ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., Suppl. 5, 2014: 107-115

# Small Mammals (Mammalia: Erinaceomorpha, Soricomorpha, Rodentia and Lagomorpha) in Ponor Special Protection Area (Natura 2000), Western Bulgaria: Species Diversity, Distribution and Conservation

***Yordan S. Koshev*[1,2]**

[1]Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Science, 1 Tzar Osvoboditel Blvd., 1000 Sofia, Bulgaria; E-mail: bgsouslik@gmail.com
[2]Bulgarian Society for Protection of Birds / BirdLife Bulgaria, Yavorov Complex, Bl. 71, Entr. 4, PO Box 50, 1111 Sofia, Bulgaria

**Abstract:** Ponor Special Protection Area (Ponor SPA) is part of the Western Stara Planina (Western Balkan Range) and includes open grasslands and forests. Twenty-seven species of small mammals were detected in it: 1 species of the order Erinaceomorpha, 7 species of the order Soricomorpha, 1 species of the order Lagomorpha and 18 species of the order Rodentia. The density of *Spermophilus citellus* has gradually decreased from 2008 to 2011during the period of study. The density of *Lepus europaeus* is relatively low. *Nannospalax leucodon* is well distributed throughout. The most common threats are the succession of habitats caused by reduction of free grazing livestock, the decrease of haymaking, burning of pastures and deforestation affecting old forests. Conservation activities with regard to small mammals and their habitats have been proposed.

**Keywords:** Micromammalia, Natura 2000, *Spermophilus citellus*, *Nannospalax leucodon*, protection, Western Stara Planina

## Introduction

Ponor Special Protection Area (Ponor SPA, BG0002005; 43°3'35'' N; 23°3'2'' E) is included in EU Directive 79/409 (Birds) and overlaps the SCI BG0001040 "Zapadna Stara Planina i Predbalkan" of Directive 92/43 (Habitats). The study area covers about 300 km$^2$ and is located about 50 km northwest of the Bulgarian capital Sofia at an altitude between 389 and 1598 m a.s.l. The landscape is characterized by limestone and dolomite with karst forms (Vassilev *et al.* 2011). The habitats with Natura 2000 codes 6520 "Mountain hay meadows" and 9150 "Medio-European limestone beech forests of the Cephalanthero-Fagion" are wide-spread in this area (Tsonev *et al.* 2014; Dimitrov, Petrova 2014). This area is of high conservation importance for birds of prey (Nikolov *et al.* 2007, Dyulgerova, Nikolov 2014). Small mammals are the main food base for many birds of prey, most of which are endangered and protected. The species composition and ecological status of the small mammals in the region of Ponor SPA have not been studied but there are such investigations in from the general region of the Western Stara Planina Mountain, where Ponor SPA is located (Markov 1968, Atanasov *et al.* 2001, Koshev, Atanasov 2005, Petrov *et al.* 2007).

The present research aimed to collect data about the small mammal species inhabiting the region of Ponor SPA, to study the distribution and abundance of significant conservation and resource species, to analyze the recorded threats for the small mammals and to offer recommendations for protection.

## Material and Methods

### Analysis of the available literature about the species composition

Information about the species composition of the small mammals was found and analyzed for the

regions of Western Stara Planina (Markov 1968), Vrachanski Balkan Natural Park (Atanasov *et al*. 2001, Petrov *et al*. 2007) and Dragoman Marsh (Koshev, Atanasov 2005).

**Species composition and mapping of species**

Through the transect method (Lovari, Rolando 2004) were found accidentally perished animals, species with daily activity, which could be observed directly or could be determined through the traces they left behind.

*Spermophilus citellus* Linnaeus, 1766*, Lepus europaeus* Linnaeus, 1758 and *Nannospalax leucodon* Nordmann, 1840 inhabit open spaces and serve as food source for many birds of prey (Peshev *et al*. 2004). Therefore, a more detailed study was carried out on their distribution and density.

All 110 *Universal Transverse Mercator* (UTM) 2×2 km squares of Ponor SPA, following Popgeorgiev *et al.* (2014), were visited during the period June–September between 2008 and 2011. The quantitative distribution of local populations of European ground squirrel (*S. citellus*) was presented on the grounds of expert assessment (Koshev 2008) in the following categories: 1) high abundance, 2) medium abundance and 3) low abundance.The distribution of *S. citellus* and *N. leucodon* was shown as presence/absence in UTM grid 2×2 km.

