This publication to be cited as:

Challenges of Establishment and Management of a Trans-Border Biosphere Reserve Between Bulgaria and Turkey in Strandzha Mountain (2005). N. Chipev (Ed.), Unesco/ BAS Workshop, 10 -13 November, Bourgas.

ISBN-10: 954-457-032-2
ISBN-13: 978-954-457-032-3

SMALL MAMMALS (*INSECTIVORA, CHIROPTERA, LAGOMORPHA, RODENIA*) IN THE AREA OF STRANDZHA MOUNTAIN, SOUTH-EASTERN BULGARIA

Vasil POPOV[1], *Ivan PANDURSKI*[1], *Rumjana PANDURSKA-WHITCHER*[1] & *Vladimir BESHKOV*[1]

[1] Institute of zoology - BAS
Tsar Osvoboditel 1, Sofia 1000

Abstract

The main purpose of this work is to present a general characteristic of the small mammal fauna of the area of Strandzha Mt. The sources of information are bibliographic research and unpublished data from the authors' own field work. The original data for 33 species, were obtained through several techniques – ultrasonic bat detecting, mist netting, refuge examination, and pitfall trapping. At a more detailed level the composition of communities of bats and terrestrial smaller mammals is described. Data are reported with regard to two environmentally different zones - outer and inner ones, differing in topography, moisture regime, vegetation, and degree of anthropogenic disturbance. One species, *Pipistrellus pygmaeus* is newly recorded in the area. We establish a list of 55 species (about 85% of Bulgarian small mammal fauna), belonging to Boreal (6 species), Nemoral (24 species), Mediterranean (20 species), and Steppe (2 species) faunal complexes. The studied area has the highest level of biodiversity of small mammal fauna among mountainous areas of comparable size in Bulgaria and can be regarded as an area of exceptional conservation value.

Key words: Shrews, bats, rodents, new records, assemblages, biodiversity.

INTRODUCTION

The Strandzha Mt is an isolated range, stretching northwest to southeast along the Black Sea coast. As a result of its geographic position, geomorphologic processes, climatic conditions, and its vegetational and faunal evolutionary processes, the Strandzha Mt has a peculiar and diversified biota (Gruev, 1988). The region is characterized by a warm (temper-

ate) humid climate and represents the westernmost extension of Euxinian broad leaf forest in Europe. At regional level, the studied area (Fig. 1) can be divided in outer zone and inner zone, differing in topography, moisture regime, vegetation, and degree of anthropogenic disturbance. The outer zone comprises the lowlands in north and along the sea coast (white areas on the map, Fig. 1). The inner zone embraces the territories with more diversified topography and higher elevation along the Bulgarian-Turkish border (shaded areas on the map, Fig. 1). Annual precipitation in the outer zone is relatively low, ranging from 495 to 670 mm, while in the inner zone it is between 700 and 990 mm (Petrov, 1997). The differences in temperatures are less pronounced, but the climate in the inner zone is somewhat cooler (mean January temperature 1.8°C, mean July temperature 22.6 °C) than in the outer zone (mean January temperature 1.9 °C, mean July temperature 23.4 °C), (Petrov, 1997). The lowlands of the outer zone historically were dominated by xero-mesophilous oak forests (Bondev, 1991). In the inner, more mesic zone less drought-resistant broad leaf forests are widely spread.

Local topography further altered vegetation patterns. Territories with gentler topography in the outer zone have widespread occurrence of forest-grassland-agricultural land mosaic, depending of relief and water supply. In this zone the native habitats are destroyed on large territories by agriculture and residential/urban development. As rural development is more accelerated in the east, near the Black Sea coast, here the forest fragmentation is more pronounced. Livestock grazing is pervasive around the villages throughout the zone. In inner zone, the relief constitutes of many relatively low ridges of varying ruggedness and orientation. Finely dissected topography interweaves land units of very different slopes, soils, moisture retention properties, and exposures determine the distribution of several forest types. South-facing slopes and ridge tops are much warmer and drier supporting light oak forests. Sheltered valleys bottoms support more mesic Euxinian oriental beech forest with understory of *Rhododendron ponticum*, specific for this part of the country. In this area, partially covered by the Strandzha National Park, the natural forest is less changed. Small patches of abandoned cultivated fields, pastures and meadows occur on flat ridges and on the bottom of Veleka River valley. Timber harvesting does not affect considerably the forest. In some places only small patches of clear cuts or partially logged stands occur.

On the basis of data available in literature, summarized in Benda et al. (2003), Peshev et al. (2004), Popov & Milchev (2001) and Popov et al. (2004) a total of 55 species of small mammals (insectivores, bats, lagomorphs, and rodents) are know to occur in the area.

In this paper we report the results of own surveys on the small mammal fauna completed mainly during several recent missions of the park, but some old unpublished records of bats are also added. The objective of the study is to contribute to the faunistic knowledge of the small mammals in the area of Strandzha Mt, to analyse the distributional patterns of some mass species within the area, to compile a checklist of species occurring in the area, and to provide a zoogeographic analysis of small mammal fauna.

Material and Methods

Bats

Field techniques used to record bats included refuge examination (RE), mist-netting (MN) and registration of echolocation and social calls by ultrasonic detector (UD).

The mist nets were set up 30 minutes before the sunset, at cave entrances, under bridges, over rivers and streams, trails or openings in the forest or along the forest edge. Nets were 36 mm mesh size, 2.6 m high and 6 m long. Captured individuals were identified to species, measured, weighed, aged (adult or juvenile), sexed, checked for reproductive condition and then released at the place of capture.

To sample bat calls, an ultrasonic bat detector Pettersson D 240 was used. The output of the bat detector was recorded with a Sony cassette recorder and analyzed using the BatSond processing software. The software transforms the ultrasonic echolocation call into a sonogram display, shown as a function of frequency and time. By using published sonograms and call characteristics of known species (Ahlén, 2004, Ahlén & Baagøe, 1999) we were able to identify bat calls. The nomenclature of bats previously known as *Pipistrellus pipistrellus* follows Jones & Barratt (1999). Hence pipistrelles of the 45 kHz phonic type (Jones & Parijs, 1993) are referred to as *P. pipistrellus*, and those of the 55 kHz phonic type are termed *P. pygmaeus*. For five sites a relatively large numbers of ultrasonic records collected during short time intervals are available. These data presented on Table 1 permit crude relative comparisons of foraging activity and abundance of mass species in the area.

