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Structure of summer bat assemblages in forests in European Russia

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Abstract: We used mist-netting to study summer bat assemblages in 3 state nature biosphere reserves in the European part of Russia from 26 June to 29 July 2013: Oksky, Ryazan region (54°44′N, 40°54′E); Voronezhsky, Voronezh region (51°55′N, 39°38′E); and "Bryansky Les", Bryansk region (52°27′N, 33°53′E). The main research efforts were in locations where *Nyctalus lasiopterus* had been captured in the past. In total, 1229 specimens of 12 bat species (*Myotis daubentonii*, *M. dasycneme*, *M. brandtii*, *M. mystacinus*, *Nyctalus noctula*, *N. lasiopterus*, *N. leisleri*, *Eptesicus serotinus*, *Pipistrellus nathusii*, *P. pygmaeus*, *Vespertilio murinus*, and *Plecotus auritus*) were caught. *N. lasiopterus* (a female subadult) was confirmed only in the Voronezhsky Reserve. The bat assemblages could be classified as forest-dwelling and dominated by long-distance migratory species (genera *Nyctalus*, *Pipistrellus*, and *Vespertilio*). Females also dominated and breeding was recorded for most of the species. The highest bat abundance (b/h index: 4.54) was in the Voronezhsky Reserve (the most southeasterly location) and the lowest (b/h index: 1.75) was in "Bryansky Les" (the most southwesterly location). The Shannon–Wiener index was higher in the Voronezhsky and Oksky Reserves but the evenness index was similar for all reserves. Bat assemblage structure in strictly protected forest areas (such as the Voronezhsky Reserve) has been stable for decades.

Key words: Bats, Chiroptera, summer assemblage, relative abundance, sex ratio, *Nyctalus lasiopterus*, *Myotis mystacinus*, European Russia, forest reserves

1. Introduction

Currently there is a lack of available information about bat distribution in the east of Europe. Most information is in Russian and often in journals not widely available internationally (e.g., Strelkov and Il'in, 1990; Il'in et al., 2002; Gashchak et al., 2013). Such an information gap results in a misconception by Western Europe researchers about the distribution, species richness, and status of bats in the "vast expanses of Russia". The most typical example of an inaccurate distribution map is with the range of *Nyctalus lasiopterus* (Schreber, 1780) in the reviews of European bats published by Dietz et al. (2009) and Battersby (2010). Thus, the European range of the species in Ukraine, Russia, and southeastern Belarus is presented as continuous, whereas the range in the west is presented as patchy and based on real occurrence. One reason for inaccurate bat distribution maps is the lack of current data, but there is also an incorrect view that Russia is continuously covered by natural woodlands, marshes, and meadows, leading to the assumption that the rarest forest-dwelling European bat species (e.g., *N. lasiopterus*) have wide distributions.

In this paper we present the results of a study of the current status of *N. lasiopterus* in European Russia, focusing on those localities where the species was previously recorded. We used a mist-netting protocol based on that previously used by Vlaschenko and Gukasova (2009, 2010), Gukasova and Vlaschenko (2011), Gukasova et al. (2011), and Prylutska (2014) to assess species presence in 3 forest biosphere reserves (Voronezhsky, "Bryansky Les", and Oksky) in the European part of Russia. Applying the same data collection protocol (working team, time of survey, research duration, etc.) allowed us to compile comprehensive information about the species present, their relative abundance and status, population structure, etc.

All 3 reserves have the same conservation status as strictly protected areas and are included in the international network of biosphere reserves. Oksky and Voronezhsky are among the oldest reserves in the former Soviet Union and

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have been protected for more than 80 years, but "Bryansky Les" is less than 30 years old. Bat studies were carried out in "Bryansky Les" only in the last decade (Sitnikova et al., 2009), whereas in the Oksky Reserve the main bat studies were undertaken at the end of the 1980s (Ivancheva and Ivanchev, 2000). The Voronezhsky Reserve was the main area for the study of the ecology of forest-dwelling species and ringing of bats in the territory of the former Soviet Union in the middle of the 20th century (Panutin, 1970, 1980). Recaptures of ringed bats from the Voronezhsky Reserve provided examples of connectivity between summer breeding areas and the wintering sites for long-distance migratory bats (genera *Nyctalus*, *Pipistrellus*, and *Vespertilio*) (Hutterer et al., 2005). It was discovered that bats migrated from the Voronezhsky Reserve to the Russian Caucasus, the Ukrainian Crimea, and the Black Sea coastal region, and to countries in central and southern Europe (Turkey, Bulgaria, Hungary, etc.) (Panutin, 1980; Hutterer et al., 2005). Strelkov (1997) noted that the woodlands of Eastern Europe were the main breeding core of long-distance migratory bats found in Central Europe. This meant that bats breeding in all of these reserves (not only Voronezhsky) could move to Central European countries for hibernation. Currently, there is pressure on breeding populations through habitat loss and fragmentation and natural selection losses over the long migration routes. There is also a new threat to populations of long-distance migratory bats that has appeared in the last decade. This is the threat from wind turbines that can kill hundreds of thousands of bats, predominantly of the genera *Pipistrellus* and *Nyctalus*, and mainly in the period of autumn migration (Rydell et al., 2010; Lehnert et al., 2014; Voigt et al., 2015). There are many papers describing bat mortality through collisions with wind turbines in Central (e.g., Rydell et al., 2010; Voigt et al., 2015) and South Europe (e.g., Măntoiu et al., 2015), in regions of bat wintering and on migration routes. However, there is no current information on the situation in breeding bat populations in the east in response to mass mortality in Southwest Europe and particularly how it may affect year-round fitness. Indeed, the one season of observations of bat assemblages that we present is insufficient for estimating population trends, but the results provide an indication of the status of breeding bat populations in the east of Europe and establish a reference point for the future assessment of population changes.

Our research aimed to: 1) display the results of a study of *N. lasiopterus* occurrence in reserves; 2) compare the current structure of the bat assemblage in the Voronezhsky Reserve obtained by mist-netting to that obtained by standard methods in the middle of the 20th century; and 3) describe the current structure of the bat assemblage as a baseline for future monitoring, with a focus on the impact of wind turbines on long-distance migratory species.

2. Materials and methods

2.1. Study area and study sites

2.1.1. Voronezhsky State Nature Biosphere Reserve

The Voronezhsky State Nature Biosphere Reserve (51°44′N, 39°34′E) is located in the Voronezh region, 450 km south-southeast of Moscow (Figure 1). It was established in 1923. The reserve is in a forest-steppe nature zone and covers 31,053 ha of the northern part of a large forest area named "Usmansky Bor" (a pine forest on the Usman River) with an area of 63,100 ha. The "Usmansky Bor" is a large forest island surrounded by agricultural landscapes (fields and meadows) and settlements. The reserve ranges from 90 to 170 m a.s.l. Two small rivers, the Usman and Ivnitsa, flow though the reserve. The southwest corner of the reserve borders the large Voronezh River. The main habitat type is mixed pine (*Pinus sylvestris*) and oak (*Quercus robur*) forest, which dominates the elevated part of the reserve. In the floodplains and lowlands the forests have predominantly deciduous tree species such as alder (*Alnus glutinosa*), aspen (*Populus tremula*), and birch (*Betula pendula*) (Zharkov and Lavrov, 1970).

The reserve was the main research area for studying forest-dwelling bats in the former Soviet Union. These studies lasted from the 1930s (Lavrov and Lavrov, 1938) to the beginning of the 1970s (Panutin, 1970). After the 1990s the research activity diminished. Bats were smoked out from tree hollows and roost sites in houses and caught by hand using fishing nets, sweep nets, and, rarely, the old type of bird-catching net. Roost sites were located by the sounds produced by the bats (Panutin, 1970). During the period of the main research activity, nearly 10,000 individuals of 10 species were caught: *Myotis dasycneme* Boie, 1825; *Myotis nattereri* Kuhl, 1817; *M. mystacinus* s.l., *Nyctalus leisleri* Kuhl, 1817; *Nyctalus noctula* Schreber, 1774; *N. lasiopterus*; *Pipistrellus pipistrellus* s.l.; *P. nathusii* Keyserling & Blasius, 1839; *Vespertilio murinus* Linnaeus, 1758; and *Plecotus auritus* Linnaeus, 1758. Additionally, *Myotis daubentonii* Kuhl, 1817 was noted in the current list of vertebrate species (Sapelnikov, 2008). Another species, *Eptesicus serotinus* Schreber, 1774, was recorded in 1987 (Lavrov, 1987). There have been 4 records of *N. lasiopterus* (on 16 June 1936, 28 May 1941, and 3 May 1961, and in May 1962), and 14 individuals have been caught in total (Panutin, 1969).

The climate is moderately continental with cold, temperate winters and warm summers. The average yearly temperature is 5.3 °C. Average monthly temperature varies from –9.9 °C in January to 19.5 °C in July. The absolute minimum is –42 °C and the absolute maximum is 40 °C. The period without freezing weather averages 133 days per year. The mean annual precipitation is 653 mm, with the minimum in February and March and the maximum in June and July (Bazilskaya, 1997).

Figure 1. Location of the reserves in European Russia (B: Bryansky, O: Oksky, V: Voronezhsky).

