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FAUNA AND STRUCTURE OF BAT (CHIROPTERA) ASSEMBLAGE OF THE NATIONAL PARK 'SMOLENSK LAKELAND', WESTERN RUSSIA

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Abstract. The data presented in this paper is a result of inventory of bat fauna and structure of assemblage in the National Park 'Smolensk Lakeland', Smolensk region, Russia. A total of 318 bats of eight species (*Myotis brandtii, M. mystacinus, M. daubentonii*, *Nyctalus noctula*, *N. leisleri*, *Pipistrellus nathusii, Vespertilio murinus* and *Plecotus auritus*) were captured in mist nets in June and July 2010. Six species were new for the territory of the National Park. *N. noctula* was a dominant, *P. nathusii* and *V. murinus* were subdominant species, other five species were rare. Among adult individuals, females were predominant. Sex ratio among subadults of dominant and subdominant bat species was equal. Six species were breeding within the territory. A comparison of our results with the data from regions adjacent to Smolensk (Bryansk, Tver, Moscow, Vitebsk) is discussed.
Key words: bats, inventory, species composition, relative abundance, National Park 'Smolensk Lakeland', Russia

Introduction

Information on the composition of bat fauna and species relative abundance in many regions of Russia is either fragmentary or still unknown (Ilyin *et al*. 2002; Ilyin 2003). Smolensk region is one of the areas where bat researches were conducted only at the beginning of the 20th century. Earlier papers by Ognev (1913, 1928) were a first attempt to systematize data on bat fauna from different uyezds (districts) of former Smolensk province (generally, central and eastern uyezds). He found nine bat species in the territory: *Myotis daubentonii*, *M. dasycneme*, *M. mystacinus* spp., *Nyctalus leisleri*, *N. noctula*, *Pipistrellus nathusii, P. pipistrellus*, *Eptesicus nilssonii*, *Plecotus auritus*. Twelve bat species are included to the Red Data Book of Smolensk region, but these data concern old records made by Ognev (1913, 1928) and Kuzyakin (1950). For this reason, we do not use the data of the Red Data Book of Smolensk region (Kruglov *et al*. 1997) for comparison with our data. In the Atlas of Bat Distribution of Russia (Ilyin *et al*. 2002) all records of bats in Smolensk region are also based on information from the beginning and middle of the 20th century (Ognev 1913; Kuzyakin 1950).

The National Park 'Smolensk Lakeland' was established for the conservation of weakly transformed natural forest territories. Bats have never been an object of special investigations in the territory of the National Park. In the list of animals and plants of the National Park (Kruglov *et al*. 1995) only two species of bats were mentioned, namely *N. noctula* and *P. auritus*. At the same time, the territory of the National Park could be estimated as a key area for bats in forests according to Resolution 4.4 of Eurobats (2003) and Boye and Dietz (2005).

Further development of special protection of this territory and working out conservation management plans should take into account bat populations, which could not be implemented without primary inventory of these animals.

The aim of the present study was to take an inventory of bat fauna in the territory of the National Park 'Smolensk Lakeland' to study species composition and structure of bat assemblage and clarify their breeding status.

Material and methods

Study area

The National Park 'Smolensk Lakeland' is situated in the north of Smolensk region and lies within the forest nature zone. It was founded in 1992 in a rather large

area of 146,237 ha. The main types of ecosystems which are significant for conservation of biodiversity are the following:
- unique system of lakes (n = 35) and rivers of different origin;
- bog and flood meadows of local streams with rare species of orchids;
- large complex of long sandy ridges and flat rises left by glaciers;
- mossy wetlands formed 9000–11000 years ago (two of them are considered among the biggest ones in the region);
- old-growth coniferous, spruce and broad-leaved forests with particular composition of flora and fauna.

