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Research Article

Terrestrial mammalian fauna (Eulipotyphla, Lagomorpha, Rodentia, Carnivora and Artiodactyla) of the Lozen Mountain, Western Bulgaria

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Abstract: The article summarises up-to-date field data on the terrestrial mammalian fauna of the Lozen Mountain collected using pitfall trapping, live trapping, camera trapping and the transect method. Twenty-seven species of five orders have been recorded between 2005 and 2020: Eulipotyphla (8), Lagomorpha (1), Rodentia (8), Carnivora (8) and Artiodactyla (2). The collected distribution data, the conservation status and the zoogeographic classification of the registered species are presented. In addition, literature sources are also reviewed and discussed. The main threats for the mammals and their habitats on the territory of Natura 2000 site "Lozenska planina" (BG0000165) are emphasised and recommendations for future management and monitoring activities are proposed.

Key words: mammals, Lozen Mountain, BG0000165, species composition, threats

Introduction

The Lozen Mountain covers the westernmost part of the Ihtiman Sredna Gora Mountain. Its boundaries are formed by the Sofia Basin to the North, the Iskar River to the Southwest and the Gabra River to the East (Galabov et al. 1977). The mountain adjoins two large water reservoirs (the Pancharevo Reservoir to the west, the Pasarel Reservoir and the Iskar Reservoir to the south). The highest peak is Popov Dyal (42.5604, 23.5642) with an altitude of 1190 m a.s.l. The ridges of the mountain are above 1000 m a.s.l. Despite its comparatively small area (about 80 km²), the mountain is characterised by a significant floristic diversity comprised of Central European, as well as Mediterranean and Submediterranean elements (Glogov 2017). The varied vegetation and relief provide a diversity of habitats and microhabitats for the animal species. An area of 1294.42 ha in the Lozen Mountain is under the protection of the Natura 2000 network (BG0000165). The southwestern part of the mountain is occupied by the fenced territory of the Iskar Hunting Ranch. Situated in the vicinity of the city of Sofia, the Lozen Mountain has an economic and recreational role, but its biodiversity is threatened by strong anthropogenic impact.

Conservation of habitat and species diversity is of particular importance given the geographical location of the Lozen Mountain, which is an important connection between the Stara Planina Mts. and the adjacent mountains on the one hand, and the Rilo–Rhodope Massif on the other hand. Habitat loss could lead to isolation of populations of species inhabiting forest and/or mountainous habitats. The Lozen Mt. is part of the two migration corridors of the brown bear (*Ursus arctos*) between Rila and Ihtimanska Sredna Gora Mountains (Dutsov et al. 2016).

Far-sighted management of ecosystems re-

quires up-to-date faunistic data concerning all taxonomic groups of plants and animals. Although easily accessible and located in close proximity to the capital Sofia, the biodiversity of the Lozen Mountain is understudied in respect to some taxa such as the terrestrial mammalian fauna. So far, there is no comprehensive faunistic investigation on mammals in the area. Simeonov (1963) have found 13 species of micromammalia in pellets of tawny owls (*Strix aluco* L.). Present-day studies are insufficient: six soricid species (Zidarova 2016) and four rodent species (Metcheva et al. 2019) have been reported for the territory of Lozen Mt. Only fragmentary data on carnivore species are found in the literature (Zlatanova 2010, Gavrilov et al. 2015, Spassov et al. 2015, Doykin et al. 2017). Red deer (*Cervus elaphus* L.), fallow deer (*Dama dama* L.), roe deer (*Capreolus capreolus* L.), wild boar (*Sus scrofa* L.) and mouflon (*Ovis ammon* L.) inhabit the fenced territory of the Iskar Hunting Ranch (Rusev 2010).

The aims of the present study were to explore the terrestrial mammalian fauna in natural and semi-natural habitats of the Lozen Mountain (species composition, distribution patterns, conservation status, zoogeographical characteristics), to reveal the threats for the mammalian species and their habitats and to propose recommendations for future management and monitoring of the Natura 2000 site "Lozenska planina" (BG0000165).

