Bulletin of the Natural History Museum, 2008, 1: 65-77.

UDC: 569.32(497.11)

SMALL MAMMALS (RODENTIA AND LAGOMORPHA) FROM GRADAŠNICA CAVE (EAST SERBIA)

ZORAN MARKOVIĆ

Natural History Museum, Njegoševa 51, 11000 Belgrade, Serbia
E-mail: zoran.markovic@nhmbeo.rs

Over 2500 items of vertebrate remains were discovered in the left, dead-end passage at the entrance of Gradašnica cave (Miroč, east Serbia). This paper presents data on Rodentia and Lagomorpha. Sixteen species were determined. Fourteen are representatives of the order Rodentia - *Sicista subtilis, Arvicola terrestris, Chionomys nivalis, Clethrionomys glareolus, Microtus arvalis, Microtus subterraneus, Cricetulus migratorius, Cricetus cricetus, Mesocricetus newtoni, Apodemus flavicollis/sylvaticus, Rattus rattus, Muscardinus avellanarius, Glis glis, Nannospalax leucodon* and two of the order Lagomorpha - *Ochotona pusilla* and *Lepus* sp. The main features of odontological material are presented, as well as a palaeoecological discussion.

Keywords: Gradašnica cave, small mammals, Rodentia, Lagomorpha, Pleistocene.

INTRODUCTION

There are about 300 registered speleological objects on the territory of Republic of Serbia. Only few of them have so far been investigated from the palentological viewpoint. One of these is the Gradašnica cave,

located on the west side of the Veliki Greben and Veliki Strnjak, nearby the Miroč village. The cave's monumental entrance is 35 metres high and 15 metres wide. Its altitude is about 380 metres above the sea level. The main channel is about 300 metres long, and is caved out of Jurassic limestone. The cave belongs to the spring-type of caves (Petrović 1976), it is partly hidden in the surrounding vegetation situated far from the main roads, and is extremely rarely visited although the cave is included into the touristic itinerary of the Đerdap National Park.

In February 1998, a multi-expert group of biologists and palaeontologists visited this cave for the very first time. It immediately proved to be very difficult to examine the whole locality throughout, due to high water level throughout the year, and to the reduced accessibility to all parts (too low ceilings and too narrow passages). It was decided that the left passage near the entrance will be investigated first, as it was the driest and most accessible one. It turned out that a great quantity of paleontological material was collected.

This paper is the first in the series of research on the fossil vertebrate fauna. We are presently dealing with the Mammalian orders of the Rodentia and the Lagomorpha. As the investigations on this locality will be continued, the species list will probably be enlarged.

The collecting of material and its subsequent determination were done by a team of experts from the Natural History Museum in Belgrade.

MATERIAL AND METHODS

About fifty kilograms of sediments were collected from the left, "dead-end" passage of the cave. The material was collected on two separate occasions, one during the winter and one during the summer season. This passage, which is very narrow, contains a wider areaof about 2.5 m^2. We investigated this area and concluded that were sure that the sediments were neither disturbed by water nor by human activity (such as digging).

The porous clay sediment, which covers the limestone slope, was nowhere thicker than fifteen centimetres. Variations in its lithological composition were undetectable, individual layers were not recognized. Therefore, we will refer to this sediment as one-layered. The collected

sediments were transported to the Natural History Museum in Belgrade, where they were washedon sieves with different mash size. In this way, the bones and teeth were collected.

It was immediately evident that the material contains the remains of animals from several different classes. In the preliminary survey, the following classes were determined: Amphibia, Reptilia, Aves and Mammalia. The mammal remains were the most numerous, representing about 80% out of 2500 items. The dental remains are the most valid ones for determining mammal species. Out of 1200 teeth, 800 belonged to Rodentia, and only 10 to Lagomorpha. These remains were analysed and the results are presented in this paper. The reamains from the items not treated here, the Chiroptera, Lypotiphla, Carnivora and Ruminantia, will be discussed in a later paper.

In the process of species identification, the collected material was compared with the specimens from the Recent Mammals Collection (RMCNHMB) in the Natural History Museum in Belgrade, and with information from the literature. All the measurements were taken by the standard rules in zoological investigation, using the binocular magnifying glass "Carl Zeiss". The measurements are here presented in mm.

