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Small Mammals (Erinaceomorpha, Soricomorpha, Rodentia, Lagomorpha) in Besaparski Ridove Special Protection Area (Natura 2000), Southern Bulgaria: Species Composition, Distribution and Conservation

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Abstract: Twenty-five species of small mammals were registered in the Besaparski Ridove Special Protection Area: Erinaceomorpha (1 species), Soricomorpha (5 species), Lagomorpha (1 species) and Rodentia (17 species). Species composition and distribution were studied by observing the traces left after the life activity as well as by using pitfall traps, live traps and owl pellets analysis. The most common species collected by pitfall traps were *Neomys anomalus* (21.18%), *Crocidura suaveolens* (20.59%), *Sylvaemus* sp. (18.20%) and *Microtus* ex. gr. *arvalis* (18.82%). During the four-year survey on the density of *Spermophilus citellus* in three types of habitats, a definite increase of ploughed pastures was observed, which occurred at 33% of the initially conducted transects. These habitat changes had an impact on the densities of *S. citellus* and *Lepus europaeus*, as the density of *S. citellus* decreased mainly in the used pastures. The most important threats for small mammals are related to the transformation of natural habitats into arable land, the intensification of agriculture and the use of rodenticides.

Ke words: Micromammalia, population density, *Spermophilus citellus*, *Nannospalax leucodon*, habitat changes, Natura 2000

Introduction

The study has been carried out within Besaparski Ridove Special Protection Area (SPA) designated according to Directive 79/409/EEC (Birds Directive). It generally overlaps with Besaparski Vazvishenia Site of Community Importance (BG0000254) designated according to Directive 92/43/EEC (Habitats Directive). The area consists of wooded limestone hills with altitudes between 350 and 536 m a.s.l., situated between the Western Rhodopes and the south-western part of the Upper Thracian Plain. The diversity of grasslands depends on the regional conditions and the origin of the vegetation. Another very important factor in the landscape is the human activity – grazing, mowing, nitrification of the soils due to overgrazing, abandonment of former pastures and meadows and regeneration of the shrub and forest communities (Tzonev et al. 2014). Three types of forest habitats were identified within Besaparski Ridove SPA: Easthern white oak forests, Pannonian-Balkanic Turkey oak – sessile oak forests, Moesian silver lime woods (Dimitrov, Petrova 2014). A total of 184 bird species, belonging to 17 orders were recorded within Besaparski Ridove SPA (Demerdzhiev 2014). All these environmental characteristics deter-

mine Besaparski Ridove as important for the conservation of national biodiversity.

Detailed studies on the small mammal fauna in the area are not available. Data were published on the Thracian Plain area (Markov 1960, Mitev 1980) as well as in publication dedicated to diet of the Barn owl (Milchev *et al*. 2004).

The aims of the present study were: (1) to determine the species composition of the small mammals (Erinaceomorpha, Soricomorpha, Rodentia, Lagomorpha) inhabiting the territory of Besaparski Ridove SPA; (2) to investigate the distribution and abundance of important conservation and resource species; (3) to analyse the identified threats for small mammals; (4) to propose recommendations for their conservation.

Material and Methods

Small mammal species composition and distribution

To study the species composition and distribution of small mammals, the following methods were used:

- Capturing small mammals by using pitfall traps dug in the ground at 30 cm depth and filled up to one-third with water. During the period May – August 2010, a total of 60 traps were set in representative habitats within the SPA (arable land, abandoned land, near water bodies). The traps were checked twice during the study period.

- Capturing small mammals by using Longworth live-traps (60 trapping nights). The traps were set in habitats where digging for pitfall traps was difficult (rocky and forested habitats).

Collecting and analysing pellets of nocturnal birds of prey, i.e. barn owl (*Tyto alba* Scopoli, 1769) and little owl (*Athene noctua* Scopoli, 1769); 20 pellets (complete and fragmented) from roosting sites within the SPA were studied.

Visual observations through visiting diverse habitats were used to identify accidentally dead individuals, diurnal species that can be directly observed or species that can be identified by the traces they leave (mole, mole rat, hare). All the 54 squares 2×2 km (22 complete and 32 partial) within Besaparski Ridove SPA were visited during the period June–September 2008–2011.

The quantitative distribution of the local populations of *Spermophilus citellus* (Linnaeus, 1766) in the study area was evaluated based on expert opinion, according to the following categories: 1) high abundance, 2) medium abundance and 3) low abundance (after Koshev 2008).

The density of *Lepus europaeus* (Linnaeus, 1766) was studied for period 2003 – 2011 according to official data from the game counts from Peshtera Hunting and Fishing Associations, within the boundaries of which Besaparski Ridove SPA is situated (Union of Hunters and Anglers in Bulgaria „National Association of Hunters and Anglers“, (http://www.slrb.org/cat19/lovna-statistika/).

Density of Spermophilus citellus

The abundance of the holes of *S. citellus* was used as an index of abundance of the species, thus the density was estimated indirectly based on the number of holes found in the study area. The relative density was calculated through transects (Sutherland 2006) 500-m long and 1.5-m wide on each side (approximate distance at which burrows can be located), where all holes of *S. citellus* were registered within three bands: 0–50 cm, 50–100 cm and 100–150 cm, on each side of the transect. A total of 60 transects were randomly generated in three types of habitats within Besaparski Ridove SPA: 22 in abandoned pastures, 18 in currently used pastures and 20 in abandoned arable lands. Each transect was examined ones.

In 2009, part of the studied habitats was ploughed and mechanical tillage took place. Plowing impacts *S. citellus* through destroys its borrow system and the grass cover (which it eats), forcing *S. citellus* to leave the inhabited territory.