**Density of *Spermophilus citellus* and *Lepus europaeus***

The density of *S. citellus* was determined indirectly, using the number of holes found in the studied regions as an index of the relative density of the species. The relative density was calculated on the grounds of data collected through transects (Sutherland 2006), which were 500 m long and 1.5 m wide on each side. All the holes of European ground squirrel were observed within 3 distance zones (0-50 cm, 50-100 cm and 100-150 cm) on each side. Prior to the field work, interviews with local stakeholders and municipalities were carried out to provide information on which grasslands were grazed or not (Nikolov 2010). A total of 51 transects were sampled randomly in Ponor SPA in two types of pastures: abandoned (32) and used (19).

The relative density of the holes of *S. citellus* has been calculated by the computer program DISTANCE 5.0 (Thomas *et al.* 2006) with model and key function chosen on the grounds of the minimum value of the Akaike's Information Criterion (AIC) (Buckland *et al.* 2001). The Shapiro-Wilk analysis (StatSoft 2004) has been applied to test the normality of data distribution. As the test did not revealed a normal distribution neither of the raw, nor of transformed data, non-parametric statistics were applied in further analyses.

The density of *L. europaeus* was estimated according to official data from the game counts in Godech and Svoge Hunting and Fishing Associations, within the boundaries of which Ponor SPA is situated (Union of Hunters and Anglers in Bulgaria „National Association of Hunters and Anglers", http://www.slrb.org/cat19/lovna-statistika/).

# Results

**Species composition**

The analysis of the data collected during the field surveys and the review of available literature showed that Ponor SPA is inhabited by 27 species of small mammals: 1 species of the order Erinaceomorpha, 7 species of the order Soricomorpha, 1 species of the order Lagomorpha and 18 species of the order Rodentia (Table 1). The sibling voles *Microtus arvalis* (Pallas, 1778) and *M. levis* (Miller, 1908) are listed in the table as "*Microtus* ex. gr. *arvalis*", but onlyspecies *M. arvalis* has been found for certain nearby Dragoman Marsh (Koshev, Atanasov 2005). The sibling mice *Apodemus flavicollis* (Melchior, 1834) and *A. sylvaticus* (Linnaeus, 1758) were recorded established by from Markov (1968).

The presence of *Neomys fodiens* (Pennant, 1771)*, Micromys minutus* (Pallas, 1771)*, Arvicola terrestris* (Linnaeus, 1758)*, Rattus rattus* (Linnaeus, 1758)*, Chionomys nivalis* (Martins, 1842) is probable, because there are suitable habitats (Peshev *et al*. 2004) and literature data (Table 1) about their distribution in the region and adjacent areas.

**Distribution and density of some small mammal species**

The European ground squirrel (*S. citellus*) is widespread, occurring in 25 of the 110 squares (2×2 km) or in 22.7% of the studied area (Fig. 1).The quantitative mapping of the species distribution revealed the regions with the highest concentration of grounds quirrels, i.e. Shiroki Val and Katsite localities (2×2 km squares: FN86B5, FN87B1, FN87C1, FN86C5). Compared with previous data and inquiries, the number of ground squirrel colonies has decreased in two squares (FN77A3 and FN77B2); the species was not found in square FN67E3, where it has been present in the past (Fig. 1).

*N. leucodon* was distributed in Ponor SPA in 7 of the 110 squares (2×2 km) or in 6.36% of the studied area (Fig. 2).The species predominantly inhabits valleys, where a sufficiently deep soil is present and where vegetable gardens are often found.

