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Faunal remains from Borsuka Cave – an example of local climate variability during Late Pleistocene in southern Poland

Jarosław WILCZYŃSKI, Barbara MIĘKINA, Grzegorz LIPECKI, Lembi LÕUGAS, Adrian MARCISZAK, Barbara RZEBIK-KOWALSKA, Ewa STWORZEWICZ, Zbigniew SZYNDLAR, and Krzysztof WERTZ

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Abstract. The Borsuka Cave is located in the southern part of Kraków-Częstochowa Upland, about 20 km west of Kraków. During excavations conducted in 2008-2010 a very rare and interesting faunal assemblage from layer VI was found, dating to the Upper Pleniglacial. Among cold steppe-tundra or taiga species such as *Rangifer tarandus, Vulpes alopex, Equus* sp. or *Coelodonta antiquitatis* taxa adapted to forest environment were also found. Associated with them we found snails, such as *Ena montana, Aegopinella pura* and *Perforatella incarnata;* insectivores, like *Sorex araneus*, carnivores, such as *Martes martes*, *Meles meles* and *Lynx* cf. *lynx;* ungulates, like *Alces alces* and *Bos primigenius* and, among rodents, *Clethrionomys glareolus*, *Apodemus sylvaticus/flavicollis* and *Castor fiber*. This assemblage is the first from southern Poland during this time period to comprise such relatively rich material, and indicates the presence of forest adapted species at the end of the Upper Plenivistulian. No similar assemblages are known from other caves from the Kraków-Częstochowa Upland, and this suggests that during Late Pleistocene in a limited area of Poland, short episodes of forest formations could appear.

Key words: Borsuka Cave, fauna, Pleniglacial, Central Europe, human remains, *Castor fiber*, *Alces alces*.

✉ Jarosław WILCZYŃSKI, Barbara MIĘKINA, Grzegorz LIPECKI, Barbara RZEBIK-KOWALSKA, Ewa STWORZEWICZ, Zbigniew SZYNDLAR, Krzysztof WERTZ, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Sławkowska 17, PL-31016 Kraków, Poland.
E-mail: wilczynski@isez.pan.krakow.pl, miekina@isez.pan.krakow.pl, lipecki@isez.pan.krakow.pl, rzebik@isez.pan.krakow.pl, stworzewicz@isez.pan.krakow.pl, szyndlar@isez.pan.krakow.pl, wertz@isez.pan.krakow.pl

Lembi LÕUGAS, Department of Archaeobiology and Ancient Technology, Institute of History, University of Tallinn, Ruutli 6, EE-10130 Tallinn, Estonia.
E-mail: lembi.lougas@tlu.ee

Adrian MARCISZAK, Department od Paleozoology, Institute of Zoology, University of Wrocław, Sienkiewicza 21, PL-50335 Wrocław, Poland.
E-mail: amarcisz@biol.uni.wroc.pl

I. INTRODUCTION

Borsuka Cave is situated in the southern part of the Kraków-Częstochowa Upland (KONDRACKI 2011), about 20 km west of Kraków, in the Kraków Valleys Landscape Park (Fig. 1). This carstic region is very rich in caves, many of which are important archaeological and palaeontological sites. The most famous are Nietoperzowa Cave and Mamutowa Cave (CHMIELEWSKI 1961; KOWALSKI 1967; KOZŁOWSKI & KOZŁOWSKI 1996), in which were discovered one of the most interesting Upper Palaeolithic inventories from Central Europe. The materials discovered in Nietoperzowa Cave, situated in the Jerzmanowice community, became the basis for the distinguish of a new Upper Palaeolithic cultural unit – Jerzmanowician. Despite the fact that these excavations have provided a very rich archaeological resource along with associated faunal assemblages, they were interrupted in the 70s of the 20th century. Thus there is a need of further investigation into prehistory of this very valuable area.

Borsuka Cave was discovered in 2007, during cataloguing and exploration of the Szklarka Valley caves carried out by Jakub NOWAK (NOWAK 2007). The reason for starting excavations in this cave was a previous accidental discovery of mammoth remains *Mammuthus primigenius*: a shaft of humerus bone, a fragment of a rib and a fragment of mandible with a molar which provided a non-calibrated date of 24,850±200 BP (Poz-26124) (NADACHOWSKI et al. 2011).

Fig. 1. Location of the Borsuka Cave in Poland and Kraków-Częstochowa Upland.

