

Biogeography of the serotine bat *Eptesicus lobatus*: a hypothesis on Caucasian roots based on morphological data

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ZAGORODNIUK, I., KANDAUROV, A. Biogeography of the serotine bat *Eptesicus lobatus*: a hypothesis on Caucasian roots based on morphological data. — A brief information is presented on the history of description, type locality, morphological and ecological features of *Eptesicus lobatus* described in 2009 from the east of Ukraine. The key features that are important for analysis in this work are related to the exceptional synanthropy of this form, its absence in the fauna of the region 50–70 years ago, the presence of a distinct post-calcarial lobe on the spur (PCL). Samples of Kazakh-Turkmen *E. turcomanus* and North Caucasian *intermedius* and Caucasian *E. serotinus* (s. l.) were considered in search for possible "donor" populations and regions. A description of a sample of the synanthropic form of *E. serotinus* (s. l.) from Gardabani (Kvemo Kartli region) is given. This form is generally similar in size to *Eptesicus lobatus*, and the morphology of the PCL is quite similar to it, although the degree of development of the PCL in some specimens is negligible. The obtained morphological data and biogeographic reconstructions on this basis support the hypothesis on Caucasian roots of *Eptesicus lobatus*.

Introduction

For many years, the genus *Eptesicus* and its "central" species *E. serotinus* remained on the sidelines of extensive taxonomic revisions, which mainly concerned small-sized bats of the genera *Myotis*, *Pipistrellus*, and *Plecotus* (Barlow *et al.* 1997; Mayer & Helversen 2001; Helversen *et al.* 2001; Zagorodniuk 2005). The genus *Eptesicus* remained out of interest and systematics assumed that, instead of differentiation, extensive interspecific hybridization takes places within the genus (Artyushin *et al.* 2009). A significant milestone was the description of the Iberian-Maghreb *E. isabellinus* as a separate species (Ibáñez *et al.* 2006), as well as the amassment of facts on the heterogeneity of the Eastern European forms, some of which did not fit into the diagnosis of *E. serotinus* s. str. and were described as *E. lobatus* (Zagorodniuk 2009). This work is devoted to the presentation of the taxonomic history and the supposed geographical distribution of the easternmost European form of *E. serotinus* (s. l.), described as *Eptesicus lobatus* from the east of Ukraine, and testing the hypothesis about possible Caucasian origin of this form.

Taxonomic history of *Eptesicus lobatus* and hypothesis of origin of its East European populations

One of the key features indicating the heterogeneity of the East European populations is that their south-eastern forms (mainly from the Donbass) turned out to be noticeably different from the nominative European form by the morphology of the post-calcarial lobe (back-spur flap, PCL). Due to the development of the post-calcarial lobe, they did not fit not only into the diagnosis of the species *Eptesicus serotinus*, but also into the diagnosis of the genus *Eptesicus* in general.

An analysis of the variability of the post-calcarial lobe in the European bats, with particular attention to the species *Eptesicus serotinus* (s. lato), was presented in 2009 (Zagorodniuk 2009). In that work, based on the results of the revision of morphological data, it was proposed to separate the south-eastern forms into an independent species *E. lobatus*¹. The range of the new species known at the time of description covered the eastern and southern regions of Ukraine, and it was assumed that the species also occurs in adjacent regions: in Rostov region, Ciscaucasia, and, possibly, in the Caucasus (Zagorodniuk 2009).

The Luhansk populations of *Eptesicus serotinus* (s. lato), in addition to their specific morphology, are characterized by two more features: this species (and the genus in general) was not noted for this region in publications 50 years ago or earlier (Zagorodniuk 2012), all new records of serotines in the region are synanthropic, and its all known shelters are artificial, mainly in human buildings (Zagorodniuk 2006, 2012). These two features indicate that the species (populations) are alien to the region. Since the rest of the territory of Ukraine has been studied in detail for the presence of "lobatus", and from the well studied western terrains the "lobatus" form could not appear, the only hypothesis is the expansion of *lobatus*-type bats from the east or south east. In other words, from the Volga or the Caucasus region.