**Table 1**.Species composition of small mammals in Ponor Special Protection Area, 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* Barrett-Hamilton, 1900 | 3 | | | LC | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Koshev, Atanasov 2005, Petrov *et al.* 2007 | found with certainty; constant |
| | Soricomorpha | | | | | | | |
| | Soricidae | | | | | | | |
| 2 | *Sorex araneus* Linnaeus, 1758 | | | 3 | LC | LC | Present study, Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| 3 | *Sorex minutus* Linnaeus, 1766 | | | 3 | LC | LC | Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| 4 | *Neomys anomalus* Cabrera, 1907 | | | 3 | LC | LC | Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| 5 | *Neomys fodiens* Pennant, 1771 | | | 3 | LC | LC | Markov 1968, Petrov *et al.* 2007 | probable/unproven |
| 6 | *Crocidura leucodon* Hermann, 1780 | | | 3 | LC | LC | Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| 7 | *Crocidura suaveolens* Pallas, 1811 | | | 3 | LC | LC | Markov 1968, Koshev, Atanasov 2005, Petrov *et al.* 2007 | found with certainty; constant |
| | Talpidae | | | | | | | |
| 8 | *Talpa europaea* Linnaeus, 1758 | | | | LC | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Koshev, Atanasov 2005, Petrov *et al.* 2007 | found with certainty; constant |
| | Lagomorpha | | | | | | | |
| | Leporidae | | | | | | | |
| 9 | *Lepus europaeus* Linnaeus, 1758 | | | 3 | LC | NT | Present study, Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| | RODENTIA | | | | | | | |
| | Sciuridae | | | | | | | |
| 10 | *Sciurus vulgaris* Linnaeus, 1758 | | | 3 | LC | NT | Present study, Markov 1968, Atanasov *et al.* 2001, Petrov *et al.* 2007 | found with certainty; constant |
| 11 | *Spermophilus citellus* Linnaeus, 1766 | 2 | 2, 3 | 2 | VU | VU | Present study, Markov 1968, Atanasov *et al.* 2001, Petrov *et al.* 2007 | found with certainty; constant |
| | Gliridae | | | | | | | |
| 12 | *Glis glis* Linnaeus, 1766 | | | 3 | LC | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Petrov *et al.* 2007 | found with certainty; constant |
| 13 | *Muscardinus avellanarius* Linnaeus, 1758 | 2, 3 | 4 | 3 | LC | NT | Presentstudy, Markov 1968, Koshev, Atanasov 2005, Petrov*et al.* 2007 | found with certainty; constant |
| 14 | *Dryomys nitedula* Pallas, 1778 | 2 | 4 | 3 | LC | NT | Presentstudy, Markov 1968, Atanasov*et al.* 2001, Koshev, Atanasov 2005, Petrov*et al.* 2007 | found with certainty; constant |

**Table 1**.Continued

| No | Latin name | Biodiversity Act 2002 | Directive 92/43 /EEC | Bern Convention | IUCN | RDB | Data source | Presence |
|---|---|---|---|---|---|---|---|---|
| | Muridae | | | | | | | |
| 15 | *Micromys minutus* Pallas, 1771 | | | | LC | NT | Koshev, Atanasov 2005 | probable/unproven |
| 16 | *Apodemus agrarius* Pallas, 1771 | | | | LC | LC | Markov 1968, Koshev, Atanasov 2005, Petrov*et al.* 2007 | found with certainty; constant |
| 17 | *Apodemus flavicollis* Melchior, 1834 | | | | LC | LC | Markov 1968, Atanasov*et al.* 2001, Koshev, Atanasov 2005, Petrov*et al.* 2007 | found with certainty; constant |
| 18 | *Apodemus sylvaticus* Linnaeus, 1758 | | | | LC | LC | Markov 1968, Atanasov*et al.* 2001, Koshev, Atanasov 2005, Petrov*et al.* 2007 | found with certainty; constant |
| 19 | *Rattus norvegicus* Berkenhout, 1769 | | | | LC | | Present study, Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| 20 | *Rattus rattus* Linnaeus, 1758 | | | | LC | | Markov 1968, Petrov *et al.* 2007 | probable/unproven |
| 21 | *Mus musculus* Linnaeus, 1758 | | | | LC | | Present study, Markov 1968, Petrov *et al.* 2007 | found with certainty; constant |
| | Arvicolidae | | | | | | | |
| 22 | *Clethrionomys glareolus* Shcreber, 1780 | | | | LC | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Petrov *et al.* 2007 | found with certainty; constant |
| 23 | *Arvicola terrestris* Linnaeus, 1758 | | | | LC | LC | Markov 1968, Koshev, Atanasov 2005, Petrov *et al.* 2007 | found with certainty; constant |
| 24 | *Microtus* ex. gr. *arvalis* | | | | LC | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Koshev, Atanasov 2005, Petrov *et al.* 2007 | found with certainty; constant |
| 25 | *Microtus subterraneus* de Selys-Longchamps, 1836 | | | | LC | LC | Present study, Markov 1968, Petrov*et al.* 2007 | found with certainty; constant |
| 26 | *Chionomys nivalis* Martins, 1842 | | | 3 | LC | NT | Markov 1968, Atanasov *et al.* 2001, Petrov*et al.* 2007 | probable/unproven |
| | Spalacidae | | | | | | | |
| 27 | *Nannospalax leucodon* Nordmann, 1840 | | | | DD | LC | Present study, Markov 1968, Atanasov *et al.* 2001, Petrov *et al.* 2007 | found with certainty; constant |