Materials and Methods

Data on the mammalian species in the Lozen Mt. were collected from 2005 to 2020. Several field methods were used: pitfall trapping, live trapping, camera trapping, transects for signs (e.g. prints and scats) and visual observations (Table 1, Fig. 1). A total of 551 individuals of five families of small mammal were trapped using pitfall and live traps: Talpidae – 1, Soricidae – 350, Gliridae – 2, Cricetidae – 112, Muridae

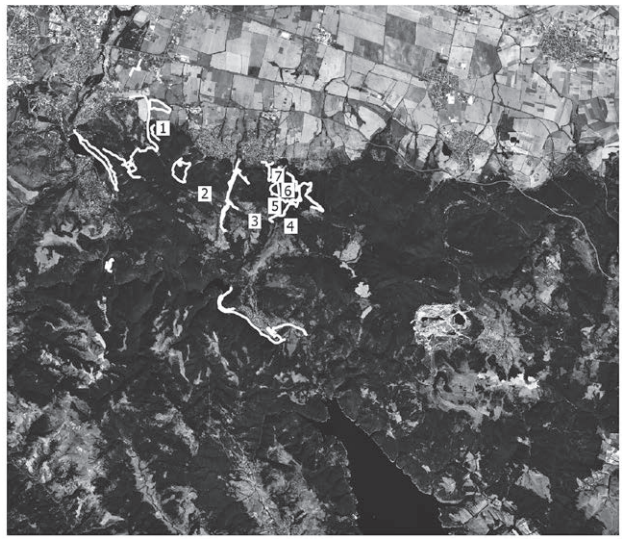

Fig. 1. Map of trapping localities (1-7) and transects (white lines): 1 – ct1; 2 – pt5; 3 – pt4; 4 – pt3; 5 – ct4; 6 – pt1-2, lt1-2, ct3; 7 – ct2 (abbreviations and description of the localities are presented in Table 1).

Table 1. Description of the habitats of the trapping areas and the applied methods. Legend: pt – pitfall trapping, lt – live trapping, ct – camera trapping.

Trapping site	Method	Habitat	Period	Number of traps
pt1	Pitfall traps	Common beech (*Fagus sylvatica*) forest	03.2006–11.2007	11
pt2	Pitfall traps	Banks of a small mountain stream covered with deciduous trees and shrubs in a common beech forest	03.2006–11.2007	10
pt3	Pitfall traps	Meadow with single shrubs and low trees, swampy in spring	03.2006–11.2007	9
pt4	Pitfall traps	Calcareous grassland with juniper (*Juniperus communis*) scrub	04.2016–09.2017	34
pt5	Pitfall traps	Rocky terrain sparsely vegetated by grasses, *Juniperus communis, Quercus* sp., and *Pinus* sp. A former wood-cutting area surrounded by forests of *Fagus sylvatica* to the north and *Pinus* sp. to the south.	04.2016–09.2017	34
lt1	Live traps	Banks of a small mountain stream covered with deciduous trees and shrubs in a common beech forest	19.07–24.07.2005	13
lt2	Live traps	Common beech (*Fagus sylvatica*) forest	19.07–24.07.2005	8
ct1	Camera trap	A strip of broad-leaved shrubs and small trees (in a servitude of a powerline) in a black pine forest	04.2019–07.2019	1
ct2	Camera trap	Mixed broad-leaved forest with predominance of oaks	08.2019–05.2020	1
ct3	Camera trap	Common beech (*Fagus sylvatica*) forest	11.2019–12.2019	1
ct4	Camera trap	Forest habitat: small patches of *Pinus sylvestris* in broad-leaved forests (beech to the north and oak to the south)	02–03.2016	1

– 86. The study covered a variety of forest and open habitats representative for the area. The fieldwork was carried out mainly on the northern slopes and the ridge of the mountain. The southern slopes were explored only in their lower parts using the transect method. All the trapping sites were located within the Natura 2000 site "Lozenska planina" (BG0000165) with the exception of ct_1, ct_2 and pt_3. About 50 % of the transects were made on its territory. The information for the distribution of some rare mammal species was supplemented by questionnaire data and literature data. Data about road mortality were based on registrations of dead animals on the Trakia motorway and its intersections in the study area.