Terrestrial small mammals

The present study is based on samples of local small mammal assemblages taken by unbaited pitfall traps. The pitfall traps (8 cm in diameter at the opening and 25 cm in depth) were dug at ground level, and filled with water solution of formalin (2 - 10 %) to a depth of approximately 10 cm. The sample sites consisted of relatively homogeneous conditions in respect to vegetation, soil and topography and represented the main structural elements of the respective landscape. At each site irregular transects of permanent pitfall traps were established. Traps were run continuously during the snow-free periods and were emptied at intervals of about 1 month. A total of 429 small mammals belonging to at least 14 species were collected.

The row data array in further analyses was percentages of each species in the total catch in each site (Table 2), so that the analyses of local assemblages showed up changes in their structure. In order to express species synecological relations as succinctly as possible an ordered two-way table was constructed by means of the TWINSPAN computer program (Hill, 1979). The maximum level of divisions was three, otherwise default values were used. The final result is a diagonal (from upper left to the lower right of the table) arrangement of species distributions along the composite gradient presented by sampling sites. The species heterogeneity of small mammal assemblages was evaluated by Simpson's inverse index (N2). Species richness was evaluated by means of rarefaction (Heck *et al.*, 1975).

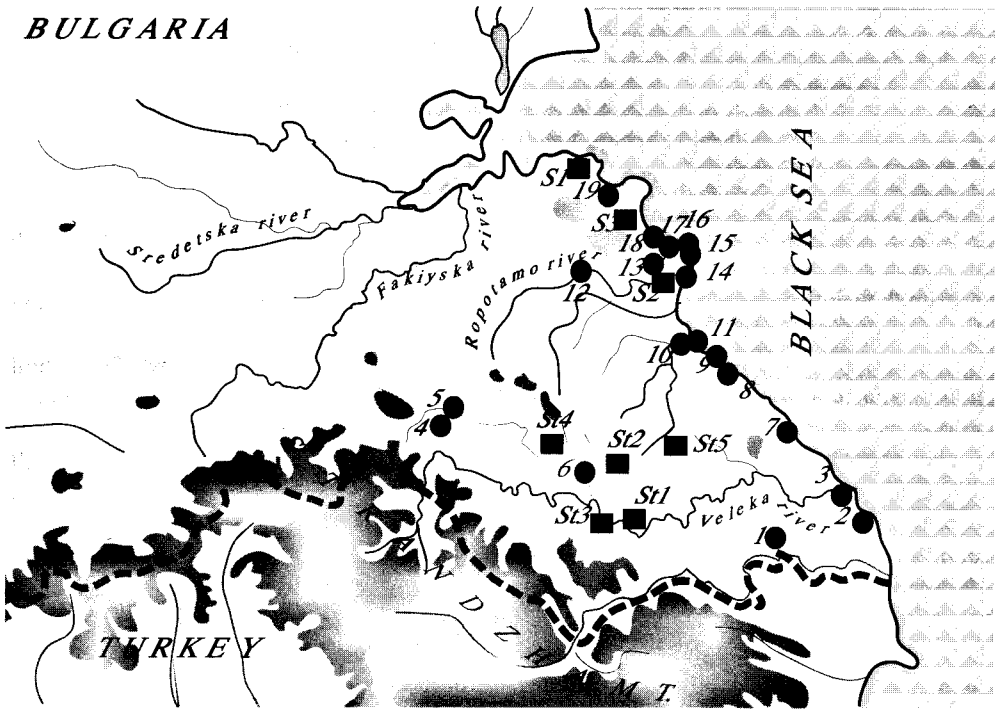

Fig. 1. Map of the area of Strandzha Mt, showing the localities of bat records (circles, denoted with numbers) and sampling sites of terrestrial small mammals (squares, denoted with letters and numbers) (for more details see text). Gradation of shaded areas represents the elevation above sea level - 300 m and 500 m.

List of localities and sampling sites (Fig. 1).

Bats

1. Maharata cave in the valley of Rezovska River; MN, 10 June 1999.
2. Silistar protected area, incl. mouths of Silistar and Butamjata Rivers, south of village of Sinemorets; MN, RE, August of 1998.
3. Mouth of Veleka River, north of village of Sinemorets; MN, June of 1999 .
4. Kaleto Cave near village of Mladejko; RE, 29 June 1989.
5. Shallow karstic niches and rocky crevices near village of Mladejko; RE, 1 – 3 April of 1970.
6. Shtramnitza river near village of Zabernovo; MN, 11 June 1999; UD, 11 September 2003, 27 July 2005.
7. Papijsko dere stream north of Ahtopol; UD, 9.09.2003.
8. Mouth of Tcherna River, south of Tsarevo; UD, 29.07.2005.
9. Tsarevo, central town area and marine park; RE, summer of 1954; UD, 27 July 2005.

10. Mouth of Karaagatch River; UD, 8.09.2003.
11. Shallow marine cave between Kiten and village of Lozenetz; RE, July – August of 1957, 1964 and 1968.
12. Ropotamo River near village of Veselie; UD, 30.07.2005.
13. Rocky complex Kaleto; RE, 22 July 1957.
14. South marine abrasion cave near Maslen nos cape; RE, October 1989.
15. Rocky complex Karaul tash, north of Maslen nos cape; RE, 23.07.1957.
16. An abandoned building between the mouth of Ropotamo river and the Korakja cape; RE, July 1957.
17. Abandoned building in the Ropotamo River valley; RE, 15 September 1968.
18. An abandoned building (Zname na Mira) north of the mouth of Ropotamo river; RE, 15 July 1996.
19. Shallow underground military construction near the holiday camp Duni; RE, 17 July 1996.

Terrestrial small mammals.

According to their location, the studied sites can be lumped in two main zones: Sites S1-S3, representing the outer zone, as defined above; sampling seasons April - November, 1993 – 1996. Sites St1-St5 representing the inner zone; sampling seasons March – October 1998 – 1999.

Outer zone

S1. Dry shrubs (*Paliurus spina-christi, Prunus spinosa, Rosa* sp.), xerotermal grass vegetation with a prevalence of *Dichantieta ischaemi, Poaeta bulbosae, Poaeta concinnae, Chrysopogoneta grylli*.

S2. Forests near the Ropotamo river - *Querceta fainetti* with mediterrnean elements, dry stands on rocks of *Fraxinus ornus* and *Carpinus orientalis*.

S3. Wetlands near the lakes of Alepu and Arkutino - march hydrophitous vegetation with prevalence of *Phragmiteta austrialis*, *Typpheta* spp., *Schoenoplecteta* spp., grass vegetation on abandoned fields with occasional shrubs of *Rosa* sp.; shrubs of *Prunus spinosa*; willow and poplar groves with lower level of *Rubus* sp.

Inner zone

St1. Open terrains - meadows, abandoned fields.