After 2009, the transects in the studied habitats were partially or completely plowed. About 8.8% of all transects in all habitats were partially destroyed and ca. 25% were completely destroyed. Within the habitat “used pastures”, 56% of transects were completely destroyed. Transects in ploughed habitats were examined but there were no holes of *S. citellus* registered along them. After that, new transects were selected in the same type of habitats, and the data collected was considered in the analyses for the corresponding year.

Software DISTANCE 5.0 was used to calculate the relative density of the holes of *S. citellus* (Thomas *et al.* 2006). During the calculations the model and the key function were selected according to the minimal value of the Akaike Information Criterion (AIC) (Buckland *et al.* 2001). Data were tested for normal distribution using the test of Shapiro-Wilk (StatSoft 2004) and due to lack of normality, even after data transformation, non-parametric statistical tests were applied (Kruskal-Wallis ANOVA).

The applied collection methods followed the guidelines approved by the American Society of Mammalogists (Sikes *et al*. 2011).

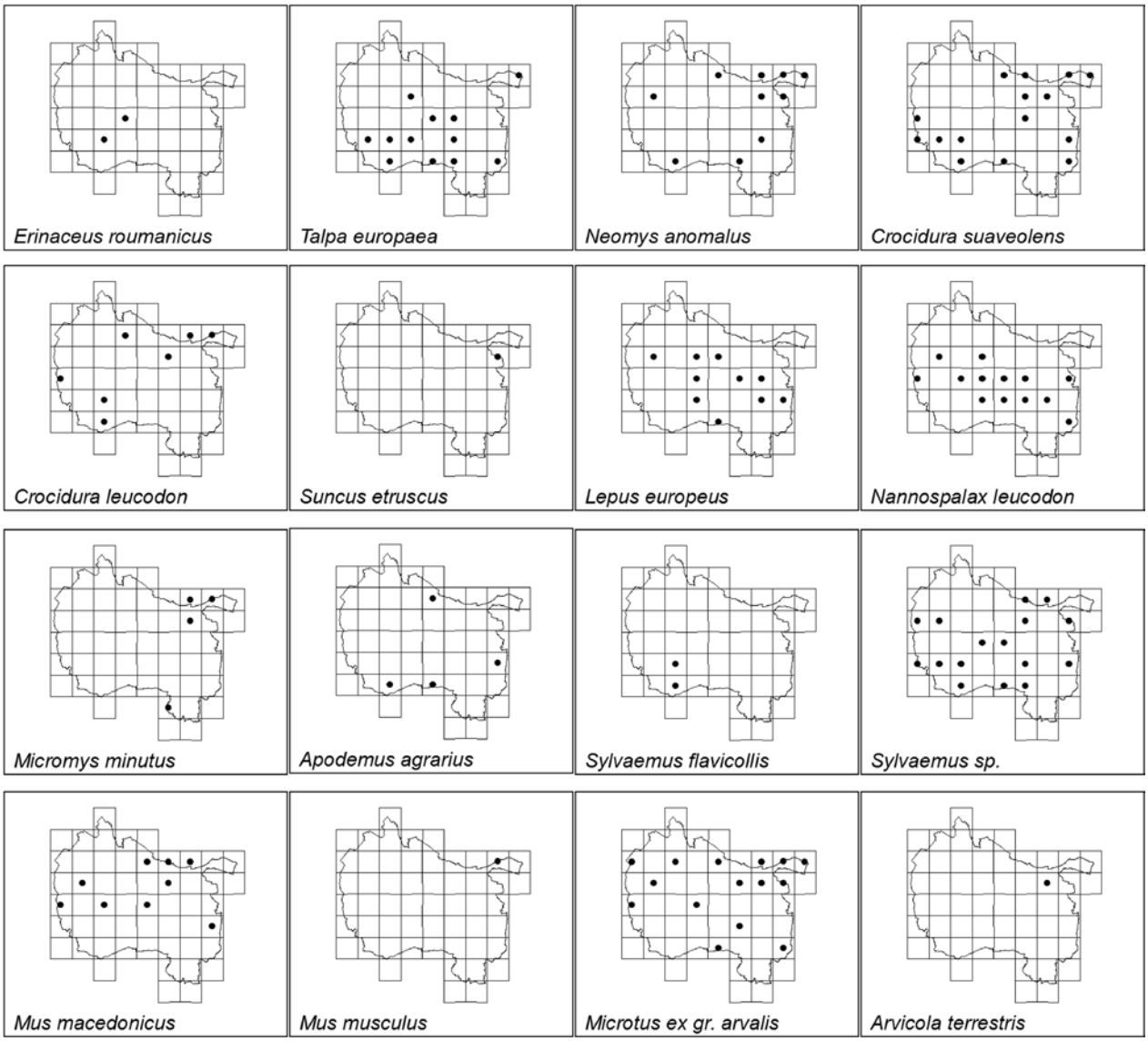

Fig. 1. Distribution of small mammals within Besaparski Ridove SPA

Results

Species composition, distribution and abundance of small mammals

The analysis of the data collected during the field surveys and the review of available literature showed that Besaparski Ridove SPA was inhabited by 25 species of small mammals: Erinaceomorpha (1 species), Soricomorpha (5 species), Lagomorpha (1 species) and Rodentia (17 species) (Table 1). The closely related grey voles (and indistinguishable without genetic analyses) *Microtus arvalis* (Pallas, 1778) and *M. levis* (Miller, 1908) (formerly known as *M. rossieameridionalis* Ognev, 1924) are listed in the table as "*Microtus* ex. gr. *arvalis*".

