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Distribution and status of the European Ground Squirrel (*Spermophilus citellus*) in Bulgaria

Rozšíření a stav populace sysla obecného (*Spermophilus citellus*) v Bulharsku

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Abstract. The European ground squirrel (*Spermophilus citellus*) is an endangered species and typically inhabits steppes and open woodland of Central Europe and the Balkans. Knowledge about its distribution and status in the southern part of its range is scanty. Distribution of the species in Bulgaria over two periods (1950–1989 and 1990–2008) and recent status of 90 colonies in three model regions (mountain region, Sofia field and Thracian valley) are evaluated in the paper. Data on 254 UTM squares inhabited by *S. citellus* during the first period and 212 UTM squares inhabited during the second period were available, but these data could not be compared because of the different survey methods used. *S. citellus* colonies in southwestern Bulgaria may be already extinct and population decline is supposed to take place at the southwestern periphery of the species' distribution range. About 30% out of 90 investigated colonies have disappeared, 28% are vulnerable and only 42% are stable. The biggest part of the extinct colonies was found in the Sofia field and Mountain region. Pastures are the most frequently occupied land use type (72%) in Bulgaria and major threats for the *S. citellus* population include pasture degradation, building up, intensification of agriculture, interruption of biological corridors and flooding. The *S. citellus* population in Bulgaria has been probably declining and current status of the species is unfavourable. The *S. citellus* conservation status in Bulgaria should be enhanced and the species should be included in the new Red Book of Animals in Bulgaria in the category "vulnerable" and should be protected according to the national biodiversity legislation.

Key words. Souslik, *Spermophilus citellus*, distribution, current status, threats, Bulgaria.

INTRODUCTION

The European ground squirrel (*Spermophilus citellus*) is an obligate hibernator and typically inhabits steppes and open woodland of Central Europe and the Balkans from the sea level to the altitude of 2500 m. It is considered to be an endangered species with declining numbers throughout its distribution range, most pronounced at its western margin (IUCN 2007).

The species distribution was one of major criteria when defining its conservation status (IUCN Standards and Petitions Working Group 2008). The climate changes caused by global warming will affect first northern species, migrants, and hibernators (Inouye et al. 2000, Humphries et al. 2002, Levinsky et al. 2007). Thus, data on the current and past distribution of the species are of crucial importance for future assessment of its status.

S. citellus is critically endangered in the northwestern part of its range. Many scientific studies and conservation projects aimed at determination of its current status, distribution, threats, etc., were carried out in the Czech Republic, Slovakia, Austria and Hungary (Cepáková & Hulová 2002, Hoffmann et al. 2003, Adamec et al. 2006). At the same time, there are numerous gaps in the knowledge on *S. citellus* distribution in the southern part of its range. In Bulgaria, the last available data on the species' distribution supplemented with maps obtained from investigations by design come from the 1950s (Peshev 1955, Markov 1957). In a previous study, Koshev & Kocheva (2007) analysed environmental factors influencing *S. citellus* distribution during the period 1930–2005 on the grounds of localities, exactly specified in literature, but did not include distribution maps from the literature and did not analyse the status and probable threats in the studied colonies.

The aim of this study was to assess distribution of *S. citellus* in Bulgaria during two periods (1950–1989 and 1990–2008); and to analyse the current status, relative abundance, type of land use, threats and/or causes of extinction for 90 colonies in three model regions in Bulgaria.

MATERIAL AND METHODS

At present, *S. citellus* occurs in loosely structured populations, or "aggregations" as Armitage (1981) termed them. In population ecology such aggregation is called local population (or only population, subpopulation, deme) and consists of several individuals that live in the same patch and are thus in interaction (Burel & Baudry 2003). In Bulgaria these *S. citellus* local populations are popularly named colonies and we use the term "colony" without any social and behavioural features.