**LEGEND**: **Biodiversity Act 2002** – Biodiversity Protection Act (State Gazette, No.77 from 9 August 2002), Appendix 2 and Appendix 3 – protected specieson 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) Extinctor possible extinct (?EX); (CR) – CriticallyEndangered; (EN) – Endangered; (VU) – Vulnerable; (NT) – NearThreatened; (LC) – LeastConcern; (DD) – Data Deficient; (NE) – NotEvaluated;
**RDB**(Red Data Book of Bulgaria, Vol. 2 Animals, 2011, Golemansky 2001) **Categories**: (EX) Extinctor possible extinct (?EX); (CR) – CriticallyEndangered; (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). Datafoundwithcertaintyarebasedonliteraturerevieworthis study;

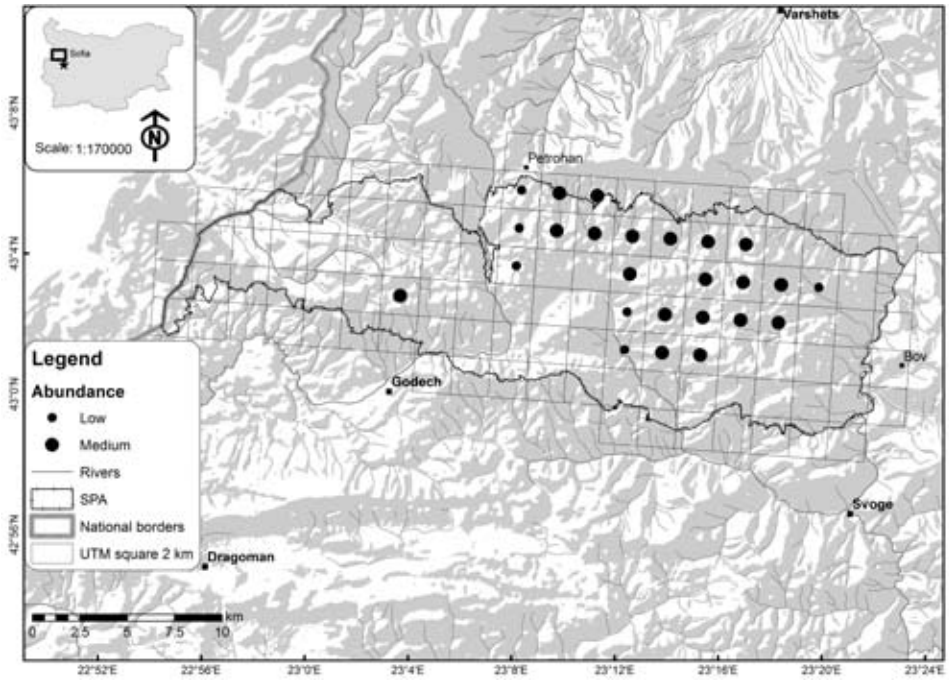


**Fig. 1.** Distribution and relative abundance map of *Spermophilus citellus* in UTM grid 2×2 km in Ponor Special Protection Area in 2008-2011

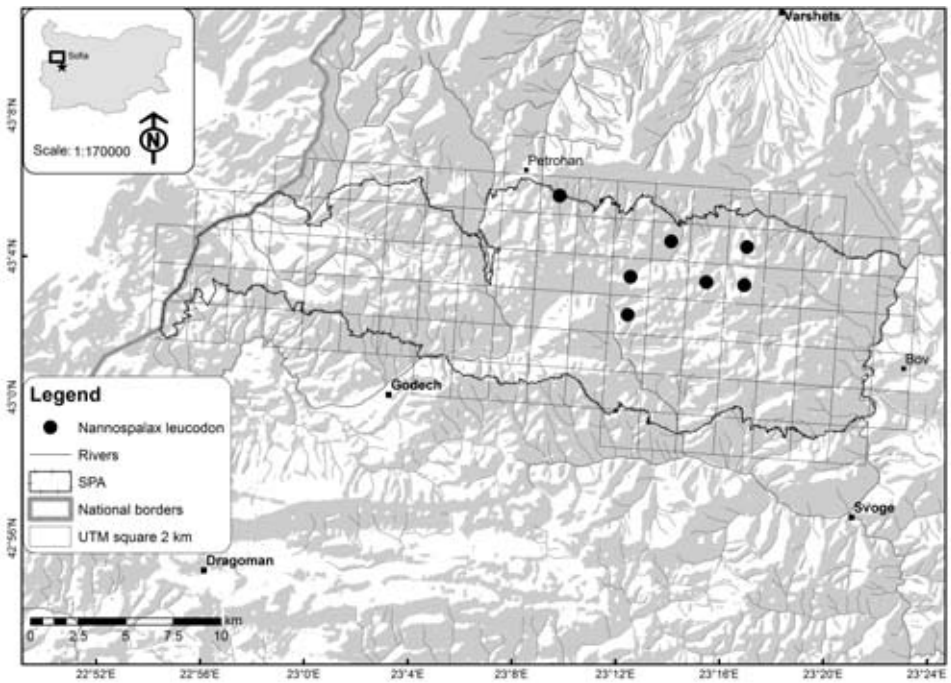


**Fig. 2.** Distribution and relative abundance map of *Nannospalax leucodon* in UTM grid 2×2 km in Ponor Special Protection Area in 2008-2011