The species determination was based on the keys available in Peshev et al. (2004) and Popov & Sedefchev (2003). Small mammals were identified based on their external morphological characters and, when needed, on their skull characteristics. In order to discriminate between *Apodemus flavicollis* and *A. sylvaticus*, the position of the posterior end of foramina incisiva after PESHEV et al. (2004) was used as a taxonomic key.

The mammalian species were classified to zoogeographical categories according to Popov (2007).

Results

Species composition

Twenty-seven terrestrial mammal species (not including synanthropic species) were found during the study in the Lozen Mt. and its foothills: Eulipotyphla – 8, Lagomorpha – 1, Rodentia – 8, Carnivora – 8, Artiodactyla – 2 (Table 2). The presented list of 32 species also includes two species that are likely to be found, one species with occasional appearance according to the literature data and two species reported in the literature.

Order Eulipotyphla. The order is presented by eight species in the study area (Fig. 2). The northern white-breasted hedgehog (*Erinaceus roumanicus*) and the European mole (*Talpa europaea*) were recorded in forest and open habitats, both in the mountain and in the farmlands at its foot. Six species of the family Soricidae were found. According to the collected data, the most widespread shrew species were *Sorex araneus*, *S. minutus* and *Crocidura suaveolens*. They were trapped in a variety of habitats including beech forest, shrubby pasture, wet meadow and drier grassland. Being absent in the beech forest, *C. leucodon* had a slightly lower ecological plasticity. The Eurasian water shrew (*Neomys fodiens*) was recorded at one locality only – the bank of the Poroyska bara Stream. Its presence is likely in a few places in the mountain that meet its specific requirements, i.e. presence of a freshwater body with year-round water flow. The Miller's water shrew (*N. anomalus*) was trapped in forest and open habitats with relatively high humidity, near a stream in a beech forest and in a seasonally swampy meadow.

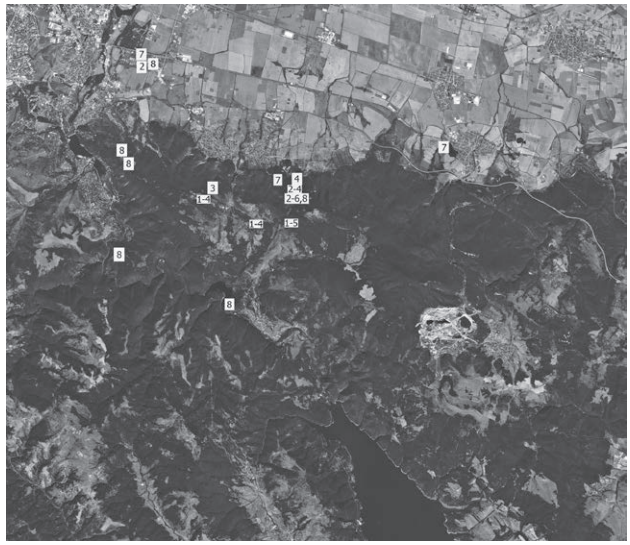

Fig. 2. Registrations of the species of order Eulipotyphla in the Lozen Mt. 1 – *Crocidura leucodon*, 2 – *Crocidura suaveolens*, 3 – *Sorex araneus*, 4 – *Sorex minutus*, 5 – *Neomys anomalus*, 6 – *Neomys fodiens*, 7 – *Erinaceus roumanicus*, 8 – *Talpa europaea.*

Fig. 3. Registrations of the species of order Rodentia and order Lagomorpha in the Lozen Mt. 1 – *Apodemus flavicollis*, 2 – *Glis glis*, 3 – *Lepus europeus*, 4 – *Muscardinus avellanarius*, 5 – *Microtus arvalis sensu lato*, 6 – *Myodes glareolus*, 7 – *Microtus subterraneus*, 8 – *Nannospalax leucodon*, 9 – *Sciurus vulgaris.*

Order Lagomorpha. The brown hare (*Lepus europaeus*) is widely distributed in the area (Fig. 3). The species was recorded in a variety of natural, seminatural and agricultural habitats in the mountain and at the mountain's foot.

