New records of *Suncus etruscus* (Soricidae, Mammalia) and its current status in Bulgaria

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Abstract: We present 17 new records of *Suncus etruscus* in Bulgaria, and the first finding of the species north of Stara Planina Mountains. The species is recorded in the diet of three owl species – *Tyto alba*, *Asio otus* and *Athene noctua*, and one bird of prey – *Aquila heliaca*. The bulk of records originated from *T. alba*, in the rest raptor species it is taken randomly and consists negligible part of their diet. Additionally, five dead shrews were used, which provided hard evidence for the presence of *S. etruscus* in north Bulgaria. All data on the species distribution in Bulgaria are summarised and the roads for its invasion are discussed. Climate change is considered as an expansion trigger for spreading of the Etruscan shrew.

Keywords: climate change, distribution, Etruscan shrew, expansion, owl pellets

Introduction

The Etruscan shrew (*Suncus etruscus* Savi, 1822) is one of the smallest living mammals in the World, with a weight of 1.2–2.3 g. (Burgin & He, 2018). Because of its small size, it is difficult to study its ecology and biology with traditional methods for small mammal research – different models of live traps (Longworth, Sherman, Trip-Traps etc.) or snap traps. It is too small to trigger the traps, however, some improvements and modifications of traps have been made (Vogel, 2012). One of the best methods for mapping its distribution is the study of owl pellets (Kahmann & Altner 1956, Lipec & Kryštufek, 1991, Popov et al., 2004). 

In Europe, it is strictly confined to the Mediterranean belt, including many islands (Spitzenberger, 1990; Libois & Fons, 1999). The distribution of *S. etruscus* is often explained via simple climatic factors such as isotherms. Kahmann & Altner (1956) suggest that its distribution is limited by mean annual isotherms of +12 °C. This viewpoint is adopted by Popov & Nijagolov (1991) for Bulgaria as well. According to Libois & Fons (1999) its distribution is limited to the mean July isotherm of 20 °C, while Lipec & Kryštufek (1991) propose that it is limited to the mean January isotherms of 0 °C. Vohralík & Sofianidou (2000) argue that such a simplification to only one climatic factor determining its distribution is unlikely, and some biological factors as competition with other shrews might limit its distribution.

The Etruscan shrew was first time found in Bulgaria relatively soon by Vohralík (1985) who reported a dead individual found near Burgas in 1980. Later, Popov et al. (2004) summarised its distribution (mainly from pellets of *T. alba*) in south-eastern Bulgaria. Since then, many new materials have been accumulated in different regional studies of small mammals or the diet of owls. This paper aims to provide new data about the distribution of *S. etruscus* and to
summarise and analyse all available information about it in Bulgaria.

Material and methods

During the period 2000–2023, we collected and analysed pellets and food remains from different birds of prey, and owls from various parts (mainly from the northeast and southeast) of Bulgaria. In total – 50173 individuals of small mammals are found in the pellets and food remains of the following species: the barn owl (*Tyto alba* Scopoli, 1769) – 38811 small mammals, from 108 localities; the eagle owl (*Bubo bubo* Linnaeus, 1758) – 168 from 5 localities, tawny owl (*Strix aluco* Linnaeus, 1758) – 569 from 7 localities; little owl (*Athene noctua* Scopoli, 1769) – 2230 from 35 localities; long-eared owl (*Asio otus* Linnaeus, 1758) – 6145 from 23 localities; long-legged buzzard (*Buteo rufinus* Cretzschmar, 1829) – 643 small mammals from 31 localities; and eastern imperial eagle (*Aquila heliaca* Savigni, 1809) – 1607 small mammals from 30 localities. Owl pellets are good and reliable tool for studying small mammal communities and detecting rare species (Heisler et al., 2016) and particularly *S. etruscus* (Kahmann & Altner, 1956; Lipej & Kryštufek, 1991). Some additional material from three dead shrews found in the vicinity of Samovodene Village (Veliko Tarnovo District, 1.04.2024, N 43.128426, E 25.578186, elevation – 322 m), and two shrews collected with pit-fall traps from Cape Emine along the Black Sea Cost – Irakli (NH73, 15.08.2010, N 42.758339, E 27.892144, elevation – 34 m) and Obzor City (NH74, 30.03.2010, N 42.783881, E 27.896111, elevation – 11 m), were used. The shrews from Samovodene Village were found mummified on the ground. The shrews are preserved in 96% alcohol and deposited in the mammalian collection of the National Museum of Natural History – Sofia (NMNHS), and in the zoological collection of the University of Forestry. Skulls were extracted and cleaned with dermestid beetles. On the upper jaw 4 unicuspids are visible, a characteristic feature that distinguishes *Suncus* from *Crocidura* shrews. Determination of materials is done following Peshev et al. (2004) and craniometrical data presented by Popov et al. (2004).