### Density of *S. citellus* and *L. europaeus*

The density of the European ground squirrel gradually dereased during the period of the study. The total number of ground squirrel holes in 2008 was 395, in 2009 – 249, in 2010 – 180 and in 2011 reached 191. The minimum calculated density was 38.32 holes/ha and the maximum was 173 holes/ha (Table 2).

The average density of *L. europaeus* varied within a very small range – the registered minimum density was 0.7 ind./100 ha and the maximum was 1.7 ind./100 ha. The highest density of the hare was observed in 2009 and the lowest in 2006 (Table 3). There were no official data of shot animals in the region of both hunting associations.

**Table 2.** Density of the holes of the European ground squirrel (*S. citellus*) in used (n = 19) and abandoned pastures (n = 32) in the region of Ponor SPA during the period 2008–2011, calculated with DISTANCE 5.0 (Thomas *et al*. 2006).

| Years | H | N | DP (%) | D (holes/ha) | CV % | 95%CI (holes /ha) |
|---|---|---|---|---|---|---|
| 2008 | UP | 218 | 18.2 | 173.0 | 20.1 | 114.9–260.4 |
| | AP | 177 | 7.3 | 69.5 | 24.3 | 42.7–112.9 |
| 2009 | UP | 173 | 9.9 | 115.9 | 20.9 | 75.4–178.0 |
| | AP | 76 | 18.3 | 53.5 | 22.7 | 34.1–84.0 |
| 2010 | UP | 118 | 32.2 | 84.86 | 23.05 | 53.5–134.5 |
| | AP | 62 | 31.6 | 29.08 | 28.7 | 16.57–51.06 |
| 2011 | UP | 111 | 10.4 | 69.1 | 26.25 | 40.47–117.9 |
| | AP | 80 | 20.8 | 38.32 | 30.6 | 21–69.9 |

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.

**Table 3.** Density (ind./100 ha) of European hare (*Lepus europaeus*) in the region of Ponor SPA. (Data of Godech and Svoge Hunting and Fishing Associations, 2003–2011)

| District | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| Godech | 0.8 | 0.2 | 0.9 | 0.7 | 0.9 | 0.9 | 1.0 | 1.1 | 1.1 | 0.9 |
| Svoge | 2.0 | 1.9 | 2.0 | 0.7 | 2.2 | 2.3 | 2.4 | 1.9 | 1.9 | 1.9 |
| Average | 1.4 | 1.1 | 1.5 | 0.7 | 1.5 | 1.6 | 1.7 | 1.5 | 1.5 | 1.4 |

# Discussion

### Species diversity and conservation status

The species diversity of the small mammals in the region was almost identical to that of the adjacent Vrachanski Balkan Natural Park, where 25 species were found and 1 species was evaluated as probable (Petrov *et al.* 2007). The two regions are very close to one another and have identical habitats.

In Ponor SPA, there are 12 species included in Appendix III and 2 species in Appendix II of the Bern Convention. Two species are listed in Annex IV and 1 species in Annexes II and III of Directive 92/43/EEC. Appendix 3 of the Biodiversity Act includes two of the above-mentioned species and Appendix 2 – three species (Table 1). Six of these species have been categorized as near threatened (NT) and one has been evaluated as vulnerable (VU) in the Red-Data Book of Bulgaria (Golemansky 2011).

The European ground squirrel has the highest conservation status among the small mammals and has been included in: theRed List of IUCN, category "vulnerable" [VU A2bc], the Red-Data Book of Bulgaria, category "vulnerable" [VU A1c], the Bern Convention, Appendix II (strictly protected species of the fauna), the Directive 92/43/EEC, Annexes II and IV, the Biodiversity Act, Appendix II (Golemansky 2011).