This hypothesis is supported not only by the previous absence of the species in eastern Ukraine, but also by the fact that the species is described for adjacent regions as being in a state of expansion (Zagorodniuk 2006). Such facts of expansion to the north were noted in many regions of Eastern Europe, including the Non-Black Earth Region (Vlasov 1995), the Volga Region (Strelkov 2004), and Polissia (Zagorodniuk 2006; Savarin 2008). The species is a relatively recent invader (about 1930) in the territory of the adjacent Kharkiv Oblast of Ukraine as well (Vlaschenko 2008; Zagorodniuk 2010). It is obvious that *E. lobatus* could appeared in the Donets basin from either the south or the east.

This hypothesis is supported by similar models of invasion into the region by another common synanthropic bat, Kuhl's pipistrelle *Pipistrellus kuhlii* (Zagorodniuk & Negoda 2001). In this work, the authors test the "Caucasian" hypothesis of the origin of East European *Eptesicus serotinus* (s. lato).

¹ Species name "*lobatus*" means in Latin the marginal outgrowth, lobe, in fact post-calcarial lobe.



Fig. 1. The Novo-Ilyenko biostation and its central building, in the roof of which a breeding colony of *Eptesicus lobatus* consisting of 30–50 individuals was found. In the summer of 2014, the biostation was destroyed as a result of hostilities.

Рис. 1. Біостанція Ново-Ілленко та її центральна будівля, в перекритті якої була материнська колонія *Eptesicus lobatus* чисельністю 30–50 особин. Влітку 2014 р. біостанцію було знищено внаслідок бойових дій.

Characteristics of typical *Eptesicus lobatus*

Eptesicus lobatus (Zagorodniuk, 2009). Type locality: biological station Novo-Ilyenko (Fig. 1) and the nearest village Kolesnikivka in Stanichno-Lugansk Raion of Luhansk Oblast, Ukraine. Type series: stored in the Zoological Museum of Lviv University (Zagorodniuk 2009). Vernacular names (Ukrainian) include Donetsk pergach and Khazar pergach (Zagorodniuk & Emelyanov 2012). At the biostation, the colony populates the space between the ceiling and the attic of a stone building; the number of this colony in 2005–2013 was about 30–50 individuals living here all year round (Zagorodniuk 2015). Taking into account the participation of the species in the transmission of rabies (Zagorodniuk & Korobchenko 2011), samples were taken twice (2008 and 2013) and positive results were confirmed in 2013; in the same 2013, the staff of the biological station destroyed the colony, and in 2014 the biological station was also destroyed (Zagorodniuk 2015).

In 2010–2013, studies of taxonomic heterogeneity of East European *Eptesicus serotinus* based on analysis of nuclear DNA were carried out (Godlevska *et al.* 2014). The 18S-ITS1-5.8S region was analysed using the BAT-16S-for1 and BAT-16S-rev1 primer set. Two distinct clades were revealed: “eastern” and “western”, the “eastern form” includes samples from eastern and southern Ukraine, Moldova, and southern Russia, including the Northern Caucasus. Samples of *E. lobatus* and *E. turcomanus* from the Lower Volga Region fall into the “eastern” clade.

An important fact is that the configuration of the known range of *E. lobatus* (after: Zagorodniuk 2009, with additions; Fig. 2) practically coincides with other species for which the directions of expansion were precisely known. These are Kuhl's pipistrelle and Caucasian jay (black-headed form of *Garullus glandarius* s. lato), which can be clearly seen from the distribution maps of these species (Fig. 2)¹. A similar configuration of geographic ranges and similar directions of expansion are also demonstrated by other species, including the yellow wagtails from the group of the black-headed wagtails (*Motacilla feldegg*).

¹ For the jay, the first information was published back in 1979 (Taranenko 1979); this form is designated as “*Garullus glandarius krynicki* Kaleniczenko, 1839”.