The location for bat mist-netting was chosen in the southeast corner of the reserve surrounding the main office in Tolshy and in the vicinity of the Cherepakhinsky (Tortoise) cordon, where *N. lasiopterus* was previously recorded (Panutin, 1970). An additional area for mist-netting was at Chistoe Lake near the same cordon (Figure 2).

2.1.2. "Bryansky Les" (Bryansk Forest) Nature State Biosphere Reserve

"Bryansky Les" (52°25′N, 33°48′E) is located in Bryansk region, 440 km southwest of Moscow (Figure 1), and was founded in 1987. The reserve is in the southeast part of the forest nature zone. The reserve ranges from 134 to 189 m a.s.l. The total area of the reserve is 12,186 ha, 80% of which is forest, 18% marshes, 1.5% meadows and openings, and 0.5% rivers and lakes. The main tree species are pine (*P. sylvestris*), spruce (*Picea abies*), birch (*B. pendula*), oak (*Q. robur*), aspen (*P. tremula*), and ash (*Fraxinus excelsior*) (Sitnikova and Mishta, 2008).

Detailed bat research in the reserve was done from 2004 to 2009. Bats were caught by mobile traps and mist-nets and roost sites were located using ultrasound detectors (Pettersson D100 and D200 (Pettersson Electronik AB) (Sitnikova et al., 2009)). Eleven species were recorded: *Myotis brandtii*, Eversmann, 1845; *M. daubentonii*; *E. serotinus*; *Eptesicus nilssonii* Keyserling & Blasius, 1839; *N. leisleri*; *N. noctula*; *P. nathusii*; *P. pygmaeus*; *Pipistrellus kuhlii*, Kuhl, 1817; *V. murinus*; and *Pl. auritus* (Sitnikova

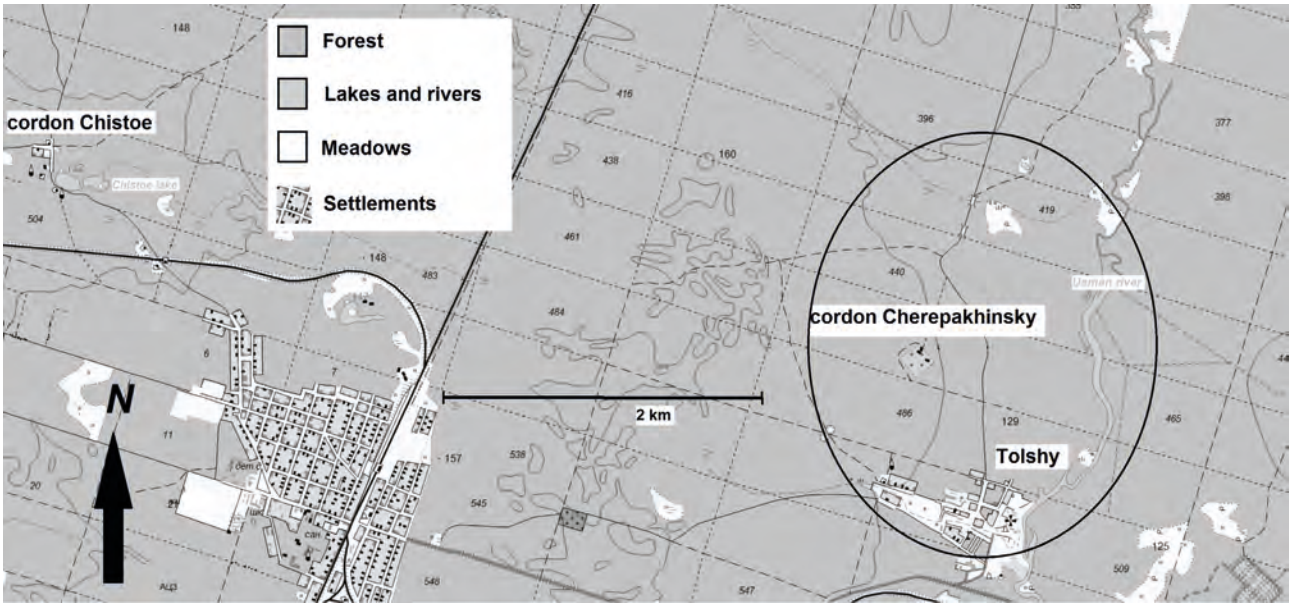

Figure 2. Location of main mist-netting site in the southeast part of the Voronezhsky State Nature Biosphere Reserve.

et al., 2009). *N. lasiopterus* was recorded only once in the reserve in 1983 (Shpilenok et al., 1997).

The climate is temperate continental with cold, temperate, and snowy winters and warm summers. The average yearly temperature is 5 °C. The average monthly temperature varies from –8 °C in January to 19 °C in July. The absolute minimum is –41.8 °C and the absolute maximum is 37.6 °C. The period without freezing weather is 140 days per year. The mean annual precipitation is 550 mm, with the minimum in December–February (25–35 mm) and the maximum in July (80–100 mm).

The area for bat mist-netting was in the southwest corner of the reserve in the vicinity of the Staroe Yamnoe cordon, near the point where *N. lasiopterus* was previously recorded. The location is on the Nerussa River floodplain (Figure 3).

2.1.3. Oksky State Nature Biosphere Reserve (54°44′ N, 40°54′ E)

The Oksky State Nature Biosphere Reserve, located in the Ryazan region 235 km southeast of Moscow (Figure 1), was founded in 1935. The reserve is in the southeast part of the Meshchera lowland (covering 10,000 km^2). The southern and eastern borders of the lowland are at the great bend of the Oka River. The reserve ranges from 80 to 130 m a.s.l. The area of the reserve is 56,027 ha, including forests (50,461 ha), marshes (2539 ha), meadows and openings (2089 ha), and rivers and lakes (637 ha). The main forest species is pine (*Pinus sylvestris*); pine forests grow on the higher parts of the reserve. The floodplains and lowlands are covered by deciduous forest with aspen (*P. tremula*), birch (*B. pendula*), oak (*Q. robur*), and alder (*A. glutinosa*) (Ivanchev, 2005). Bat research in the reserve was done by Ivancheva and Ivanchev (2000) from 1984 to 1990. Ten species were described (*M. daubentonii*, *M. dasycneme*, *N. leisleri*, *N, noctula*, *N. lasiopterus*, *E. nilssonii*, *Pipistrellus pipistrellus* s.l., *P. nathusii*, *V. murinus*, and *Pl. auritus*). The main method of bat catching was using a sweep net outside hollows and a net outside roost sites in buildings (Ivancheva and Ivanchev, 2000). Roost sites were identified by the sounds produced by the bats.

The climate is moderately continental with cold and snowy winters and warm summers. The average yearly temperature is 4.2 °C. The average monthly temperature varies from –11.6 °C in February to 19.8 °C in July. The absolute minimum is –45 °C and the absolute maximum is 34–35 °C. The period without freezing weather is 120–135 days a year. The mean precipitation is 535 mm, with a minimum in February (25 mm) and a maximum in July (72 mm).

The location for bat mist-netting was chosen in the southeast corner of the reserve in the vicinity of the Lipovaya Gora (Linden Hill) cordon, where a previous record of *N. lasiopterus* was made (Ivancheva and Ivanchev, 1989). The location is situated in the area of confluence of the Pra and the Oka rivers (Figure 4).

2.2. Mist netting protocol and data collection

Fieldwork took place in the Voronezhsky and “Bryansky Les” reserves from 26 June to 12 July 2013 and in the Oksky Reserve from 12 to 29 July 2013. Bat mist-netting was undertaken in accordance with the approach previously used for Eastern European forests (Vlaschenko and Gukasova, 2009; Gukasova and Vlaschenko, 2011; Prylutska, 2014) and using the basic recommendations