The conservation status of a species does not always correspond to its real status. E.g., *Nannospalax leucodon* was evaluated in IUCN Red Data Book as "DD", i.e. "data-deficient species", but this evaluation has been due to uncertainty of the taxonomy and subspecies differentiation of this species. It could be found that some or all of them are rare and endangered, when the subspecies differentiation of the lesser mole-rat becomes clear (Kryštufek 1999). On the other hand, such species as *Neomys fodiens*, *Neomys anomalus* and *Chionomys nivalis* are rare stenotopic taxa; th latter species is also a glacial relict (Peshev *et al.* 2004).

We can conclude that the following small mammals inhabiting Ponor SPA and having high conservation importance need special protection together with their habitats: *Erinaceus roumanicus* (Barrett-Hamilton, 1900), *Muscardinus avellanarius* (L., 1758), *Dryomys nitedula* (Pallas, 1778), *Sorex araneus* (L., 1758), *Sorex minutus* (L., 1766), *N. anomalus* Cabrera, 1907, *Crocidura leucodon* (Hermann, 1780), *Crocidura suaveolens* (Pallas, 1811), *Sciurus vulgaris* (L., 1758), *Spermophilus citellus*, *Chionomys nivalis*, *Nannospalax leucodon* and *Lepus europaeus*.

### Distribution and density of *Spermophilus citellus* and *Lepus europaeus*

Analysis of the density of *S. citellus* expressed in

abundance of holes in Ponor SPA showed significant differences between the four years in the studied variables ($H = 47.17$, $df = 3$, $n=193$, $p<0.001$, Kruskal-Wallis ANOVA by Ranks; StatSoft 2004). Currently, it is not clear how many holes correspond to one ground squirrel. Straka (1961) has found that one ground squirrel occupies about 13 holes, but this statement should not be accepted unconditionally because in some cases one hole could be occupied by several animals.

The status of *S. citellus* in Ponor SPA is unfavorable due to several reasons. This species is extinct in adjacent regions such as Kom Peak and Vrachanski Balkan Natural Park or is threatened in the region of Dragoman and Aldomirovtsi Marshes (Koshev, unpublished data). Its numbers have decreased in several places in Ponor SPA (present study).

Often natural disasters such as floods have caused large-scale mortality among ground squirrels. In 1991 and 1995 speleologists have found hundreds of drowned ground squirrels in the underground lakes of Katsite Cave after heavy rains in that region. The ground squirrel numbers abruptly decrease after such floods and the species does not even occur for several years in the affected areas. Undoubtedly, the mass mortality of ground squirrels and probably of other rodents affects the numbers of birds of prey, which are feeding on them (Stoyanov 2001).

According to Nikolov (2010) during the last 20 years, after the political changes in the country, the number of grazing animals in the area has significantly decreased. Nowadays, the average sheep density in Ponor Mt is about 0.03 animals per hectare. As a result, the typical grassland communities have changed (Vassilev *et al.* 2014) and the habitats suitable for ground squirrels have decreased. Koshev (2008) has found that pastures degradation is the reason for extinction of ground squirrel colonies in mountainous regions of Bulgaria in 63% of the cases.

The region has repeatedly undergone human-induced fires of open areas. In April 2009, the largest fire within the Ponor SPA has been registered. Burning has destroyed ground-cover grass vegetation on which *S. citellus* feeds.

Using rodenticides to control *S. citellus* (and other rodents, too) against over-population is still a problem. For example, in 2012 residents of the village Zimevitsa argued that the local upsurge in the population of *S. citellus* damages their crops and turned to local authorities with a request to allow them to use rodenticides.

The European hare is a food resource for birds of prey and carnivores and therefore is an important part of the food chain. The hare numbers constantly decrease in the country (P. Genov, unpublished data). In the studied region, it is among the lowest and according the official information the shooting of hares is not allowed in either municipality.

**Threats for small mammals**

The following threats for small mammals in the SPA have been identified:

• Succession of habitats caused by reduction of free grazing livestock and decrease of haymaking. The European ground squirrel is most threatened by this.

• Major increase of arable lands in the studied region and mostly conversion of grasslands situated in the valleys, where ground squirrel density is highest.

• Artificial and/or natural afforestation destroys valuable open habitats and interrupts main ecocorridors connecting the ground squirrels in the SPA to other populations, for example in the Sofia Plain.

• Burning of pastures – if this practice persists and intensifies in the future, it will cause a major negative impact on the ground squirrel population in the region.

• Poaching of hare – hunting utilizing headlights and unauthorized shooting while hunting other game species could further diminish the valuable bird prey base.

• Fragmentation by main road E79 – the road passes through Ponor SPA dividing it into two parts. The road traffic not only interrupts the eco-corridors used by large and small mammals but could also cause significant mortality of animals (Kambourova-Ivanova et al. 2012).