Distribution maps presented in the paper are based on geo-referenced data using the UTM (Universal Transverse Mercator) grids. The system is the most frequently recommended and applied for illustration of mammal distribution (Mitchell-Jones et al. 1999). The distribution data were plotted on a map of Bulgaria with 1254 (complete and incomplete) 10×10 km squares of the UTM grid using the database by Michev (1999). *S. citellus* distribution in Bulgaria was assessed during two periods of different length, characterized by different social, economic and agricultural conditions and different availability of the data. Data on occurrence of the *S. citellus* in Bulgaria include:

(a) published records: directly connected (Markov 1953, Peshev 1955, Markov 1957, Paspalev & Peshev 1957, Straka 1961, Mitev 1968, Spassov et al. 2002, Minkova 2004, Georgiev 2004) and indirectly connected literature like parasitological and faunistic studies (cf. faunal papers listed by Peshev et al. 2004). We also reconstructed maps from Peshev (1955), Markov (1957) and Spassov et al. (2002), which were overlapped on the UTM grid using the GIS software (AcrView GIS 9.2, ESRI); (b) own data collected during our studies; (c) field counts from biological surveys; (d) specimens from museum collections; (e) questionnaires; (f) personal communications by field biologists; (g) unpublished personal observations of other researchers (see Koshev & Kocheva 2007).

The database of records collected in the present study is a part of the "Concenption for conservation of the European ground squirrel (*Spermophilus citellus*) habitats in NATURA 2000" (Stefanov 2006).

During **the first period (1950–1989)**, Bulgarian farming was carried out in large public farms averaging thousands of hectares. The land and livestock were state property and were included in co-operative farms, where large amounts of agro-chemicals were used (Ilieva 2006, Bachev 2007). *S. citellus* was not included in the Red Book of Animals in Bulgaria (1985), and what is more, the Bulgarian Ministry of Agriculture determined *S. citellus* as a pest, and applied special measures for its extermination (Peshev 1955, Straka 1961).

Many changes occurred in Bulgaria in the **second period (1990–2008)** – the so-called post-communist period. The public co-operative farms were closed down, and the land was returned to private owners. As a result, the previous large fields were partitioned into many small pieces and many of them were left uncultivated (Ilieva 2006, Bachev 2007). The number of grazing livestock in the country decreased

dramatically. The total area of pastures also decreased, as a part of them got degraded. According to the Bulgarian Biodiversity Act from 2002, the *S. citellus* itself is not a protected species, but its habitats, which are priorities for selection of NATURA 2000 sites, are protected.

In order to obtain additional data we verified historical localities by visiting 90 *S. citellus* colonies in Bulgaria during the period 2005–2008. We investigated sites in three model regions: **Sofia field** – 19 sites situated in the Sofia field and adjacent regions with various types of intensive anthropogenic pressure and mean altitude of 550 m a. s. l.; **Thracian valley** – 52 sites situated in the westernmost part of the Thracian valley with mean altitude of 300 m a. s. l., well developed agriculture, mainly vegetable gardens, orchards and vineyards; **mountain region** – 19 sites in regions with the altitude above 700 m a. s. l. and hilly country in the western and central Stara Planina Mts, Vitosha Mt, Lozen Mt, western Sredna Gora Mts, Rila Mts and western Rhodopes Mts.

We surveyed each site for any *S. citellus* traces using transects of a different length depending on the size of the site. If no *S. citellus* colony was found on a particular site, we looked for *S. citellus* in suitable habitats in the surroundings. In each colony during the active season, before juveniles emerged above ground (March, April or May depending on the altitude), we took the GPS coordinates with the Garmin *e*Trex Legend and determined the following categories:

Status. *Extinct* – no traces (active animals, used burrow entrances, or fresh feaces) of *S. citellus* discovered; *Vulnerable* – recently stable but potentially threatened colonies; *Increasing* – colonies which increase their area and abundance (such were not discovered); *Stable* – strong stabile colonies without any obvious sources of threat.

Type of land use. *natural grassland* – open grass habitats without livestock grazing, mowing and cultivating; *pastures* – sites used only for livestock grazing; *pastures/meadows* – sites used for livestock grazing and mowing; *meadows* – sites used only for mowing (such were not discovered); *agricultural areas* (*in general*) – cultivated sites used for agriculture; *urban areas* – sites situated in green areas of the cities; *unknown* – sites, for which we had no information about the previous type of land use, because they were completely destroyed for example by building-up.