Data visualisation is performed using ArcGIS 10.3.1 (ESRI, Redlands, CA, USA) and mean annual temperature (BIO1) from WorldClim 2 (Fick & Hij-
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**Results**

Remains of *S. etruscus* were uncovered from pellets of *T. alba, A. otus, A. noctua* and *A. heliaca* (Table 1). The bulk of records came from *T. alba* pellets. The Etruscan shrew was found in 71 localities (UTM 10×10 km square) in Bulgaria as 17 of them are new ones and most are close to already reported localities in the south-eastern part. The relative abundance of *S. etruscus* varies between 0.86–13.51% from all identified shrews in the samples, with an average of 2.27% of the shrews in samples consisting of more than 100 shrews. Among the other found shrew species are *Crocidura sueaveolens* Pallas, 1811, *C. leucodon* Hermann, 1780, *Sorex minutus* Linnaeus, 1766, *S. araneus* Linnaeus, 1758 and *Neomys milleri* Mottaz, 1907. The Etruscan shrew was a negligible part from the diet (<0.06%) of *A. otus, A. noctua* and *A. heliaca*, it was presented by a single individual. Despite the large sample size, we did not find *S. etruscus* in the diet of *S. aluco, B. bubo* and *B. rufinus*.

The Etruscan shrew was recorded for the first time from the Eastern Rhodopes Mountains – Malki Voden Village (UTM – MG11), and from the foothills of the mountain – Malko Gradište (MG12) and Slaveevo Village (MF29).

The records of *S. etruscus* from north Bulgaria should be highlighted – Samovodene Village (LH87) and Maslarevo Village (LG37). These are the first records of the species north of Stara Planina Mountains.

The presented current distribution of *S. etruscus* (Fig. 1) includes our new data and published ones.

Fig. 1. Current distribution of *Suncus etruscus* in Bulgaria projected onto isothermal zones categorised according to their annual mean temperature.
Vohralík, 1985; Popov & Nijagolov, 1991; Vohralík & Sofianidou, 2000; Popov, 2000; Popov et al., 2004; Georgiev, 2004; Georgiev, 2005; Stoyncheva & Georgiev, 2005; Milchev et al., 2006; Milchev, 2012; Nedyalkov & Koshev, 2014; Milchev, 2022; Nedyalkov et al., 2023). All records, even those from the northern part of Bulgaria, are within the annual isotherms of +12 °C (Fig. 1). It seems this simple climatic factor could explain much of the species distribution.

Discussion

Despite its small size and imperfect thermoregulation, the Etruscan shrew shows great invasion and dispersal ability. For a long time it remained unclear and questionable the origin of *S. etruscus* in Europe, as several hypotheses were applied (Garcia et al., 2020). The recent revision of paleontological materials (Garcia et al., 2020) revealed its Asian origin, and that the species arrived in Europe via the Eastern Mediterranean area approximately 4000 years ago (Late Holocene). This colonisation route is also supported by genetics (Castiglia et al., 2023).

There are no fossil records from Bulgaria (Popov, 2018), unfortunately, there are a few Holocene sites with small mammals from south Bulgaria and the archaeological sites are not adequately sampled for small mammals.