• Deforestation of old forests affects forest species such as Dryomys nitedula, Muscardinus avellanarius, Glis glis (L., 1766) and Sciurus vulgaris.

• Climate warming has negative impact on hibernating mammals (*D. nitedula*, *M. avellanarius*, *G.glis* and *S. citellus*) (Inouye *et al.* 2000).

**Conservation activities**

• Development of environmentally friendly forms of agriculture and livestock breeding.

• Stimulating free pasture breeding and mowing; maintenance and conservation of natural grasslands and meadows.

• Preservation of old-growth forests, which keep the rich diversity of small mammals of conservation importance.

• Limiting the transformation of meadows and grasslands into arable lands.

• Limiting the hunting of brown hare in order to protect and preserve its population.

• Limiting the construction of forest roads and enforcing the speed limits on the roads.

• During the construction of new roads (or renovation of old ones) to provide dry passage ways for small mammals, guiding paths and noise barriers.

All investment projects related to the building of new road infrastructure, construction, forest management projects, etc., should be mandatorily assessed for environmental impact and for compatibilitywith the goals of the Natura 2000 Network of Protected Areas and co-ordinated with scientific institutes and universities.

In order to establish the species composition of the small mammals and the population characteristics of the species of conservation importance completely, it is recommended to continue the scientific research.

# Conclusions

The present study revealed rich species diversity of small mammals in Ponor SPA, typical for this part of Western Stara Planina.The density of *Spermophilus citellus* has gradually decreased during the period of study. The density of *Lepus europaeus* is relatively low. *Nannospalax leucodon* is well distributed. There are various kinds of threats depending on the species and habitat specificity. Conservation activities are proposed.

**Acknowledgements:** The study is realized within the framework of the Project "Conservation of globally important biodiversity in high nature value semi-natural grasslands through support for traditional local economy", GEFSEC Project №43595, implemented by the Bulgarian Society for Protection of Birds. The author is grateful to Stoyan Nikolov, Georgi Popgeorgiev and Maria Kocheva for their essential help in field, laboratory and cameral work. The author thanks Yurii Kornilev and two anonymous reviewers for the useful comments and suggestions that improved the manuscript.

**References**

Atanasov N., I. Pandourski, R. Pandourska and B. Guéorguiev 2001. Contemporary investigations on the fauna of the Natural Park „Vratchanski Balkan". – In: *Natural potential and stable development of the mountainous regions. Balkan scientific – practical conference*. Symposium. Vratsa (Alpiko – BG print), 82-97. (In Bulgarian).

Buckland S., D. Anderson, K. Burnham, J. Laake, D. Borchers and L. Thomas 2001. Introduction to Distance Sampling. London (Oxford University Press), 432 p.

Dimitrov M., D. Petrova 2014. Forest Habitats in Ponor Special Protection Area (Natura 2000), Western Bulgaria: Characteristics, Status Assessment and Management Recommendations. – *Acta zoologica bulgarica,* **Suppl. 5**: 9-20.

Dyulgerova S., S. C. Nikolov 2014. Avifauna in Ponor Special Protection Area (Natura 2000), western Bulgaria: Composition, conservation status and changes over the last 30 years. – *Acta zoologica bulgarica,* **Suppl. 5**: 97-106.

Golemansky V. (ed.) 2011. Red Data Book of the Republic of Bulgaria.Vol. 2 Animals.Digital edition. Natural habitats. Sofia (IBER – BAS & MOEW). URL: http://e-ecodb.bas.bg/rdb/en/vol2/

Koshev Y. 2008. Distribution and status of European ground squirrel (*Spermophilus citellus*) in Bulgaria. – *Lynx* (Praha), n.s., **39** (2): 251-261.

Koshev Y., N. Atanasov 2005. Ecological - faunistic investigation of small mammals (Micromammalia) in the region of Dragoman Marsh (Western Bulgaria). In: First National Scientific Conference of Ecology "Biodiversity, Ecosystems, Global changes", Sofia, Bulgaria. Sofia (Petekston Publishing House). 179-185. (In Bulgarian with English summary).

Kambourova-Ivanova N., Y. Koshev, G. Popgeorgiev, D. Ragyov, M. Pavlova, I. Mollov and N. Nedialkov 2012. Effect of Traffic on Mortality of Amphibians, Reptiles, Birds and Mammals on Two Types of Roads between Pazardzhik and Plovdiv Region (Bulgaria) – Preliminary Results. – *Acta zoologica bulgarica*, **64** (1): 57-67.