Relative abundance. The density of *S. citellus* populations varies with large amplitude within a short period of time (Hoffmann et al. 2003), so long term studies are necessary for its assessment. At present, no uniform methods of estimation of *S. citellus* density are available for monitoring studies (Cepáková & Hulová 2002, Katona et al. 2002). We investigated the *S. citellus* abundance by counting the vertical spring burrow entrances on a 1 ha plot and by direct counting of animals (Katona et al. 2002). According to the Bulgarian conception for conservation of *S. citellus* habitats in NATURA 2000 sites (Stefanov 2006), we classified the relative *S. citellus* abundance into four categories (slightly modified): A: 100–15 inds/ha; B: 14–2 inds/ha; C: <2 inds/ha; D: insignificant (only single individuals and/or burrow entrances observed all over the surface of the studied localities; E: none (no animals observed nor active burrow entrances found). In some cases when we observed colony extinction (some examples in the Thracian valley), we recorded their relative abundance before they became extinct.

Threats and/or probable causes of extinction. In many cases the exact cause of *S. citellus* colony extinction could not be specified and remained unknown. We pooled together the probable causes of extinction and threats because they combine the negative effects on *S. citellus* colonies. We used the following categories: *pasture degradation* – intrusion of shrubs and trees into the grassland; *cultivation* – mechanical cultivation of the habitat such as ploughing and planting of different crops; *flooding* – inundations from some water source; *building-up* – construction of roads, residential building, industrial building, wind turbines, etc.; *agro-chemicals* – treating with different kinds of chemicals in agriculture; *unknown* – the causes or threats were unknown; *none* – no sources of threat were observed.

When we had insufficient information on the causes of extinction, we inquired people of high expertise, who worked in the study region and had observations on habitat and *S. citellus* population changes (i.e. livestock experts, veterinarians, agronomists, mayors of settlements, field biologists, etc.).

Statistics. The study regions were compared by pairs for each category using the Mann-Whitney U-test; for comparison of three model regions the Kruskal-Wallis ANOVA for multiple independent samples was used. All statistical analyses were made with Statistica for WINDOWS 7.0. Release 2004, StatSoft.

RESULTS

Distribution in the period 1950–1989

Using all available precise and specified data from the literature, *S. citellus* occurrence was reported from only 186 sites, covering 110 UTM squares (8.78% of the country area). When we overlapped the distribution maps from Peshev (1955) and Markov (1957) on a UTM map, we saw the complete pattern of *S. citellus* distribution. In total, *S. citellus* occurrence was recorded at 297 sites in Bulgaria in 1950–1989. These sites cover 254 squares of the UTM mapping grid, i.e. 20.25% of the country area (Fig. 1).

The species was not present in southwestern Bulgaria (with some exceptions near the towns of Petrich and Kulata) which is well-wooded. On the other hand, it was widespread in the Danube plain, southern Dobrudzha, Thracian valley, Sofia field, sub-Balkan fields, and Kyustendil valley. *S. citellus* also inhabited the following mountains: Vitosha, Rila, Koniavska Planina, Sredna Gora, Lozen, Plana, and Rhodopes.

Distribution in the period 1990–2008

For the period 1990–2008 we found 275 sites covering 212 UTM squares or 16.9% of the country area (Fig. 2). Based on the results of our survey, the species disappeared from the