II. STUDY SITE AND METHODS

Borsuka Cave (50º9'53.94''N; 19º42'12.23''E) is situated in the lower course of the Szklarka Valley, on its northern slope. Szklarka Valley is nearly 9 km long, its main axis oriented NNE-SSW, at the bottom of which are encountered a few rock formations. The slopes of the valley are very steep, formed by calcareous rocks, rising ca. 30 m above the bottom of a narrow, meandering stream. The Borsuka Cave is situated on the siliceous outlier, within a distance of merely 100 m from the spot where the Szklarka stream runs into Racławka stream. In front of the cave entrance, of NE exposition, there is a well preserved cave terrace, from its northern and eastern part undercut by the Szklarka stream and its nameless tributary.

Excavations were carried out between 2008-2010. A trench of 4 x 3 m was situated next to the visible cave entrance and oriented with its longer side along the north-south axis (Fig. 2). It covered a ditch of modern times, of irregular outline, with dimensions of ca. 120 x 120 cm and a depth of app. 80 cm. The size and location of the trench were necessary to recognise the terrace sedimentations as well as the degree of its destruction. During the course of the excavation sediments of Holocene and Pleistocene age (reaching a depth of 2.5 m) within an area of 12 sq. m were explored.

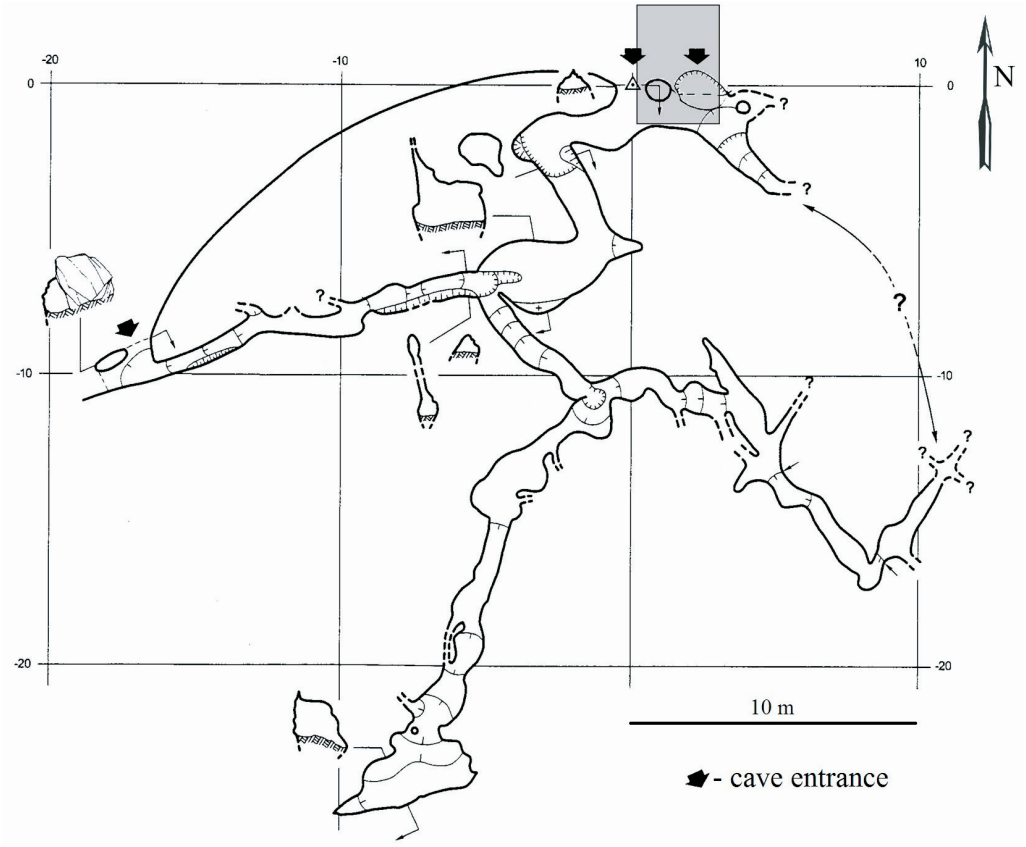

Fig. 2. Borsuka Cave, location of the trench: grey rectangle (after NOWAK 2007, changed).