Forests cover 74% of park territory. The main habitats are spruce (*Picea abies*) and aspen (*Populus tremula*) forests, in some places – mixed forests with birch (*Betula pendula*), pine (*Pinus sylvestris*), oak (*Quercus robur*) and alder (*Alnus glutinosa*). They are about 140–250 years old on average, because during long periods of the 18th–20th centuries some species of trees were important for local timber industry and were cut in great numbers. But there are small areas difficult to access, where 400-year-old trees still grow.

The climate is moderately continental with warm and humid summers and moderately cold winters with persistent snow cover and well expressed transitional periods. The average yearly temperature varies between 4.1–4.3°C. The average monthly temperature varies from -8.3°C in January to +17.0°C in July. The absolute minimum is -45°C and absolute maximum +34–35°C. The period of plant vegetation continues about 180 days. This territory is characterised by the maximum mean annual atmospheric precipitation within the Smolensk region – more than 700 mm, with minimum in February (40–43 mm) and maximum in July (96–97 mm).

A preliminary survey of the territory was conducted on 1–6 June 2010, and the main part of the research, inventory of bat fauna, was done on 15–28 July 2010.

Bats were caught using nylon mist nets (length 12 × 3 m, mesh size 15 mm).

The inventory of bat fauna and structure of assemblage was realized according to the previously developed scheme applied in Ukraine (Gukasova & Vlaschenko 2010). The inventory was conducted in one of the typical forest habitats of the territory, in the surroundings of Lakes Loshamie and Old Bottom. Mist nets were installed in nine main sites (Table 1). The distance between capture sites was different (600 m on average, max distance between sites was 3355 m) and all sites covered the area of about 400 ha. Capture sites were in the following types of habitats: lake shores, forest edges and forest (Fig. 1).

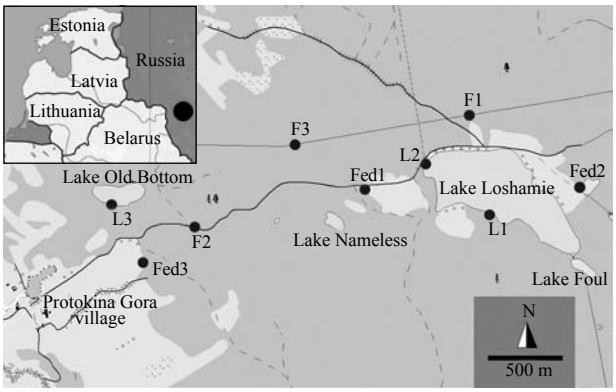

Figure 1. Sites of inventory in the surroundings of Lakes Loshamie and Old Bottom, July 2010 (L1-3 – lake shores, Fed1-3 – forest edges, F1-3 – forest roads or opening).

Two rounds of mist-netting were conducted at each capture site (two nights at every site). Every time mist nets were put exactly in the same places. Bats were usually mist-netted from sunset till 10–30 min before sunrise. Each night one mist net was set up in several sites concurrently.

Besides nine main capture sites at Lake Loshamie, four additional sites (in the surroundings of Lake Loshamie and in other parts of the National Park) were selected (Table 1).

In June, seven nights of capture were spent with the total duration of mist-netting of 30.5 hours (time from the moment when first bats appeared in the air till taking mist net down) and three bats were caught. During the inventory period at Lake Loshamie, 18 nights with 117.5 hours were spent and 241 bats of eight species were caught. Six additional capture-nights at the same sites as in June and at Lakes Foul and Nameless (25.5 hours, 74 individuals) were spent in July. Altogether, 31 capture-nights at 18 capture sites were mist-netted in the area and the total duration of mist-netting was 173.5 hours.

Bats were kept in textile bags near the net throughout the night. We recorded species, sex and age and identified breeding status of adult individuals of both sexes. The main features in identifying bat age were: ossification degree of joints of finger phalanx of the wing (the presence of cartilage at sight check), size and shape of nipples for females. We took into consideration the degree of grind of the canine teeth among medium and big size bat species.

