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THE NEOGENE SMALL MAMMALS FROM SERBIA - COLLECTION METHODS AND RESULTS

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Research into fossil remains of small mammals in the Neogene localities in Serbia has been extensively performed in the last fifteen years only. Using special methods to extract the remains from sediment, experts from the Natural History Museum in Belgrade were able to discover over 3000 odontological remains and identified more than a hundred species of small mammals. Based on the systematic composition of associations, fossil representatives of small mammals are classified within the MN Zones and the geological age of the site is determined.

Key words: small mammals, MN zones, Neogene, Serbia.

INTRODUCTION

As in any other scientific field, it gradually became apparent in paleozoology that in order to open the path toward easier solutions to greater questions, the study of certain fields, provisionally labeled as narrow, is essential. Lulled by discoveries of large bones of dinosaurs and large mammals (dominated by proboscideans), the public started to expect paleontology to keep providing new sensations that would fill the galleries of natural history museums. In addition to attending to these records, the

ambition of paleozoology to contribute to the determination of the paths of evolution grew and gradually the fresh record of a tooth belonging to a small mammal became equally as important for science as the whole skeleton of a mastodon. Although it may seem strange at first, the story that may be told by fossil remains of an animal barely visible to the naked eye is in fact the real reflection of the environment at the time of its existence. The small animal is susceptible to all changes and cannot easily migrate; if the conditions for its survival are not met it will quickly become extinct and be replaced by another species. This is the very essence of evolution and without it the stratigraphy, the main goal of paleontology, would not make sense.

In order to become included in the modern world of paleozoological research, during the early 1990s the paleontologists of the Natural History Museum in Belgrade established a Collection of Small Fossil Mammals. The first objects of study were the cave deposits, where numerous remains were discovered that helped elucidate the ways of life in Quaternary period. The wide distribution of well-studied Tertiary sediments in Serbia has presented new possibilities for discovering more remains of small mammals. In the late 1990s, with the support of paleomicromammaliology experts from abroad, research was started at several sites in Central Serbia. The resulting cooperation included field researchers from the Netherlands, Austria and Greece. Among the established sites, Sibnica 1 and Vračevići may be considered rich in their number of determined mammal species. Although only in the preliminary phase of research, the site at Riđake is one of the richest in the world in terms of the number of collected specimens.

During the excavations at the sites with remains of Tertiary small mammals, numerous remains of other vertebrates (fish, amphibians, reptiles and birds) were also collected. Their identification will help in preparing even more precise reconstructions of the living conditions of these ancient habitats.

HISTORY OF RESEARCH OF SMALL MAMMALS IN NEOGENE OF SERBIA

In the monograph Stratigraphy of Cenozoic (Geology of Serbia), the introductory chapter presenting the general description of Tertiary sediments also points out the need to assign greater importance to studies of so called micromammalia, with the special notation that they were neither collected nor studied in our region (Stevanović 1977). The only records at the time were those presented by Petronijević (1967) in his doctoral thesis. Although his studies were mostly directed toward the excavations of

remains of large mammals, the collected remains of small mammals have an exceptional importance as first steps in the paleomicromammaliology of Serbia. Although scarce they are extremely important for stratigraphic determination of the sediments in which they were recorded.

Since that period up to the 1990s there have been no special-purpose excavations of fossil remains of small mammals in Tertiary sediments. Several accidental records on Miocene sediments of Levač Basin from the sediments of Crnča stream banks at Belica were included in a paper by Dolić (1980). Direct communication with the author revealed that these were jaws with teeth of some unidentified rodents. Unfortunately these remains were not preserved.

In the summer of 1996, the team from the Natural History Museum in Belgrade, including curator-paleozoologist Zoran Marković and geological conservator Miloš Milivojević, started the studies of fossil remains of small mammals in Tertiary sediments. The first excavations were performed in the village Gornja Sibnica at Levač Basin. The results of sifting the sediment taken from the site, which in lithological composition and structure closely resembled the original Petronijević site, were not promising. Almost fifty years of impact by various agents (primarily water) have completely altered the structure and relief of Ravanski Potok, the stream where mammal remains were originally discovered in the banks. The numerous landslides caused by flash floods that undermined the clay--containing sediments are now luxuriantly overgrown with vegetation. Even the local people who lived there at the time of excavation by Petronijević's team could not precisely locate the old excavation site. Instead of it a new locality was discovered (Sibnica 1), which differs from the original one in geological age, so both sites are even more significant in a stratigraphic sense.

The next step included systematic excavations at other sites where there was any possibility of finding micromammalian remains. Seventeen new sites were recorded, and all are subject to ongoing research.