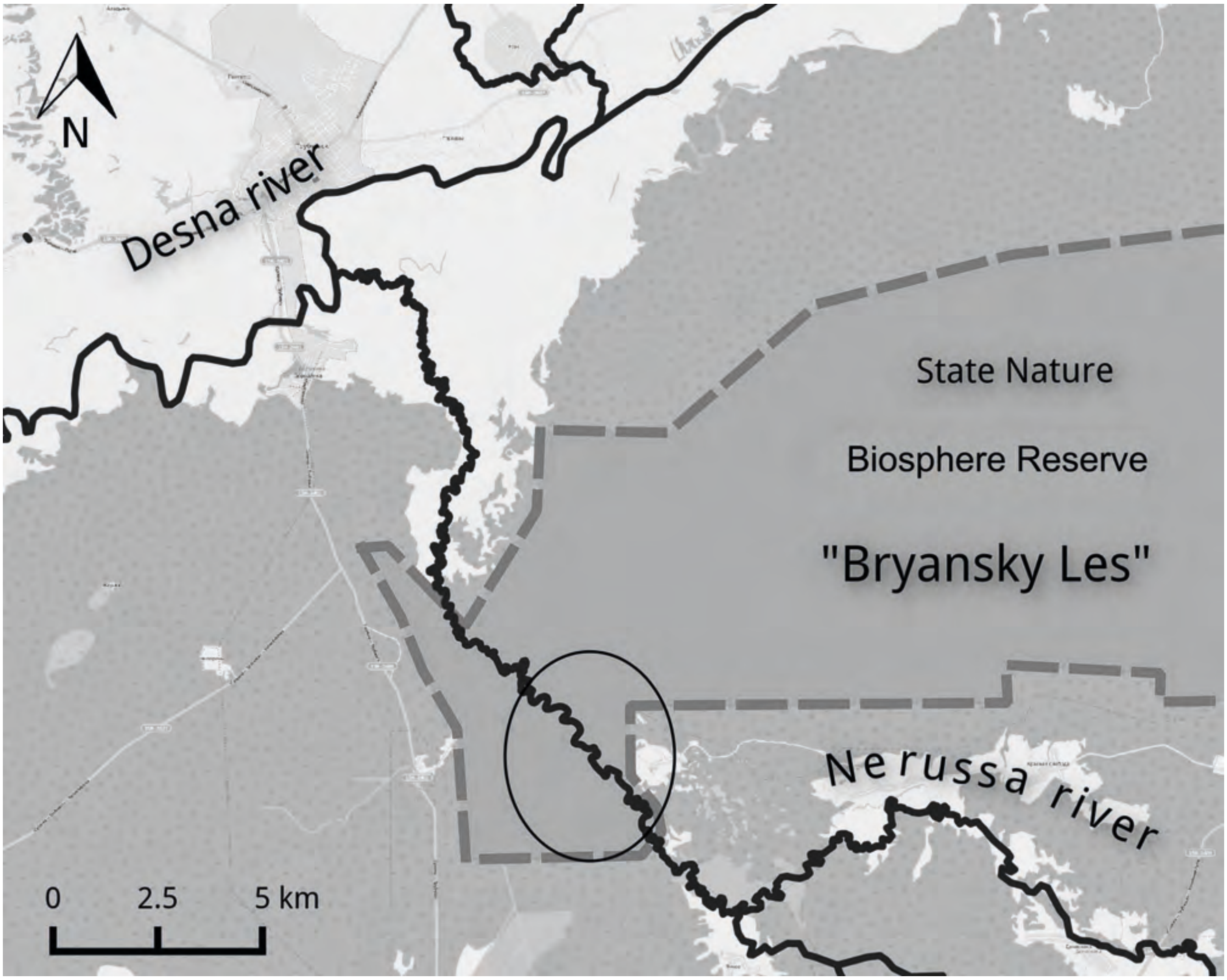

Figure 3. Location of main mist-netting site in "Bryansky Les" State Nature Biosphere Reserve.

outlined by Kunz et al. (2009). In each reserve we selected one location (500–1200 ha) for the main mist-netting effort close to a point where *N. lasiopterus* had been recorded in the past (Figures 2–4). Mist-netting points were selected in the main habitat types: river banks, forest lakes and ponds, forest roads, and forest edges. The relationship of main mist-netting points to habitat types is presented in Table 1. Additional mist-netting was done in the Oksky and Voronezhsky Reserves. In Oksky these were at the guest house of the Lipovaya Gora cordon (2 sites, 3 mist-nets) and Brykin Bor village near the central reserve office (2 sites, 4 mist-nets) (Figure 2). In Voronezhsky these were at the guest house of the Cherepakhinsky cordon (2 sites, 3 mist-nets), Chistoe Lake (1 site, 2 mist-nets) (Figure 3), and one preliminary mist netting (1 site, 1 mist-net).

A full list of captured bats is presented in Table 2 with coordinates of mist-netting sites and dates. For the Voronezhsky and Oksky Reserves the coordinates of mist-netting sites were set post factum by using satellite images from Google Earth. In the "Bryansky Les" Reserve the coordinates were identified with a Garmin eTrex 30 GPS.

Bats were caught using Chinese ultrathin nylon mist-nets (12 (10) × 3 m length; mesh size 15 mm). The mist-nets were opened from sunset until 10–30 min before sunrise. We conducted mist-netting in 2 sites simultaneously on most nights.

Bats were kept in textile bags near the net during the night. We identified species, sex, and age for all captured specimens and also breeding status of adult individuals of both sexes. The main features used in identification of age were degree of ossification of joints of finger phalanx of the wing (using the presence of cartilage through a visual check) and size and shape of nipples for females. We considered the degree of wear of the canine teeth among medium and large bat species. Forearm length and body mass were measured in each case when possible.

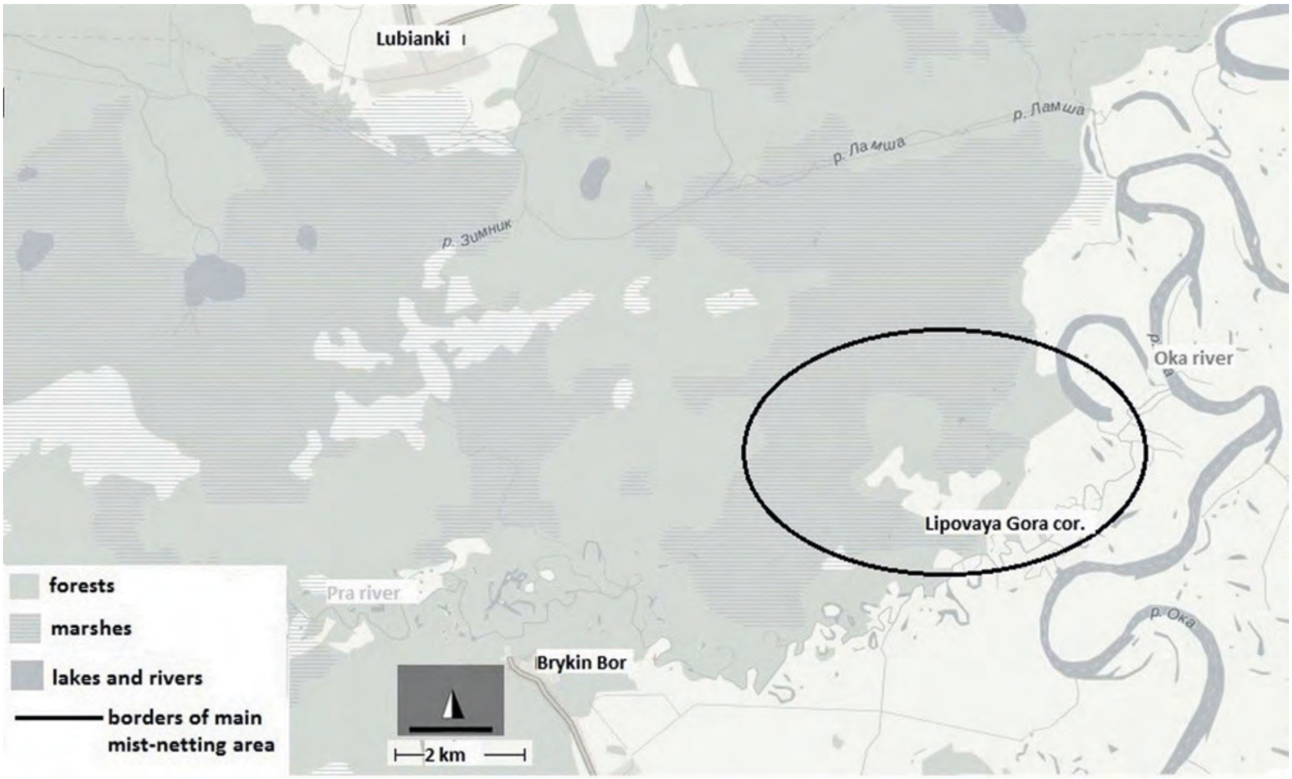

Figure 4. Location of main mist-netting site in Oksky State Nature Biosphere Reserve.

Table 1. Results from mist-netting in different habitat types in Voronezhsky, "Bryansky Les", and Oksky State Nature Biosphere Reserves.

Habitat types	Reserves		
	Voronezhsky (Tolshy)	"Bryansky Les" (Chukhray)	Oksky (Lipovaya Gora)
Banks of rivers	3* 3	6 6	3 5
Forest roads	3 3	5 5	3 3
Forest lakes and ponds	2 3	2 2	2 2
Forest edges	1 2	1 1	2 3
Total time mist-netting (hours)	72.75	88.5	78

*: Above the line is the number of mist-netting sites and below the number of mist nets used.

After processing, bats were released the next evening. During the daytime bats were kept in textile bags with several individuals in each bag placed inside houses to protect bats from sunlight, drafts, etc. All measures of bat capturing, holding, and carrying in bags were ethical, with respect for animal welfare and conservation of protected species, according to Sikes et al. (2007). None of bats were injured or killed during the study.

Long-distance migratory species (*N. noctula*, *P. nathusii*, and *P. pygmaeus*) were ringed using special bat rings (Aranea, Poland).

Several tissue samples were taken using the standard protocol (Rossiter, 2009) for future confirmation of species status by genetic analyses. Two species groups were of particular interest: *P. pipistrellus* s.l. and *M. mystacinus* s.l. In the field we used a current bat identification key (Dietz and von Helversen, 2004; Dietz et al., 2009). The genetic analyses were conducted by the Museum of Natural History in Berlin, Germany.

The index of bats per hour (b/h) was calculated on the basis of mist-netting success and bat abundance (Gukasova and Vlaschenko, 2011). The total number of captured bats for all nights (N_m) was divided by time (in hours, accurate to 15 min) (H) of mist-netting (b/h = N_m/H).