RESULTS

On the basis of dental material, fourteen species of Rodentia and two species of Lagomorpha were identified (Tab. 1).

Table 1. – List of species and material.

Species	Material
Sicista subtilis (Pallas 1773)	1M2 dext., 1m3 dext
Arvicola terrestris (Linnaeus, 1758)	1 mandible dext. (m1-m2), 2M1 sin., 3M2 sin., 1M2 dext, 1M3 dext., 1m1 sin., 2m2 sin., 1m1 dext.
Chionomys nivalis (Martins 1842)	4M1 sin., 3M2 sin., 1M3 sin., 2M1 dext., 3M2 dext., 1M3 dext., 7m1 sin., 2m2 sin., 1m3 sin., 5m1 dext., 3m2 dext.
Clethrionomys glareolus (Schreber 1780)	11M1 sin., 6M2 sin., 2M3 sin., 8M1 dext., 7M2 dext., 1M3 dext., 4m1 sin., 5m2 sin., 1m3 sin., 8m1 dext., 3m2 dext.

Species	Material
Microtus arvalis (Pallas 1779)	9M1 sin., 13M2 sin., 4M3 sin., 6M1 dext., 3M2 dext., 3M3 dext., 14m1 sin., 7m2 sin., 5m3 sin., 10m1 dext., 8m2 dext., 2m3 dext
Microtus subterraneus (de Selys-Longschamps 1836)	7M1 sin., 3M2 sin., 5M3 sin., 8M1 dext., 8M2 dext., 3M3 dext., 3m1 sin., 4m2 sin., 1m3 sin., 11m1 dext., 2m2 dext., 4m3 dext.
Cricetulus migratorius (Pallas 1773)	1 maxilla dext. (M1-M3), 1M2 dext., 2m1 sin.
Cricetus cricetus (Linnaeus, 1758)	1 maxilla dext. (M1-M3), 2m3 sin, 1m3 dext.
Mesocricetus newtoni (Nehring 1898)	1 maxilla dext. (M2-M3), 2 mandibles sin. (m2-m3), 1 mandible dext. (m2-m3), 3M1 sin., 1M1 dext., 2M2 dext., 1m1 sin., 1m2 sin., 1m3 sin., 2m1 dext., 3m3 dext.
Apodemus flavicollis (Melchior 1834) / *Apodemus sylvaticus* (Linnaeus, 1758)	1 maxilla sin. (M1-M2), 1 maxilla dext. (M1-M2), 1 mandible sin. (m1-m3), 1 mandible dext. (m2-m3), 21M1 sup.sin., 15M2 sin., 7M3 sin., 23M1 dext., 11M2 dext., 3M3 dext., 29m1 sin., 21m2 sin., 4m3 sin., 25m1 dext., 23m2 dext., 8m3 dext.
Rattus rattus (Linnaeus, 1758)	1 mandible dext. (m1- m3)
Muscardinus avellanarius (Linnaeus, 1758)	1M1 dext., 1m1 sin.
Glis glis (Linnaeus 1766)	6P4 sin, 27M1 sin., 13M2 sin., 2M3 sin., 4P4 dext., 20M1 dext., 10M2 dext., 11M3 dext., 7p4 sin., 17m1 sin., 14m2 sin., 4m3 sin., 2p4 dext., 26m1 dext., 18m2 dext., 3m3 dext.
Nannospalax leucodon (Nordmann 1840)	1 maxilla sin. (M2-M3), 2M1 sin., 1M2 sin., 1M3 sin., 1M2 dext., 2M3 dext., 1m1 sin., 2m2 sin., 1m3 sin., 2m1 dext., 3m2 dext., 2m3 dext.
Ochotona pusilla (Linnaeus 1769)	1 mandible sin. (m1-m2), 1M1 sin., 1p3 dext., 1m1 dext., 1m2 dext., 2m3 sin
Lepus sp.	1P4 sin., 1M3 sin., 1m2 dext

The remains of *Sicista subtilis* (Fig. 1a) are very rare. Only two molars were discovered. Its morphological and morphometrical features are the same as in the recent *Sicista subtilis* (RMCNHMB). There are also no differences from the previously known fossil material from several

localities in Serbia: Smolućka Pećina cave (Dimitrijević 1991), Vrelska Pećina cave (Marković & Pavlović 1991) and Mandina Pećina cave (Marković 1998). However, the small number of teeth found prevents us from reaching any conclusions about the *Sicista subtilis* population at the time of sediment accumulation.