Six erinaceomorph and soricomorph, one lagomorph and 14 rodent species were registered in Besaparski Ridove SPA during the field survey (Table 2). 221 individuals of small mammals were registered through pitfall traps, live traps and owl pellets. Based on existing publications and the experience of the authors, we expect six additional species to possibly occur in the study area as well.

In the total number of captured individuals by the pit fall traps, insectivores (Sociromorpha) and rodents (Rodentia) are almost equally represented with 52 % and 48%, respectively. The distribution of the identified species is presented on 2×2 km grid on maps (Fig. 1).

Order Erinaceomorpha

Family Erinaceidae

The Northern White-breasted Hedgehog (*Erinaceus roumanicus* Barrett-Hamilton, 1900) is a widely distributed species in all the country (Popov, Sedefchev 2003). It was registered in only two squares of the study area.

Family Talpidae

The European Mole (*Talpa europea* Linnaeus, 1758) can be found mainly in orchards and close to rivers and other water bodies, where the soil is moist and its favourite food (earthworms) is abundant.

Family Soricidae

The Miller Water Shrew (*Neomys anomalus* Cabrera, 1907) is not closely related to water and can be found throughout the study area. It is one of the most abundant species in the small mammal communities, representing 21% of the collected individuals (170 ind.) by pitfall traps. It has been registered in various habitats: river and lake banks, old irrigation channels as well as in alfalfa fields.

The Bicoloured White-toothed Shrew (*Crocidura leucodon* Hermann, 1780) and the Lesser White-toothed Shrew (*Crocidura suaveolens* Pallas, 1811) were found to be common throughout the region. They inhabit open areas such as abandoned lands, hedges, meadows, shrubs and forests edges. These are two of the most widespread and common species of Besaparski Ridove SPA, representing 27% of the individuals collected (170 ind.) by pitfall traps.

The Etruscan Shrew (*Suncus etruscus* Savi, 1822) was reported from Bulgaria 30 years ago (Vohralik 1985). Research during the following years, mainly based on pellets from the Barn Owl (*Tyto alba*), has demonstrated that the species is widespread in south-eastern Bulgaria (Popov *et al*. 2004, Milchev *et al*. 2004, authors' unpublished data). In the study area, there were two individuals registered by pitfall traps, in the vicinities of the village of Trivoditsi. This finding is a new location for the species in Bulgaria.

The representatives of the genus *Sorex* are typical for Bulgarian mountains but have rarely been found in low numbers in some lowland parts of the country (Peshev *et al*. 2004). In the lowlands of SE Bulgaria, more common is the Eurasian Pygmy Shrew (*Sorex minutus* Linnaeus, 1766), unlike the Common Shrew (*Sorex araneus* Linnaeus, 1758) (Milchev *et al*. 2004, our unpublished data from diet of Barn Owl). Such distribution could be explained by the differences in the biology of the two species: the Common Shrew lives in complex underground tunnels and feeds mainly on earthworms, which are abundant in moist soils, while the Pygmy Shrew has varying diet that includes flies, mosquitoes, spiders, etc., and typically uses the tunnels of other species (Yalden 1981). The Pygmy Shrew was found in Barn owl pellets close to the zone (UTM KG79) (Milchev *et al*. 2006).

Order Lagomorpaha

Family Leporidae

The European Hare is a common species, registered in 10 of the study squares. The density of *L. europaeus* reaches the average values for the country (P. Genov, personal communication). In the study area, the density varied between 1.3 and 6.7 ind./100 ha. The highest density levels were reported in 2003, while the lowest ones in 2009. The number of the hunted hares in the area reaches between 3.4% and 17.4% of the total number of counted animals (Table 3).

Family Sciuridae

The European Ground Squirrel (*Spermophilus citellus*) is widespread within Besaparski Ridove SPA, which is confirmed by its registration in 44 out of the 57 2×2 km squares, or 77% of the total area of the studied territory. Based on the quantitative mapping of its distribution, it was found that the territories with the highest concentration are the surroundings of the following settlements: Isperihovo, Krichim, Novo Selo and Capitan Dimitrievo (2×2 km squares: KG8601, KG8602, KG8603, KG8610, KG8611, KG8612, KG8613, KG8614, KG8615) (Fig. 1). The highest level of anthropogenic impact (plowing of habitats) was observed in the following 9 2×2 km squares: KG8603, KG8606, KG8607, KG8614, KG8615, KG8619, KG8620, KG8622, KG9602.

During the four years of sampling, the density of the European Ground Squirrel gradually decreases, from 232 holes in 2008 and 261 holes in 2009 to 154 in 2010 and 84 in 2011. The average density in the grasslands of Besaparski Ridove SPA is 17.8 holes/ha (n = 81, CV = 27.9%; 95% CI = 10.37–30.76; d.f. = 83.27). The minimum calculated density is 11.47 holes/ha while the maximum one is 91 holes/ha (Table 4).

Family Gliridae

Two of the four species of dormice occurring in Bulgaria are widespread in the country – the Edible Dormouse (*Glis glis* Linnaeus, 1766) and the Forest Dormouse (*Dryomys nitedula* Pallas, 1778). They can be found from the sea level up to high altitudes in the mountains (Peshev *et al*. 2004). Although not recorded, their presence in the study area is likely, especially in suitable habitats around the villages of Biaga and Capitan Dimitrievo.