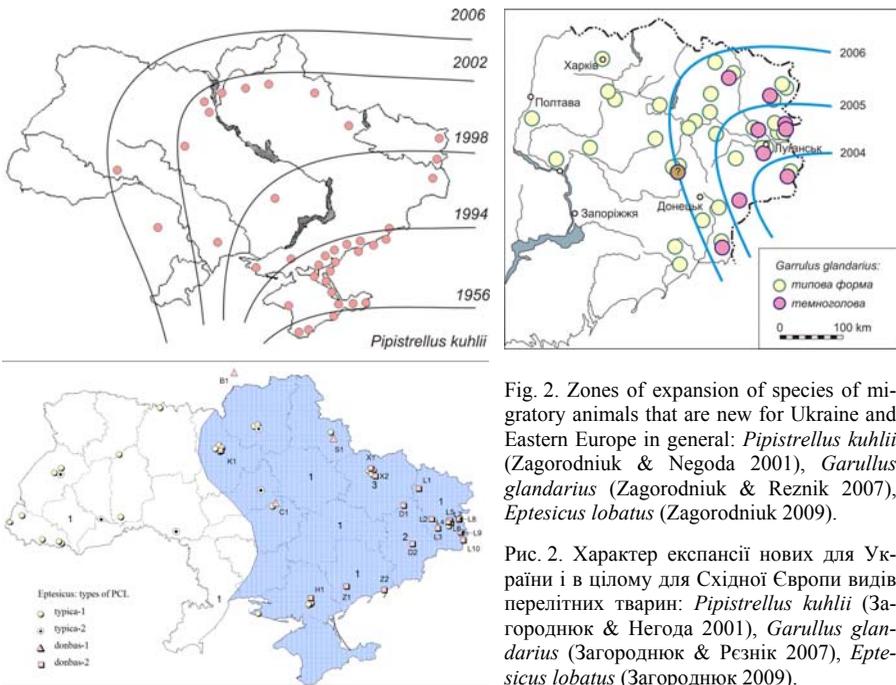


Fig. 2. Zones of expansion of species of migratory animals that are new for Ukraine and Eastern Europe in general: *Pipistrellus kuhlii* (Zagorodniuk & Negoda 2001), *Garrulus glandarius* (Zagorodniuk & Reznik 2007), *Eptesicus lobatus* (Zagorodniuk 2009).

Рис. 2. Характер експансії нових для України і в цілому для Східної Європи видів перелітних тварин: *Pipistrellus kuhlii* (Загороднюк & Негода 2001), *Garrulus glandarius* (Загороднюк & Резнік 2007), *Eptesicus lobatus* (Загороднюк 2009).

“Eastern” hypothesis

To the east of the Donets and Don basin, the subspecies *Eptesicus serotinus turcomanus* is distributed, which was described by Eversmann in 1840 from Kazakhstan, from the territory "between the Aral and Caspian Seas" (Ognev 1928). In the original description, there is no information about the post-calcarial lobe in the *turcomanus* group (as well as the North Caucasian *intermedius* Ognev, 1927) (see: Ognev 1927; 1928); the samples of *turcomanus* we studied also lack it.

The authors, in addition to the descriptions, studied the materials stored in the Zoological Museum of Kyiv University and in the National Museum of Natural History NAS of Ukraine. The sample is small (4 spec.), but it is sufficient to understand the key features. This form has: 1) small body size, particularly forearm length, 2) light (desert) color of the fur, 3) the absence of post-calcarial lobe, and, moreover, developed internal skeleton. At the same time, the samples from the *E. lobatus* range, according to molecular data, clearly tend to the group “*turcomanus*” (Çoraman *et al.* 2013; Juste *et al.* 2013). The following note is important: we use the name “*turcomanus*” for samples from Kazakhstan and adjacent regions of the Trans-Caspian Sea (including Turkmenistan), which corresponds to its descriptions, but in the cited genetic works, the name “*turcomanus*” is used for individuals from Ciscaucasia, the Don region and Volga region.

