 is a semi-natural site, while successional changes greatly affected Kazimieravas 2, so the latter site has preserved more diverse Macrolepidoptera community with a low abundance of specific bog species. There were no great differences in species composition in the edge and the central part of the same raised bog. Neither dense nor more open parts of the same bog contained different species composition. A qualitative comparison of Macrolepidoptera communities shows no marked differences within each bog site. The open bog sites (Palios 1 and Palios 2) formed a different group, while other pine bogs were grouped together.

The bog size was revealed to affect the abundance of stenotopic species. Small raised bogs or their fragments maintain a higher percentage of tyrphoneutral species, as they easily immigrate into bogs from adjacent habitats. Small raised bogs are very sensitive to changes of hydrological regime and transform into forests quicker than big ones. Such successional changes lead to the extinction of specialis and an increase of generalis species.

ACKNOWLEDGEMENTS

The author thanks Dr. P. Ivinskis for reviewing the article and valuable comments.

Received
13 April 2001

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MAKRODRUGIAI PIETRYČIŲ LIETUVOS AUKŠTAPELKĖSE

S a n t r a u k a

Naktinių makrodrugių tyrimai atlikti 2000 m. 5 pietryčių Lietuvos aukštapelkėse. Tyrimų metu surinkti 11 683 individai, priklausantys 372 rūšims. Didžiausias individų ir rūšių skaičius surastas sukcesinėje pelkėje (3578:212), bet specifinių pelkių rūšių gausumas joje buvo mažiausias (5,95%). Atvirai plyninei pelkei buvo būdinga mažiausias pelkių rūšių skaičius [10], bet jų gausumas buvo gana didelis (< 50%). Nustatyta, kad natūralios ir pusiau natūralios aukštapelkės yra išlaikiusios būdingą pelkių rūšių kompleksą. Rūšių palyginimas parodė, kad yra panašiausios imtys iš tos pačios aukštapelkės. Nebuvo nustatyta ryškių skirtumų tarp pelkių rūšių sudėties tankiame aukštapelkės pakraštyje ir atviresnėje centrinėje pelkės dalyje. Remiantis gautais rezultatais nustatyta teigiama koreliacija tarp pelkės dydžio ir specifinių pelkių rūšių.

Raktažodžiai: Macrolepidoptera, tirfobiontai, tirfofilai, Lietuva