Arvicola terrestris (Fig. 1b) is represented by only a few dental remains. None of the molars differs from typical *Arvicola terrestris* teeth, neither by size nor by morphology. Just the combined length of m1-m2 in the specimen QVSM 1398/8 is somewhat smaller than from specimens in recent material (RMCNHMB). Judging by tooth wear, it is surely an adult specimen, Its anterocomplex is not different from that in the comparative specimens. *Arvicola terrestris* has been registered in all Serbian Pleistocene localities.

The morphological features and dimensions (Fig. 1c) of *Chionomys nivalis* molars are indistinguishable as well as from recent animals from the surrounding area as from fossil specimens. Dimensions of m1 are in the range given as average for the species in Table 2. So far, *Chionomys nivalis* has been found on the following Serbia localities: Smolućka Pećina cave (Dimitrijević 1991), Vrelska Pećina cave (Marković & Pavlović 1991), Vasiljska Pećina cave (Dimitrijević 1997), Kamenjak (Marković 1995) and Mandina Pećina cave (Marković 1998).

Table. 2. - Lenght of m1 of fossil and recent *Chionomys nivalis* (n - number of specimens, x - middle range).

Locality	n	min-max	x
Gradašnica cave	6	2.84-3.02	2.95
Smolućka Pećina cave (Dimitrijević 1991)	36	2.60-3.30	2.91
Temnata cave (Popov 1994)	179	2.45-3.32	2.92
Meča Dupka cave (Popov 1985)	64	2.57-3.36	2.98
Recent, Swiss (Krapp 1982)	7	2.60-3.20	2.84
Recent, Italy (Krapp 1982)	13	2.70-3.10	2.98
Recent, Bulgaria (Popov 1985)	9	2.81-3.37	3.07
Recent (RMCNHMB)	10	2.63-3.29	3.02

The brachiodonty of *Clethrionomys glareolus* molars from the Gradašnica cave allows us to make conclusions about the age of every specimen in the moment of death. Most discovered molars belonged to young individuals (about 60%), 30% were middle aged specimens, and

about 10% senile ones. There are no morphological or morphometric differences between these specimens and recent ones (RMCNHMB), or ones cited from other localities from Upper Pleistocene in Serbia (Dimitrijević 1997).

Molars of *Microtus arvalis* have the same morphological characteristics as recent representatives of this species from Serbia.

Remains of *Microtus subterraneus are* numerous among the Gradašnica cave microtines. Lengths of m1 from the Gradašnica cave and other localities are given in Tab. 3. *M.subrerraneus* is also found in most localities in Serbia (Dimitrijević 1997).

Table 3. - Lengths of m1 of *Microtus subterraneus* from Gradašnica cave and others locality (n - number of specimens, x - middle range).

Locality	n	min-max	x
Gradašnica cave	14	2.50-2.69	2.59
Temnata cave (Popov 1994)	23	2.40-2.85	2.60
Meča Dupka cave (Popov 1985)	35	2.46-2.95	2.68
Recent, Deutschland (Niethammer 1982)	24	2.40-2.72	2.53
Recent, Bulgaria (Popov 1985)	16	2.42-2.95	2.71
Recent (RMCNHMB)	10	2.45-2.87	2.66

The morphological and morphometric features of *Cricetulus migratorius* (Fig. 1d) from Gradašnica cave are comparable to fossil remains of this species from localities in Serbia, Bulgaria and Romania (Dimitrijević 1997; Marković 1997).