Order Rodentia. Eight rodent species were found in the Lozen Mt. during the study (Fig. 3). The red squirrel (*Sciurus vulgaris*) was found in coniferous and broad-leaved forests, as well as in gardens in the adjacent villages. Two species of the family Gliridae were recorded in the study area. The edible dormouse (*Glis glis*) was trapped in a beech forest and the hazel dormouse (*Muscardinus avellanarius*) – in a stream bank's scrub in a beech forest habitat, mixed broad-leaved forest dominated by oaks, as well as in a shrubby grassland on the ridge of the mountain. The collected data showed that the common vole, *Microtus arvalis* (sensu lato), was typical for the grasslands at the mountain's ridge, while the European pine vole (*Microtus subterraneus*) was found both in forest and open habitats. The yellow-necked mouse (*Apodemus flavicollis*) and the bank vole (*Myodes glareolus*) were widespread in the forests and their edges. The lesser blind mole rat (*Nannospalax leucodon*) inhabited the pastures and grasslands at the mountain's ridge and slopes. One species (*Spermophilus citellus*) has recently become extinct in the study area. This rodent inhabited the pastures at the mountain's ridge until 2000 (Stefanov & Markova 2009, questionnaire data).

Order Carnivora. According to the collected data (8 species recorded), the most common carnivorous species in the Lozen Mt. were the marten (*Martes* sp.), the red fox (*Vulpes vulpes*) and the European badger (*Meles meles*; Fig. 4). They were recorded in forest as well as in open habitats at the mountain's ridge, slopes and foot. The golden jackal (*Canis aureus*) was found at the northern and southern lower slopes of the mountain, near settlements. It is common in the mountain's surroundings (author's unpublished data). The least weasel (*Mustela nivalis*) was recorded in forest and agricultural habitats, but the species seemed to be comparatively rare in the study area (only two registrations). The European otter (*Lutra lutra*) found suitable habitat only along the Iskar River, because the streams in the study area are too small and impermanent. However, during that study the species was not registered in the area of the Pancharevo and the Pasarel Reservoirs. The only record (questionnaire data) concerned the Iskar Reservoir. However, it should be emphasised that the river section between the Pancharevo and the Iskar Reservoirs,

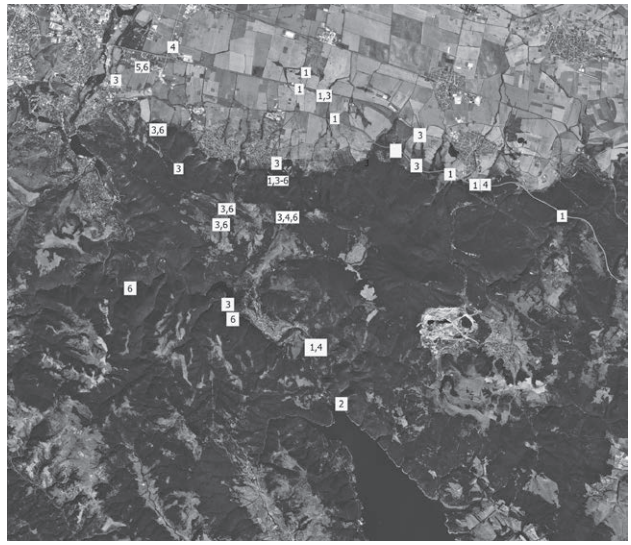

Fig. 4. Registrations of the species of order Carnivora in the Lozen Mt. 1 – *Canis aureus*, 2 – *Lutra lutra*, 3 – *Martes* sp., 4 – *Meles meles*, 5 – *Mustela nivalis* , 6 – *Vulpes vulpes.*