All animals after biometrical process were released as soon as possible. All measures related to bat capturing, holding and carrying in bags were ethical, respectful for animal welfare and conservation of protected species, according to Gannon (2007).

We used the species relative abundance parameter

(Strelkov & Ilyin 1990) and general average of bats per hour (b/h) index to assess bat species abundance in the studied territory and capture success. We used Pearson's Chi-square test (χ^2) for comparison between received sex ratio of bats and expected 1:1 ratio (for species with the number of individuals more than 10).

Results and discussion

Species composition

Eight bat species were captured in the National Park 'Smolensk Lakeland' during the inventory: *M. brandtii*, *M. mystacinus*, *M. daubentonii*, *N. noctula*, *N. leisleri*, *P. nathusii*, *V. murinus* and *Pl. auritus* (Table 2). One species (*M. dasycneme*) was identified with an ultrasound detector. We recorded this species twice at the Lakes Baklanovskoe (3 June 2010) and the Nameless (28 July 2010) (Table 1). Seven out of nine recorded bat species are new for the territory of the National Park 'Smolensk Lakeland'.

Considering peculiarities of our scheme of bats capture, it is difficult to compare our results with literature data because papers about results of mist-netting of bats in such small territories in Russia are very scanty. But we tried to compare our results with data (obtained by mist nets and mobile traps at bat hunting areas) from regions adjacent to Smolensk (Table 2).

The northern part of Smolensk region was a 'white spot' in bat research till nowadays. For adjacent western Vitebsk region (Belarus), eight bat species are known (Kurskov 1981). In Tver region, which is north of the National Park 'Smolensk Lakeland', nine bat species were recorded (Glushkova & Fedutin 2002). There is no general review of bat fauna of Moscow region, and we used data of the Prioksko-Terrasny Nature Reserve (south of the region) (Albov *et al*. 2009). 14 bat species are known for adjacent southern Bryansk region (Sitnikova *et al*. 2009).

At the territory of the National Park 'Smolensk Lakeland' *P. pipistrellus/pygmaeus* was not recorded in 2010. It stays unknown unless this species was captured by chance and was connected with our small study site, or this species is really rather rare in the north of Smolensk region. In the south (Bryansk region) and south-east (Moscow region) it is a common and even mass species. In Vitebsk region, only two records of this species are known. It was mentioned that *P. pipistrellus* s. l. was rarer in the territory of Vitebsk and Mogilev regions than in the western part of Belarus. This species was not found in Tver region. *P. pipistrellus* s. l. is considered to be the rarest bat species in the areas further north than 57–58ºN (Bogdarina & Strelkov 2003); only two records are known from that region. Hence, this species is really rare and has a sporadic distribution in the north of Smolensk region.

Our finding of *N. leisleri* is the most northwestern point of its distribution in Russia (Ilyin *et al*. 2002) (apart from old records by Ognev 1913). This species has never been found further to the west from Vitebsk region. In general, only one record of *N. leisleri* north from Minsk latitude (in the territory of Belarus) is known.

Bats of genus *Eptesicus* were not caught in Smolensk region, but were recorded in Bryansk and Tver regions. In the two latter regions, no records of *E. serotinus* have been made until recently (Ilyin *et al*. 2002). At the same time, it is known that this species spread its distribution to the north. It was firstly recorded in Bryansk region in 2003, and several years later its northern border of range moved on for 100–150 km. This species was also earlier found to the west from the National Park 'Smolensk Lakeland', in Vitebsk region. At the present moment, this species is increasing in numbers in the southeastern part of Belarus (Savarin 2008). This species can possibly be found in southern parts of Smolensk region or will be mentioned there soon. Taking into consideration that our study site in the National Park 'Smolensk Lakeland' was situated far away from any large human settlements, a probability of capture of this species was rather low. At the same time, another species of this genus, *E. nilssonii*, was earlier recorded in the territory of Smolensk region (Ognev 1913; Ilyin *et al*. 2002) and could well inhabit the territory of the National Park 'Smolensk Lakeland'. This species is rather common in the north of Pskov (Chistyakov 2000, 2002) and Tver regions and in the areas further north than 57–58ºN (Bogdarina & Strelkov 2003). At the same time in the south and south-east of Bryansk and Moscow regions, only single findings are known (Ilyin *et al*. 2002). Peculiarities of distribution of *E. nilssonii* through the territory of the National Park 'Smolensk Lakeland' need further studies.