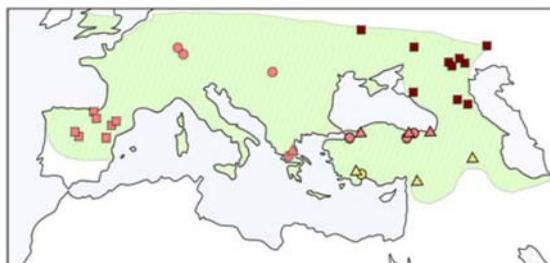


Fig. 4. Distribution of genotypes, one of which (■) should be identified as *lobatus* but it is marked as *turcomanus* (fragment from: Çoğaman *et al.* 2013).
Рис. 4. Поширення генотипів, один з яких (■) має бути ідентифікований як *lobatus*, проте позначений як *turcomanus* (фрагмент із: Çoğaman *et al.* 2013).

As it is clearly seen from the data presented in Fig. 4, the geographic range of different genotypes of *E. serotinus* (s. l.) is distributed so that one of them (dark squares) clearly corresponds to the assumed range of *E. lobatus*.

Materials from the Caucasus

Eptesicus serotinus is a common species in the Caucasus, particularly in Georgia (Bukhnikashvili *et al.* 2004). A separate form of the group *Eptesicus serotinus* was described from the Caucasus — *E. s. intermedius* Ognev, 1927. Type locality: North Ossetia, Vladikavkaz, Murtazovo¹ (Ognev 1927). Pavlinov and Lisovsky (2012) suggested a possible synonymy of *intermedius* Ognev, 1927 and *lobatus* Zagorodniuk, 2009.

The authors of this article examined samples of *Eptesicus serotinus* from Eastern Georgia, from the Gardabani managed reserve in the vicinity of the municipal center of Gardabani, Kvemo Kartli region. All specimens were captured in one place, in the attic of the administrative building of the reserve. The colony had been known since 1987. In total, 14 specimens were captured on 22 June 2012, most of them females, and one male². For each of them, in addition to the general analysis of morphology (including signs of age and length of the forearm), the degree of development and morphological features of the post-calcarial lobe were studied. Photographs were taken on 9 December 2014, clippings from them are shown in Fig. 3.

As one can see, all individuals have an post-calcarial lobe. In many individuals, it is well developed and has a T-shaped crista with a powerful cartilaginous whip directed towards the heel: this whip, like a spring, supports the post-calcarial lobe and covers the control crista muscle. Everything as in typical *E. lobatus*, as described earlier (Zagorodniuk 2009). In some individuals, the post-calcarial lobe is low and the crista in it is poorly developed (type PCL1 in Table 1 contrary to type PCL2)³. In general, the degree of development of the post-calcarial lobe is somewhat lower compared to the sample of *E. lobatus* from the east of Ukraine.

¹ Murtazovo is a railway station in the Mineralnye Vody region, in the city of Terek.

² This sample was collected on the initiative and with the active participation of Ivan Kuzmin and is kept in the Zoological Museum at Ilya University (Tbilisi).

³ Within both types we differ variants 1-/1+ and 2-/2+ (e.g. "pcl2+").