St2. Light oak forest (*Quercus polycarpa, Q. frainetto*) with well developed herbaceous stratum.

St3. Riparian forest near Veleka River.

St4. Dark hornbeam forest in a small gorge with a temporary stream.

St5. Oriental beech forest with understory of *Rhododendron ponticum*, along a temporary stream.

Results and discussion

Species account

Rhinolophus hipposideros: loc. 2 - one dead specimen, found in a small cave.

Rhinolophus ferrumequinum: some individuals were caught in mist nets (loc. 1, 6 or observed in abandoned constructions – loc. 16, 19.

Rhinolophus euryale: one dead specimen – loc. 2.

Rh. blasii/ Rh. euryale: small colonies of about 30 individuals – loc. 13, 17.

Rhinolophus blasii: the characteristic ultrasounds with a maximum frequency of about 92 KHz (Fig. 2) were recorded at loc. 6.

Myotis myotis: one dead specimen - loc. 18.

Myotis blythii: individual specimens were observed on a few occasions – loc. 11.

Myotis myotis / M. blythii; these cryptic species emitted very similar calls, recorded at loc. 12; probably both species formed a part of the mixed colony (together with *Miniopterus schreibersii*) in loc. 14.

Myotis daubentonii: a common species in the river valleys and wetlands of the studied area. It formed about 40 % of mist net catches in site loc. 2. Pregnant females were caught in loc. 3. During the summer, a high activity of this species was repeatedly observed above the water surfaces – loc. 2, 3, 6, and 10 (Table 1). Isolated specimens were observed and registered by ultrasounic detector (Fig. 3) above the water surfaces – loc. 7, 8, 12.

Myotis bechsteini: a single subadult specimen was caught in loc. 2; it can be supposed that the species reproduces on the territory of the protected area Silistar, but the local population has a low density.

Myotis emarginatus: a colony of about several hundreds specimens together with nearly the same number of medium-sized horseshoe bats was observed loc. 15; isolated specimens were found in loc. 5.

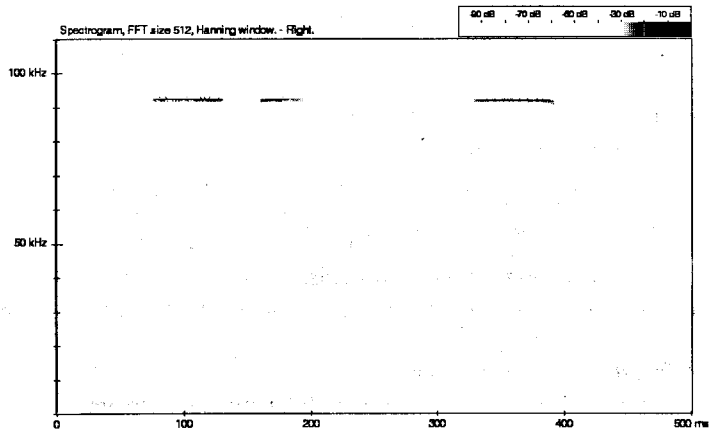

Fig. 2. *Sonogram of echolocation calls of Rhinolophus blasii at 92.2 KHz; Shtramnitza river near Zabernovo village.*

Table 1. *Relative activity of bats in some sites in the area of Strandzha Mt (in % of detected ultrasonic species records from the total number of registered calls).*

Site / Species	Loc. 6: 27.07.2005: 21.00 h – 23.30 h	Loc. 7: 9.09.2003: 20.30 h – 21.30 h	Loc. 8: 29.07.2005: 20.30 h – 22.00 h	Loc. 10: 8.09.2003: 20.30 h – 23.10 h	Loc. 12: 30.07.2005: 20.30 h – 22.30 h
Rh. blasii	6.4	-	-	-	-
P. pipistrellus	-	89 .2	79	52 .0	48 .8
P. pygmaeus	3 .2	1 .8	2 .5	7 .0	-
P. nathusii/kuhlii	-	-	6 .8	15 .0	-
M. daubentonii	79 .0	3 .7	1 .7	7 .8	18 .6
N. leisleri	-	-	4 .3	14 .0	-
N. noctula	-	5 .3	0 .8	0 .8	11 .6
E. serotinus	8 .0	-	1 .7	0 .4	11 .6
Undetermined	3 .4	-	3 .2	3 .0	9 .4
Number of records	88	55	75	218	50

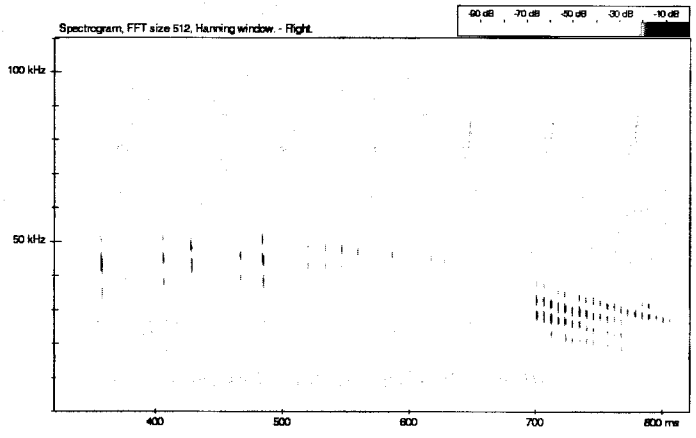

Fig. 3. *Sonogram of echolocation calls of Myotis daubentonii with a feeding "buzz" in the end - high repetition pulses indicating prey attack. Butamjata River near Sinemoretz village.*

Eptesicus serotinus: the serotine formed about 20% of mist netting catches in loc. 2; two specimens were caught in loc. 6. In a few occasions its echolocation calls (Fig. 4) were recorded in loc. 8, 10, 12.