The molar dimensions of *Cricetus cricetus* (Fig. 1e) are somewhat smaller than expected from the extant animal, but the number of remains is lowand the variation unknown, therefore we conservatively assign it to - *cricetus*. The morphological features are like those from the recent hamsters from Serbia (RMCNHMB) and from fossil specimens (Dimitrijević 1997; Marković 1997).

Mesocricetus newtoni (Fig. 1f) is the most numerous hamster species in Gradašnica cave. By observing tooth wear, it is estimated that mostly older animals are represented here. The morphological features

are comparable to *Mesocricetus newtoni* from Serbian localities and nearby localities and of recent and fossil specimens from Romania and Bulgaria (Dimitrijević 1997; Marković 1997). This species occurs, so far, in all Serbian Pleistocene localities.

It is very difficult to differentiate between *Apodemus flavicollis* and *Apodemus sylvaticus,* two sympatric species, ontheir morphological features. The dimensions of M1 and the occurrence of TL 12, used by Tvrtković (1979) are not universally assumed to be a good differentiation character, so they were not used here. The only remains of *Rattus rattus* has all the features as in recent specimens.

Two molars of *Muscardinus avellanarius* are discovered like recent material fromthe Natural History Museum in Belgrade. This speciesis known from: Smolućka Pećina cave (Dimitrijević, 1991), Vrelska Pećina cave (Marković & Pavlović 1991), Vasiljska Pećina cave and Petnička Pećina cave (Dimitrijević 1997).

Glis glis are among the most numerous remains discovered in the sediment. Although the teeth belong to individuals of different ages, there are no morphological differences between these and recent or fossil comparative specimens. *Glis glis* is a common species in the cave sediments of Serbia.

The *Nannospalax leucodon* (Fig. 1g) teeth represent different ages, but most teeth belong to subadult specimens. All the teeth have features typical for the species (Topachevskii 1969; Savić 1982).

Although there is only scantly remains of *Ochotona pusilla* (Fig. 1h) in the material, they are identical with specimens discovered in the Upper Pleistocene deposits of Serbia (Dimitrijević 1988) and its immediate surroundings (Malez 1979).

Only the remains of one *Lepus* sp. juvenile individual were discovered, but these don't allow us to determinate on the species level accurately.