METHODS OF SEPARATING FOSSIL REMAINS OF SMALL MAMMALS FROM THE SEDIMENT

The fossil remains of micromammalia are exceptionally difficult to recognize in the sediment on the excavation site. This is particularly true for the individual teeth as some of them are less than a millimeter in length (Eomidae, Gliridae). The most efficient way of their separation is sifting the sediment. If technical and financial conditions allow, the sifting is performed at the site. This method was applied at the sites Sibnica and Tavnik. The other method is to bring the unsifted material to the Museum

to be processed. In both cases sifting is performed with specially constructed vibro-sieves (Fig. 1).

Fig. 1. - Sieving sediment.

By using an aggregate for the production of an alternating current (220V/50Hz) necessary for powering the motor of the sieve and the sinking water pump, the activity at the excavation site becomes equal to that in laboratory conditions. The size of sieve holes is 0.7 and 2.0 millimeters. The process of sediment preparation is the same in both cases. Before the sifting the sediment must be desiccated. The most efficient way is to strew broken pieces of sediment on water-resistant dark foil, on an open flat surface, preferably exposed to sun and wind (Fig. 2). Later the sediment is sunk into plastic buckets filled with water. If the sediments are composed of loose sandstones or sandy clays only one session of desiccation is necessary; otherwise, it must be repeated at least once and perhaps several times.

If the sediment contains organic particles such as pieces of coal, detritus and tiny roots from recent plants, a small amount of concentrated (99.8%) acetic acid (CH_3COOH) and 30% hydrogen peroxide (H_2O_2) is added to the water. This reaction forms large amounts of foam and the organic remains become concentrated on the surface. After 24 hours they are removed for possible paleobotanical analysis. Remains are washed under a strong jet of water from the showers. Use of vibro-sieves significantly accelerates separation when compared to the static system of sieves. The time necessary to sift the sediment is consequently decreased to

one third of the original time. The greatest amount of sediment was processed from the Sibnica site (4000 kilograms), followed by Vračevići (1900), Tavnik (700), Lazarevac (200), Bele Vode (40) and Brajkovac (120 *kg*). The number of sifted specimens is directly proportional to the amount of processed sediment and potential richness of the site. The amount of sediment depends on the length and type of excavation as well as on the accessibility of the site. The richness of the site is influenced by the way in which the remains arrived at the deposition environment. The richest sites are those where the remains were found in situ. These are mostly entrances of fossil caves (Riđake) or sinkholes (Venčac). In such cases the remains originated from the feeding habits of owls or other predators. In the freshwater sediments the remains are most abundant in the lens of the

Fig. 2. - Drying sediment.

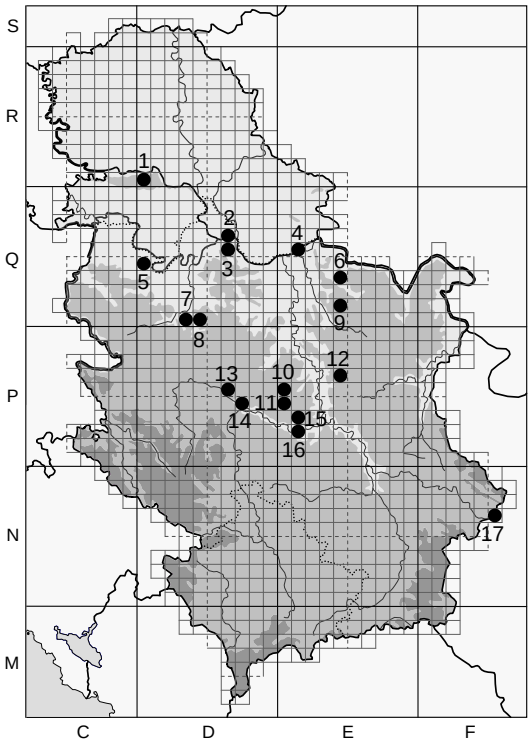
coastal areas of swamps and marshes. In this case the remains of small animals are also the product of feeding habits of predatory animals (most commonly storks). The concentrations of remains may be increased by the erosion of surrounding paleosoil by temporary watercourses. In that case the fossil material (particularly the bones) bears visible results of transport (scratches, rounded edges at points of breakage etc.) and the teeth are isolated and mostly without roots.