The binomial test was used for comparison of sex ratios. For estimation of species richness, the Shannon–Wiener index was used. An evenness index was calculated using indexes derived from the Shannon–Wiener index.

3. Results

We captured 1229 bats in all reserves (639 individuals at Voronezhsky, 155 at "Bryansky Les", and 435 at Oksky) (Table 2). In total, 12 species were recorded (11 at Voronezhsky, 8 at "Bryansky Les", and 10 at Oksky). The b/h index was the highest in the Voronezhsky Reserve, the southern location, and the lowest in "Bryansky Les", the western location (Table 3). The Shannon–Wiener index was the highest in the Voronezhsky and Oksky Reserves compared to "Bryansky Les", but the evenness index was close to 0.8 in all the reserves (Table 3).

3.1. Voronezhsky State Nature Biosphere Reserve

The following species were recorded during our study: *M. daubentonii*, *M. dasycneme*, *M. brandtii*, *N. leisleri*, *N. noctula*, *N. lasiopterus*, *E. serotinus*, *P. nathusii*, *P. pygmaeus*, *V. murinus*, and *Pl. auritus* (Tables 2 and 3). Two species from groups difficult to identify were later confirmed by genetic analyses: *P. pygmaeus* (2 samples) and *M. brandtii* (1 sample). From 28 June to 12 July in the vicinity of Tolshy village, 331 individuals of 10 species were caught (Table 3). At Chistoe Lake 221 individuals of 9 species were caught, including *N. lasiopterus* (Table 2). In the guest house in the Cherepakhinsky cordon, 22 individuals of 3 species dwelling in this house were caught (Table 2).

The species relative abundance for the vicinity of Tolshy village is presented in Table 3. The dominant species was *N. noctula* (40.8%), and subdominant species (with rates of more than 10%) were *N. leisleri* and *P. nathusii*. Species with a rate of less than 10% and more than 4% were *M.*

Table 2. List of all bats caught in the Voronezhsky, "Bryansky Les", and Oksky State Nature Biosphere Reserves.

Point (ID)	Geographic coordinates	Dates of 2013 (dd.mm) and species abbreviation* and sex-age status
Voronezhsky State Nature Biosphere Reserve		
R1	51°52′44″N, 39°39′32″E	26–27.06 *M. daub* ♀ad, 7♂♂ad; *M. das* 4♂♂ad; *N. noc* 24♀♀ad, 4♂♂ad; *N. leis* ♀ad; *E. ser.* 2♀♀ad; *P. nath* 2♀♀ad, 9♀♀sad, ♂ad, 6♂♂sad; *P. pyg* ♀ad; *V. mur* 3♂♂ad.
Cordon Cherep.	51°53′18″N, 39°38′54″E	27.06 *E. ser* ♂sad.
		30.06 *E. ser* 4♀♀ad, ♀sad, ♂sad; *P. nath* ♂sad; *V. mur* 13♂♂ad, ♂sad.
Fr1	51°53′14″N, 39°38′50″E	28–29.06 *M. daub* ♂ad; *M. bran* 2♀♀ad; *P. nath* ♂sad; *P. pyg* ♀ad, ♀sad; *Pl. aur* ♀ad; *V. mur* ♂ad.
R2	51°52′35″N, 39°39′33″E	01–02.07 *M. daub* 4♀♀ad, 9♂♂ad, ♂sad; *M. bran* ♀ad; *N. noc* 3♀♀ad, ♂sad; *N. leis* ♀ad, ♂ad; *P. nath* ♀ad, ♀sad, ♂ad, 3♂♂sad; *P. pyg* 2♀♀ad, 2♀♀sad; *E. ser* ♀ad.
L1	51°54′03″N, 39°39′31″E	02–03.07 *M. daub* ♂ad; *M. bran* 2♀♀ad, 2♀♀sad, 2♂♂sad; *N. noc* 4♀♀ad, 3♀♀sad, ♂ad; *P. nath* ♀ad, 4♀♀sad, ♂ad, 4♂♂sad; *P. pyg* ♀ad, 3♂♂sad; *V. mur* 2♂♂sad.
		M. bran ♀ad, ♀sad; *N. noc* ♀ad, ♂sad; *N. leis* ♀ad; *P. nath* 3♂♂sad; *P. pyg* 2♀♀sad; *V. mur* ♂ad.
L2	51°52′51″N, 39°38′34″E	03–04.07 *M. daub* 2♂♂sad; *M. bran* ♂sad; *N. noc* 20♀♀ad, 18♀♀sad, ♂ad, 10♂♂sad; *N. leis* 4♀♀ad, 6♀♀sad, ♂ad, 4♂♂sad; *E. ser* 6♀♀ad, 2♀♀sad, ♂ad.
		P. nath 2♀♀sad, 2♂♂sad; *P. pyg* ♀ad, 4♀♀sad, 2♂♂sad; *V. mur* 2♀♀sad, 2♂♂sad, 3♂♂ad.
Chistoe Lake	51°54′02″N, 39°33′32″E	06–07.07 *M. daub* 4♂♂ad; *M. bran* ♀ad, ♀sad, ♂ad; *N. noc* 19♀♀ad, 16♀♀sad, 2♂♂ad, 20♂♂sad; *N. leis* 2♀♀sad; *N. las* ♀sad; *P. nath* 2♀♀sad, ♂ad, 2♂♂sad; *P. pyg* ♀ad, 2♂♂sad; *V. mur* ♂ad, 3♂♂sad.
		M. daub ♂sad; *M. bran* ♀ad, ♂sad, ♂ad; *N. noc* 28♀♀ad, 35♀♀sad, 7♂♂ad, 29♂♂sad; *N. leis* 3♀sad, ♂sad; *P. nath* 2♀♀ad, 4♀♀sad, 5♂♂sad; *P. pyg* 2♀♀ad, 8♀♀sad, 8♂♂sad; *E. ser* ♀ad; *V. mur* 2♀♀sad, ♂ad, 2♂♂sad.
R3	51°53′22″N, 39°39′56″E	08–09.07 *M. das* ♀sad; *M. daub* ♀sad, ♂ad, 3♂♂sad; *N. noc* 9♀♀ad, 16♀♀sad, 3♂♂ad, 8♂♂sad; *N. leis* ♀sad; *P. nath* ♀ad; *P. pyg* ♂sad; *E. ser* ♀sad; *V. mur* ♀sad.

Table 2. (Continued).

Point (ID)	Geographic coordinates	Dates of 2013 (dd.mm) and species abbreviation* and sex-age status
Fr2	51°53′N, 39°38′E	08–09.07 *M. daub* ♀sad; *M. bran* ♀sad, ♂sad; *N. noc* 2♂♂sad; *N. lei* ♀sad, 4♂♂sad; *E. ser* ♀sad; *V. mur* ♀sad, ♂ad, ♂sad; *P. aur* 3♀♀ad, 2♂♂ad.
Fedg	51°53′45″N, 39°39′07″E	09–10.07 *N. noc* ♀sad; *N. leis* ♀sad; *P. pyg* ♂sad; *V. mur* ♂sad.
		M. bran ♀sad; *N. noc* ♀sad; *N. leis* 7♀♀ad, 5♀♀sad, 5♂♂sad; *E. ser* ♂sad; *P. nath* ♀sad, 2♂♂sad; *V. mur* 2♂♂ad; *P. aur* ♀ad.
Fr3	51°53′12″N, 39°39′03″E	09–10.07 *P. aur* ♀ad.
R1	51°52′44″N, 39°39′32″E	11–12.07 *M. das* ♂ad; *M. daub* 2♀♀ad, 2♀♀sad, ♂ad, 3♂♂sad; *M. bran* ♀sad, ♂sad; *N. noc* 6♀♀ad, 13♀♀sad, 2♂♂ad, 11♂♂sad; *N. leis* ♀ad, ♂sad; *E. ser* ♀ad, 2♂♂sad; *P. nath* ♂ad, 5♂♂sad; *V. mur* ♂ad, ♂sad.
"Bryansky Les" State Nature Biosphere Reserve		
F1	52°26′49″N, 33°51′28″E	03–04.07 *M. bran* 2♀ad, ♀sad; *N. noc* ♀ad, ♀sad; *P. pyg* ♀sad; *V. mur* ♂sad.
R1	52°27′7″N, 33°51′48″E	04–05.07 *N. noc* 12♀♀ad, 4♀♀sad, 3♂♂sad; *P. nath* ♂sad; *V. mur* ♂ad.
R2	52°27′22″N, 33°51′34″E	04–05.07 *N. noc* 6♀♀ad, 9♀♀ sad, ♂ad, 7♂♂sad.
F2	52°26′39″N, 33°50′49″E	05–06.07 *M. bran* 2♀ad, ♀sad, ♂sad; *P. aur* ♂ad; *P. pyg* ♀ad , ♀sad.
F3	52°26′17″N, 33°52′21″E	05–06.07 *N. noc* ♀ad; *V. mur* ♂sad.
L1	52°27′9″N, 33°53′35″E	07–08.07 *M. bran* ♀sad; *M. daub* ♂ad, ♀sad; *N. noc* 3♀♀ad, ♀sad, ♂sad; *P. nath* 6♀♀sad, 3♂♂sad; *P. pyg* 3♂♂sad; *V. mur* 3♀♀sad, 5♂♂sad.
L2	52°27′8″N, 33°53′37″E	09–10.07 *N. leis* ♀sad; *P. nath* 2♀♀ad, 2♀♀ sad, 3♂♂sad; *P. pyg* ♀ad; *V. mur* ♀sad.
R3	52°27′47″N, 33°50′58″E	07–08.07 *M. bran* ♀sad; *P. pyg* ♂sad.
		09–10.07 *M. daub* ♂sad; *P. pyg* 2♀♀sad; *P. nath* ♂sad.
F4	52°26′56″N, 33°51′20″E	08–09.07 *M. bran* ♂sad; *P. nath* 4♀♀ad, 2♀♀sad; *P. aur* ♀ad.
F5	52°26′56″N, 33°50′52″E	08–09.07 *M. bran* 5♀♀ad, 2♀♀sad, ♂sad; *N. noc* ♂sad; *P. nath* 2♀♀ad, 4♀♀sad, ♂sad; *P. aur* ♀ad.
R4	52°26′49″N, 33°52′37″E	11–12.07 *N. leis* ♀sad.
R5	52°26′48″N, 33°52′42″E	11–12.07 *M. daub* ♀sad.
R6	52°26′56″N, 33°52′31″E	11–12.07 *M. daub* ♀sad; *N. noc* ♂sad.
Oksky State Nature Biosphere Reserve		
Guest house	54°43′54″N, 40°57′46″E	14.07 *M. das* ♀ad; *V. mur* ♂sad.