In spite of old mentions about *M. mystacinus* s. l. in Smolensk region by Ognev (1913), factual records of *M. mystacinus* and *M. brandtii* in this region were unknown (Strelkov 1983; Ilyin *et al*. 2002). Our findings of *M. mystacinus* and *M. brandtii* could be considered the first reliable records of these species in the region. *M. mystacinus* is rather rare in the western part of Russia in contrast to a similar species *M. brandtii.*

Relative abundance

N. noctula represents half of all captured bats (n = 318) at the territory of the National Park 'Smolensk Lakeland' (Fig. 2), *P. nathusii* and *V. murinus* were subdominant species and other five species were rare. Such structure of relative abundance with dominant forest dwelling species (*N. noctula* and *P. nathusii*) reflects natural conditions of the study area. At the same time, it is

Table 1. Characteristics of all capture sites and results of capture in the National Park 'Smolensk Lakeland', 2010.

Name and coordinates	Characteristics	Capture date	Number of individuals and bat species
'Ancient settlement' (Fed1)*	Forest edge near the forest road outgoing to a	15–16,	–
55˚30'33N, 31˚58'25E	big glade	23–24 July 2010	–
'North edge' (Fed2)*	Forest edge at northern Lake Loshamie shore,	20–21,	1 Pn
55˚30'14 N, 31˚56'54E	about 300 m from water	26–27 July 2010	1 Vm
Protokina Gora (Fed3)*	Forest edge with high grass and bush, 200 m	21–22,	–
55˚30'34N, 31˚59'54E	south from the forest road	27–28 July 2010	1Vm
'LEP1'(F1)*	Clearing of high-voltage aerial line channel	17–18,	1 Pn, 3Vm
55˚30'49N, 31˚59'5E	(20 m in width) across the spruce-aspen forest overgrown with bush shoots	26–27 July 2010	1 Mb, 11 Nn, 1 Pn, 17 Vm
'Stream' (F2)*	Forest glade with desiccated stream, forest road	19–20,	1 Vm
55˚30'26N, 31˚57'29E	cross the glade	24–25 July 2010	–
'LEP2' (F3)*	Clearing of high-voltage aerial line channel	21–22,	2 Vm
55˚30'42N, 31˚47'49E	(20 m in width) across the spruce-aspen forest overgrown with bush shoots	27–28 July 2010	–
'Loshamie1' (L1)*	Small glade at the southern shore of Lake	16–17,	1 Md, 15 Nn 6 Pn, 4 Vm, 1 Pa
55˚30'25N, 31˚59'16E	Loshamie	20–21,	1NI, 18 Nn, 5 Pn 4 Vm
		28–29 July 2010	1 Vm
'Loshamie2' (L2)*	Western shore of Lake Loshamie, forest close to	17–18,	1 Mm, 5 Pn, 7 Vm
55˚30'40N, 31˚58'52E	the water	23–24 July 2010	–
'Lake Old Bottom'(L3)	Southern shore of the lake with birch and pine,	19–20,	3 Md, 23 Nn, 44 Pn
*55˚30'28N, 31˚56'43E	forest close to the water	24–25 July 2010	1 Md, 1 NI, 36 Nn, 21 Pn, 2 Vm, 2 Pa
Lake Nameless	Small lake surrounded by pine-spruce forest and	31 July –	3 NI, 47 Nn, 2 Pn,
55˚30'26N, 31˚58'13E	peat moss bog, in the west from the Loshamie	1 August 2010	6 Vm
Lake Foul	Small separate part of Lake Loshamie in the east,	31 July –	8 Nn, 1 Vm
55˚30'15N, 31˚59'47E	with peat moss bog banks surrounded by forest	1 August 2010	
Lake Baklanovskoe	Open sand shore of the lake	2–3 June –	1 Pn
55˚29'30N, 31˚39'8E		14–15 July 2010	1 Md, 5 Vm
Vasilievka 55˚29'33N,	Open plot of a small Vasilievka River with a	5–6 June 2010	1 Md, 1 Nn
31˚55'29E	wooden bridge over it. Scrub on the banks		