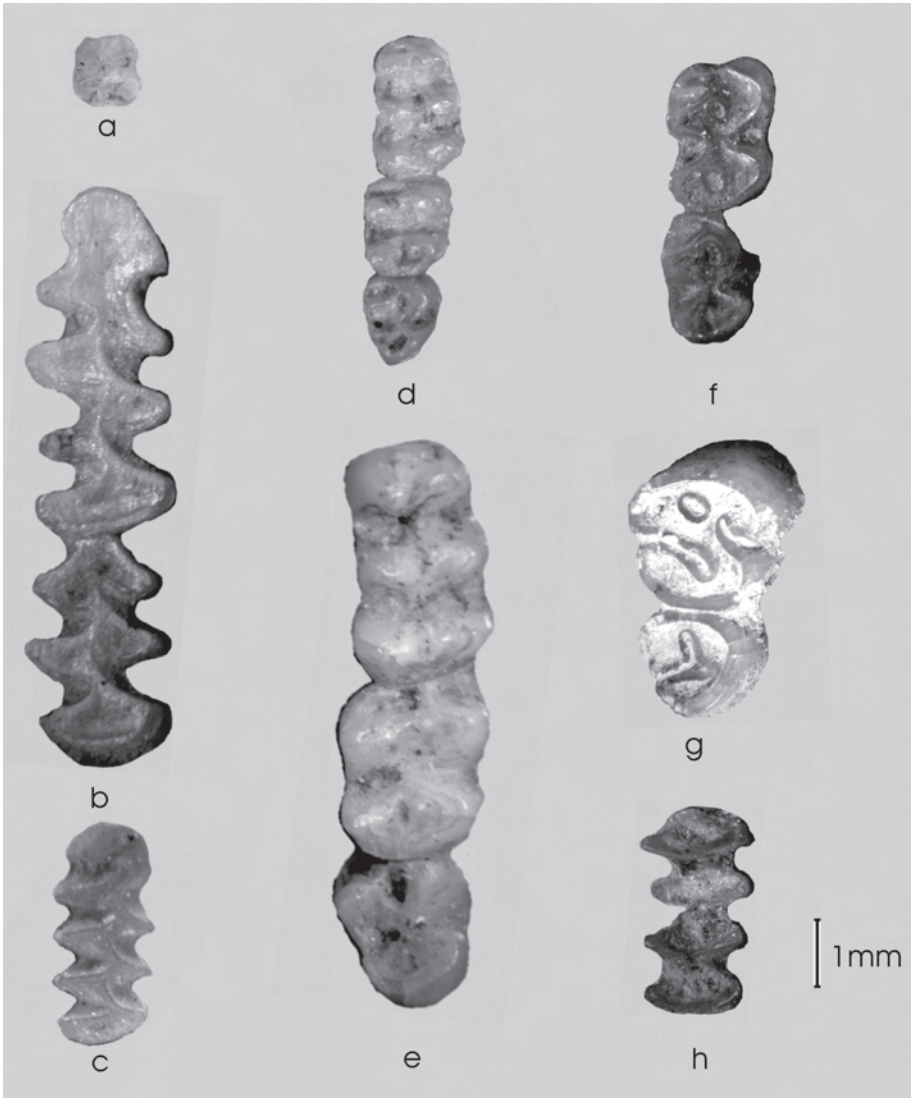

Fig. 1. – a) *Sicista subtilis* – M2 dext. (QVSM1/1); b) *Arvicola terrestris* – m1-2 dext. (QVSM2/1); c) *Chionomys nivalis* – m1 dext. (QVSM4/15); d) *Cricetulus migratorius* - M1-3 dext. (QVSM14/1); e) *Cricetus cricetus* – M1-3 dext. (QVSM12/1); f) *Mesocricetus newtoni* - M2-3 dext. (QVSM13/1); g) *Nannospalax leucodon* - M2-3 dext. (QVSM6/1); h) *Ochotona pusilla* – m1-2 dext. (QVSM1/1).

DISCUSSION

Although a relatively small net weight of sediments was collected, the quantity of fossil material extracted was so great, and so many remains of small mammals were positively identified, that we can discuss the geological age of the association, and the palaeoecological features of the time of deposition.

The remains were accumulated in the place which is certainly not the habitat of any of these species. Only the dormouse customarily uses caves to cache food, like seeds and berries. A dormouse corpse, about a year old, was discovered in the furthest part of the cave. The author assumes that it probably died of old age. Anyhow, it should be rather considered a guest, not a regular tenant. The bones did not bear any signs of being transported by water on any other geomorphological agents. Therefore, the most probable means of transporting and accumulation of this material is by the means of predators. Although no recent material was discovered, such a cave is a natural habitat for some of the owl species in the past, and also ocassionally for some members of the order Carnivora (*Mustela nivalis, Vulpes vulpes* and *Martes* sp.).

We compared this material with the mammal remains taken out of recent owl pellets, available in the Mammals collection of the Natural History Museum in Belgrade, and with data from Andrews (1990). Analyzing the pattern of skull and mandible breakage, it became evident that most remains were part of owl prey.

Some of the cave species are extinct in the area now (*O. pusilla, M. newtoni, C. migratorius, S. subtilis*), while the others are still present (Petrov 1992). We have concluded that sediments in this part of the cave accumulated slowly, without interuptions, for a very long time, although the sediment is only fifteen centimetres thick. Therefore, there is a problem of dating the material. If we use data from other caves in Serbia (Dimitrijević 1991; 1997; Marković & Pavlović 1991; Marković 1995; 1998) as well as those in Bulgaria (Popov 1984; 1985; Pradel 1989) which are geographically very close indeed, we may estimate the time of accumulation as Upper Pleistocene.

Differences in morphology and size between the material from Gradašnica cave and the caves it was compared to, are either not significant or are completely absent.

The fossil *Rodentia* and *Lagomorpha* fauna from the Gradašnica cave sediments may be characterized as a mixture of steppe and forest faunal elements, with several species belonging to other biotopes, such as forest-steppe, mountain meadows, stony mountain peaks, wet forest clearings. The current surroundings of this cave near Miroč are geomorphologically very diverse and support this finding closely.