Table 2. (Continued).

Point (ID)	Geographic coordinates	Dates of 2013 (dd.mm) and species abbreviation* and sex-age status
		20–21.07 *M. das* 2♀♀ad, 2♀♀sad, ♂ad, 2♂♂sad; *N. noc* 2♀♀sad, ♂sad; *N. leis* ♀sad, ♂sad; *P. nath* 4♀♀sad, 3♂♂sad; *V. mur* 7♀♀sad, ♂ad, ♂sad.
		M. das 6♀♀ad, 4♀♀sad, 3♂♂sad; *M. daub* ♂sad; *M. bran* ♂ad, ♂sad; *N. noc* 6♀♀sad, ♂sad; *N. leis* ♀ad, ♂sad; *P. nath* ♀ad, 13♀♀sad, 10♂♂sad; *V. mur* ♀ad, 6♀♀sad, 8♂♂sad.
R1	54°43′30″N, 40°57′50″E	15–16.07 *M. das* ♂ad; *M. daub* 13♀♀ad, 9♀♀sad, 6♂♂ad, 3♂♂sad; *M. bran* ♂ad, ♂sad; *N. noc.*♀ad, 4♀♀sad, ♂sad; *N. leis* ♀ad, 3♂♂sad; *P. nath* 7♀♀ad, ♀sad, 5♂♂sad; *P. pyg* 2♀♀sad; *V. mur* ♀sad, 4♂♂sad.
		15–16.07 *N. noc* 7♀♀ad, 4♀♀sad, 7♂♂sad; *P. pyg* ♀sad.
Fr1	54°43′56″N, 40°55′39″E	17–18.07 *M. bran* 2♂♂ad, ♂sad; *N. noc* ♀ad, ♀sad; *P. nath* ♀sad; *Pl. aur* ♀ad, 2♂♂sad.
Fedg1	54°44′01″N, 40°57′05″E	17–18.07 *M. mys* ♀sad; *V. mur* ♂sad.
R3	54°44′04″N, 40°59′13″E	18–19.07 *M. das* ♂ad; *M. daub* ♂ad; *N. noc* ♀sad, ♂sad, ♂ad; *P. nath* ♂sad; *P. aur* ♀ad, 2♀♀sad.
		M. das 2♀♀ad, ♀sad, 4♂♂ad, 4♂♂sad; *M. daub* 5♀♀ad, ♀sad, 11♂♂ad, 7♂♂sad; *M. bran* ♀ad, ♂sad; *N. noc* 14♀♀ad, 15♀♀sad, 2♂♂ad, 17♂♂sad; *N. leisl* 2♀♀sad, ♂sad; *P. nath* 5♀♀ad, 9♀♀sad, 2♂♂sad; *P. pyg* ♀sad; *V. mur* 6♀♀sad, 4♂♂sad; *P. aur* 2♀♀ad, ♀sad, 2♂♂sad.
L1	54°44′02″N, 40°58′06″E	20–21.07 *N. noc* 5♀♀ad, 22♀♀sad, 13♂♂sad; *N. leis* 2♀♀ad, ♀sad, ♂sad; *P. nath* ♀ad, ♀sad, 3♂♂sad; *V. mur* ♂sad.
Fr2	54°43′39″N, 40°57′16″E	23–24.07 *M. das* ♂ad, ♂sad; *M. bran* ♀ad, 5♀♀sad, 4♂♂ad, 3♂♂sad; *N. noc* ♀ad, 2♂♂sad; *N. leis* ♀sad, ♂sad; *P. nath* ♀sad, ♂ad, ♂sad.
Fedg2	54°43′35″N, 40°57′16″E	23–24.07 *P. nath* ♀sad.
Fr3	54°43′25″N, 40°56′48″E	23–24.07 *M. bran* 2♀♀ad, ♂sad; *N. noc* ♀sad, ♂sad; *P. aur* ♂sad.
L2	54°44′15″N, 40°58′26″E	24–25.07 *N. leis* ♀ad; *P. nath* ♂sad.
R2	54°44′04″N, 40°59′19″E	24–25.07 *P. nath* 2♀♀sad, 2♂♂sad; *P. aur* ♂ad.
Brykin Bor	54°42′51″N, 40°51′27″E	27–28.07 *M. bran* ♀ad, ♂ad; *P. nath* 5♀♀ad, 5♀♀sad, 2♂♂sad; *P. pyg* ♀ad, 2♀♀sad, ♂sad.
		P. aur ♂ad.
	54°42′47″N, 40°51′14″E	28.07 *M. das* 6♂♂ad; *P. nath* ♀ad; *P. pyg* ♂?.
		M. daub ♀ad, ♂ad; *P. nath* ♀ad; *P. pyg* ♀sad.

*: *M. das – M. dasycneme*, *M. daub – M. daubentonii*, *M. bran – M. brandtii*, *M. mys – M. mystacinus*, *N. noc – N. noctula*, *N. leis – N. leisleri*, *N. las – N. lasiopterus*, *E. ser – E. serotinus*, *P. nath – P. nathusii*, *P. pyg – P. pygmaeus*, *V. mur. – V. murinus*, *Pl. aur – Pl. auritus*.

daubentonii, *M. brandtii*, *E. serotinus*, *P. pygmaeus*, and *V. murinus* – these could be estimated as not rare, while the remaining 2 species (*Pl. auritus* and *M. dasycneme*) were rare.

Table 4 shows the sex ratio for adult bats of 3 species and subadult bats of 7 species from Tolshy. Among adult individuals of long-distance migratory species, females were dominant (*N. leisleri* (binominal test, $P \leq 0.05$) and *N. noctula* (binominal test, $P \leq 0.05$)). In a sedentary species like *M. daubentonii*, the proportion of sexes was equal (binominal test, $P \geq 0.05$). The sample sizes of adult individuals of other species were too small for statistical

Table 3. Relative abundance of summer bat assemblages in Voronezhsky, “Bryansky Les”, and Oksky State Nature Biosphere Reserves.

Species	Voronezhsky Reserve		“Bryansky Les”	Oksky	
	Tolshy	Chistoe Lake		Lipovaya Gora	Brykin Bor
M. daubentonii	32; 9.6%*	5; 2.3%	6; 3.9%	56; 18%	2; 6.4%
M. dasycneme	2; 0.6%	-	-	15; 4.8%	6; 19.3%
M. brandtii	17; 5.1%	6; 2.7%	19; 12.2%	23; 7.4%	2; 6.4%
M. mystacinus	-	-	-	1; 0.3%	-
E. serotinus	16; 4.8%	1; 0.5%	-	-	-
N. leisleri	44; 13.3%	6; 2.7%	3; 1.9%	14; 4.5%	-
N. noctula	135; 40.8%	156; 70.6%	64; 41.2%	122; 39.5%	-
N. lasiopterus	-	1; 0.5%	-	-	-
P. nathusii	34; 10.3%	16, 7.2%	34; 21.9%	45; 14.5%	14; 45.1%
P. pygmaeus	23; 7%	21; 9.5%	10; 6.5%	4; 1.3%	6; 19.3%
V. murinus	20; 6%	9; 4%	16; 10.3%	17; 5.5%	-
Pl. auritus	8; 2.4%	-	3; 1.9%	13; 4.1%	1; 3.2%
Total	331; 99.9%	221; 100%	155; 99.8%	310; 99.9%	31; 99.7%
B/h index	4.54	-	1.75	3.97	-
Shannon–Wiener index	1.86	-	1.64	1.8	-
Evenness index	0.81	-	0.79	0.78	-

*: The first number is bats caught, the second is percentage of each species.

Table 4. Sex ratio in adult and subadult bats for common species in Voronezhsky, “Bryansky Les”, and Oksky State Nature Biosphere Reserves (samples of more than 10 individuals of both sexes).