* – the main sites of inventory; Md – *Myotis daubentonii*, Mm – *M. mystacinus*, Mb – *M. brandtii*, Nl – *Nyctalus leisleri*, Nn – *N. noctula*, Pn – *Pipistrellus nathusii*, Vm – *Vespertilio murinus*, Pa – *Plecotus auritus*

Table 2. List of bat species caught in 'Smolensk Lakeland' and adjacent regions.

Species	'Smolensk Lakeland'	Bryansk region	Tver region	South part of Moscow region	Vitebsk region (Belarus)
M. brandtii	+	+	+	+	
M. mystacinus	+		+		+
M. dasycneme		+	+	+	+
M. daubentonii	+	+	+	+	+
M. nattereri		+		+	
N. leisleri	+	+		+	
N. noctula	+	+	+	+	+
N. lasiopterus		+			
E. serotinus		+			+
E. nilssonii		+	+		
P. nathusii	+	+	+	+	
P. pygmaeus		+		+	
P. pipistrellus s. l.					+
P. kuhlii		+			
V. murinus	+	+	+	+	+
Pl. auritus	+	+	+	+	+
References	Our data	Sitnikova *et al*. 2009	Glushkova & Fedutin 2002	Albov *et al*. 2009	Kurskov 1981

unknown why the part of over-water hunting species (*M. daubentonii*) was so small, though the inventory was realized around water bodies.

Therefore, we could only discuss which bat species were dominant in the mist-netting captures in adjacent regions during summer period. In Bryansk region (n =

226) the dominant species were *P. pygmaeus*, *P. nathusii*, *V. murinus*, *N. noctula*, *E. serotinus* and *M. daubentonii*; they had approximately similar parts – 4–5% (Sitnikova *et al*. 2009).

In the south of Moscow region (n = 114) *P. nathusii* (44%) was a dominant species, and *M. daubentonii*, *M brandtii* and *M. dasycneme* (more than 10%) were subdominant. *N. noctula* constituted only 4% and *V. murinus* 1.7% (Albov *et al*. 2009). In Tver region (n = 142) *P. nathusii* (29.5%) was the dominant species, *M. brandtii* and *V. murinus* were subdominant, *N. noctula* and *E. nilssonii* represented only 10% (Glushkova & Fedutin 2002).

Thus, *N. noctula* was not a dominant species in areas adjacent to Smolensk region. Our data possibly reflect local peculiarities of bat population in the surroundings of Lake Loshamie. A considerable part of *P. nathusii* and *V. murinus* could be supposed as a typical peculiarity of bat population in wide areas of boreal Russian forests.

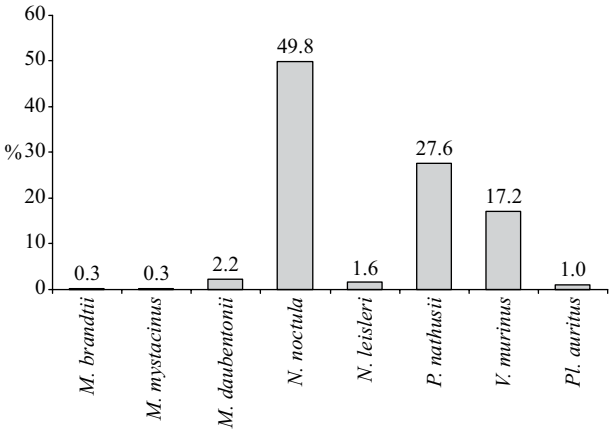

Figure 2. Relative abundance of eight bat species captured with mist nets in the National Park 'Smolensk Lakeland' (n = 318).