Before regular exploration began, a layer of over-heaped rubble consisting of red-brown clay had to be removed from the terraces in front of the cave, from the area of prospected survey. The above-mentioned clay most probably originates from the cave interior. Apart from numerous remains of fauna, a single flint flake was found within this layer. Systematic exploration was then performed by means of mechanical removal of successive layers, measuring 10 cm of thickness, in which each encountered artefact was recorded three-dimensionally.

III. CHRONO-STRATIGRAPHY

The trench, taking up an area of 12 sq. metres, yielded a significant number of artefacts, diversified in respect of both chronology as well as typology. The archaeological material, including fragments of pottery, flint artefacts and bone remains, was obtained from all of the layers except marked V and VII. Within the trench the following stratigraphic situation was encountered (Fig. 3):

Layer I: sediment of over-heaped clay most probably originating from the interior of the cave (an old heap).

Layer II: deposit of humus of black-dark brown colour, measuring 20 cm thickness, constituting a ceiling part of the actual stratigraphic sequence. In this layer a total number of 123 fragments of vessel pottery were obtained. The prevailing quantity of pottery finds lay within the loose humus layer, reaching on average a depth of ca. 20 cm. The oldest re-

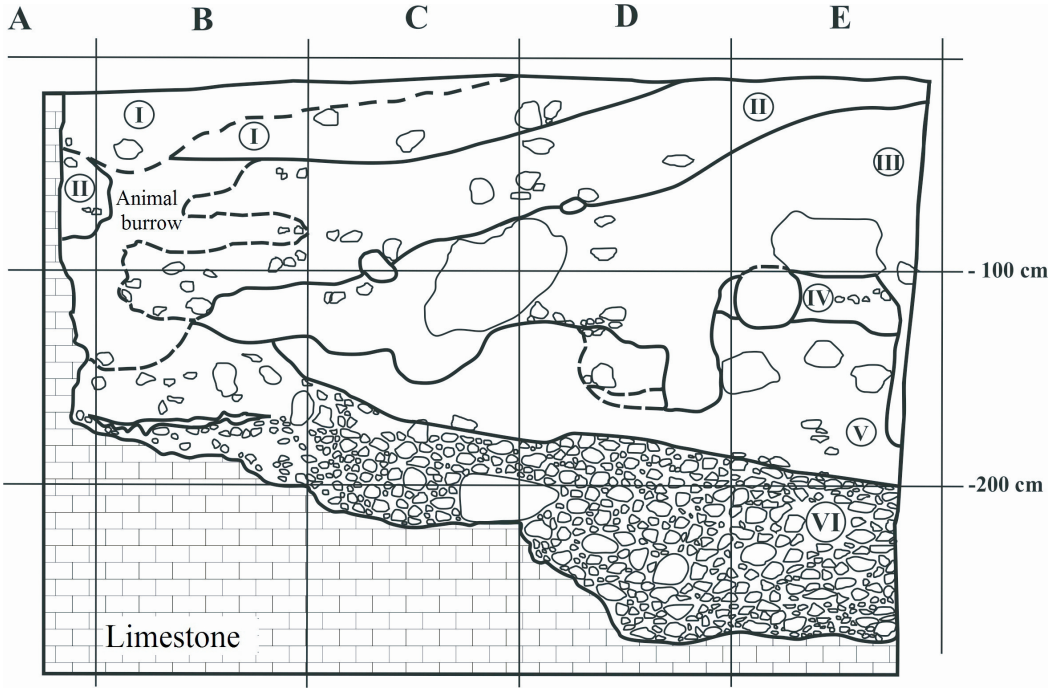

Fig. 3. Borsuka Cave, western profile (indication of the layers like in the text). Layer VII is not visible at profile – it occurs only in the cavity of the rock of the southern part of the trench.

mains of clay vessels refer, in terms of chronology, to exploitation of the cave in the Early Bronze Age. Pottery material dated to the High Middle Ages consists of 28 fragments.