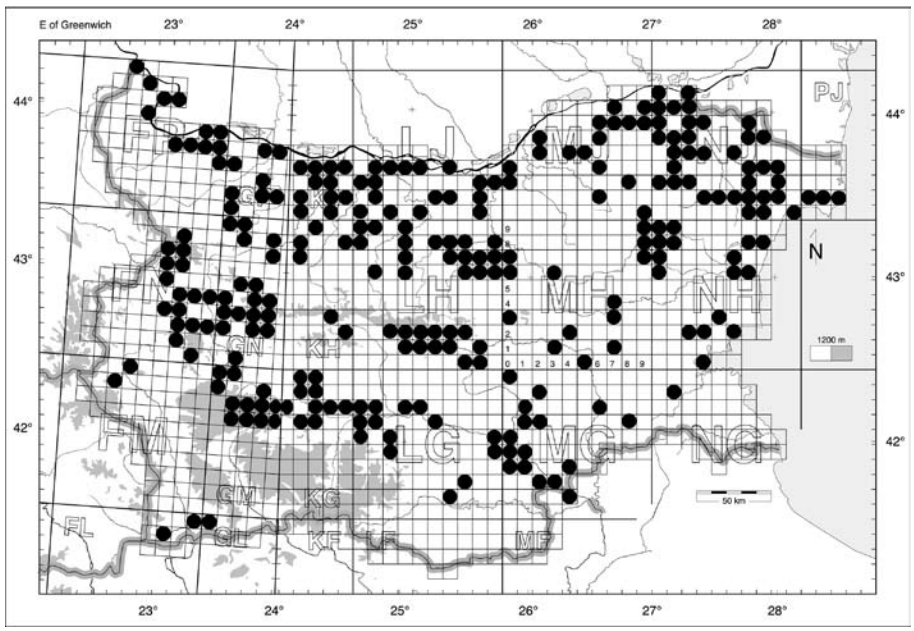

Fig. 1. Distribution of the European ground squirrel (*Spermophilus citellus*) in Bulgaria in the first period (1950–1989), based on the present study and the maps by Peshev (1955) and Markov (1957).
Obr. 1. Rozšíření sysla obecného (*Spermophilus citellus*) v Bulharsku v letech 1950–1989 na základě vlastních dat a publikovaných map Pesheva (1955) a Markova (1957).

Table 1. Investigated European ground squirrel (*Spermophilus citellus*) colonies with their current status, type of land use, relative abundance, and threats and/or causes of extinction in three model regions in Bulgaria

Tab. 1. Přehled hodnocených parametrů 90 kolonií sysla obecného (*Spermophilus citellus*) ve třech modelových oblastech Bulharska – současný stav (status), typ stanoviště (typ of land use), relativní hustota populace (relative abundance), příčiny ohrožení a/nebo zániku kolonie (threats/causes of extinction)

model regions	Sofia field		Thracian valley		mountain region		total	
category	number	%	number	%	number	%	number	%
status								
extinct	11	58	10	19	6	32	27	30
vulnerable	4	21	10	19	11	58	25	28
stable	4	21	32	62	2	11	38	42
type of land use								
natural grassland	2	11	0	0	1	5	3	3
pastures	5	26	45	87	15	79	65	72
pastures / meadows	0	0	0	0	3	16	3	3
agricultural areas [general]	1	5	4	8	0	0	5	6
urban areas	0	0	3	6	0	0	3	3
unknown	11	58	0	0	0	0	11	12
relative abundance								
A (100–15 ind/ha)	2	11	2	4	0	0	4	4
B (15–2 ind/ha)	2	11	19	37	0	0	21	23
C (<2 ind/ha)	3	16	25	48	11	58	39	43
D – insignificant	1	5	2	4	2	11	5	6
E – none	11	58	4	8	6	32	21	23
threats / causes of extinction								
pasture degradation	2	11	0	0	13	68	15	17
cultivation	5	26	2	4	1	5	8	9
flooding	1	5	4	8	0	0	5	6
building up	10	53	0	0	1	5	11	12
agro-chemicals	0	0	2	4	1	5	3	3
unknown	1	5	2	4	1	5	4	4
none	0	0	42	81	2	11	44	49

region around the towns of Petrich and Kulata (UTM: FL78; FL99; GL09) near the Greek and Macedonian border. On the other hand, we observed large concentration of *S. citellus* sites in southern Dobrudzha, central-western Bulgaria, western part of the Thracian valley and eastern Rhodopes.

Current status in three model regions

About 30% of 90 investigated colonies disappeared, 28% were vulnerable and only 42% were stable (Table 1). We did not find increasing colonies. Most of the *S. citellus* colonies inhabited pastures – 65 (72%). The major threat for *S. citellus* colonies were pasture degradation (in 15 cases – 17%), building up (in 11 cases – 12%), and habitat destruction caused by cultivation of fields. These threats made up 35% of the total threats, while no threats were observed in

49% of the colonies. We found a highly significant difference between the three model regions in all categories: current status (χ^2=16.60, df=2, p<0.001), type of land use (χ^2=19.58, df=2, p<0.001), relative abundance (χ^2=20.09, df=2, p<0.001), and threats/cause of extinction (χ^2=37, df=2, p<0.001).