Species	Voronezhsky Reserve (Tolshy)				“Bryansky Les”				Oksky (Lipovaya Gora)			
	Adults		Subadults		Adults		Subadults		Adults		Subadults	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
M. daubentonii	6* 31.6%	13 68.4%	4 30.7%	9 69.2%	-	-	-	-	18 50%	18 50%	10 50%	10 50%
M. brandtii	-	-	6 54.5%	5 45.4%	-	-	7 70%	3 30%	4 36.4%	7 63.6%	5 41.6%	7 58.3%
N. leisleri	14 87.5%	2 12.5%	13 46.6%	15 53.6%	-	-	-	-	-	-	4 40%	6 60%
N. noctula	43 86%	7 14%	52 61.2%	33 38.8%	26 89.6%	3 10.4%	17 48.6%	18 51.4%	29 90.6%	3 9.4%	48 53.3%	42 46.6%
P. nathusii	-	-	8 28.5%	20 71.4%	-	-	17 68%	8 32%	13 92.8%	1 7.1%	16 51.6%	15 48.4%
P. pygmaeus	-	-	8 47%	9 52.9%	-	-	-	-	-	-	-	-
V. murinus	-	-	4 36.4%	7 63.6%	-	-	5 38.5%	8 61.5%	-	-	7 41.2%	10 58.8%

*: Above the line is the number of individuals and below the percentage.

analyses, but for *M. brandtii* only adult females (n = 6) were recorded at Tolshy and only males at Chistoe Lake (Table 2). For *P. nathusii* at Tolshy (3♀♀ad, 3♂♂ad), like in the general sample (7♀♀ad, 5♂♂ad), the ratio was close to 1:1. We only recorded adult females of *P. pygmaeus*. For *E. serotinus*, females dominated (Tolshy: 8♀♀ad, ♂ad), as they did among adult *Pl. auritus* (6♀♀ad, 2♂♂ad) (Table 2). It was quite curious that adult individuals of *V. murinus* were represented only by males (Tolshy n = 9; all data n = 27) (Table 2).

Among subadult bats, the sex ratios were equal for the 6 species listed in Table 4 (binominal test, $P \geq 0.05$). Only for *P. nathusii* did females dominate (binominal test, $P \leq 0.05$).

All bat species caught during this study were breeding within the reserve area (subadult individuals or lactating females; Table 2).

In the guest house of the Cherepakhinsky cordon we found and mist-netted bat colonies. The first species (*V. murinus*) lived under the iron side sheet and emerged from an entrance not more than 0.7 m above the ground. Every evening we noted a cat (living with the cordon's workers) that caught some of these bats during emergence. Half of the captured *V. murinus* had injuries (less than 1 cm opening in membranes, broken fingers in a wing, trauma on the legs). No adult females were captured from this roost site (Table 2). The other colony (of *E. serotinus*) lived in the attic of the guest house.

3.2. "Bryansky Les" State Nature Biosphere Reserve

We caught 8 bat species during our study: *M. brandtii*, *M. daubentonii*, *N. leisleri*, *N. noctula*, *P. pygmaeus*, *P. nathusii*, *V. murinus*, and *Pl. auritus*. Two specimens of *M. brandtii/mystacinus* (♀♀ad) had morphological characteristics of *M. mystacinus* (absence of cingulum), but results of genetic analyses referred them to *M. brandtii*.

The species relative abundance for the "Bryansky Les" location is presented in Table 3. *N. noctula* was the dominant species with 40% of records; *M. brandtii*, *P. nathusii*, and *V. murinus* were subdominant species, with proportions of more than 10%. Species with proportions of less than 10% and more than 4% (*M. daubentonii* and *P. pygmaeus*) could be estimated as not rare, while the remaining 2 species (*N. leisleri* and *Pl. auritus*) were rare.

Among long-distance migratory species, *N. noctula* females were dominant (binominal test, $P < 0.05$). Among subadult bats the sex ratios were equal in cases of sample sizes of more than 10 individuals (binominal test, $P > 0.05$) (Table 4).

In *Pl. auritus* we caught only adult specimens; thus, we could not reveal the reproductive status of this species. All but one (*Pl. auritus*) of the bat species were recorded as breeding in the reserve area (subadult individuals and lactating females were captured; Table 2).

3.3. Oksky State Nature Biosphere Reserve

We caught 10 species in the Oksky reserve during our study: *M. daubentonii*, *M. dasycneme*, *M. brandtii*, *M. mystacinus*, *N. leisleri*, *N. noctula*, *P. nathusii*, *P. pygmaeus*, *V. murinus*, and *Pl. auritus*. The species from groups difficult to identify were confirmed by genetic analyses as *M. brandtii* (2 samples) and *M. mystacinus* (1 sample). In Lipovaya Gora, 310 individuals of 10 species were caught. Near the guest house of the Lipovaya Gora cordon, 94 individuals of 7 species were caught (*M. brandtii*, *M. dasycneme*, *M. daubentonii*, *N. noctula*, *N. leisleri*, *P. nathusii*, and *V. murinus*). There was a mixed-species colony of *M. dasycneme* (9♀♀ad, 5♀♀sad, 5♂sad) and *V. murinus* (♀ad, ♂sad) in the guest house (figures in brackets are the numbers captured during emergence; totals are presented in Table 2). The other species were lured in by distress calls of bats that had just been caught. In Brykin Bor 31 individuals of 6 species were caught (*M. brandtii*, *M. dasycneme*, *M. daubentonii*, *P. nathusii*, *P. pygmaeus*, and *Pl. auritus*) (Table 2).

The species relative abundance for Lipovaya Gora is presented in Table 3. *N. noctula* was the dominant species, with 40% of records. *M. daubentonii* and *P. nathusii* were subdominant species, with more than 10% of records. Species with fewer than 10% and more than 4% of records (*M. brandtii*, *M. dasycneme*, *N. leisleri*, *V. murinus*, and *Pl. auritus*) could be estimated as not rare. The remaining 2 species (*M. mystacinus* and *P. pygmaeus*) were rare.

In Table 4 the sex ratio for adult bats of 5 common species from Lipovaya Gora is presented. Among long-distance migratory species (Hutterer et al., 2005) females are dominant (*P. nathusii* (binominal test, $P \leq 0.05$) and *N. noctula* (binominal test, $P \leq 0.05$)). For *N. leisleri*, only adult females (n = 4) were recorded (Table 2). Among the group of sedentary species of the genus *Myotis* there was an equal sex ratio for *M. daubentonii* (binomial test, $P \geq 0.05$) and *M. brandtii* (binominal test, $P \geq 0.05$) and a male bias for *M. dasycneme* (2♀♀ad, 7♂♂ad). For *Pl. auritus*, females were dominant (Table 2). Among subadult bats the sex ratios were equal where sample sizes exceeded 10 (binomial test, $P \geq 0.05$) (Table 4).

All bat species recorded in the reserve bred in this area (subadult individuals and lactating females were captured; Table 2).

In the wooden single-story guest house of the Lipovaya Gora cordon, a breeding colony of *M. dasycneme* was recorded. In other building 1 km away from Lipovaya Gora, we also noted one more bat colony (species unidentified). There were also many subadult individuals caught during mist-netting in Lipovaya Gora. In contrast, in Brykin Bor (9 km further up the Pra river; Figure 4), only adult males of *M. dasycneme* were caught (Table 2). We did not note spatial segregation of sex groups for other bat species during our survey in the reserve.

4. Discussion

4.1. Inventory of *N. lasiopterus* status

Our focal species, *N. lasiopterus*, was confirmed only in one reserve. We caught young bats, meaning that a breeding micropopulation still exists in the Voronezhsky Reserve. However, we caught the bats at a different location than that recorded in the 1960s. The exact information about the location of roost sites was found in the archive of the reserve. It was found that the forest plot where the roost was located, on the northern border of the Tolshy village, was cut down in the 1970s. However, it was only several hectares in size, and it is known that species of the genus *Nyctalus* can use dozens of tree roosts during the summer season (Boye and Dietz, 2005) and *N. lasiopterus* moves up to 100 km per night (Popa-Lisseanu et al., 2009). It is clear that the loss of this roost tree did not have an impact on the species moving from the plot where it was recorded. Most probably this colony moved around the whole reserve area, or even the whole Usmansky Bor forest. It is important to note that on satellite images the border between the protected area of the reserve and the management part of the forest is clearly visible. The whole natural area of the reserve area is in the north and there is a patchwork of clear cuttings in the south. We hypothesized that forest harvesting was the main factor for the decline of local *N. lasiopterus* populations (Vlaschenko et al., 2010) in forest-steppe oak forests. This means that more than 80 years of strictly protected management on 30,000 ha of the Voronezhsky Reserve has maintained a breeding micropopulation of *N. lasiopterus*.

Currently this record of a breeding micropopulation of *N. lasiopterus* is only the second known for the East European part of the forest-steppe nature zone. The other breeding micropopulation exists in Samara Bend on the Volga River (Smirnov et al., 2014), 720 km to the northeast. In the Ukrainian part of the forest-steppe zone this species has been listed as extinct (Vlaschenko et al., 2010, 2012). Only one location of a breeding micropopulation of *N. lasiopterus* is currently known in Ukraine, in the north in a forest nature zone (Gashchak et al., 2013), and this location is 650 km southwest of the Voronezhsky Reserve. The next known breeding micropopulation to the west is located more than 750 km to the southwest in Hungary and the south of Slovakia (Uhrin et al., 2006; Estók and Gombkötő, 2007; Estók, 2011).