Layer III: At the depth of 20 cm a red-dark brown clayish sediment emerged, within which numerous strongly weathered siliceous chunks, sporadically measuring up to 50 cm in diameter, occurred. In the western part of the trench this layer was more than 1 meter deep. This layer, yielded almost 188 flint artefacts. They do not constitute a homogenous inventory. The collection includes a distinctive component of Mesolithic specimens, which is undoubtedly proved by the occurrence of few microliths. The material in question is characterized by significant vertical dispersion – the specimens occurred within a range of depths between 60 and 115 cm. A fragment of mandible of a wildcat *Felis silvestris* and a fragment of humerus bone of a badger *Meles meles*, obtained from layer III, were radiocarbon dated. They provided non-calibrated dates of 3,920±35 BP (Poz-27235) and 4,175±35 BP (Poz-27281) respectively. The inventory lacks any stone tools or characteristic waste material resulting from their production; therefore, it is difficult to determine the cultural affiliation of the assemblage. The manner of raw material processing itself, as well as the presence of cores for mostly flakes, with occasional discoid ones in some cases, and finally, the abovementioned radiocarbon dates (though they may correspond with the later/earlier period, having no connection with the stone assemblage) may altogether indicate that the inventory should be referred to the Eneolithic or Early Bronze Age. Intense human activity is also evidenced by many small fragments of burned bones discovered in this layer.

Layer IV: At the depth of 60-70 cm, in the NE corner of the trench, colluvial loess sediment of grey-yellow colour was discovered. It was considerably loose and, in contradiction to layer III, was deprived of siliceous chunks. Layer IV, of 50 cm thickness, reaches a maximum depth of 100-120 cm. In this layer a few bones were also recovered, but it is very likely (on a base of the state of preservation) that they have been transferred from the upper layers as a results of the activity of animals. Mesolithic inventory consists of 105 flint artefacts, among them the most numerous being microliths what shows the merely short-term stay of this community.

Layer V: From the depth of ca. 120 cm strongly compact loess sediment emerged, lying *in situ*, of livid-yellow colour, the level of which slightly descended northward towards the existing cave terrace. Within this layer no archaeological or paleontological material has been found, whereas, as the depth increased, the more numerous siliceous, tiny, sharp-edged rubble appeared, which at the depth of ca. 150 cm constituted rubble sediment. This layer corresponds with the significant cooling of the climate connected with the period after Last Glacial Maximum.

Layer VI: At the depth of 150 cm to bedrock (180-250 cm) there was a layer containing sharp-edged unweathered limestone rubble filled clay material of greyish-yellow colour. During excavations in layer VI valuable paleontological and archaeological material for studies of the Upper Pleniglacial of the region was collected. It is a unique assemblage, consisting of human remains accompanied with numerous personal ornaments made of teeth of large ungulates (Fig. 4). During the excavations, six human deciduous teeth were discovered. These are: a right first upper incisor (udi1), a left second upper incisor (udi2), right and left maxillary first molars (udm1), a left mandibular first molar (ldm1) and part of the cusp of a deciduous molar. They occurred west of the concentration of the pendants, in

Fig. 4. Borsuka Cave, pendants made of the incisors of European elk *Alces alces* (scale bar: 2 cm).

the NW corner of the trench. They are the only human remains discovered in the site. The teeth are of a child aged as *infans I* (1-1.5 years old) at the moment of death (ALQAHTANI et al. 2010); the sex cannot be determined. Although no traces of a burial pit were encountered, the character of the discovered assemblage suggests that we are dealing with an intentional burial of a child.

Layer VII: the cavity of the rock was filled with a layer of dark brown clay in which the numerous remains of small fauna were discovered (including amphibians). There was no archaeological material.

IV. FAUNAL REMAINS

Remains of different taxa of snails, fish, amphibians, reptiles, birds and mammals have been found in all layers except in layer V. The materials were collected during the field work and sediment samples were taken from layer I to V for wet sieving, with all the sediment from layer VI and VII undergoing wet sieving. All this material is stored at the Institute of Systematics and Evolution of Animals Polish Academy of Sciences, Kraków.

Snails (Gastropoda)

Fifteen taxa of land snails have been recognized. Shells or their fragments were found in layers I, IV, VI and VII (Table I), but most come from layer VI (Table II). In layers I and IV there were only some unidentifiable shell fragments of Clausiliidae, Zonitidae, Limacidae and Helicidae and in layer VII only one *Aegopinella pura* shell was found.