Most species identified during the examination of the material, are still regular members of the area's fauna, while several other species have disappeared. None of the species found in the fossil material is wholly extinct. If we use data from the Pleistocene and Holocene of Europe and SE Asia, we can map the previous distribution of species, some of theranges of several species have shrank, for example those of *Cricetulus, Mesocricetus* and *Spalax*, which are now restricted to small areas in Eurasia. On the other hand, *Ochotona* is now present only in Asia.

The remains of these animals have mostly been extracted from the upper strata of all the localities so far investigated in our country. In some of them, for example in the Mandina pećina cave, we can still follow the formation of sediments and find the extremely useful biostratigraphic sonde. It is assumed that it may be also possible to observe a change of the climatic conditions, or the expansion of some competitive or predatory species with regard to the reduced ones.

The analysis of *Ochotona* distributions would probably yield very good results. As this animal is, when present, a favourite prey of mouse weasels, foxes, ermines and many birds of prey, it would be very suitable for statistical analyses. The climate change also has a great influence on this animal, which has the highest body temperature among all mammals (40,1°C) (Schneider 1988). Pikas cache food for winter in very large mounds, which may be easily destroyed by other animals, such as badgers, goats, roe deer, sousliks, and in recent time also by rats. This would result in the extermination of the pika's from most seemingly suitable terrains. If we remember that *Ochotona* was registered in the Nineteenth Century even in Southwestern and Western Russia and Eastern Ukraine (Gureev 1963), we can attribute some of the pika decline to human influence, too.

CONCLUSION

In the left, dead-end passage at the entrance of Gradašnica cave, remains of seventeen identified species of small mammals were collected, with features of recent specimens. They also do not differ species found in sediments in other localities in nearby areas. No differences were found when these remains were compared with the material from the Recent Mammals Collection from the Natural History Museum in Belgrade, or with the citations from literature.

The fauna is diverse by character, but fits closely into the geographic position of the locality. There are species characteristic for the steppe, forest, high mountains and meadows, and glacial forms are absent.

REFERENCES

Andrews, P. (1990): Owls, Caves and Fossils. - Cook J., Publ. Nat. Hist. Mus., London

Dimitrijević, V. (1988): The first finding of steppe pika *Ochotona pusilla* Pallas (Lagomorpha, Mammalia) in Serbia. Ann. Geol. Penins. Balk. **51**: 379-389.

Dimitrijević, V. (1991): Quaternary Mammals of the Smolućka Cave in Southwest Serbia. - Paleont. Jugoslav. **41**: 1-88.

Dimitrijević, V. (1997): Upper Pleistocene Mammals From Cave Deposits in Serbia). Ann. Geol. Penins. Balk. **61**(2): 179-370.

Gureev, A. A. (1963): Zajceobraznie (Lagomorpha). In Sokolov, I. I. (*ed*.): Mlekopitajušćie fauni SSSR 1: 223-265 - Akademija nauk SSSR, Zoologičeskij institut. - Moskva, Leningrad. [in Russian]

Krapp, F. (1982): *Microtus nivalis* - Schneemaus. In Niethammer J., Krapp F. (*eds*): Handbuch der Saugetiere Europas, 2(1): 261-284. - Wiesbaden

Malez, M. (1979): Prilog poznavanju rasprostranjenosti stepske zviždare u gornjem pleistocenu Hrvatske. Rad JAZU **383**(18): 345-361. [in Croatian]

Marković, Z., Pavlović, G. (1991): First investigation results for Vrelska cave fauna, Bela Palanka, Serbia. Ann. Geol. Penins. Balk. **55**(1): 221-230.

Marković Z. (1995): Fossil Mammals of Serbia. In Gurnell, J. (*ed.*): 2nd European Congress of Mammalogy. Book of Abstracts: 50-51. – Southampton University, Southampton.