N. lasiopterus was not confirmed in the "Bryansky Les" and Oksky Reserves during our study. Closer examination of the record of *N. lasiopterus* from "Bryansky Les" makes us think that the record is questionable. It was a dead bat that was found on the ground in 1983 (Shpilenok et al., 1997), but the finder was not a bat expert and he did not take a photo, so we think there is very little chance that it was really *N. lasiopterus*. The bat research in the reserve in the 1990s and 2000s did not confirm the species' presence (Sitnikova et al., 2009). In general though, local researchers in the Bryansk region think that *N. lasiopterus* is not rare, so we cannot ignore this information (Prokofev and Gorbachev, 2010). However, those conclusions are based on acoustic surveys performed using the iBats monitoring car transect method (Prokofev and Gorbachev, 2010). The ultrasound detector model (Tranquility Transect) and recording regime (320 ms) were not sufficient to get a record of required length and quality of sound for exact identification. Our opinion is that the iBats car transect method is not the proper way to identify this species. Confirmation requires the use of the standard method described by Estók and Siemers (2009). We think that amateurs involved in the iBats program in Russia could not properly identify this species.

In the Oksky Reserve, VP Ivanchev showed us the group of trees where *N. lasiopterus* was recorded and we carried out mist-netting in the surrounding area. The previous record (♀ad, ♀sad of *N. lasiopterus* in a colony of 66 *N. noctula*) was on 13 August 1987 and these could have been migratory individuals from near or distant locations (Ivancheva and Ivanchev, 1989). It is also well known that *N. lasiopterus* can move up to 90–130 km per night (Popa-Lisseanu et al., 2009) between roosts and roosting and hunting habitats during the breeding season. In autumn migration these could be significantly longer distances. On the other hand, the lack of records of *N. lasiopterus* in these 2 reserves confirms the idea that this species is rarer than is suggested in current reviews (Dietz et al., 2009). There is a misconception that sites in this geographical region where individuals of *N. lasiopterus* were caught in the past are still used by a breeding micropopulation. Our negative results in "Bryansky Les" and the Oksky Reserve suggest that one record of *N. lasiopterus* is not enough to confirm the species' presence. In this study we present new facts in order to reevaluate the IUCN status of *N. lasiopterus* to a more threatened category. We consider *N. lasiopterus* to be extinct based on our mist-netting results and the IUCN recommendation: 'A taxon is presumed "extinct" when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historic range have failed to record an individual' (IUCN, 2011).

4.2. Changing in the bat assemblage in the Voronezhsky State Nature Biosphere Reserve

An excellent archive of LS Lavrov's and KK Panutin's data on bats is still available in the Voronezhsky Reserve. The data from the archive complement the information from published papers (Panutin, 1970; Sosnovtseva (Dmitrieva), 1974a, 1974b; Panutin, 1963, 1969, 1974, 1980). The methodological approach used by KK Panutin was labor- and time-consuming and for this reason the main research area was not more than 5 km^2, mainly to the north of Tolshy village (Figure 2) (Panutin, 1970). Our mist-netting efforts were in the same area. We caught 10 species in Tolshy in 2013 (Table 3); KK Panutin captured 10 species, too, but his collections lacked *M. daubentonii* and *E. serotinus* and included *M. nattereri* and *N. lasiopterus*. Two other species had different scientific names: *M. mystacinus* and *P. pipistrellus*. After revision, *M. mystacinus* from the Voronezhsky Reserve was referred to *M. brandtii* (Strelkov and Buntova, 1983; Strelkov, 1983a, 1983b), as confirmed by our study. The revision of the *P. pipistrellus* species group based on morphological data of museum collections was done by Kruskop (2007). He identified most *P. pipistrellus* s. str. from the Voronezhsky Reserve as *P. pygmaeus*. Data of our study support the conclusions of Kruskop (2007).

The following species relative abundance was recorded by Panutin (1970) from 1956 to 1965 (n = 6308): *M. brandtii* – 1.93%, *M. dasycneme* – 1.71%, *M. nattereri* – 0.7%, *N. noctula* – 56.4%, *N. leisleri* – 4%, *N. lasiopterus* – 0.12%, *P. nathusii* – 11.2%, *P. pygmaeus* – 13.5%, *V. murinus* – 6.3%, and *Pl. auritus* – 4.1%. Because of different methods of bat capturing we could not compare KK Panutin's data with our own statistically. In our sample there is a bigger ratio of *M. brandtii* and *N. leisleri* (Table 3), but a smaller ratio of *Pipistrellus* species. In both samples, *N. noctula* is the dominant species, and *M. dasycneme* is the rarest one (if we exclude *M. nattereri* and *N. lasiopterus*). These differences could also be a reflection of the methodological approach: colonies of *Pipistrellus* species are easier to search for than those of *Myotis* species. Furthermore, Panutin (1970) noted that most colonies of *Pipistrellus* lived in buildings in Tolshy village. It is more difficult to find tree hollows with *Myotis*. Panutin (1970) also wrote that the ratio of *N. leisleri* was probably undervalued in his sample. However, the relative abundances currently and in the past look very similar. We could conclude again that strictly protected management at the forest reserve area has conserved the bat species relative abundance for years. Semiferal cats could impact the house-dwelling summer bat populations even in core of strictly protected areas, not only in urban areas (Russo and Ancillotto, 2015).

Panutin (1970) gave data on the density of bat summer (July) populations in the vicinity of Tolshy village per 1 km^2. They were: *M. brandtii* – 10–15 individuals, *M. dasycneme* – 15–25, *N. noctula* – 75–80, *N. leisleri* – 8–10, *P. nathusii* – 150–250, *P. pygmaeus* – 100–200, *V. murinus* – 50–100, and *Pl. auritus* – 10–15. Three hundred bats captured in the vicinity of Tolshy village (total area of about 5 km^2) could be less than 10% of the local population. We think than this estimate is an important addition to the mist-netting methodological approach (Vlaschenko and Gukasova, 2009; Gukasova and Vlaschenko, 2011). It total, during 17 days of fieldwork in 2013, we caught an equal number of bats to that caught by researchers in the 1960s in a whole summer season.

The sex ratio in adult bats described by Panutin (1970) was not detailed. More information on this for the Voronezhsky Reserve was presented in the papers of Lavrov (1953) and Strelkov (1999). It was noted that the main difference in results of sex ratio in bat summer populations is a result of differing collection methods, mist-netting and catching from roost sites (Strelkov, 1999; Vlaschenko and Gukasova, 2009). The adult males live separately from the nursery colonies and are rarely caught by researchers studying the roost sites. Conversely, mist-netting allows adult males to be caught in a more natural ratio. Previously, adult females only were recorded for *N. leisleri*, *P. pygmaeus*, and *Pl. auritus* (Lavrov, 1953). In this study we added data on adult males for the local summer population for *N. leisleri* and *Pl. auritus*. The percentage of adult females has been recorded for the following species: *M. brandtii* (99.1% (Lavrov, 1953)), *N. noctula* (98.2% (Lavrov, 1953) and 90%–95% (Panutin, 1980)), *P. nathusii* (99.5% (Lavrov, 1953) and 97.5% (Strelkov, 1999)), and *V. murinus* (86.8% (Lavrov, 1953) and 75.4% (Strelkov, 1999)). In most cases in our study we got a lower percentage of adult females than was known before (Table 4). For *V. murinus* we caught only adult males. In this case, the reasons for this curious result are a small sample size, a methodological error, or coincidence; it is not a real sex ratio for this species. On the other hand, Panutin (1970) described colonies of adult males of *V. murinus* in the Voronezhsky Reserve. Obviously the ratio of adult males of the northern part of the species range for *V. murinus* is bigger in comparison with other long-distance migratory species.

The absence of big water bodies in the vicinity of Tolshy village is probably reflected in the ratio of semiaquatic bats. *M. dasycneme* is the rarest species and among *M. daubentonii* adults, males dominate. In fact, the Usman River is a suboptimal habitat for these *Myotis* species.

4.3. "Bryansky Les" State Nature Biosphere Reserve

The bat fauna in the "Bryansky Les" Reserve and in the Bryansk region has been well studied (Glushkova et al., 2004; Sitnikova et al., 2009), especially compared with most other regions of European Russia. In this study we confirmed 8 of 11 bat species known for the reserve. We worked in the natural part of the reserve, away from settlements. For this reason we did not capture house-dwelling bats such as *E. serotinus*, *E. nilssonii*, and *P. kuhlii*. We caught 2 bats with the morphological features of *M. mystacinus* but genetically they were confirmed as *M. brandtii*; identification was more difficult as they were females. *M. mystacinus* is not known for the Bryansk region but it was recorded further north in the Smolensk, Tver, and Moscow regions (Gukasova et al., 2011; Glushkova and Fedutin, 2002; Kruskop and Pozhidaeva, 2014). All examples of *P. pipistrellus* s.l. captured by us were identified as *P. pygmaeus* s.str. on the basis of complex morphological peculiarities (Dietz and von Helversen, 2004; Dietz et al., 2009). The bat species relative abundance for the reserve, with forest-dwelling species dominating, is typical for woodland areas. The data on sex ratio in adult bats significantly completes the picture of the sex ratio of bats in European Russia. During our study, adult males of *N. noctula* were captured for the first time on the territory of the reserve (Table 2). The sex ratio among subadult bats does not significantly differ from 1:1, which is typical for European bats (Strelkov, 1999; Rakhmatulina, 2000).