Pipistrallus pipistrellus. The common pipistrelle formed 25% of mist netting captures in loc. 2. The species is exceptionally numerous in urban areas. For instance, during the end of July 2005, all recorded echolocation calls in the central town area and in the marine park of Tsarevo belonged to *P. pipistrellus*. It is very frequent around the street lights of Sinemoretz

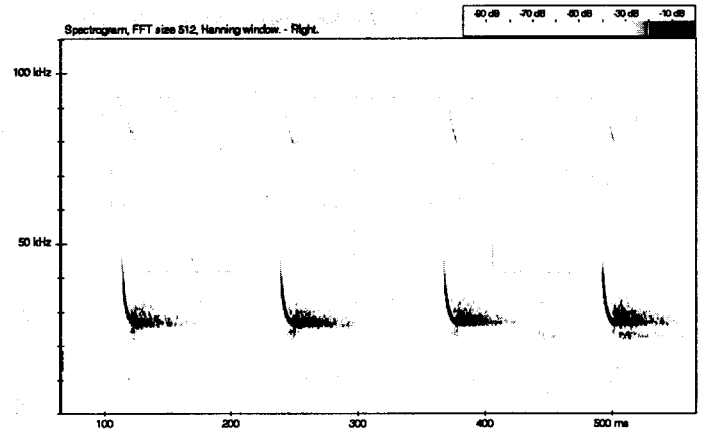

Fig. 4. *Sonogram of echolocation calls of Eptesicus serotinus at 26.5 – 27.0 KHz; Butamjata River near Sinemoretz village.*

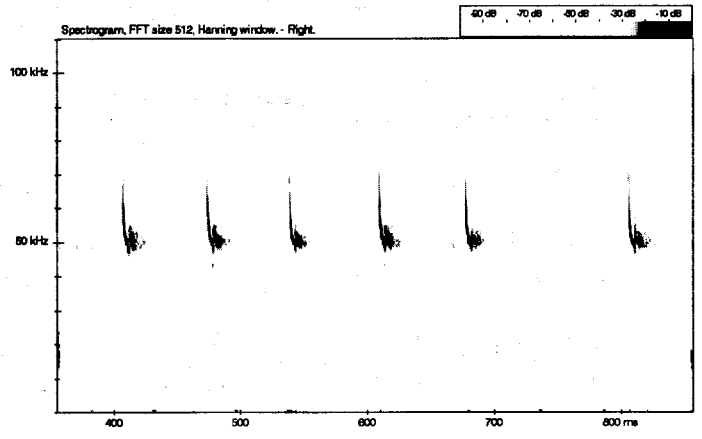

Fig. 5. *Sonogram of echolocation calls of Pipistrellus pipistrellus at 45. 0 KHz; Karaagatch river near Kiten.*

village. It forages actively above the water surfaces of locs. 7, 8, and 12. A very high degree of foraging activity was registered in loc. 10, where on 8 September 2003 evening departures of large groups of common pipistrelle were observed, leaving the hollows of old poplars and foraging later above the river. Here, for the period of 20.30 h to 23.10 h, 271 echolocation calls (Fig. 5) were recorded, forming 52 % of the total observed bat activity (Table 1).

Pipistrellus pygmaeus: The soprano pipistrelle was recorded only by ultrasonic detector. Flying and foraging together with the common pipistrelle, the soprano pipistrelle emits echolocation calls with a maximum frequency ranging between 54.5 KHz and 62.5 KHz (Fig. 6). The specimens recorded in locs. 6, 7, and 8, had a peak frequency of about 55 KHz. The species was recorded mainly above the water surfaces. The highest activity was observed in loc. 10 (Table 1).

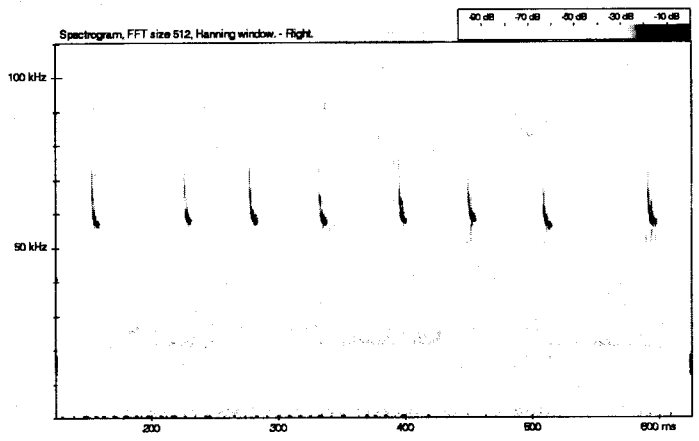

Fig. 6. *Sonogram of echolocation calls of Pipistrellus pygmaeus at 58.0 KHz; Karaagatch river near Kiten.*

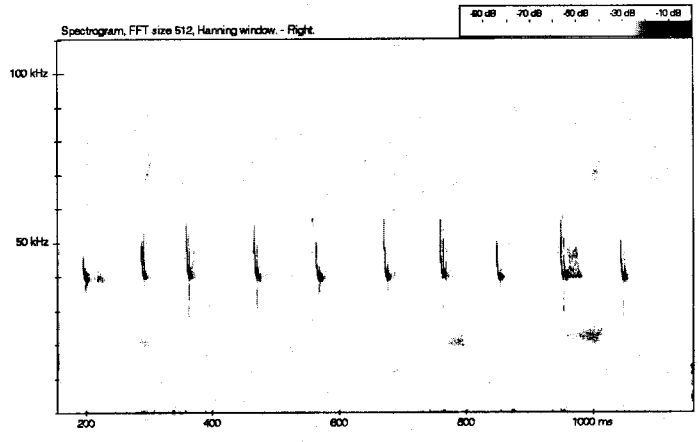

Fig. 7. *Sonogram of echolocation calls of Pipistrellus nathusii/kuhlii at 38.0 – 40.0 KHz; Karaagatch river near Kiten.*

Pipistrellus kuhlii : one specimen was netted in loc. 2; having in mind the other records in the area (Benda et al. 2003) it can be supposed that the species regularly occurs in the region of Strandzha Mountain.

Pipistrellus kuhlii/nathusii: the ultrasound records of "pipistrellus" type with a maximum frequency between 36 and 42 KHz (Fig. 7) can not be determined unequivocally. Foraging activity of such *Pipistrellus* species was registered in locs. 8, 10, and 12.

Nyctalus noctula: this species is à common member of the bat community in the studied area; it was often observed flying high above the ground at the end of the day and it was frequently recorded by ultrasound detector (Fig. 8) in locs. 7, 8, and 12; two specimens were caught by mist netts - loc. 2, a subadult female, loc. 7, an adult male.