Marković, Z. (1998): Novi rezultati istraživanja fosilne faune kičmenjaka Mandine pećine. - Zbornik radova Ekološka istina. VI naučno-stručni skup o prirodnim vrednostima i zaštiti životne sredine: 249-250. - Negotin. [in Serbian]

Niethammer, J., Krapp, F. (1982): *Microtus arvalis* – Feldmaus. In Niethammer, J., Krapp, F. (*eds*): Handbuch der Saugetiere Europas 2(1): 284-319. - Wiesbaden.

Niethammer, J. (1982): *Microtus subterraneus* - Kurzohrmaus. In Niethammer J., Krapp F. (*eds*): Handbuch der Saugetiere Europas, 2(1): 397-419. - Wiesbaden

Petrov, B. (1992): Mammals of Yugoslavia (Insectivores and Rodents). - Nat. Hist. Mus. Suppl. 37, Belgrade.

Petrović, J. (1976): Jame i pećine SR Srbije. - Vojna biblioteka. Pravila i udžbenici 39, Vojno izdavački zavod, Beograd. [in Serbian]

Popov, V. V. (1985): Drobnite bozainci (Mammalia - Insectivora, Rodentia, Lagomorpha) ot gornopleistocenskite otaložnija v pešćarata „Meča dupka" (Zapadna Stara planina), II Opisanie na vidovite. Acta zool. Bulg. **26**: 23-49. [in Bulgarian]

Popov, V. V. (1994): Quaternary Small Mammals from Deposits in Temnata-Prohodna Cave System. In Kozlowski, J. K., Laville H., Ginter, B. (*eds*): Temnata Cave. Excavations in Karlukovo Karst Area, Bulgaria: 11-53. - Jagiellonian University Press 2(1), Cracow.

Pradel, A. (1989): *Cricetinae* and *Murinae* (Rodentia) from Bacho Kiro Cave, Bulgaria. - Acta zool. Cracov. **32**(12): 547-560.

Savić, I. (1982): *Microspalax leucodon* - Westblindmaus. In: Niethammer, J., Krapp F. (*eds*): Handbuch der Saugetiere Europas 2(1): 543-570. - Akademische Verlagsgesellschaft, Wiesbaden.

Schneider, E. (1988): Calling Hare or Pika. In Grzimek, B. (*ed.*): Grzimek's Encyclopedia of Mammals 4: 314-324. - McGraw-Hill, London, New York.

Topachevskii, V. A. (1968): Mlekopitajušćie, Slepišćovie (Spalacidae). In Bihovskij, B. E. (*ed.*): Fauna SSSR 3(3): 1-247. - Akademija nauk SSSR, Zoologičeskij institut, Leningrad. [in Russian]

Tvrtković, N. (1979): Razlikovanje i određivanje morfološki sličnih vrsta podroda *Sylvaemus* Ognev & Vorobiev 1923 (Rodentia, Mammalia). Rad JAZU **383**(18): 155-186. [in Croatian]

СИТНИ СИСАРИ (RODENTIA И LAGOMORPHA) ИЗ ГРАДАШНИЧКЕ ПЕЋИНЕ (ИСТОЧНА СРБИЈА)

Зоран Марковић

Р Е З И М Е

Пећина Градашница налази се у близини села Мироч у источној Србији. Око 50 кг седимента сакупљено је из пећине и испрано системом сита различитих промера. На тај начин издвојен је остеолошки и одонтолошки материјал припадника *Amphibia*, *Reptilia*, *Aves* и *Mammalia*. Од укупног броја, 800 примерака припада представницима ситних глодара - *Sicista subtilis, Arvicola terrestris, Chionomys nivalis, Clethrionomys glareolus, Microtus arvalis, Microtus subterraneus, Cricetulus migratorius, Cricetus cricetus, Mesocricetus newtoni, Apodemus flavicollis/sylvaticus, Rattus rattus, Muscardinus avellanarius, Glis glis, Nannospalax leucodon*. Лагоморфа обухвата 10 примерака, на основу којих су утврђени представници врста *Ochotona pusilla* и *Lepus* sp. Сви анализирани остаци имају одлике савремених представника и не разликују се од остатака пронађених у седиментима других локалитета у Србији и у суседним областима. То су врсте типичне за степе, шуме, високе планине и пашњаке.