Family Spalacidae

The Lesser Mole Rat (*Nannospalax leucodon* Nordmann, 1840) is a typical representative of the steppe habitats and one of the commonest species in the study area. Its presence was confirmed in 12 squares. This species is characterized by large chromosomal polymorphism. There are more than 10 chromosomal forms described from Bulgaria (Peshev 1983). Near Novo Selo village, Savic (1982) described a new subspecies of Mole Rat – *Nannospalax*

Table 1. Species composition of small mammals in the region of Besaparski ridove SPA, with indication of their conservation status, data source and degree of presence. For details, see the legend below

No	Latin name	Biodiversity Act 2002	Directive 92/43 /EEC	Bern Convention	IUCN	RDB	Data source	Presence
	ERINACEOMORPHA							
	Erinaceidae							
1	*Erinaceus roumanicus*	3			LC	LC	Observation	found with certainty; constant
	SORICOMORPHA							
	Soricidae							
2	*Sorex minutus*			3	LC	LC		probable/unproven
3	*Neomys anomalus*			3	LC	LC	Pitfall trap, pellets	found with certainty; constant
4	*Crocidura leucodon*			3	LC	LC	Pitfall trap, pellets	found with certainty; constant
5	*Crocidura suaveolens*			3	LC	LC	Pitfall trap, pellets	found with certainty; constant
6	*Suncus etruscus*	3		3	LC		Pitfall trap	found with certainty; constant
	Talpidae							
7	*Talpa europaea*				LC	LC	Observation	found with certainty; constant
	LAGOMORPHA							
	Leporidae							
8	*Lepus europaeus*			3	LC	NT	Observation	found with certainty; constant
	RODENTIA							
	Sciuridae							
9	*Sciurus vulgaris*			3	LC	NT		probable/unproven
10	*Spermophilus citellus*	2	2, 3	2	VU	VU	Observation	found with certainty; constant
	Gliridae							
11	*Glis glis*			3	LC	LC		probable/unproven
12	*Dryomys nitedula*	2	4	3	LC	NT		probable/unproven
	Muridae							
13	*Micromys minutus*				LC	NT	Pitfall trap	found with certainty; constant
14	*Apodemus agrarius*				LC	LC	Pitfall trap	found with certainty; constant
15	*Sylvaemus flavicollis*				LC	LC	Pitfall trap	found with certainty; constant
16	*Sylvaemus sylvaticus*				LC	LC		found with certainty; constant
17	*Rattus norvegicus*				LC		Observation	found with certainty; constant
18	*Rattus rattus*				LC		Observation	found with certainty; constant
19	*Mus musculus domesticus*				LC		Observation	found with certainty; constant
20	*Mus macedonicus*				LC	LC	Pitfall trap	found with certainty; constant
	Arvicolidae							
21	*Arvicola terrestris*				LC	LC	Pitfall trap	found with certainty; constant
22	*Microtus* ex. gr. *arvalis*				LC		Pitfall trap	found with certainty; constant
23	*Microtus subterraneus*				LC	LC		probable/unproven
	Spalacidae							

Table 1. Continued

No	Latin name	Biodiversity Act 2002	Directive 92/43 /EEC	Bern Convention	IUCN	RDB	Data source	Presence
24	*Nannospalax leucodon*				DD	LC	Observation	found with certainty; constant
	Myocastoridae							
25	*Myocastor coypus*				LC			probable/unproven

Legend: Biodiversity Act 2002 – Biodiversity Protection Act (State Gazette, No.77 from 9 August 2002), Appendix 2 and Appendix 3 – protected species on the territory of Bulgaria.

Directive 92/43/EU – Recommendation No.43 on the conservation of threatened mammals in Europe (1995) and its Amendment (1996) adopted by the Standing Committee of Council of Europe; Annex II – species whose conservation requires the designation of special areas of conservation, Annex IV – species of community interest in need of strict protection;

Bern Convention – Convention on the conservation of European wildlife and natural habitats, adopted by the Council of Europe in 1998: Appendix II – strictly protected fauna species, Appendix III – protected species;

IUCN – The 2013 IUCN Red List of Threatened Species (IUCN 2013); **Categories: (**EX) Extinct or possible extinct (?EX); (CR) – Critically Endangered; (EN) – Endangered; (VU) – Vulnerable; (NT) – Near Threatened; (LC) – Least Concern; (DD) – Data Deficient; (NE) – Not Evaluated;

RDB (Red Data Book of Bulgaria, Vol. 2 Animals, 2011, Golemansky 2011) **Categories**: (EX) Extinct or possibly extinct (?EX); (CR) – Critically Endangered; (EN) – Endangered; (VU) – Vulnerable; (NT) – NearThreatened; (LC) – LeastConcern; (DD) – Data Deficient; (NE) – NotEvaluated**;**

Presence – found with certainty; constant/temporary/accidental; probable/unproven (there are favorable conditions, but the species was not found in studies). Data found with certainty are based on literature review or this study.