4.4. Oksky State Nature Biosphere Reserve

The period of intensive study of bats in the reserve was from 1984 to 1990 (Ivancheva and Ivanchev, 2000). In that period, 9 bat species were confirmed (*M. daubentonii*, *M. dasycneme*, *N. leisleri*, *N. noctula*, *N. lasiopterus*, *P. pipistrellus* s.l., *P. nathusii*, *V. murinus*, and *Pl. auritus*), and one (*E. nilssonii*) was described based on previous literature (Alexandrov and Morozov, 1982). In this study we confirmed 7 species (*M. daubentonii*, *M. dasycneme*, *N. leisleri*, *N. noctula*, *P. nathusii*, *V. murinus*, and *Pl. auritus*) from the previous list. All examples of *P. pipistrellus* s.l. captured by us were identified as *P. pygmaeus* s.str. on the basis of complex morphological peculiarities (Dietz and von Helversen, 2004; Dietz et al., 2009). We caught and genetically confirmed *M. brandtii* and *M. mystacinus*. In previous studies it was noted that this species group needed validation for the reserve area (Ivancheva and Ivanchev, 2000). We have not confirmed the presence of *N. lasiopterus* or *E. nilssonii* in our study. In a previous paper on the Oksky Reserve (Ivancheva and Ivanchev, 2000), the authors expressed an opinion about the possible wrong identification of *E. nilssonii* by preceding researchers (Alexandrov and Morozov, 1982). We have also not confirmed this species. As the result, the current list of bat species in the Oksky State Nature Biosphere Reserve could include 10 or even 12 bat species. In relation to bat species recorded for all the Ryazan region (Ivancheva and Ivanchev, 2000), only *M. nattereri* was not recorded in the reserve.

The bat species relative abundance for Lipovaya Gora in the reserve, characterized by dominant forest-dwelling species, is typical for woodland areas of middle European Russia (Gukasova et al., 2011; Dudorova et al., 2014) and north (Gashchak et al., 2013) and northeastern Ukraine (Vlaschenko and Gukasova, 2009; 2010; Prylutska, 2014). One of the particularities of relative species abundance in Lipovaya Gora is the high ratio (Figure 4) of semiaquatic (Strelkov and Il'in, 1990) species (*M. dasycneme* and *M. daubentonii*). The presence of a nursery colony of *M. dasycneme* in the Lipovaya Gora cordon confirms the breeding status of this bat in the reserve, as before this species was known only through a record of a single male (Ivancheva and Ivanchev, 2000). The pattern of spatial sex-age group distribution of the species needs to be studied more in the future. We could hypothesize that breeding groups of *M. dasycneme* prefer the area closer to Oka River because the Oka is much bigger than the Pra, and the floodplain has the more open water needed by this species (Dietz et al., 2009). On the other hand, difference in sex spatial distribution could be explained by the short duration of mist-netting in Brykin Bor.

The data on sex ratio in adult bats improve the picture of the sex ratio of bats in the area of European Russia. The sex ratio among subadult bats does not significantly differ from 1:1, which is typical for bats (Strelkov, 1999; Rakhmatulina, 2000).

4.5. Status of *M. mystacinus, P. pygmaeus* and *E. nilssonii*

Besides *N. lasiopterus*, we need more information on the distribution of 3 other species, *M. mystacinus*, *P. pygmaeus*, and *E. nilssonii*, in European Russia and Ukraine. Results of this study confirm that *M. brandtii* is a more common species in woodlands of European Russia than *M. mystacinus*, which is patchily distributed and less numerous (Strelkov and Buntova, 1983; Il'in et al., 2002; Gukasova et al., 2011; Kruskop and Pozhidaeva, 2014).

The current data suggest that east of the Dnieper River (central Ukraine) *P. pipistrellus* s.l. is represented by *P. pygmaeus* (Kruskov, 2007; Vlaschenko and Gukasova, 2009, 2010; Vlaschenko et al., 2012; Gashchak et al., 2013). The absence of *P. pipistrellus* s.str. in this area is questionable. There are unidentified individuals that could be *P. pipistrellus* (Kruskov, 2007) and there are some records of echolocation calls at 44 kHz frequency. Individuals that could be positively identified as *P. pipistrellus* were recorded in the Ukrainian Crimea (unpublished) and were noted for the Caucasus only (Kruskov, 2007). Our conclusion is that the distribution of *P. pipistrellus*/*pygmaeus* is quite opposite to the species distribution on maps shown by Battersby (2010).

E. nilssonii is distributed widely in European Russia from the forest-steppe zone of the Volga River (Il'in et al., 2002) or the Caucasus (Il'in et al., 2002) in the south to the high latitudes in the north (Bogdarina and Strelkov, 2003); in some locations, it is the most common species (Smirnov et al., 2013). However, the species is distributed patchily and there are many regions (Il'in et al., 2002) and areas (Albov et al., 2009) in the mid-European Russia where *E. nilssonii* is absent or very rare (Gukasova et al., 2011). It is one more example of a misconception about the distribution of some bat species in European Russia (Dietz et al., 2009; Battersby, 2010).

4.6. Analysis of bat assemblages

The total number of species recorded in European Russia and Eastern Ukraine amounts to 15 (if *P. pipistrellus/pygmaeus* counts as one) (Strelkov and Il'in, 1990; Vlaschenko, 2006). The biggest species number was in the Voronezhsky and Oksky Reserves and the b/h and Shannon–Wiener indexes were also higher. This result could be due to local habitat types in each mist-netting site. On the other hand, we could interpret it more speculatively and hypothesize that in the reserves with a longer history of strictly protected management bat assemblages are more abundant and rich. This hypothesis could be tested in the future by more sampling. However, it is a good contribution to the current literature to use bats as a bioindicator group among vertebrates (Jones et al., 2009; Russo and Jones, 2015). Unlike the b/h and Shannon–Wiener indexes, the evenness index was similar for all 3 reserves.

The species relative abundances and b/h indexes in this study could be compared with locations where we did mist-netting using the same methodological approach. There were locations from boreal forest in the Smolensk region (Russia) in the north (Gukasova et al., 2011) through the forest nature zone in the Chernobyl Zone (Ukraine) (Prylutska, 2014) to 2 oak forests on the south border of a forest-steppe nature zone (Kharkiv region, Ukraine) (Vlaschenko and Gukasova, 2009, 2010). All these bat assemblages were similar, with a dominance of *N. noctula* (40% to 70%) and a general dominance of long-distance migratory bats (from 98.3% in the Chernobyl Zone to 65.3% in the Oksky Reserve). The rate of *Myotis* species depends on the presence or absence of rivers and lakes in each location of mist-netting. The rate varies from the total absence of *Myotis* species in the Chernobyl Zone, where only one little stream is flowing, to 33.7% of these species in the Oksky Reserve on the bank of one of the biggest rivers in European Russia. The rate of *Pl. auritus* was the highest in the Oksky Reserve (Table 3) and in all other locations it was no more than 2.5%. The rate of *V. murinus* increases from the south to the north, from less than 1% in the south of the forest-steppe zone to 17.5% in the Smolensk region. The ratio of *P. pygmaeus* and *P. nathusii* changes inversely; the first species is more abundant in the south and the second more abundant in the north. *V. murinus* and *P. nathusii* are probably found in higher latitudes than *P. pygmaeus* (Hutterer et al., 2005). The highest rate of *N. leisleri* is in the middle of the south-north gradient at 51°N (17% in Chernobyl Zone and Voronezhsky Reserve; see Table 3).

The highest b/h index was in the south, in the forest-steppe zone (6.08 and 3.98 in the Kharkiv region and Voronezhsky Reserve, respectively; see Table 3) where forests were like islands (not more than 70,000–80,000 ha) surrounded by agriculture or settlements, and all forest-dwelling bats were concentrated in these forests. In the forest nature zone where woodlands cover most of the land and bats could be distributed more randomly, the b/h index was smaller (3.12 in the Chernobyl Zone and in "Bryansky Les" and Oksky; see Table 3). In boreal forests of Smolensk the index was 2.17.

In conclusion, we confirm Strelkov's (1997) idea about the forest areas of Eastern Europe as the main breeding region for most long-distance migratory species for Eastern and Central Europe. Our comparison of the bat assemblage structure in the Voronezhsky Reserve in the past and currently showed that in strictly protected forest areas the assemblages have been stable for decades. Such protection management is an excellent way for ensuring the long-term conservation of the breeding part of species' ranges. However, these efforts could be ineffective if a significant part of the population is killed by wind turbines on migration routes (Lehnert et al., 2014; Voigt et al., 2015). The next research steps will be: 1) broader research on migration routes with a focus on those from European Russia through Ukraine and Moldova to Bulgaria, Romania, and Turkey, as the idea of such a research program was proposed by Hutterer et al. (2005) but has not yet been realized; 2) continuation of study of *N. lasiopterus* in Eastern European forests, which includes a focus on testing which method is better, acoustic recording or mist-netting; and 3) future monitoring of summer bat forest assemblages in Eastern Europe and additional data from management forests.

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