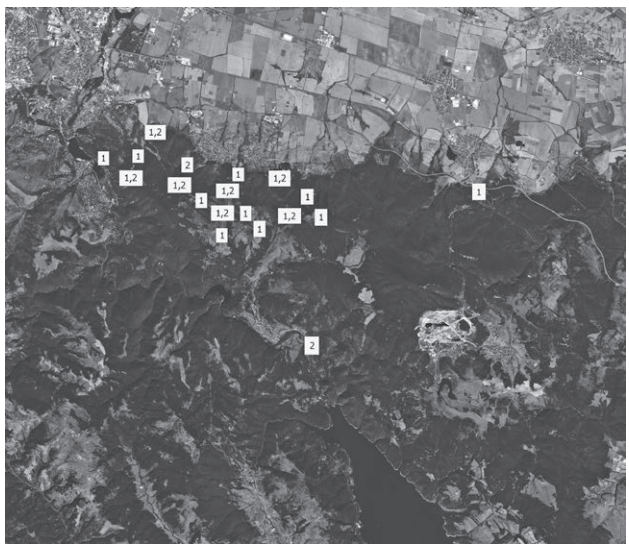

Fig. 5. Registrations of the species of order Artiodactyla in the Lozen Mt. 1 – *Capreolus capreolus*, 2 – *Sus scrofa*.

which is adjacent to the Lozen Mt., is pointed out as a potential site important for the European otter (Georgiev & Koshev 2006). The brown bear (*Ursus arctos*) has occasional appearance in the mountain according to the literature data (Gavrilov et al. 2015, Spassov et al. 2015); this species was observed close to the Pasarel Reservoir from local hunters in 2019 (questionnaire data).

Order Artiodactyla. Two species of this order were found in the Lozen Mt. during the study: the wild boar (*Sus scrofa*) and the roe deer (*Capreolus capreolus*) (Fig. 5). The data showed they both are widespread in the area. The wild boar is one of the

Table 2. Species composition of mammals in the Lozen Mt.: method of registration, conservation status and zoogeographic classification. Legend: pt – pitfall trapping, lt – live trapping, ct – camera trapping, tr – transect method, qd – questionnaire data, ld – literature data; * – species most likely to be found, but their presence has not yet been confirmed; ** – species with occasional appearance/migrants; [1] – for E. *concolor*; [2] – for *E. europaeus*; [3] – for *N. anomalus*. Faunal complexes: EUS – Eurasian steppe complex; NEM – Nemoral faunal complex; MED – Mediterranean faunal complex; BOR – Boreal faunal complex. Faunal elements: SEE – South (East) European; EE – European element; EFE – Eurosiberian forest element; SME – Submediterranean element; ESFE – Eurosiberian forest-steppe element; TRPHE – Transpalearctic or Holarctic element; BSEE – Balkan (and Southeast European) element; WDSA – Widely distributed in southern areas.