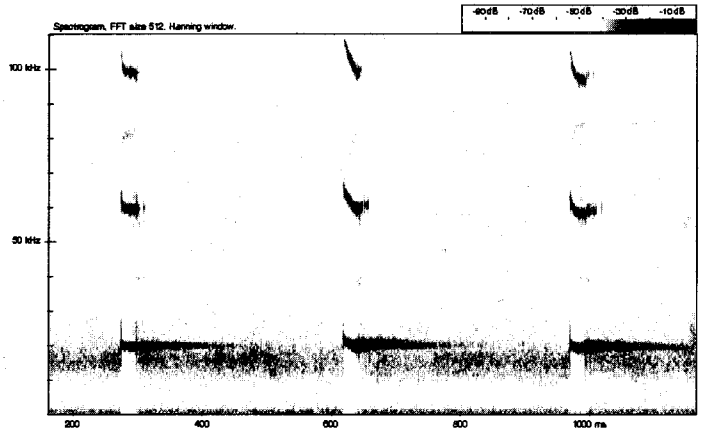

Fig. 8. *Sonogram of echolocation calls of Nyctalus noctula at 18.5 KHz; Ropotamo river near Veselie village.*

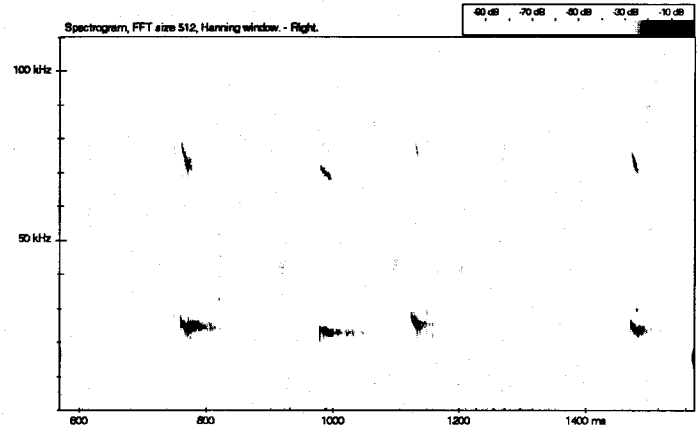

Fig. 9. *Sonogram of echolocation calls of Nyctalus leisleri at 22.5 KHz; Karaagatch river near Kiten.*

Nyctalus leisleri: the specific echolocation calls of foraging individuals with a maximum frequency of about 22 KHz (Fig. 9) were recorded in loc. 8; the species formed 15 % of the total bat activity in loc. 10 (Table 1).

Nyctalus lasiopterus: the species is considered to be rare in Bulgaria; although found in a few localities, *N. lasiopterus* is a characteristic species of Strandzha Mountain; it was netted in loc. 2; one specimen was found in a building in Tsarevo by Juryi Gorelov in the summer of 1954.

Miniopterus schreibersii : the species was captured only once in loc. 2; a large mixed colony together with *Myotis myotis/blythii* (a total of about 2700 – 3000 individuals) was

observed in October 1989 in loc. 14; a reproductive colony of about 800 individuals was found on 29 June 1989 in loc. 4.

Sorex minutus. The pygmy shrew occurs in forests, bushes and abandoned fields in the inner zone of the studied area. It is particularly abundant in humid beech forest. The species is rare in the other zone, occurring in low abundance in humid forests only.

Neomys anomalus. The water shrews from the Black Sea coast formed a rather homogeneous assemblage. On the basis of their external features (tail without keel or with poorly developed one, confined to the terminal third; small stiff hairs on hind food, etc.) and measurements, they can be referred safely to *N. anomalus*. The Miller's water shrew is common in wet habitats, both in inner and outer zone. Its great relative abundance in humid beech forest should be mentioned.

Crocidura leucodon. The discrimination between *Crocidura leucodon* and *C. suaveolens* meets considerable difficulties in Southeastern Europe, where the second species reaches a considerable size. Although *C. leucodon* averages larger than *C. suaveolens*, most external measurements show large overlap (Vohralik, Sofianidou, 1992). The frequency distribution histograms of the height of procesus coronoides, a character commonly used for separation between closely related shrew species, demonstrates bimodality, indicating the occurrence of both species in the studied area. Accordingly, the shrews with a height of coronoid process of more than 4. 6 mm were referred to *C. leucodon*, and those with a coronoid process height of less then 4.6 mm - to *C. suaveolens*. The bicoloured white-toothed shrew occurs in low density in open terrains and light forest with a well developed herbaceous stratum. It is more frequent in the outer than in inner zone.

Crocidura suaveolens. The lesser white-toothed shrew occurs in open terrains and humid forests in outer zone. In inner zone it is restricted to anthropogene disturbed sites.

Suncus etruscus. One specimen of the pygmy white-toothed shrew was captured at the shrubbery near an abandoned field. The data from owl pellets (Popov et al., 2004) showed that the species does not occur in the inner zone.

Dryomys nitedula. Isolated specimens of the forest dormouse were captured in light forests and shrubs near wetlands of outer zone.

Mus macedonicus. According to criteria proposed by Orsini (1982) all specimens collected in the southern Black Sea area were referable to *M. macedonicus* (=*M. abbotti*) (Aufftay et al. 1990). Indirect evidence that the material represents outdoor forms is the circumstance that all mice were captured in the wild far from buildings, predominantly in shrubs and forest edges of inner zone.

Micromys minutus. The harvest mouse occurs rarely in wet places in both zones.

Apodemus agrarius. The striped field mouse was found only in inner zone, in wet habitats (shrubs, riparian forest, wet meadows) on the bottom of the Veleca River valley.

Sylvaemus sp. The extreme similarity of *Sylvaemus sylvaticus* and *S. flavicollis* in Bulgaria causes considerable difficulty in the identification of some specimens, especially juvenile and subadult ones. Only individuals judged to be adultus by tooth-wear were determined by means of criteria proposed earlier (Popov, 1993). The juvenile and subadult specimens were denoted as *Sylvaemus* sp. Based on capture data for adult specimens (Table 2), it seems likely the majority of the specimens undetermined to species level to belong to *S. flavicollis*. They dominated the pitfall catches in forested sites, especially in inner zone.

Sylvaemus flavicollis. The yellow necked mouse occurs regularly in all studied sites, being dominant in the forests.

Sylvaemus sylvaticus. The wood mouse is a rare species, occurring in open terrains, shrubs, and oak forest edges.

Microtus guentheri. The Guenter's vole is a quite abundant species in abandoned fields and dry meadows of inner zone. One specimen was captured in an anthropogene disturbed meadow.

Microtus ex gr. *aravalis*. Since a reliable differentiation of *Microtus arvalis* and *M. epiroticus* Ondrias, 1966 on the basis of external measurements and skull morphology is still problematic (Gerasimov et al., 1984, Vohralik, 1985, Vohralik, Sofianidou, 1992) the material of the field voles is denoted as *Microtus* ex gr. *arvalis*. The field voles were captured in open terrains of outer zone only.

Microtus subterraneus. The common pine vole occurs regularly in shrubs, humid meadows, and forests of inner zone. It is very rare in outer zone, restricted to humid forests.

Species associations

Bats

The data presented in Table 1 can be regarded as a combined index of relative bat abundance and activity. The five sites where the bat's echolocation activity was sampled in a greater detail represent riparian habitats or wetlands. The first one (loc. 6) is located in inner zone, far from human settlements and can be characterized as semi-mountain riparian site - a deep and narrow sheltered valley of a cold fast running stream, overgrown with mesic and dark broadleaf forest. *M. daubentonii* appeared to be the most common species in this environment, representing 79% of calls in that site.