We also found significant differences in the investigated categories in different regions:

Current status. The percentage of extinct colonies was highest in the Sofia field (58%) and in the mountain region – 32%. We did not find significant differences between these two regions. On the other hand, the percentage of stable colonies was highest in the Thracian region (62%). There was a highly significant difference between the Thracian valley and Sofia field (U=312, p<0.01, M-W U-test) and between the Thracian valley and mountain region (U=252, p<0.001, M-W U-test). The differences between the Sofia field and mountain region were not significant. This suggests that *S. citellus* colonies in the Sofia field and mountain region were more threatened by extinction than those in the Thracian valley.

Type of land use. Majority of the colonies inhabit pastures – 72% or 65 colonies. The highest percentages are found in the Thracian valley (87%) and mountain region (79%). Unfortunately, we have no information about habitat type at many sites in the Sofia field, as many *S. citellus* colonies disappeared within a short time because of the fast urban sprawl of Sofia after 1950.

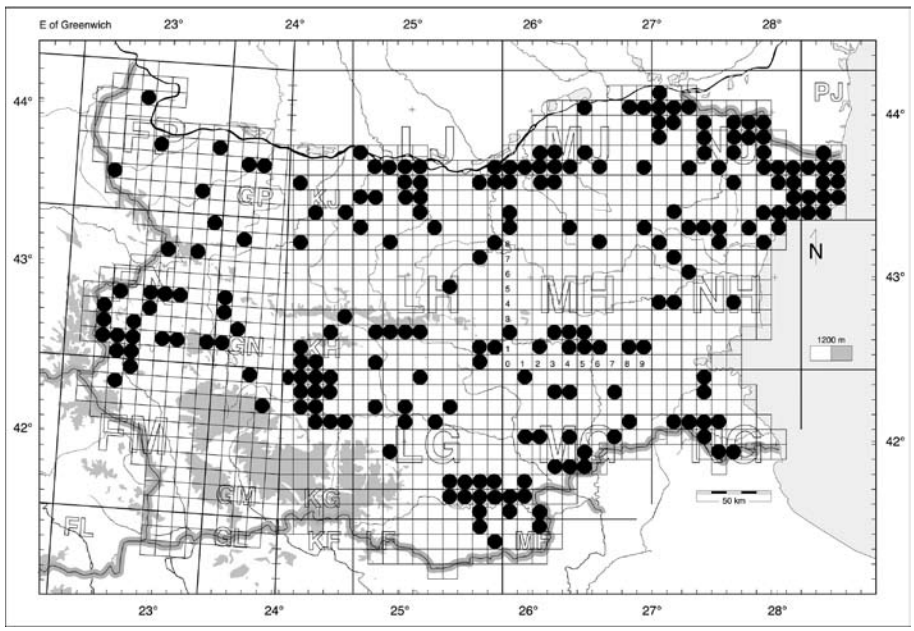

Fig. 2. Distribution of the European ground squirrel (*Spermophilus citellus*) in Bulgaria in the second period (1990–2008), based on the present study and the maps by Spassov et al. (2002), Minkova (2004) and Georgiev (2004).

Obr. 1. Rozšíření sysla obecného (*Spermophilus citellus*) v Bulharsku v letech 1990–2008 na základě vlastních dat a publikovaných map Spassova et al. (2002), Minkové (2004) a Georgieva (2004).

This is probably the reason of the highly significant difference found between the Sofia field and Thracian valley (U=253.5, p<0.001, M-W U-test) as well as between the Sofia field and mountain region (U=89.5, p<0.01, M-W U-test).