Species	Method of registration	Conservation status						Zoogeographic classification	
		D 92/43/EEC	Biodiversity Act	Bern Convention	CITES	BRDB	IUCN	Faunal complex	Faunal elements
Erinaceus roumanicus (Barrett-Hamilton, 1900)	ct, tr		III[1]	III[2]			LC	NEM	SEE
Talpa europaea (Linnaeus, 1758)	pt, tr						LC	NEM	EE
Sorex araneus (Linnaeus, 1758)	pt, tr			III			LC	BOR	EFE
Sorex minutus (Linnaeus, 1766)	pt, tr			III			LC	BOR	EFE
Neomys milleri (Mottaz, 1907)	pt			III[3]			LC	NEM	EE
Neomys fodiens (Pennant, 1771)	pt, lt			III			LC	BOR	EFE
Crocidura leucodon (Hermann, 1780)	pt			III			LC	NEM	SEE
Crocidura suaveolens (Pallas, 1811)	pt			III			LC	MED	SME
Lepus europaeus (Pallas, 1778)	ct, tr			III			LC	BOR	ESFE
Sciurus vulgaris (Linnaeus, 1758)	ct, tr			III			LC	NEM	TRPHE
Dryomys nitedula (Pallas, 1778)	ld	IV		III			LC	NEM	SEE
Glis glis (Linnaeus, 1766)	lt			III			LC	NEM	EE
Muscardinus avellanarius (Linnaeus, 1758)	pt, qd	IV	III	III			LC	NEM	EE
Myodes glareolus (Schreber, 1780)	pt						LC	BOR	EFE
Microtus arvalis (sensu lato)	pt						LC	BOR	ESFE
Microtus subterraneus (de Selys-Longchamps, 1836)	pt						LC	NEM	EE
Arvicola amphibius L. (Linnaeus, 1758)	ld						LC	BOR	EFE
Nannospalax leucodon (Nordmann, 1840)	tr						LC (Eu) DD (Gl)	EUS	BSEE
Apodemus flavicollis (Melchior, 1834)	pt, lt, ct						LC	NEM	EE
Canis aureus (Linnaeus, 1758)	ct, tr	V	IV				LC	MED	WDSA
Canis lupus (Linnaeus, 1758) **	ld	II, V	II, IV	II	II	VU [A1c]	LC	NEM	TRPHE
Vulpes vulpes (Linnaeus, 1758)	ct, tr						LC	NEM	TRPHE
Mustela putorius (Linnaeus, 1758) *	-			III			LC	NEM	EE
Meles meles (Linnaeus, 1758)	ct, tr			III			LC	NEM	TRPHE
Lutra lutra (Linnaeus, 1758)	qd	II, IV	II, III	II	I	VU	NT	BOR	EFE
Mustela nivalis (Linnaeus, 1766)	ct, tr		III	III			LC	NEM	TRPHE
Martes foina (Erxleben, 1777)	ct, tr			III			LC	MED	SME
Martes martes (Linnaeus, 1758) *	-	V	III	III		EN	LC	BOR	EFE
Ursus arctos (Linnaeus, 1758) **	ld, qd	II, IV	II, III	II	II	EN	LC	NEM	TRPHE
Felis silvestris (Schreber, 1777) * – a hybrid recorded during the study	ct	IV	III	II	II	EN	LC	NEM	TRPHE
Sus scrofa (Linnaeus, 1758)	ct, tr						LC	NEM	TRPHE
Capreolus capreolus (Linnaeus, 1758)	ct, tr			III			LC	BOR	EFE

Note: The conservation status of some species has not been updated according to the recent taxonomic studies. These cases are specified in the heading.

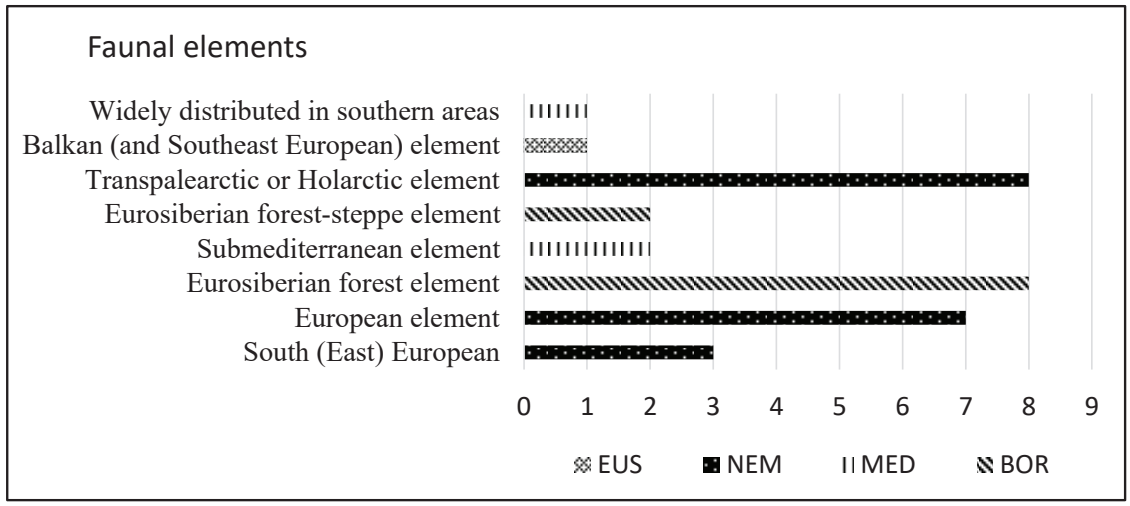

Fig. 6. Zoogeographical structure of the mammalian fauna of the Lozen Mountain, presented as number of species of every faunal element (abbreviations are presented in the heading of Table 1).

main game species. The collected questionnaire data indicated the presence of red deer (*Cervus elaphus*) in the western part of the mountain but it was not confirmed during the fieldwork.