The remaining localities (locs. 7, 8, 10, 12) belong to the outer zone and can be characterized as low-elevation wetlands with large open surfaces of slow moving water (locs. 8, 10) or riparian sites (locs. 7, 12). They are situated close to settlements. The acoustic data indicate that the most common species to inhabit this type of habitats is *P. pipistrellus*. This species appears to prefer lower elevation sites, as it was not captured in the semi-mountain environment of inner zone. The second most common species, *M. daubentonii*, made up for 1.6 – 18.6% of all recorded echolocation calls. *Pipistrellus kuhlii/nathusii, Nyctalus leisleri, N. noctula, E. serotinus* were also quite common species in sites of outer zone.

Given the limited data collected it would be difficult to draw more general conclusions, but, on a general scale, it appears that the low-elevation riparian and wetland sites held the greatest species diversity. This finding is not surprising, having in mind the increased foraging opportunities near large water bodies in low altitude. The more forested mid-elevation riparian sites held lower diversity. When looking at distribution across the regional altitudinal gradient, it seems that *M. daubentonii* was the most prevalent species at higher elevations and perhaps the most tolerant of associated climatic conditions.

Although the above data provide some consistent information about structure of bat associations some limitations should be taken into account. In general, we have a limited

understanding of detection probability, both within and between species. Literary data show some species can be detected regularly while other species may have been under-represented. In part, this may be explained by the broad range of call intensity in bat echolocation calls, and the fact that higher frequencies tend to attenuate more in the open air than lower frequencies, therefore avoiding detection at greater distances (Fenton and Bell 1981). For example, species with high-intensity and lower frequency calls, can be detected at distances exceeding 30 m, while the species with low-intensity call, appears to be detectable only if it passes within 5 m of the microphone (O'Farrell and Gannon 1999). Therefore, reliable comparisons of relative abundance between species are difficult to make and one needs to be mindful of these limitations when interpreting such results.

Terrestrial small mammals

The results of TWINSPAN analysis of pitfall data are presented on Table 2. The first level of division separates small mammal assemblages according to the strongest gradient in the area in terms of two main landscape characteristics – humidity and development of forest cover. The left group (A) represents forested sites, or small sized open sites under more humid climatic conditions, characteristic for the inner zone, and seasonally inundated forest from the outer zone. The right group (B) comprises shrubs and open sites under drier climate, characteristic for the outer zone. The group A is characterized by more mesophilous

Table 2. *TWINSPAN classification of sampling sites in the area of Strandzha Mt according to the structure of small mammal assemblages (% of sample total)*

Division I	A						B	
Division II	A1				A2			
Site / Species	St2	St3	St4	St5	St1	S2	S1	S3
Sorex minutus	4.17	3.03	8.33	13.92	9.30	5.00	-	-
Apodemus agrarius	-	6.06	-	-	9.30	-	-	-
Microtus subterraneus	4.17	9.09	-	3.80	13.95	1.67	-	-
Microtus guentheri	-	-	-	-	2.32	-	-	-
Neomys anomalus	-	-	-	54.43	11.62	5.00	-	66.45
Crocidura leucodon	4.17	-	-	-	9.30	1.67	8.69	-
Sylvaemus sp.	66.67	63.64	83.33	15.19	13.95	48.33	17.39	9.03
Sylvaemus flavicollis	16.67	18.18	8.33	12.65	11.62	26.67	8.69	3.87
Crocidura suaveolens	-	-	-	-	11.62	10.00	17.39	7.74
Micromys minutus	-	-	-	-	4.65	1.67	-	1.29
Sylvaemus sylvaticus	4.17	-	-	-	2.32	-	4.35	2.58
Suncus etruscus	-	-	-	-	-	-	4.35	-
Dryomys nitedula	-	-	-	-	-	-	4.35	0.64
Mus macedonicus	-	-	-	-	-	-	13.04	0.64
Microtus aravalis	-	-	-	-	-	-	21.74	7.74
Sample size	24	33	12	79	43	60	23	155
Heterogeneity (N2)	2.08	2.24	1.41	2.80	9.20	3.12	6.87	2.15

species – *Apodemus agrarius, Sorex minutus*, and *Microtus subterraneus*. The last two species are generally more common in Bulgarian mountains. Group B is characterized by species which are more common, or occur only in outer zone, under more dry and warmer climate – *Suncus etruscus, Dryomys nitedula, Mus macedonicus, Microtus arvalis*. Within group A, the second level of division separates the small mammal assemblages from forested sites in inner zone (A1) from these from open and shrubby sites in inner zone and forested site from outer zone (A2). The last group of sites involves *Crocidura suaveolens* and *Micromys minutus*, and *Microtus guentheri*, which do not occur in the forested sites of the inner zone.

The anthropogene disturbed sites from both zones (St1 and S1) shows the greatest diversity. The environment of these sites might be an example of a patchy habitat, where some degree of 'intermediate disturbance', has led to high levels of small mammal diversity.

The rarefaction curves (Fig. 10) for both zones, based on pitfall data, indicate that the species richness is greater in outer zone. This result reflects the greater number of habitat types represented in the sampling sites in this zone.

These data, although still fragmentary, indicate that climatic characteristics, mainly precipitation and temperature, associated with vegetation and anthropogenic disturbance affect distribution, abundance and diversity of terrestrial small mammals in the area of Strandzha Mt.