Sex ratio and breeding status

The part of adult females of *P. nathusii* caught in the National Park 'Smolensk Lakeland' was 68.6% (Table 3). Data from northern regions are contradictory. In Tver region adult males were absent from captures. In Pskov and Leningrad regions sex ratio among adult bats (n = 17) was 1:1 (Chistyakov 2001). To the south, in Bryansk region, the part of adult females was 86.5% (n = 37). In Moscow region adult males were captured sporadically. The part of adult females of *N. noctula* in our captures was 92.5% (Table 3). Material on this species for comparison between Smolensk and adjacent regions is absent. Among adult *V. murinus,* the part of females was 72% in our captures (Table 3). In Tver region (n = 20) the percentage of females was 80%, and it is similar to our findings. In the south of Bryansk region only adult females were captured (n = 8). Obviously, we do not have enough data for full comparison or explanation of differences in sex ratio among adult bats of these three species.

The most complete review of sex ratio among migrant bat species was presented by Strelkov (1999). He noticed that this parameter is variable among adult bats in wide areas of the former USSR and this question needs further investigations. Strelkov (1999) showed that the method of capture can affect the value of this parameter. We confirmed it by our research (Vlaschenko & Gukasova 2009). Thus, we should compare only the samples received by identical methods of capture, for example, animals captured using mist nets. But there is a lack of sufficient number of samples of bats captured with mist nets in the western part of Russia.

Two adult males of *N. leisleri* were captured in the surroundings of Lake Loshamie. In the south, in the forest-steppe nature zone, adult males of this species have never been found (Strelkov & Ilyin 1990; Vlaschenko 2009). At the same time, isolated findings of adult males of this species are known from the south of Moscow region (Likhachev 1980) and in the north of Ukraine (southern border of the forest nature zone) (Gaschak & Vlaschenko, unpubl.). Strelkov (1999)

Table 3. Number and breeding status of captured bat species (n) in the National Park 'Smolensk Lakeland' presented in sex and age categories.

Species	Adult females	Adult males	Subadult females	Subadult males	Total	Breeding status
M. daubentonii	2	–	1	4	7	breed
M. brandtii	1	–	–	–	1	?
M. mystacinus	–	1	–	–	1	?
N. leisleri	1	2	2	–	5	breed
N. noctula	50	4	53*	51*	159†	breed
P. nathusii	24	11	23*	29*	87	breed
V. murinus	26	10	11*	8*	55	breed
Pl. auritus	2	–	1	–	3	breed
Total	106	28	91	92	318	

* – groups which do not statistically significantly differ from 1:1 ratio (χ^2-test); † – one bat escaped from the bag before measuring

noticed that for migrant species the part of adult males is higher closer to hibernation places, and other authors mentioned same for sedentary species of bats (Snit'ko 2007). Hence, the greatest numbers of adult males of *N. leisleri* in the north, in the forest zone, and their scarcity in the south could be explained by two migration routes of this species. Bats, which hibernate in the Caucasus and in the Black Sea region, migrate to the north and in the breeding part of its range they are represented only by adult females. Another part of the population migrates from Central Europe to Russia and to the north of Ukraine. Using exactly this way of migration, adult males of *N. leisleri* spread through the forest zone. Two similar migration routes are also known for *N. noctula* (Hutterer *et al*. 2005).