Zoogeographic classification

The mammal fauna of the Lozen Mt. was diverse in zoogeographical terms (Fig. 6, Table 2). Most species belonged to the Nemoral faunal complex associated with mesophilous broad-leaved Palearctic forests, which were widely distributed in the area, as well as to the Boreal complex characterised by species with broad temperature tolerance. A precondition for the strong predominance of such species is the temperate continental climate characterised by warm summer, cold winter, large annual temperature amplitude, spring-summer maximum and winter minimum of rainfall and sustainable snow cover (Velev 2002). A characteristic feature of Lozen Mountain is that it falls into a rain shadow, formed by the higher adjacent mountains, which determines the less precipitation there. Thereby, the open habitats in the mountain's ridge and foot provide suitable conditions also for species associated with comparatively arid and/or warm climates such as the Eurasian steppe and the Mediterranean ones.

Threats

The location and the accessibility of the Lozen Mt. make it highly endangered by various human impacts. A number of activities affect animal populations and lead to destruction of natural habitats. Hunting, poaching and logging (including illegal) are very intense in the area. The last activity concerns predominantly natural beech and oak forests. Open habitats are also changing drastically. Part of one of the most suitable for the lesser blind mole rat habitats in the area was destroyed in 2019 due to the construction of a large residential area at the northwest foot of the mountain.

The human presence is enhanced in most of the mountain's territory and the outdoor activities (tourism, off-roading, construction works, hunting, etc.) lead to disturbance all year round. Feral dogs and cats were repeatedly recorded during the study. The data from camera traps showed that in most cases the roaming dogs are hunting dogs: they cause disturbance and are potential competitors of the carnivore species for food resources. The presence of feral cats creates a risk of hybridisation between the European wildcat (*Felis silvestris silvestris* Schreber 1777) and domestic cats (*F. s. catus*), that has been found in many places in Europe (Oliveira et al. 2008, Say et al. 2012, Nussberger et al. 2014). Genetic hybridisation is considered a serious threat for wild-living animal populations (Rhymer & Simberloff 1996). Multiple domestic cats and no wildcats were recorded in the forest habitats during this study. Only one individual can be considered a hybrid based on its external morphology.

The collected data showed that road mortality is another serious threat for the mammalian fauna of the Lozen Mt. (Fig. 7). Dozens of individuals of eight species were found run over the roads in the area of the Lozen Mt. since 2013. Ten individuals from six species were recorded for 2019 only. Most of the accidents took place on the adjacent section of the Trakia Motorway. This high traffic motorway impeded the free movement of mammals in the area as no wildlife crossing structures had been built in

this section. The most common victims were the jackal and the stone marten. The main road junction points appeared to be the hottest spots in terms of the number of mammalian road kills.

Recommendations for future management and monitoring of the Natura 2000 site "Lozenska planina":

- restrictions on logging, off-roading and the expansion of built-up area in the vicinity of the Natura site;
- hunting/poaching control;
- monitoring and measures for conservation (if needed) of the streams and ponds – limited water sources of great importance for the carnivores and the ungulates, as well as for the Eurasian water shrew;
- well-planned reintroduction of the European souslik in the previously inhabited by the species localities, accompanied by appropriate measures for conservation and management of its habitat, as well as annual monitoring of the species;
- reduction of road accidents on the Trakia Motorway, in the vicinity of the Natura site, by green infrastructure solutions (underpasses, overpasses, culverts) aimed to provide safe movement of mammals through fragmented habitats, thus creating a good connection for migrants between the Lozen Mt. and the other parts of the Sredna Gora Mt.;
- measures to reduce the number of feral dogs and cats.