Teeth are separated by hand while the sifted material is observed under the binocular microscope. After the separation, the odontological material is treated in the ultrasonic bath in order to be cleaned of impurities. Teeth processed in this way are placed in lines on plasticine ribbons (without lipids) placed on glass platelets. Then these teeth may be easily observed under the binocular lens or photographed. The dimensions of plates are 80×45 *mm*, so they may be easily placed into and removed from plastic

boxes specially made for storing small specimens in the collections. The photographing process for the museum documentation is performed with a digital camera attached via an adapter to the binocular lens with a specially constructed movable base. Each tooth has its own inventory number in the Collection of Tertiary Small Mammals (TVSM – Tertiary Vertebrates Small Mammals) at the Natural History Museum in Belgrade. The number is written on a paper label next to the line of teeth.

RESULTS

The material processed in this way so far includes 3517 teeth of small mammals from 17 Neogene localities in Serbia (Map 1). So far over a hundred species have been identified.



Map 1. - Map of the Neogene small mammals localities in Serbia: 1. Paragovo; 2. Veliko Selo; 3. Leštane; 4. Drmno; 5. Riđake; 6. Snegotin; 7. Vračevići; 8. Brajkovac; 9. Melnica; 10. Sibnica 1; 11. Sibnica 2; 12. Popovac; 13. Tavnik; 14. Oplanići; 15. Lazarevac; 16. Bela Voda;17. Mazgoš.

In cases when there were no available reliable characters that could be used for determination to species level, determination was made to genus level. According to the composition of associations, they were placed in MN zones (MN - *Mammals Neogene*) (Tab. 1).

Table 1. - MN zonation of localities based on small mammals (Marković 2003, 2008a, 2008b, 2009, Marković & Pavić 2004a, 2004b, 2005, 2006, Marković 2008a, 2008b, Marković *et al.* 2008, Marković 2009, Marković *et al.* 2004, 2008, Pavić & Marković 2005, 2006, Petronijević 1967).

MN zone	Localities	**Small mammals fauna list**
18	Riđake	*Blackia* sp., *Spermophilinus* sp., *Miomys occitanus, Micromys* sp., *Apodemus* cf. *atavus*, *Apodemus dominans, Pliomys ucrainicus, Baranomys longidens, Allocricetus bursae*, *Mesocricetus* sp., *Estramomys simplex*, *Keramidomys* sp., *Glis minor, Muscardinus pliocaenicus, Dryomimus* sp., *Glirulus pusillus, Prospalax priscus*
17	Drmno	Chiroptera sp., *Desmanella* sp., *Apodemus dominans, Kowalskia* sp.
16	Mazgoš	*Prolagus* cf. *mishauxi*, Microtinae indet.
9	Tavnik	Lypotiphla indet., *Prolagus* sp., *Megacricetodon similis* (Fahlbusch), *Miodyromys wesselsi* n. sp.
7+8	Vračevići	*Lanthanotherium sansaniens, Galerix socialis*, *Mioechinus* sp., *Plesiosorex schaffneri*, *Proscapinus sansaniensis*, *Plesiodimylus chantrei*, *Dinosorex pachignathus*, *Dinosorex sansaniensis*, Chiroptera indet., *Prolagus* sp., *Lagopsis* cf. *verus*, *Amphilagus fontannesi*, *Spermophilinus bredai*, *Eomyops oppligeri*, *Keramidomys mohleri*, *Anomalomys gaudryi*, *Pliospalax* sp., *Megacricetodon minor*, *Democricetodon affinis*, *Democricetodon freisingensis*, *Collimys longidens*, *Eumyarion latior*, *Byzantinia bayraktepensis*, *Muscardinus sansaniensis*, *Myoglis meini*, *Microdyromys koenigswaldi*, *Paraglirulus werenfelsi, Miodyromys aegercii*
6	Leštane	*Galerix* cf. *exilis*
	Veliko Selo	*Megacricetodon bavaricus*
	Bele Vode	*Democricetodon mutilus, Cricetodon mein, Miodyromys aegercii*
	Lazarevac	*Prolagus* sp., *Galerix* sp., *Spermophilinus bredai, Miopetaurista dehmi, Megacricetodon minor, Democricetodon mutilus, Cricetodon meini, Miodyromys aegercii*
	Brajkovac	*Galerix socialis, Paraglirulus werenfelsi, Megacricetodon similis, Cricetodon* cf. *hungaricus, Eurolagus* sp., *Prolagus* sp.
	Sibnica 3	*Desmanodon* sp.
5-6	Popovac	*Galerix exilis, Cricetodon meini*
5	Oplanići	Talpidae indet.
	Melnica	Talpidae indet., *Galerix* sp
	Paragovo	*Cricetodon* cf. *meini*
4	Sibnica 1	*Galerix symeonidisi*, Talpidae indet., Soricidae indet., Chiroptera indet., *Spermophilinus bredai*, *Miopetaurista dehmi*, *Neopetes hoeckarum*, *Blackia miocaenica*, *Pseudotheriodomys parvulus*, *Anomalomys aliverienensis*, *Heramys eviensis*, *Democricetodon mutilus*, *Eumyarion weinfurtheri*, *Glis minor comlicatus*, *Soersomuscardinus alpinus*, *Glirulus ekremi*, *Microdyromys ligidensis*, *Bransatoglis fugax, Bransatoglis astaracensis*
	Snegotin	*Albertona balkanica*, *Galerix symeonidisi*, *Sorex* sp., *Oligosorex* sp., *Heterosorex ruemkeae*, *Myxomygale engesseri*, Talpidae sp., *Microdyromis* sp., *Anomalomys aliveriensis*, *Megacricetodon primitivus*, *Cricetodon aliveriensis*, *Gliridinus eurodon, Myodiromis* sp.