Relative abundance. The biggest part of the colonies (66%) showed the relative abundance between the categories C and B. However, the percentage of colonies with no information about their abundance before extinction was considerable – 23%. We found a highly significant difference between *S. citellus* colonies in the Thracian valley and Sofia field (U=258.5, p<0.001, M-W U-test) as well as between the Sofia field and mountain region (U=214.5, p<0.001, M-W U-test).

Threats and/or causes of extinction. Almost half of the colonies (49%) were not threatened. The percentage of non-threatened colonies was highest in the Thracian valley (81%). In the Sofia field, 53% of the threats/causes of extinction was due to construction of roads, residential building and industrial building, while in the mountain region the major threat was pasture degradation (68%). We found significant differences among the three regions: between the Sofia field and Thracian valley (U=134, p<0.001, M-W U-test), between the Sofia field and mountain region (U=105, p<0.01, M-W U-test), and between the Thracian valley and mountain region (U=124, p<0.001, M-W U-test).

DISCUSSION

It seems that the data on *S. citellus* distribution in the period 1950–1989 should be used with some reservations. For example, according to the maps published by Markov (1957), the species was widespread in the eastern Rila Mts (UTM: GM16, 17, 26, 27, 36, 37, 38, 46, 47). However, during the 1950s, as well as nowadays, these squares were completely covered by forests. The only colonies in this part of the eastern Rila Mts were found on the Belmeken peak and at Kurtovi (Valchi) Poliani (UTM: GM37).

When we tried to compare the data and determine the *S. citellus* population trend and distribution changes between the first and second period, we encountered certain complications. It was so difficult to compare the data from 1950–1989 with those recorded in 1990–2008 because they were collected in periods of a different length, in isolated parts of the country, and using different methods. In the first period, the *S. citellus* distribution data were obtained in accordance with the specific scientific interests of that time. Most of the data were collected during surveys of mammal fauna, e. g., in the forest windbreaks of Dobrudzha (Markov 1953), in the Stara Planina Mts, Kyustendil valley, sub-Balkan fields, or during specific taxonomic and ecological studies. In many cases, only general statements on numbers and common occurrence of the *S. citellus* can be found in the literature. Therefore, maps published in this paper may be useful as a basis for future investigations, but cannot be used for a comparison between the two periods. Only the sites precisely specified in the literature are of scientific significance.

After 1990, numerous conservation projects were implemented and many new data were collected: in southern Dobrudzha and central-western Bulgaria (Spassov et al. 2002), eastern Rhodopes (Minkova 2002), Sakar Mt (Georgiev 2004), Strandzha Nature Park (S. Ivanov – unpubl.), and at many other sites in Bulgaria (Koshev & Kocheva 2007, D. Ragyov – unpubl.). At first sight the distribution pattern seems to be different, but we think that the differences are due to the different methods of investigation rather than to the real changes in species distribution.

We did not found the previously known *S. citellus* colonies around the towns of Petrich and Kulata (UTM: FL78, FL99, GL09) near the Greek and Macedonian border. We think that

S. citellus may be already extinct in this southwestern corner of Bulgaria. Moreover, Spassov et al. (2002) noticed that in central-western Bulgaria (FN22, 23, 24, 31, 32, 41, 42, and 43) the species is almost absent from the regions where it showed mass occurrence 10–20 years ago. This fact is very interesting because also in Greece and Macedonia many colonies known in the 1980s or 1990s have now disappeared or are close to extinction (IUCN 2007). Perhaps we observe a similar population decline at the southwestern periphery of the *S. citellus* distribution range as reported from the northwestern periphery.

In contrast to the widely accepted opinion that the current status of *S. citellus* in Bulgaria is stable and that the populations in some regions may be even increasing (IUCN 2007), our results show that in comparison with the period 1950–1989, 30% of the investigated colonies have become extinct recently. The most frequent threat for *S. citellus* habitats in the Thracian valley was flooding, as a half of the colonies were situated near the rivers, and at the same time the rivers represented major dispersal corridors for the species (Koshev in press). This situation is abnormal for a species vulnerable mostly to floods (Hoffmann et al. 2003). The mean distance between active colonies in this model region was 3.25±1.4 km and between extinct *S. citellus* colonies 5.95±2.37 km. Destruction of natural dispersal corridors between colonies with high isolation index was probably a complementary cause of colony extinction (Koshev in press).