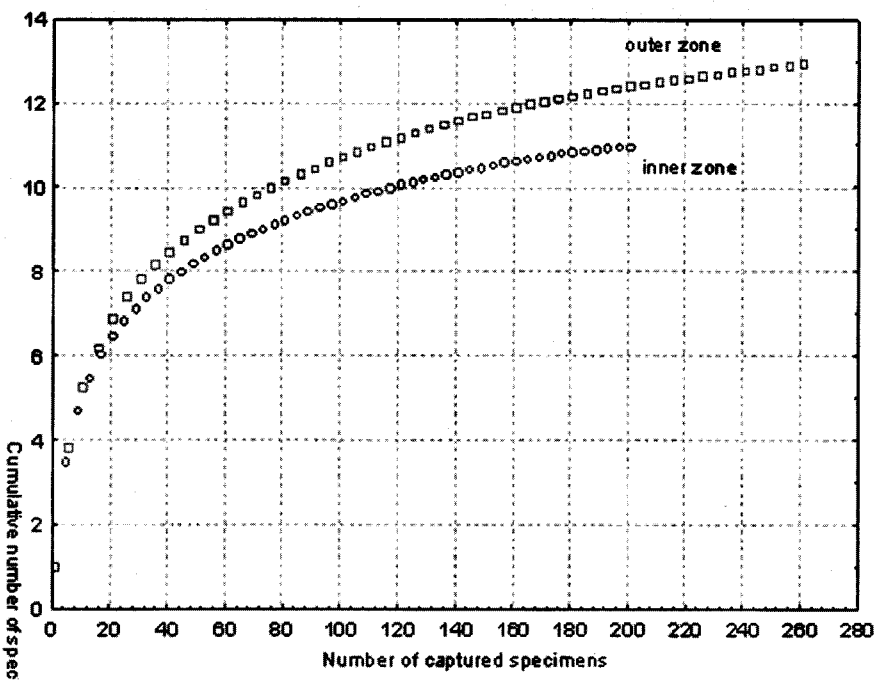

Fig. 10. *Rarefaction curves for small mammals, captured by pitfall trapping in two zones in the area of Strandzha Mt, SE Bulgaria*

Faunistic and zoogeographical remarks

The species of small mammals to date known in the studied area are 55. The only species newly recorded in the area is *Pipistrellus pygmaeus* (Leach, 1825). The total number of species in the area of Strandzha Mt is rather high among other mountainous areas in Bulgaria, whose faunistic diversity has been recently analysed. The approximate numbers of species recorded are as follows: Centralen Balkan – 47 (Beron et al., 2000a), Rila – 39 (Beron et al., 2000b), Pirin – 32 (Popov et al., 2005). This great diversity of small mammals in the studied area is apparently a result of its geographic location, in view of the fact that it is essentially contributed by the Mediterranean and West-Asiatic elements, rare or lacking in other parts of Bulgaria. In order to provide a more detailed analysis of the zoogeographical structure of the small mammal fauna the species recorded up to now in the area in Strandzha Mt (*Mus musculus, Rattus rattus*, and *R. norvegicus*) are classified in the following zoogeographical categories (cf. Popov, in press).

(1) Boreal faunal complex - 6 species. Cold resistant species with a wide temperature tolerance;

(a) Euro-Siberian forest elements: *Sorex minutus, S. araneus, Plecotus auritus, Arvicola terrestris.*

(b) Euro-Siberian forest-steppe elements: *Lepus capensis, Microtus arvalis* (s. l.).

(2) Nemoral complex – 24 species. Thermotolerant species, associated with mesophilous broad-leaf forest of Palearctic.

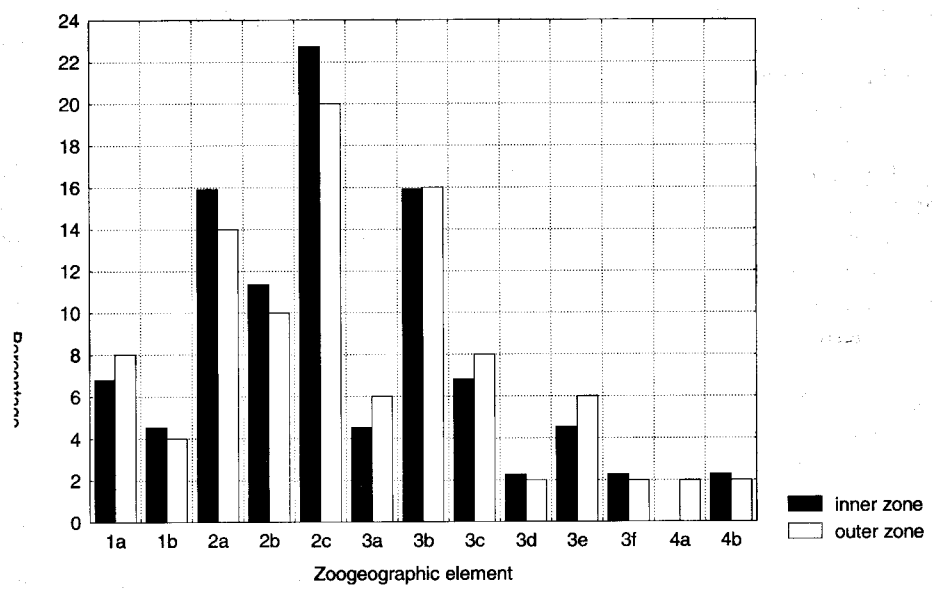

Fig. 11. *Zoogeographic structure of the small mammal fauna in the area of Strandzha Mt, SE Bulgaria*

(a) Transpalearctic or Holarctic elements (species associated with forested areas): *Myotis nattereri, M. mystacinus, M. daubentonii, Nyctalus noctula, Pipistrellus pipistrellus, P. nathusii, Sciurus vulgaris, Micromys minutus, Apodemus agrarius.*

(b) South (East) European and (West) Asian elements: *Erinaceus concolor, Crocidura leucodon, Nyctalus lasiopterus, N. leisleri, Dryomys nitedula.*

(c) European element: *Talpa europaea, Neomys anomalus, Myotis bechsteinii, Barbastella barbastellus, Pipistrellus pygmaeus, Glis glis, Muscardinus avellanarius, Sylvaemus flavicollis, S. sylvaticus, Microtus subterraneus*;

(3) Mediterranean faunal complex - 20 species. Thermophilic species, associated with the southern parts of Europe, Asia Minor, and Central Asia.

(a) Widely distributed in southern areas: *Suncus etruscus, Rhinolophus blasii, Miniopterus schreibersii;*

(b) Sub-Mediterranean element (species widely distributed outside the Mediterranean (s. str.), but tending to occur in thermo-xerophilous landscapes): *Crocidura suaveolens, Rhinolophus ferrumequinum, Rh. hipposideros, Myotis blythii, M. emarginatus, Plecotus austriacus, Hypsugo savii, Eptesicus serotinus;*

(c) Mediterranean element: *Rhinolophus euryale, Rh. mehelyi, Myotis capaccinii, Pipistellus kuhlii*;

(d) West Mediterranean element: *Myotis myotis*;

(e) East Mediterranean element (sensu lato, including Sub-Iranian, Asia Minor, and Balkan species): *Myomimus roachi, Mus macedonicus, Microtus guentheri*;

(f) Euxinian element (species, associated with the relict broadleaf forest of the Caucasian region, invading the Balkan Peninsula via the Pontic Chain): *Talpa levantis.*

(4) Eurasian steppe complex – 2 species. Species associated with the periphery of the arid core of Eurasia.