Table I

Presence of the different class of animals in layers from Borsuka Cave (+ means presence of a particular class in the layer)

Classes	Holocene				Pleistocene		
	Layer I	Layer II	Layer III	Layer IV	Layer V	Layer VI	Layer VII
Gastropoda	+	–	–	+	–	+	+
Pisces	–	–	–	–	–	+	–
Amphibia	+	+	–	–	–	+	+
Reptilia	+	+	–	–	–	–	–
Aves	+	+	+	+	–	+	+
Mammalia	+	+	+	+	–	+	+

Table II

List of the snail (Gastropoda) taxa and number of specimens from the Borsuka Cave – number of identified specimens (NISP)

Taxon	Holocene				Pleistocene		Total NISP
	Layer I	Layer II	Layer III	Layer IV	Layer VI	Layer VII	
	NISP	NISP	NISP	NISP	NISP	NISP	
Columella columella (G. MARTENS, 1830)	–	–	–	–	2	–	2
Pupilla loessica LOŽEK, 1954	–	–	–	–	5	–	5
Ena montana (DRAPARNAUD, 1801)	–	–	–	–	1	–	1
Discus rotundatus (O.F. MÜLLER, 1774)	–	–	–	–	3	–	3
Vitrea crystallina (O.F. MÜLLER, 1774)	–	–	–	–	1	–	1
Aegopinella pura (ALDER, 1830)	–	–	–	–	–	1	1
Aegopinella sp.	–	–	–	–	2	–	2
Nesovitrea hammonis (STRÖM, 1765)	–	–	–	–	2	–	2
Oxychilus glaber (ROSSMÄSSLER, 1835)	–	–	–	–	1	–	1
Zonitidae	–	–	–	2	4	–	6
Limacidae	–	–	–	7	14	–	21
Clausilia dubia DRAPARNAUD, 1805	–	–	–	–	3	–	3
Clausiliidae	1	–	–	–	4	–	5
Perforatella incarnata (O.F. MÜLLER, 1774)	–	–	–	–	1	–	1
Helicidae	–	–	–	2	6	–	8
Total	1	0	0	11	49	1	62

Fishes (Pisces)

Fishes were found only in sediments of layer VI and belong to at least four taxa (Table III). Three vertebrae are identified to species level; one comes from the perch *Perca fluviatilis* and two from the burbot *Lota lota*, one to genus level; the whitefish *Coregonus* sp., and three to the family Cyprinidae.

Table III

Fishes (Pisces) from the Borsuka Cave – number of identified specimens (NISP)

Taxon	Holocene				Pleistocene		Total NISP
	Layer I	Layer II	Layer III	Layer IV	Layer VI	Layer VII	
	NISP	NISP	NISP	NISP	NISP	NISP	
Perca fluviatilis LINNAEUS, 1758	–	–	–	–	1	–	1
Lota lota (LINNAEUS, 1758)	–	–	–	–	2	–	2
Coregonus sp.	–	–	–	–	1	–	1
Cyprinidae	–	–	–	–	3	–	3
Total	0	0	0	0	7	0	7

Amphibians (Amphibia)

The herpetofaunal assemblage of the Borsuka Cave is dominated by the brown frog *Rana temporaria*, represented by remains of at least 177 individuals found mainly in layer VI (Table IV). The remaining few amphibian fossils belong to the toad *Bufo* sp., which is hardly identifiable to species level.

Table IV

Amphibians (Amphibia) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Rana temporaria KOCH, 1872	5	5	–	–	–	–	–	–	244	143	54	29	303
Bufo sp.	–	–	2	1	–	–	–	–	2	2	–	–	4
Total	5	5	2	1	0	0	0	0	246	145	54	29	307

Reptiles (Reptilia)

Reptilian remains, belonging exclusively to snakes, come from layers I and II (Table V). The most common species is the Aesculapian snake *Zamenis longissimus*. In layer I it is associated with the grass snake *Natrix natrix*. The third species, the adder *Vipera berus*, is represented by four vertebrae coming from layer I; it is the least common snake.

Table V

Reptiles (Reptilia) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Zamenis longissimus (LAURENTI, 1768)	27	1	2	1	–	–	–	–	–	–	–	–	29
Natrix natrix (LINNAEUS, 1758)	15	1	–	–	–	–	–	–	–	–	–	–	15
Vipera berus (LINNAEUS, 1758)	4	1	–	–	–	–	–	–	–	–	–	–	4
Total	46	3	2	1	0	0	0	0	0	0	0	0	48

Birds (Aves)

At the Borsuka Cave the bones of 16 bird taxa were found (Table VI). The following bird species occur in the Pleistocene layers (VI, VII); the goshawk *Accipiter gentilis*, willow grouse *Lagopus lagopus*, ptarmigan *Lagopus muta*, black grouse *Tetrao tetrix*, and red-backed shrike *Lanius collurio*. Layer IV is poor in faunal remains, containing only two bird taxa: the black grouse and the capercaillie *Tetrao urogallus*. In the younger layers (I-III), remains of domestic birds were also found, such as the chicken *Gallus gallus* forma *domestica* and goose *Anser anser* forma *domestica*.