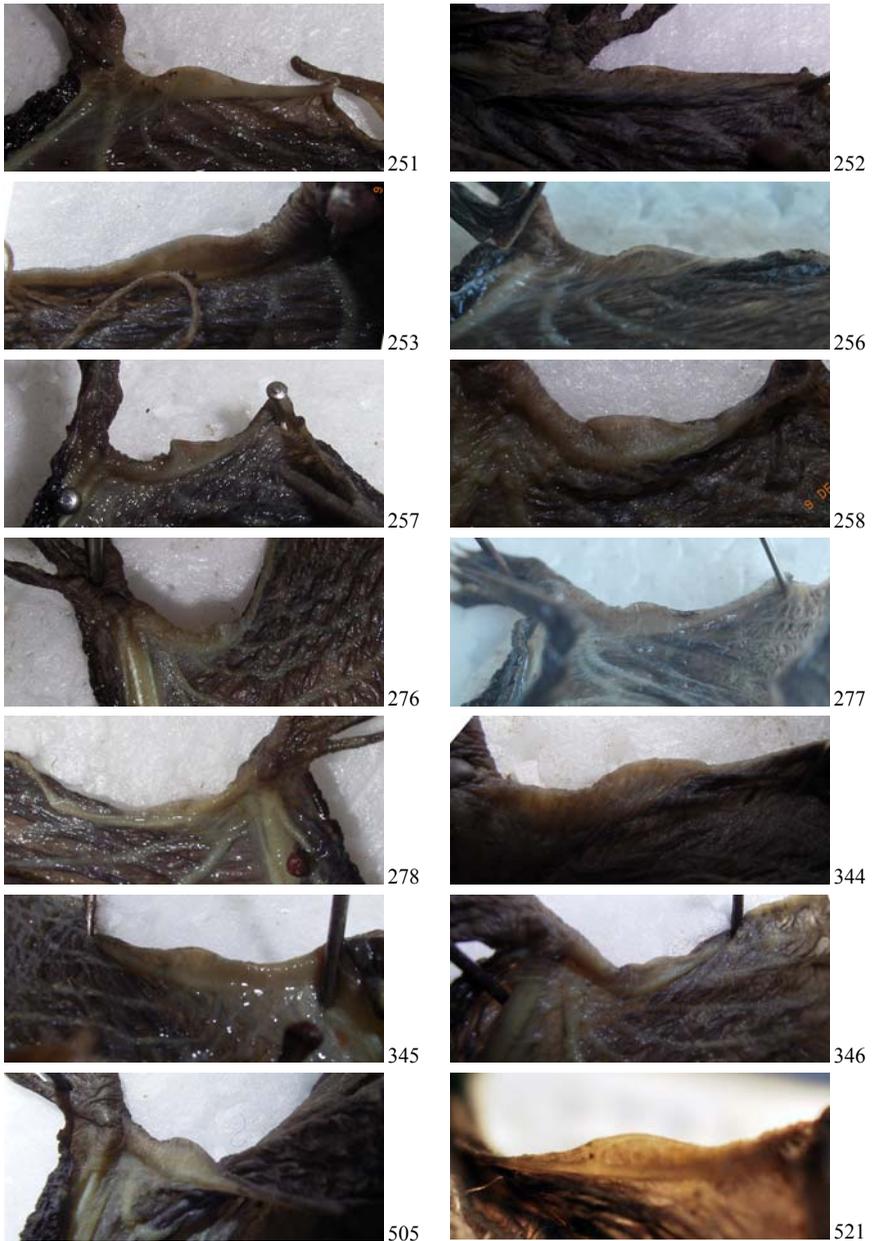


Fig. 4. Morphology of the post-calcarial lobe of *Eptesicus serotinus* from Gardabani: variants of variability in the studied sample of 14 individuals. [Рис. 4. Морфологія епіблеми *Eptesicus serotinus* із Гардабани: варіанти мінливості у дослідженій вибірці з 14 особин.]

Table 1. Development of the post-calcarial lobe (PCL), body weight and forearm length in *E. serotinus* from Gardabani (individual variations)

Таблиця 1. Виразність епіблеми (PCL), вага тіла і довжина передпліччя у вибірці *E. serotinus* з Гардабані (індивідуальна мінливість)

No.	PCL	Sex	Weight	Forearm	No.	PCL	Sex	Weight	Forearm
251	pcl2	f	24	54.5	277	pcl2-	f	25	54.6
252	pcl1-	f	25	53.1	278	pcl1-	f	25	52.6
253	pcl2-	f	22	54.7	344	pcl1-	m	18	47.0
256	pcl2+	f	25	53.6	345	pcl1+	f	24	54.3
257	pcl2-	f	21	50.4	346	pcl1+	f	26	54.1
258	pcl1	f	–	53.0	505	pcl2+	f	24	53.0
276	pcl1	f	24	53.4	521	pcl2-	f	23	53.7

Table 2. Forearm length in *E. serotinus* from Gardabani and Luhansk

Таблиця 2. Довжина передпліччя у *E. serotinus* з Гардабані та Луганська

Sample	min–max	mean + SD	Typical variants of PCL
Gardabani (females)*	50–55 (n = 13)	53.5 ± 1.15	middle development, pcl1- ... pcl2+
Luhansk (females)	51–56 (n = 14)	53.1 ± 1.44	strong development, pcl2- ... pcl2+
Luhansk (males)	50–53 (n = 14)	51.4 ± 0.84	poor development, pcl1- ... pcl2-

* There is only one male in the sample from Gardabani: No 344 with FA = 47.0 mm (see table 1).