Sex ratio among subadult bats does not statistically significantly differ from 1:1 ratio, which is typical of bats (Strelkov 1999; Rakhmatulina 2000). According to our findings (Table 2), six bat species breed in the National Park 'Smolensk Lakeland'. For *N. leisleri*, *N. noctula*, *P. nathusii* and *V. murinus,* all sex-age groups were found. These species also breed in adjacent Belarus, Bryansk, Tver, Moscow and Pskov regions. The reproductive status of *M. brandtii* stays unknown in the territory of the National Park 'Smolensk Lakeland'; it could possibly breed there too, because there are known findings of subadult bats in adjacent Bryansk, Tver and Moscow regions. It is difficult to evaluate the status of *M. mystacinus*; it is possible that this species does not breed in the region. In Tver region only one bat (adult male) was captured, the same as in the National Park 'Smolensk Lakeland'.

Results of inventory and bats/hour index

Our scheme of bat fauna inventory was previously successfully tested at two forest territories in Ukraine and then implemented in the territory of the National Park 'Smolensk Lakeland'. The base for further use of this scheme was its implementation in the National Nature Park 'Gomolshanski lessy', where all ten species known for that territory were caught. All expected bat species were caught, reaching 430–450 bat specimens in the territory (Vlaschenko & Gukasova 2009). In our study site (Lake Loshamie) 241 bats of eight species, with the rarest species (*M. brandtii*, *M. mystacinus* and *Pl. auritus*) among them, were captured during the inventory. In additional sites, only common species were captured, and results of the inventory were confirmed. Such characteristic of relative abundance of bats was 2.17 bats/hour for the surroundings of Lake Loshamie, whereas b/h index for forest-steppe oak forests of Ukraine was 3.98 and 6.08 (Vlaschenko & Gukasova 2010). From b/h index value for Lake Loshamie it is not difficult to calculate that in order to achieve 430 bats in this territory we should spend minimum 90 additional hours of mist-netting. We could not realize one more inventory round of capture in summer 2010.

A lower value of b/h index in the conditions of boreal forests of Smolensk region, in comparison to oak forests of Ukraine, demonstrates a decrease of general abundance of bats from south to north.

We could conclude that the inventory was successfully realized in the conditions of northern boreal forests. The findings of rare bat species and a great number of common species of all age-sex groups in captures prove this. The received samples of bats make it possible to reliably estimate sex ratio of mass species and subsequently compare with data from other regions.

The key advantage of the used scheme of inventory is continuity and a possibility of repeated inventory in 3–5 years in the same study sites. A repeated analysis of bat fauna and population conditions in a little while could become a bat population monitoring of full value in the National Park 'Smolensk Lakeland'. This is also an advantage of the proposed scheme of bat fauna inventory in comparison to mist-netting at random sites.

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Šikšnosparnių (Chiroptera) fauna ir bendrijos sudėtis nacionaliniame parke „Smolensko ežerynas", vakarų Rusija

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Santrauka

Straipsnyje pateikiami šikšnosparnių apskaitos ir jų bendrijos sudėties nacionaliniame parke „Smolensko ežerynas" (Smolensko sritis) duomenys. 2010 m. birželio ir liepos mėnesiais voratinkliniais tinklais buvo sugauta 318 šikšnosparnių, priklausančių 8 rūšims (*Myotis brandtii*, *M. mystacinus*, *M. daubentonii*, *Nyctalus noctula*, *N. leisleri*, *Pipistrellus nathusii*, *Vespertilio murinus* ir *Plecotus auritus*). Šešios rūšys nacionalinio parko teritorijoje užregistruotos pirmą kartą. *N. noctula* buvo dominuojanti rūšis, *P. nathusii* ir *V. murinus* subdominuojančios, o likusios penkios retos. Tarp suaugusių individų dominavo patelės. Dominuojančių ir subdominuojančių lytiškai nesubrendusių patelių ir patinų skaičius buvo vienodas. Nacionaliniame parke veisėsi šešios šikšnosparnių rūšys. Apskaitos rezultatai palyginti su duomenimis, gautais iš kaimyninių Smolensko sričių – Briansko, Tverės, Maskvos ir Vitebsko.

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