Table 2. Small mammal species in Besaparski Ridove SPA recorded by three methods: pitfall traps, analyses of pellets of birds of prey and live traps

Species	Pit fall trap		Pellets		Live trap	
	N	%	N	%	N	%
Talpa europaea	5	2.94				
Neomys anomalus	36	21.18	1	2.9		
Crocidura leucodon	11	6.47	3	8.6		
Crocidura suaveolens	35	20.59	13	37.1	2	13
Suncus etruscus	2	1.18				
Micromys minutus	3	1.76	1	2.9		
Apodemus agrarius	2	1.18			3	19
Sylvaemus flavicollis	2	1.18				
Sylvaemus sp.	29	17.06			9	56
Mus macedonicus	12	7.06	1	2.9	2	13
Mus musculus domesticus			1	2.9		
Mus sp.			6	17.1		
Arvicola terrestris	1	0.59				
Microtus ex gr. *arvalis*	32	18.82	9	25.7		
Total	170	100	35	100	16	100

leucodon tracius, which is characterised by unique chromosome number and number of chromosomal arms 2n = 56 (NF = 88). Peshev (1983) described another unique karyotype, 2n=54 (NF=88), from the surroundings of the city of Pazardzhik. The intraspecies and interspecies systematics of the genus *Nannospalax* on the Balkans and in the Middle East are non-concordant and various authors have controversial views on the taxonomic status of the various chromosomal forms, recognising them as distinct species or as subspecies of the same species. Each chromosomal form has an allopatric or parapatric distribution (Kryštufek 1999). The latest molecular studies (based on cytochrome b) suggest that there is probably only one (genetically homogenous) species distributed in Europe, i.e. *Nannospalax leucodon* (see Kryštufek *et al.* 2012).

Family Arvicolidae

In Bulgaria, the genus *Microtus* is represented by two sibling species, *Microtus* (s.str.) *arvalis* (Pallas, 1778) and *Microtus* (s.str.) *levis* (Miller, 1908) (Peshev *et al*. 2004). Their identification based on conventional characteristics (e.g. fur colour, body and skull size) is practically impossible (Peshev *et al*. 2004). From the Plovdiv area, the presence of *Microtus* (s.str.) *levis* has been confirmed (Kral 1975). Further taxonomic research is needed to determine the present voles' species.

The European Water Vole (*Arvicola terrestris* Linnaeus, 1758) is a common species around river bank and dams. In the study area, it has been registered close to a small water reservoir near Trivoditsi village but we presume its distribution is wider.

The presence of the European Pine Vole (*Microtus subterraneus* de Selys-Longchamps, 1836) is likely. The species was found in Barn Owl pellets from the vicinity of the SPA (UTM KG88) (Milchev *et al*. 2006).

Family Muridae

The species belonging to the genus *Sylvaemus* are the most common and widespread rodents in

Table 3. Density of *L. europaeus* (ind./100 ha) in Besaparski Ridove SPA in the region of Peshtera Hunting and Fishing Association for period of 2003–2011

Density/shooting	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Ind./100ha^2	6.7	5.1	4.6	4.8	4.3	3	1.3	2.8	2.8	3.9
% shooting	17.4	15.8	6.5	6.5	3.4	5.3	13.5	3.6	0	8

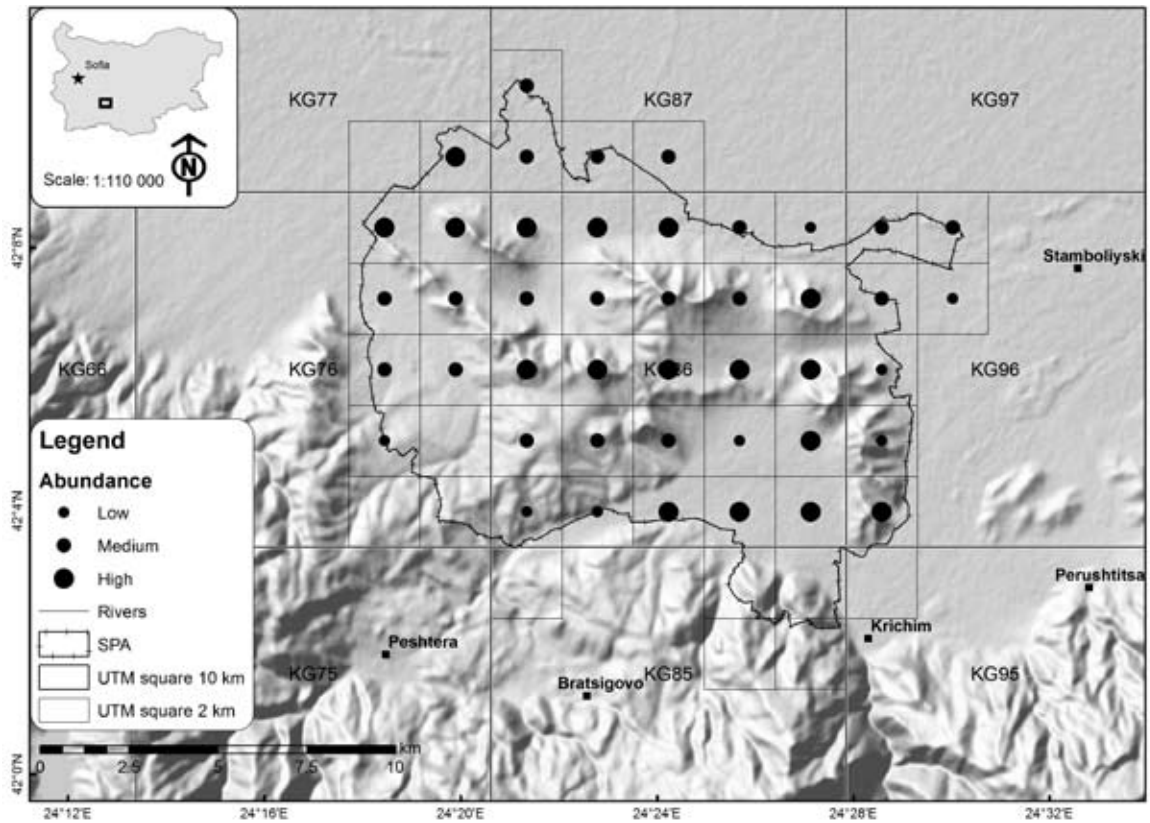

Fig. 2. Distribution and abundance of European Ground Squirrel (*Spermophililus citellus*) within Besaparski Ridove SPA between 2008 and 2011

Europe. They can be found everywhere from the sea level up to mountainous altitudes, in various types of habitats. Based on preliminary analyses of some exterior characteristics (fur colour of back and belly) and measures (relative length of the tail to the body, length of tarsus), an assumption can be made that two species can be found in the area, *Sylvaemus sylvaticus* Linnaeus, 1758 and *Sylvaemus flavicollis* Melchior, 1834, common and widespread species in Besaparski Ridove.