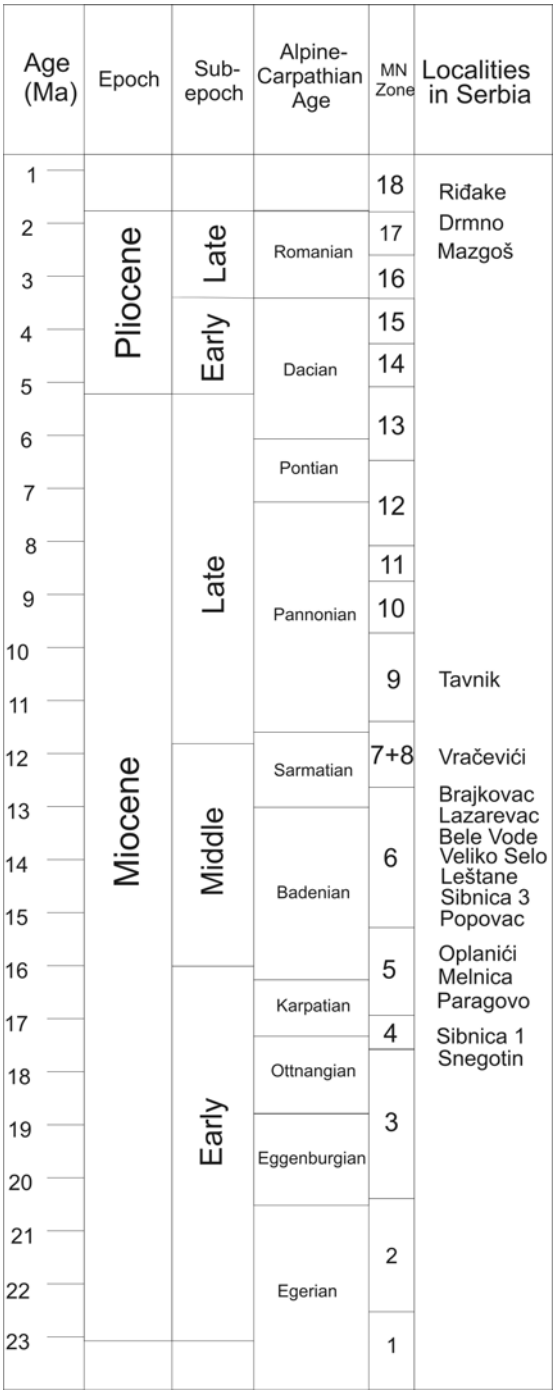


Fig. 3. - Chronostratigraphic positions of the small mammals Neogene localities in Serbia

The zones represent series of fossil mammal associations of individual sites, lined up in chronological sequences according to the stage in evolution and appearance or disappearance due to migration or extinction of specific taxa (De Bruijn *et al.* 1992).

The geological age (Fig. 3) of sediments in which the remains were recorded was determined by correlation with other sites in Europe and Turkey.

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СИТНИ СИСАРИ НЕОГЕНА СРБИЈЕ - МЕТОДЕ САКУПЉАЊА И РЕЗУЛТАТИ

ЗОРАН МАРКОВИЋ, МИЛОШ МИЛИВОЈЕВИЋ

Р Е З И М Е

Истраживања фосилних остатака ситних сисара на неогеним локалитетима Србије интензивно се врше тек у последњих петнаест година. Стручњаци Природњачког музеја из Београда, користећи посебне методе за издвајање остатака из седимента, успели су да открију преко 3000 одонтолошких остатака на основу којих је извршена идентификација преко сто врста ситних сисара. На основу састава асоцијација одређена је геолошка старост локалитета и припадност MN зонама.