With the exception of the goshawk, tawny owl *Strix aluco* and red-backed shrike all identified species (although there are no cut marks) could be associated with the consumption habits of man as a subject of livestock (chicken *Gallus gallus* forma *domestica*, goose *Anser anser* forma *domestica*, mallard *Anas platyrhynchos*, pigeon *Columba* sp.) or hunting (capercaillie *Tetrao urogallus*, black grouse *Tetrao tetrix*, willow grouse *Lagopus lagopus*, ptarmigan *Lagopus muta*, corncrake *Crex crex*, woodcock *Scolopax rusticola*). 84% of the remains come from body parts which were rich with meat (i.e. coracoid and six bones which constitute the proximal and the medial parts of the limbs). The rest of the bones (i.e. the distal parts of limbs and the axial skeleton) were found singly and form only 16% of the all remains. This suggests that deposition was not natural, and the remains might have been deposited as the remnants of human food.

Table VI

Birds (Aves) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Anser albifrons (SCOPOLI, 1769)	–	–	1	1	–	–	–	–	–	–	–	–	1
Anser anser forma domestica (LINNAEUS, 1758)	1	1	1	1	–	–	–	–	–	–	–	–	2
Anser sp.	–	–	1	–	–	–	–	–	–	–	–	–	1
cf. *Anser* sp.	–	–	–	–	–	–	–	–	1	1	–	–	1
Anas platyrhynchos (LINNAEUS, 1758)	2	1	1	1	–	–	–	–	–	–	–	–	3
Anseriformes size of *A.platyrhynchos*/*Mergus*	–	–	1	–	–	–	–	–	–	–	–	–	1
Accipiter gentilis (LINNAEUS, 1758)	–	–	–	–	–	–	–	–	1	1	–	–	1
Lagopus lagopus (LINNAEUS, 1758)	–	–	–	–	–	–	–	–	1	1	–	–	1
Lagopus muta (MONTUS, 1776)	–	–	–	–	–	–	–	–	1	1	–	–	1
Tetrao tetrix (LINNAEUS, 1758)	4	1	2	1	–	–	1	1	3	1	1	1	11
Lagopus lagopus/Tetrao tetrix	–	–	–	–	–	–	–	–	2	–	–	–	2
cf. *Tetrao tetrix*	–	–	–	–	–	–	–	–	1	–	–	–	1
Tetrao urogallus (LINNAEUS, 1758)	–	–	–	–	–	–	1	1	–	–	–	–	1
Bonasa bonasia (LINNAEUS, 1758)	–	–	1	1	–	–	–	–	–	–	–	–	1
Perdix perdix BRISSON, 1760	–	–	1	1	–	–	–	–	–	–	–	–	1
Gallus gallus forma domestica (LINNAEUS, 1758)	4	1	9	1	1	1	–	–	–	–	–	–	14
Galliformes indet. middle-size	1	–	–	–	–	–	–	–	–	–	–	–	1
Crex crex (LINNAEUS, 1758)	–	–	3	1	–	–	–	–	–	–	–	–	3
Scolopax rusticola LINNAEUS, 1758	–	–	1	1	–	–	–	–	–	–	–	–	1
Columba sp.	–	–	1	1	–	–	–	–	–	–	–	–	1
Strix aluco LINNAEUS, 1758	1	1	–	–	–	–	–	–	–	–	–	–	1
Lanius collurio LINNAEUS, 1758	–	–	–	–	–	–	–	–	1	1	–	–	1
Aves indet.	–	–	4	–	–	–	–	–	4	–	–	–	8
Total	13	5	27	10	1	1	2	2	15	6	1	1	59

Mammalia

Insectivores (Soricomorpha)

The remains of insectivores (order Soricomorpha GREGORY, 1910) from Borsuka Cave are not numerous (Table VII). They represent two families (Soricidae and Talpidae) from three genera (*Sorex* LINNAEUS, 1758, *Neomys* KAUP, 1829 and *Talpa* LINNAEUS, 1758) and five species: *Sorex araneus, Sorex runtonensis, Neomys fodiens*, *Neomys anomalus* and *Talpa europaea*. Four of them are extant and only one, *S. runtonensis*, is extinct.