The Striped Field Mouse (*Apodemus agrarius* Pallas, 1771) is a mesophilous species related to wet habitats. In the studied area, it is an intrazonal species and can be found along river banks, small water reservoirs and lakes. The species was registered in four squares.

The Harvest Mouse (*Micromys minutus* Pallas, 1771) is related to wet habitats, mainly of open type: rice fields, wetland banks, channels and rivers. The species is widely distributed in the rice fields near the towns of Plovdiv and Pazardzhik (Mitev 1969). It was registered in four squares. In one of them, close to Kozarsko village, the Striped Field Mouse was observed in an atypical habitat, i.e. in abandoned non-used meadow far from water sources.

In the urban areas, the synanthropic species such as the Black Rat (*Rattus rattus* Linnaeus, 1758), the Brown Rat (*Rattus norvegicus* Berkenhout, 1769) and the House Mouse (*Mus musculus domesticus* Schwarz, Schwarz, 1943) were registered. The data on their presence were collected mainly through enquiries among the local people.

The Balkan short-tailed Mouse (*Mus macedonicus* Petrov & Ruzic, 1983) was registered in abundant fields and bushy habitats nearby arable land. In contrast to The House Mouse, this species never enters human settlements.

Table 4. Density of the holes of the European Ground Squirrel (*S. citellus*) in the region of Besaparski Ridove SPA during the period 2008–2011, calculated with DISTANCE 5.0 (Thomas et al. 2006). Legend: H – type of habitat, UP – used pasture, AP – abandoned pasture; N – sample size; DP –detection probability; D – density; CV – coefficient of variation; CI – confidence interval

Year	H	N	DP (%)	D (h/ha)	CV %	95%CI (h/ha)
	UP	115	27.5	91.0	24.3	55.8 – 148.3
2008	AP	70	22.3	30.7	25.0	18.6 – 50.7
	LA	48	10.0	23.4	44.5	9.7 – 56.4
	UP	155	16.2	86.2	29.9	47.4 – 156.7
2009	AP	73	16.5	26.9	29.8	14.9 – 48.7
	LA	33	11.2	18.3	45.8	7.5 – 45.0
	UP	47	30.4	43.4	23.75	27.28 – 70.25
2010	AP	37	15.2	28.52	33.82	14.54-55.93
	LA	70	199	54.25	29.14	30.36-96.93
	UP	33	19	11.47	47.66	4.56-28.83
2011	AP	32	32	30	37.87	14.41-63.25
	LA	19	9.9	11.84	66.83	3.39-41.34

Family (Myocastoridae)

The Nutria (*Mycastor coypus* Molina, 1792) is an invasive species that has expanded its range in southern Bulgaria (Peshev *et al*. 2004). The species is common in the rice fields between the towns of Plovdiv and Pazardzhik and along the Maritsa River (unpublished data), which passes through the northern part of the study area. For this reason, the species was included in the species checklist of the protected area as tentative.

Discussion

Species composition and conservation status

In Besaparski Ridove SPA, we registered 6 species of insectivores, 1 lagomorph species and 17 rodent species, most of which are widely distributed in Bulgaria. The European Ground Squirrel is a high conservation priority species, categorized as Vulnerable (VU) in the IUCN Red list. This SPA is globally important for the conservation of two chromosome forms of the Mole Rat. The trends of intensification of the agriculture and plowing of abandoned lands during the last few years can negatively impact the species. The chromosomal forms of the Mole Rat are distributed allopartically or parapatrically, with no crossbreeding between them, and additional taxonomical and ecological studies are needed (Kryštufek *et al.* 2012).

Distribution and density of small mammal species

Species densities varied between 1–8 species per square (median 4) (Fig. 2). Small mammal species variety depends on the heterogeneity of the habitat (Kryštufek, Griffiths 2002). Generally, the hilly landscape dominates in Besaparski Ridove SPA, but in the lower parts water is retained (water reservoirs and fishing ponds) and rivers are crossing (Maritsa, Stara Reka). Exactly in these diversified habitats (near to the villages Trivoditsi, Kapitan Dimitrievo, Biaga), the greatest diversity of small mammals was recorded.

In Europe the greatest diversity of rodent species largely occurs in the steppe–deciduous forest ecotone, which probably reflects both recent and historical ecology (Kryštufek, Griffiths 2002). The transition of the deciduous forest into steppe is gradual, with an intervening forest-steppe belt that is often several hundred km wide; high rodent density thus correlates well with increased environmental heterogeneity (Kryštufek, Griffiths 2002).

After analyzing the density of *S. citellus* in Besaparski Ridove SPA, the abundance of the holes during the four years of research indicates statistically significant difference between the tested variables ($H = 24.23$, $df = 3$, $n = 273$, $p < 0.001$, Kruskal-Wallis ANOVA by Ranks; StatSoft 2004).