Kryštufek B. 1999. *Nannospalax leucodon*. – In: Mitchell-Jones A. J., G. Amori, W. Bogdanowicz, B. Kryštufek, P. J. H. Reijnders, F. Spitzenberger, M. Stubbe, J. B. M. Thissen, V. Vohralík and J. Zima (eds): The Atlas of European Mammals. London(Academic Press), 262-263.

Inouye D. W., B. Barr, K. B. Armitage and B. D. Inouye2000. Climate change is affecting altitudinal migrants and hibernating species. – *Proc. Nat. Acad. Sci. USA*, **97** (4): 1630-1633.

IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 31 December 2013.

Lovari S., A. Rolando 2004. Guida allo studio degli animali in natura. Bollati Boringhieri, Torino (Italy), 240 pp.

Markov G. 1968. Insektenfressende Sauge- und Nagetiere in Westlichen "Stara-Planina" Gebirge. – *Bull. l'Inst. zool. et Musee*, **28**, 96-118. (In Bulgarinan., German summary)

Nikolov S. C. 2010. Effects of land abandonment and changing habitat structure on avian assemblages in upland pastures of Bulgaria. – *Bird Conservation International,* 20: 200-213.

Nikolov S. C., B. Tonchev, B. Barov and G. Stoyanov 2007. Ponor. – In: Kostadinova I., M. Gramatikov (eds): Important Bird Areas in Bulgaria and NATURA 2000. Sofia (Bulgarian Society for the Protection of Birds), 136-137.

Peshev T., D. Peshev and V. Popov 2004. Fauna na Balgariya. No. 27. Mammalia. The Fauna of Bulgaria. Vol. 27. Mammalia. Sofia (Editio Academica "Marin Drinov"). 632 p. (in Bulgarian, with English summary).

Petrov B., G. Stoyanov, B. Guéorguiev, Ch. Deltshev, P. Stoev, Z. Hubenov, K. Donchev, B. Zlatkov, S. Zidarova, D. Chobanov and T. Ljubomirov 2007. Fauna of Nature Park

"Vrachanski Balkan". – In: Management Plan of Nature Park "Vrachanski Balkan". Bulgaria (Agrolesproject Ltd.).470 p. (in Bulgarian).

Popgeorgiev G. S., N. D. Tzankov, Y. V. Kornilev, B. Y. Naumov and A.Y. Stoyanov 2014. Amphibians and Reptiles in Ponor Special Protection Area (Natura 2000), Western Bulgaria: Species Diversity, Distribution and Conservation. – *Acta zoologica bulgarica,* **Suppl. 5**: 85-96.

StatSoft. 2004. STATISTICA 7.0 Data Analysis Software. StatSoft, Inc. http://www.statsoft.com/

Stoyanov G. 2001. The birds of the Ponor Mountain. – *Forestry Ideas,* **25**: 101-125. (In Bulgarian).

Straka F. 1961. Prinos varhu bioecologiata i borbata s evropejskia laluger (*Citellus citellus* L.) v Bulgaria [Beitrag zur Bioökologie und Bekämpfung des europäischen Ziesels (*Citellus citellus* L.) in Bulgarien]. – *Proc. Centr. Res. Inst. Plant Prot*., **1**: 24-63 (in Bulgarian, with a summary in German).

Sutherland W. 2006. *Ecological Census Techniques*. 2nd ed. Cambridge (Cambridge University Press), 433 p.

Thomas L., J. Laake, S. Strindberg, F. Marques, S. Buckland, D. Borchers, D.Anderson, K. Burnham, S. Hedley, J. Pollard, J. Bishop and T. Marques 2006. Distance 5.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/

Tzonev R., C. Gusev and G. Popogeorgiev 2014. Scrub, Grassland and Rocky Habitats in Ponor Special Protection Area (Natura 2000), Western Bulgaria: Mapping and Assessment of Conservation Status. – *Acta zoologica bulgarica,* **Suppl. 5**: 21-32.

Vassilev K., H. Pedashenko, N. Velev and I. Apostolova 2014. Grassland Vegetation of Ponor Special Protection Area (Natura 2000), Western Bulgaria. – *Acta zoologica bulgarica,* **Suppl. 5**: 61-73.

Vassilev K., H. Pedashenko, S. C. Nikolov, I. Apostolova and J. Dengler 2011. Effect of land abandonment on the vegetation of upland semi-natural grasslands in the Western Stara Planina, Bulgaria.– *Plant Biosystems,* **145** (3): 654-665.