According to Popov et al. (2004) *S. etruscus* invaded Bulgaria via the valleys of the Maritsa and Tundzha rivers, but not along the Black Sea Coast. The species occurs in the lowlands of SE Bulgaria – Thracian Valley and most of the records are along the basin of these two rivers. Our new records showed that *S. etruscus* has been also using the valley of the Arda River to penetrate the Eastern Rhodopes Mountains – supported by our records from Slaveevo (MG11) and Malki Voden (MG29). The Eastern Rhodopes are characterised by the Mediterranean climate and biota (plants and animals) spreading through the Arda River Valley (Gruev & Kuzmanov, 1999). Other Mediterranean species found in the area are Roach’s mouse-tailed dormouse (*Myomimus roachi* Bate, 1937), found together with *S. etruscus* in Malki Voden (MG11) (Nedyalkov, 2013) and Harting’s voles (*Microtus hartingi* Barrett-Hamilton, 1903) widely distributed and common in the lower part of Arda River (Ivailovgrad District).

The Balkan Mountains (Stara Planina) is a long mountain chain (560 km) with a width between 15–45 km and a mean height of 722 m (the highest peak – 2376 m). It stretches east-west across central Bulgaria serving as a bioclimatic barrier and dividing the country into two well-defined parts – southern with a Mediterranean (or sub Mediterranean) climate (excluding the high mountains), and northern – with a moderately continental climate (Kopralev, 2002). Stara Planina is a biological barrier and prevents the free exchange of plants and animals (Gruev & Kuzmanov, 1999).

One of the potential routes for invasion in north Bulgaria is via the mountain pass – Pass of Republic (highest point 700 m) and the valley of Belitsa and Yantra rivers, as both our records from the north are within or close to the valley of Yantra River. The highest record of *S. etruscus* from the Balkans is about 600 m (Vohralík & Sofianidou, 2000), but in Anatolia it is found up to 1300 m (Kryštufek & Vohralík, 2001). *S. etruscus* is reported from the southern slopes of Alps in Slovenia (Kryštufek, 2003).

This route is supported by records from the southern slope of Stara Planina – Kazanlak Valley, where the species has been found in owl pellets (Milchev, 2012).

Another invasion hypothesis of north part of Bulgaria includes overcoming of Balkan Mountains trough their edge at Black Sea Coast and subsequently using the Kamchia or Danube valleys to reach the Yantra Valley and the Danubian Plain. Similar distribution patterns could be recognised in a variety of other Mediterranean species (*Pelobates syriacus* Boetteger, 1889, *Testudo graeca* Liannaeus, 1758, *Lacerta trilineata* Bedriaga, 1886, *Pseudopus apodus* Pallas, 1775, etc.) (Stojanov et al., 2011). Our record of the species in the Cape Emine area confirms such a hypothesis. However, it needs to be proved by more extensive work and sampling along the expansion routes.

The reported new records showed a rapid disperse of *S. etruscus* in Bulgaria, as it has managed to pass the main barrier between south and north Bulgaria – Stara Planina, probably it has happened in the last few decades. It seems the species invaded the new territories in Bulgaria via river valleys – Maritsa River, Tundzha River, Arda River and Yantra River. Potential routes for invasion of north Bulgaria are the mountain passes in the eastern part of Stara Planina or along the Black Sea Coast. The expansion of ther-
moxerophilic Mediterranean species as S. etruscus, in areas with continental climate could be driven by climate change and warming of the region. Similar effect is registered on small mammals in Italy, where S. etruscus spread (for over 30 years) to new territories (Szpunar et al., 2008). Owl pellets are a powerful tool for mapping and tracing the distribution of S. etruscus in Bulgaria, more attention, and samples from the north and southwestern part of Bulgaria are needed. According to the map, there is potential suitable conditions for the species in the southwestern part of Bulgaria – valleys of Struma and Mesta rivers. The species is recorded in Greece close to the border (Hellenic Zoological Society, 2023).

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