(a) East European-West Asian element: *Cricetulus migratorius*;

(b) Balkan (and Southeast European) element: *Spermophilus citellus..*

This information is summarised in Fig. 11, separately for outer and inner zone. The zoogeographic structure of both zones is quite similar, indicating the main role of geographical position of the area. The differences concern the absence of steppe elements in inner zone which agrees with the environment in this zone – more humid and forested. The data on Fig. 11 show that Strandzha Mt represents a blend zone of three main complexes – Boreal, Nemoral, and Mediterranean. The species, belonging to the last two complexes predominate the fauna.

References

Ahlén, I. & Baagře, H. J. 1999. Use of ultrasound detectors for bat studies in Europe - experiences from field identification, surveys and monitoring. *Acta Chiropterologica* 1, 137-150.

Ahlén, I. 2004. Heterodyne and time expansion methods for identification of bats in the field and through sound analysis. Pp 72- 79 in: Brigham, R.M., Kalko, E.K.V., Jones, G., Parsons, S., Limpens, H.J.G.A. (Eds.). *Bat Echolocation Research – tools, techniques and analysis.* Bat Conservation International, Austin, Texas, April 2002.

Auffray J. Ch., J. T. Marshall, L. Thaler, F. Bonhomme. 1990. Focus on the nomenclature of European species of *Mus*. *Mouse Genome* 88, 7 – 8.

Benda, P., I. Horáček. 1998. Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part I. Review of distribution and taxonomy of bats in Turkey. *Acta Soc. Zool. Bohem.* 62, 255 – 313.

Benda, P., T. Ivanova, I. Horáček, V. Hanák, J. Červenó, J. Gaisler, A. Gueorgieva, B. Petrov, V. Vohralik. 2003. Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 3. Review of bat distribution in Bulgaria. *Acta Soc. Zool. Bohem.* 67, 245–357.

Beron, P., V. Beshkov, V. Popov, M. Vassilev, R. Pandurska, T. Ivanova. 2000a. Biodiversity of small vertebrates (Pisces, Amphibia, Reptilia, Mammalia-Isectivora, Chiroptera, Lagomorpha and Rodentia) in the Central Balkan National Park. *Biological Diversity of the Central Balkan National Park*, 363-422. Pensoft.

Beron, P., V. Beshkov, V. Popov, M. Vassilev, R. Pandurska, T. Ivanova. 2000b. Biodiversity of small vertebrates (Pisces, Amphibia, Reptilia, Mammalia-Ibsectivora, Chiroptera, Lagomorpha and Rodentia) in the Rila National Park. *Biological Diversity of the Rila National Park*, 333-360. Pensoft.

Bondev, I. 1991. The vegetation of Bulgaria. St. Kliment Ohridski University Press, Sofia. 183 p. (In Bulgarian with English summary).

Gerassimov, S., V. B. Michajlova, Ch. M. Nikolov. 1984. On the distribution of *Microtus arvalis* (Pallas, 1778) and *Microtus epiroticus* (Ondrias, 1966) in Bulgaria. *Acta zool. bulg.* 25, 3 - 8 (in Russian, with a summary in English).

Gruev, B. 1988. General biogeography. Sofia, Nauka I Izkustvo. 396 p. (In Bulgarian).

Heck, K., L., Jr., G. van Belle, D. Simberloff. 1975. Explicit calculation of the rarefaction diversity measurement and the determination of sufficient sample size. *Ecology* 56, 1459-1461.

Hill, M. O. 1979. TWINSPAN a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell Univ., Ithaca, New York , 48 p.

Jones, G. & Barratt, E. M. (1999). *Vespertilio pipistrellus* Schreber, 1774 and *V. pygmaeus* Leach 1825 (currently *Pipistrellus pipistrellus* and *P. pygmaeus*; Mammalia, Chiroptera): proposed designation of neotypes. *Bull. Zool. Nomencl.* 56,182-186.

Jones, G. & Parijs, S. M. van (1993). Bimodal echolocation in pipistrelle bats: are cryptic species present? *Proc. R. Soc. Lond. B Biol. Sci.* 251, 119-125.

Fenton, M.B., and G.P. Bell. 1981. Recognition of species of insectivorous bats by their echolocation calls. *Journal of Mammology* 62, 233-243.

O'Farrell, M.J., and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. *Journal of Mammology* 80, 24-30.

Orsini, Ph. , 1982. Facteurs regissant la repartition des souris en Europe: interet duu modele souris pour une approch des processus evolutives. *These*. Acad. de Montpellier, Univ. Sci. et Techn. Languedoc. 134 p.

Petrov, P. 1997. Landscape structure. In: Iordanova, M. & D. Donchev (eds.) *Geography of Bulgaria*, Sofia. "Prof. Marin Drinov" Academic Publishing Hose. 340 – 356.

Peshev, Ts., D. Peshev, V. Popov. 2004. Fauna of Bulgaria. Vol. 27. Mammalia. Sofia. "Prof. Marin Drinov" Academic Publishing Hose. 633 p. (In Bulgarian with English summary).

Popov, V. V. 1993. Discriminant criteria and comparative study on morphology and habitat selection of *Apodemus sylvaticus* (Linnaeus, 1758) and *Apodemus flavicollis* (Melchior, 1834) (Mammalia, Rodentia, Muridae) in Bulgaria). *Acta zool. bulg.* 46, 100- 111.

Popov, V.V. (in press). Biogeographical and ecological spatial patterns of terrestrial mammals in Bulgaria. In: Fet, V., Popov, A. (eds.). *Ecology and Biogeography of Bulgaria*. Kluwer Academic Publishers, Dordrecht.

Popov, V. V, B. Miltchev. 2001. New data on the morphology and distribution of *Talpa levantis* Thomas, 1906 (Mammalia: Insectivora) in Bulgaria. *Acta zool. bulg.* 53, 3, 79-94.

Popov, V. V, Miltchev, B, Georgiev, V. C., Dimitrov, H. A., Chassovnikarova, Ts. 2004. Landscape distributional pattern and craniometry of *Suncus etruscus* (Mammalia: Insectivora, Soricidae) in SE Bulgaria. *Acta zool. bulg.* 56, 3: 299-312.

Popov, V., D. Dimova, Ch. Delchev. 2005. Biodiversity of National Park Pirin. Bulgarian Foundation for Biodiversity. Sofia. 95 p.

Vohralik, V. 1985. Notes on the distribution and the biology of small mammals in Bulgaria (Insectivora, Rodentia). I. *Acta Univ. Carolinae - Biologica* 1981, 445 - 461.

Vohralik, V., T. Sofianidou. 1992. Small Mammals (Insectivora, Rodentia) of Thrace, Greece. *Acta Universitatis Carolinae, Biologica* 36, 341 - 369.