According to Demerdzhiev *et al*. (2014) the arable land in Besaparski Ridove SPA in 2010 was increased by 22.7% in comparison to 2006, which equals to 1869.48 ha. A significant reduction of the areas of all categories of grasslands was observed. „Grasslands" were reduced by 24.83% or 1772.14 ha in 2010. „Grasslands with shrubs < 25 %" were reduced by 9.76 % (176.64 ha). „Grasslands with single trees" were reduced by 7.6 % (76.3 ha). Insignificant increase of the area of „Grasslands with shrubs > 25 %" was observed (2.97%, 29.03

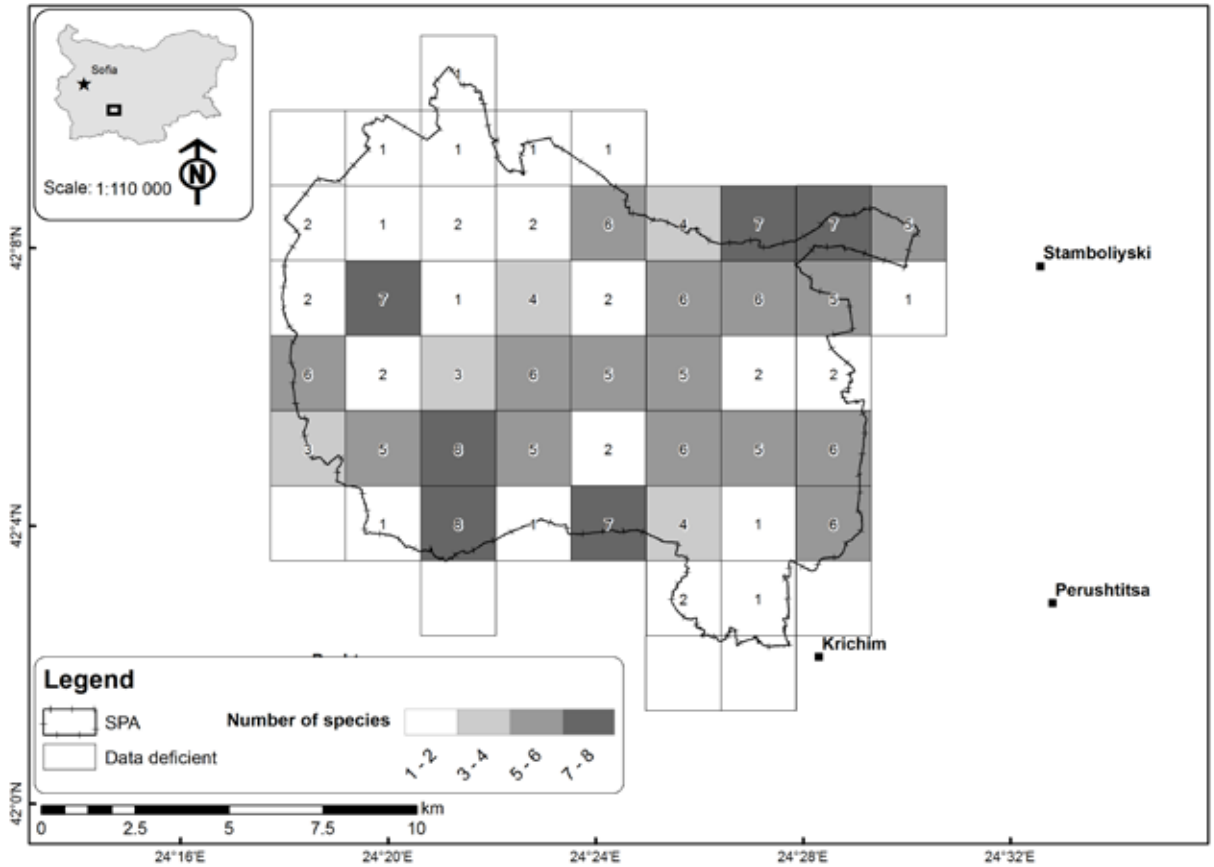

Fig. 3. Species richness of small mammals within 2×2 km square in Besaparski Ridove SPA

ha). Plowing of intensively used pastures is used for granting subsidies under measure 213 of the Rural Development Program: „NATURA 2000 payments" or payments for farmlands linked to Directive 2000/06/EC (Dobrev *et al.,* 2014, Demerdzhiev *et al*. 2014, Popgeorgiev *et al*. 2014).

The observed destruction of habitats through mechanical tillage after 2009 definitely influences the number and abundance of small mammals in the study area, and especially the abundance of *S. citellus* and *L. europaeus*. The European Ground Squirrel population decrease was greatest in the habitat types „used pasture" and "abandoned pasture", which are the most affected by land cultivation.

A decrease in the density of *L. europaeus* was also observed, with the lowest registered density of 1.3 ind. /100 ha. Undoubtedly, the density of this game species is influenced by other factors such as the percentage of shot animals (which did not decrease at the same rate) and the number of predators. The reduction of these two prey species affects also the number of birds of prey and mammals that feed on them. As an example, the number of the Eastern Imperial Eagle (*Aquila heliaca* Savigny, 1809) decreases after 2009, the productivity, breeding success and the success rate of Long-legged buzzard (*Buteo rufinus* Cretzschmar, 1829) decreased (Demerdzhiev *et al.* 2014). The decline in the density of *S. citellus* and the destruction of its habitats, probably impacts the distribution and the density of the Marbled Polecat (*Vormela peregusna* Güldenstädt, 1770). This species has been registered in 2010 close to Isperihovo village (Kiril Metodiev, unpubl. data) and after that its habitats have been transformed into arable lands.