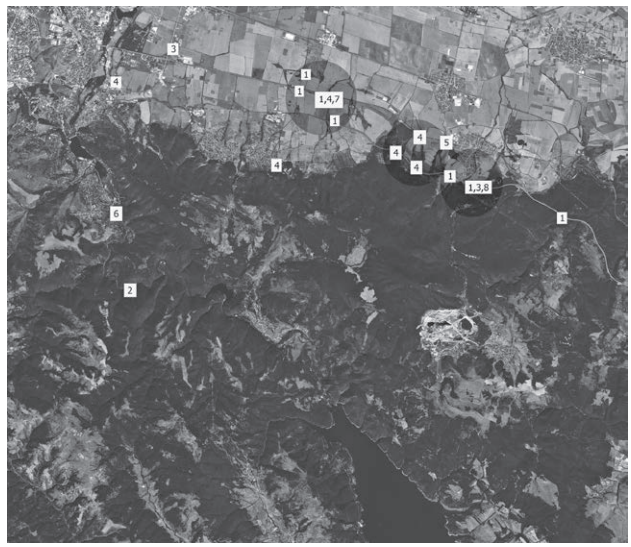

Fig. 7. Registrations of mammals killed by road traffic in the area of the Lozen Mt. 1 – *Canis aureus*; 2 – *Vulpes vulpes*; 3 – *Meles meles*; 4 – *Martes foina*; 5 – *Erinaceus roumanicus*; 6 – *Sciurus vulgaris*; 7 – *Lepus europaeus*; 8 – *Capreolus capreolus*; semi-transparent circles – hottest spots of mammalian road kills.

Discussion

This study presents the most complete data on terrestrial mammals in the Lozen Mt. to date. The species richness in the area was relatively high: 27 species were recorded during the terrain work. One more species is known to appear occasionally on the territory of the Lozen Mt.: the grey wolf, *Canis lupus* (data from the Executive Agency for Forests of Ministry of Agriculture and Food, as well as author's personal data from the adjacent territory in the Plana Mt., only 7 km from the Lozen Mt.). The presence of several species is still uncertain, but it is likely due to the proximity of the Vitosha and Plana Mountains, where they occur. Due to the problematic morphological discrimination between *Martes foina* and *M. martes* and the impossible or questionable discrimination of their scats and tracks, this study evidenced only the presence of the stone marten (photo and video materials from camera traps). Therefore, all the registrations of martens were considered as *Martes* sp. However, the presence of the pine marten in the Lozen Mt. is probable as the species inhabits similar habitats and altitudes in neighbouring territories in the Vitosha Mountain (Doykin et al. 2017). The wild cat (*Felis silvestris*) has also been found there (Petrov 2008), but only one individual (probably hybrid) was registered in the Lozen Mountain during this study. The presence of the European polecat (*Mustela putorius*) is also not entirely excluded, although the scarce recent data for this species suggest that its number in the country is declining. Due to the uncertain morphological discrimination between *Microtus arvalis* and *M. rossiaemeridionalis*, the term *Microtus arvalis* (*sensu lato*) was used in this study. However, the characteristics of the study area suggest the presence of *Microtus arvalis* as a species more closely associated with the mountains in comparison with *M. rossiaemeridionalis* (Nedyalkov et al. 2019).

Synanthropic rodent species (*Mus musculus* and *Rathus norvegicus*) were reported for the study area by Simeonov (1963) and Metcheva et al. (2019), but they were not caught during this study as the target mammal communities were those from natural habitats. The water vole (*Arvicola amphibius* L.) and the forest dormouse (*Dryomys nitedula* Pall.) were also reported about half a century ago (Simeonov 1963), but the collected data did not confirm their current presence.

The implementation of more intensive and detailed studies would probably supplement the species list and would give a more accurate picture of the distribution patterns and the habitat preferences of the mammals on the territory of the Lozen Mt. The habitats in the area are important as migration corridors for some species of conservation significance, such as the brown bear, the grey wolf and the European otter. The anthropogenic pressure on ecosystems and on mammals, in particular, is strong. This calls for measures to be taken for reducing the harmful effects of human activity.

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