We found highly significant differences in threats and/or causes of extinction between the three regions. This fact suggests that the intensity of anthropogenic pressure varies and was not the same in different parts of country.

In Bulgaria we did not record *S. citellus* in habitats intensively managed by man (with some exceptions), in contrast to the Czech Republic where *S. citellus* prefer habitats like airfields, camping sites, a golf course etc. (Cepáková & Hulová 2002). These results suggest that the differences in habitats, threats and current status in the particular parts of the country should be taken into consideration in planning of future conservation activities.

CONCLUSIONS

We can conclude that the following factors are major threats for *S. citellus* population in Bulgaria:

– Pasture degradation. Irregular grazing leads to overgrazing or insufficient grazing. The pastures become overgrown with shrubs and trees. This factor was very clearly expressed in mountain regions of the country.

– Building-up. Construction of roads, industrial building, residential building, golf courses, reservoirs, wind turbines, etc. At present, this factor is most powerful at the Bulgarian Black Sea coast (building of new settlements, hotels, wind turbines), in natural steppe habitats and near the settlements (industrial building).

– Intensification of agriculture (enlargement of agricultural lands, more agro-chemicals used, larger areas cultivated). Transformation of pastures, natural grasslands and meadows into arable fields and perennial plantations.

– Interruption of major biological corridors especially between *S. citellus* colonies with high isolation index. Most frequently through forestation, building-up, cultivation, etc.

– Flooding. Irregular water control sometimes leads to inundation of *S. citellus* colonies.

– Catching. In some Bulgarian regions Gypsy communities catch *S. citellus* as food. However, this factor seems to be insignificant at present days.

Our analysis shows that the *S. citellus* population in Bulgaria probably declines and its current status is unfavourable. Thus, we suggest that the *S. citellus* conservation status in Bulgaria should be enhanced. The species should be included in the new Red Book of Animals in Bulgaria with in the category "vulnerable" and should be protected according the national biodiversity legislation.

SOUHRN

Sysel obecný (*Spermophilus citellus*) je typickým obyvatelem stepí a otevřené krajiny střední Evropy a Balkánu. V některých oblastech nyní patří mezi ohrožené druhy, znalosti o stavu populace a jeho rozšíření v jižní části areálu byly dosud jen omezené. V práci jsou shrnuty údaje o rozšíření sysla na území Bulharska v období 1950–1989 a 1990–2008. Z prvního období jsou k dispozici data o výskytu sysla ve 254 čtvercích síťového mapování, v pozdějším období byl jeho výskyt zaznamenán v 212 čtvercích. Data z těchto dvou období však byla získána odlišnými metodami, proto nebylo možné provést jejich srovnání. Některé kolonie sysla v jihozápadním Bulharsku již pravděpodobně zanikly a s největší pravděpodobností dochází na jihozápadním okraji areálu k celkovému úbytku početnosti jeho populace. Na základě získaných dat bylo rovněž provedeno ověření historického výskytu a hodnocení současného stavu vybraných kolonií ve třech modelových oblastech (horské oblasti nad 700 m n. m., Sofijská kotlina a Thrácká nížina). Z celkem 90 sledovaných kolonií přibližně 30% již zaniklo, 28% je ohroženo a jen 42% lze považovat za stabilní. Nejvíce zaniklých kolonií bylo zjištěno v Sofijské kotlině a v horských oblastech. Sysel obecný se v Bulharsku vyskytuje především na pastvinách (72% kolonií). K hlavním faktorům ohrožujícím jeho existenci patří degradace pastvin, rozvoj výstavby, intenzifikace zemědělství, přerušení migračních koridorů a záplavy. V Bulharsku pravděpodobně dochází k poklesu populace sysla obecného a současný stav tohoto druhu lze označit jako nepříznivý. Proto by se měl zvýšit jeho ochranářský statut. Sysel obecný by měl být zařazen do nové Červené knihy ohrožených druhů živočichů Bulharska v kategorii zranitelný (vulnerable) a měl by být chráněn v rámci zákona na ochranu biodiverzity.

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