In Besaparski Ridove SPA, a significant increase of 12.33% (100.33 ha) was observed also in orchards and vineyards (Demerdzhiev *et al*. 2014). In vineyards in Austria intermingled with grassland and small fields and with ground vegetation, it was observed a relatively high population density of *S. citellus* (34 ind./ha); this is possibly attributable to low predation because vine plants provides cover from above while not obstructing sight near the ground (Hoffmann *et al*. 2008). In Besaparski Ridove SPA, the vineyards are well fenced (do not permit small mammals to enter) and intensively cultivated (regularly ploughed and maintained without grass vegetation). These tillage and guarding methods hamper the entry and resettlement of species such as *S. citellus* and *L. europaeus.*

The use of rodenticides against species considered as pests also has a negative impact on

small mammal populations. In March 2008, near Isperihovo village we registered a massive use of poison against *S. citellus*.

The increasing intensification of the agriculture influences also the structural and species diversity of the small mammal communities. Zejda (1996) presented the data on small mammal communities for a 30-year period, during which the proportion of the arable land increased and that of the natural habitats decreased. This transformation in land use significantly impacted the quantitative and qualitative composition of small mammals. The highest impact was on shrews (*Sorex*, *Crocidura*), which decreased more than 5 times, while the abundance of *Sylvaemus* spp. and the Common Vole (*M. arvalis*) increased.

Habitat change influences not only the composition but it reflects on the diversity of small mammals. When the natural habitats are replaced by different types of agrocenoses, there is less diversity among small mammals, and communities are dominated by generalist species able to adapt to the new conditions. Although the species diversity of small mammals is reduced, generally their abundance is increased, mainly due to the increase in the abundance of generalist species (Gentili *et al*. 2014)

To a large extent, the structure of small mammal communities and especially those of rodents is determined by the type of the crops grown. In the cereal fields the seed-feeding species are dominating such as mice (*Sylvaemus* sp*., Mus macedonicus*), while *M. arvalis* is more numerous in alfalfa (Heroldova *et al*. 2007).

Threats for small mammals

Conversion of natural and semi-natural habitats to arable lands. It applies mostly to pastures, which are preferred habitats of *S. citellus* and *N. leucodon*. In many cases, these habitat changes result from bad and/or poorly implemented governmental ecological policy.

Planting vineyards or re-cultivation of old ones. The increase in intensively cultivated vineyards (without grass vegetation) directly destroys the suitable habitats for *S. citellus, L. europaeus* and other small mammal species.

Use of agricultural chemicals (rodenticides, pesticides and artificial fertilizers). The use of rodenticides was registered in the surroundings of Isperihovo village. This factor directly reflects on the biological diversity in the area, especially on rodent populations.

Opening and active exploitation of quarries and lime factories. The increase of inert materials extraction directly destroys European Ground Squirrel colonies and pollutes the environment, indirectly deteriorating habitats. The noise from the machines directly disturbs communication between individuals of *S. citellus*, and thus their social behaviour, which is one of the best forms of protection for the species from predators (Górecki *et al*. 2011).

Reduction of grazing. The decrease in numbers of freely grazing livestock in the region has a detrimental effect on the population of *S. citellus* through loss of suitable low grasses (Koshev 2008).

Ploughing of pastures. If this practice is maintained and increased, in the future it is highly probable to have great negative impact on the populations of small mammals in the area.

During poaching of hares (hunting with car headlights and shooting hares during the hunting of other game species) strongly influences the low population density of the species.

Complete pasture clearance and lack of hedges between agricultural areas deprives small mammals (hedgehog, hare, etc.) from shelter. (Gelling *et al.* 2007).

Conservation activities

Creating a mechanism for impeding subsidies received after plowing of pastures, especially those inhabited by priority conservation species as *S. citellus*.

Developing ecological and environmentally friendly forms of agriculture and stock breeding. Supporting pasture farming and mowing. Maintaining and protecting natural grasslands.

Limiting the transformation of meadows and pastures in arable land.

Limiting the hunting on hares, to preserve its population.

All investment projects, consisting on development of new road infrastructure, building, quarries, new yards etc., should be subject of an obligatory Environmental Impact Assessment, evaluation of the compatibility with the ecological network Natura 2000 and coordination with scientific institutions.

Aiming to determine the complete small mammal species composition and the population characteristics of the conservation priority species, it is recommended the continuation of scientific research.

Prohibiting of opening new quarries, reducing the intensity of the work of the currently existing ones.

Limiting the use of pesticides and complete prohibition of using rodenticides.

Purchasing land purchase by NGOs, aimed at its preservation and management.

Leaving hedges between large fields of arable land, as well as certain number of shrubs within the pastures.

Conclusions

Besaparski Ridove SPA is an important territory for the conservation of *S. citellus* and the *Nannospalax leucodon tracius* "subspecies" (2n = 56, NF = 88), described from Novo Selo village (Savic 1982). During the four-year survey on the density of *S. citellus* in three types of habitats, a definite increase of ploughed pastures was observed, which occurred at 33% of the initially conducted transects. These habitat changes negatively influenced the number of *S. citellus* and *L. europaeus*. The density of *S. citellus* decreased in all studied habitats, and especially within used pastures.

There are various threats depending on the species and the specifics of the habitat. The most important threats are related to the conversion of natural habitats into agricultural land, intensification of agriculture and the use of rodenticides. Additional studies are needed to establish the full composition of species in the SPA, and conducting taxonomic research on the genera *Nannospalax*, *Microtus* and *Sylvaemus*.

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