The degree of development of the post-calcarial lobe correlates with body size: it is less developed in small-sized individuals, and the pcl2+ variant is noted only in large individuals (Table 2). Earlier, we associated the differences in the degree of its development with sex: in males, which are smaller, it is often less developed (Zagorodniuk 2009). Such correlation with size, possibly, can explain the weak development of the post-calcarial lobe in other forms, particularly in *turcomanus*.

Analysis of the Caucasian hypothesis

Expansions of species often take place in certain directions. For mammals of Ukraine and adjacent countries, the main direction of expansion is the northeast and northwest (Zagorodniuk 2006), that is, for *E. lobatus*, the source of expansion could be Ciscaucasia. A similar vector of dispersal is also demonstrated by other species (see Fig. 2), especially by those prone to synanthropy, e.g. *Pipistrellus kuhlii*.

Of the three groups of facts (morphological similarity, synanthropy, and direction of expansion), one can speak about the close relationship between *E. lobatus* and the Caucasian *E. serotinus* (s. l.). It is also important that these data coincide with the distribution of haplogroups of *E. serotinus* (see Fig. 4; after: Çoraman *et al.* 2013). In addition, there is an important conclusion about the similarity of mtDNA of *turcomanus* with South Russian *serotinus* (in fact, *lobatus*) and about their "huge" difference from West European *serotinus* (s. str.) (Artyushin *et al.* 2009, 2012).

In the future, the name "*lobatus*" will be replaced to the name of one of the adjacent previously described forms. Most likely this will be "*intermedius* Ognev, 1927" from North Ossetia (Ognev 1927), but in its original description there is no information about the post-calcarial lobe as in modern descriptions (Smirnov & Kurmaeva 2011). By craniology, this form is equally separated from the Russian "*serotinus*" s. l. (essentially *lobatus*) and Transvolga *turcomanus* (ibid.).

Thus, morphological data, based on which *E. lobatus* was described, indicate its similarity to the Caucasian *E. serotinus* (s. l.). This similarity allows to explain the possible pathways for the formation of the *E. lobatus* range, the type locality of which is located in the zone of recent expansion of this form into the region of eastern Ukraine. This conforms to data on genetic variability of *E. serotinus* (s. l.).

The information available to date suggests that the range of the "*lobatus*" type of *E. serotinus* (s. l.) extends from north-eastern Ukraine to the Volga region and intermontane valleys between the Greater and Lesser Caucasus.

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Резюме

ЗАГОРОДНЮК, І., А. КАНДАУРОВ. Біогеографія пергача *Eptesicus lobatus*: гіпотеза про кавказьке коріння на основі морфологічних даних. — Наведено стислу довідку про історію опису, типове місцезнаходження, морфологічні та екологічні особливості *Eptesicus lobatus*, описаної 2009 року зі східної частини України. Ключові особливості, важливі для аналізу у цій праці, пов'язані з виключною синантропністю цієї форми, її відсутності у фауні регіону ще 50–70 років тому, наявністю виразної епіблеми на шпорі. У пошуках можливих «донорських» популяцій і регіонів розглянуто вибірки казахстансько-туркменських *E. turcomanus* та північнокавказьких *intermedius* та кавказьких *E. serotinus* (s. l.). Наведено опис вибірки синантропної форми *E. serotinus* (s. l.) з Гардабані (край Квемо Картли). Ця форма загалом подібні за розмірними показниками з *Eptesicus lobatus*, а за морфологією епіблеми цілком збігається з нею, хоча ступінь розвитку епіблеми у частини зразків є незначним. Отримані морфологічні дані і біогеографічні реконструкції на цій основі підтримують гіпотезу про кавказьке коріння *Eptesicus lobatus*.