The most numerous (43 specimens, 16 individuals and all five species) and diverse assemblage (four shrews and one mole) was found in layer VI. Three species, *S. runtonensis*, *N. fodiens* and *N. anomalus*, were exclusively found in this layer. In layers I and VII only *S. araneus* and *T. europaea* were present.

Table VII

Insectivores (order Soricomorpha GREGORY, 1910) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Sorex runtonensis HINTON, 1911	–	–	–	–	–	–	–	–	4	2	–	–	4
Sorex araneus LINNAEUS, 1758	1	1	–	–	–	–	–	–	30	8	9	4	40
Neomys anomalus CABRERA, 1907	–	–	–	–	–	–	–	–	3	2	–	–	3
Neomys fodiens (PENNANT, 1771)	–	–	–	–	–	–	–	–	4	2	–	–	4
Talpa europaea LINNAEUS, 1758	5	2	–	–	–	–	–	–	2	2	1	1	8
Total	6	3	0	0	0	0	0	0	43	16	10	5	59

Carnivores (Carnivora)

In the sediments of the Borsuka Cave at least 11 carnivore species from four families (Mustelidae, Felidae, Canidae and Ursidae) were found (Table VIII). The most numerous species are the red fox *Vulpes vulpes* and badger *Meles meles*, fossil material of which is represented by a few dozen bones from animals of different age classes. For other species only a few specimens were assigned. Additionally, two bones (juvenile mandible with milk dentition and a single femur bone) of an undetermined polecat of *Mustela* ex. gr. *eversmanni-putorius* were found.

Table VIII

Carnivores (Carnivora) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Vulpes lagopus (LINNAEUS, 1758)	–	–	–	–	–	–	1	1	15	2	–	–	16
Vulpes vulpes (LINNAEUS, 1758)	2	1	76	2	–	–	–	–	–	–	–	–	78
Vulpes sp.	–	–	–	–	–	–	–	–	32	–	–	–	32
Mustela erminea LINNAEUS, 1758	–	–	–	–	–	–	–	–	1	1	–	–	1
Mustela nivalis LINNAEUS, 1766	–	–	–	–	–	–	–	–	2	1	–	–	2
Mustela ex gr. *eversmanni-putorius*	–	–	–	–	2	1	–	–	–	–	–	–	2
Martes martes LINNAEUS, 1758	–	–	–	–	–	–	1	1	2	1	–	–	3
Gulo gulo LINNAEUS, 1758	–	–	–	–	–	–	–	–	1	1	–	–	1
Meles meles LINNAEUS, 1758	9	2	11	2	16	2	5	1	1	1	1	1	43
Ursus arctos LINNAEUS, 1758	–	–	–	–	1	1	–	–	1	1	–	–	2
Ursus sp.	1	1	–	–	–	–	2	1	–	–	–	–	3
Felis silvestris SCHREBER, 1777	2	1	1	1	1	1	1	1	–	–	–	–	5
Lynx cf. *lynx* LINNAEUS, 1758	–	–	–	–	–	–	–	–	2	1	–	–	2
Total	14	5	88	5	20	5	10	5	57	9	1	1	190

The mammalian fauna of layer VI includes at least eight carnivore taxa: the arctic fox *Vulpes lagopus* (Fig. 5), brown bear *Ursus arctos*, stoat *Mustela erminea*, least weasel *Mustela nivalis*, pine marten *Martes martes*, wolverine *Gulo gulo*, badger and probably an Eurasian lynx *Lynx* cf. *lynx*. The most numerous species in layer VI is arctic fox, which is represented by at least 15 bones from a minimum of two individuals.

Proboscideans (Proboscidea)

Bones of the woolly mammoth *Mammuthus primigenius* were only discovered during speleological excavations in the entrance of the cave, the previously mentioned fragments of mandible, humerus, and rib. On the fragment of the rib numerous, parallel cut marks are visible caused by filleting (Fig. 6). Unfortunately during archaeological excavations remains of this species were not found.

Fig. 5. Borsuka Cave, arctic fox *Vulpes lagopus* mandible from layer VI (scale bar: 2 cm).

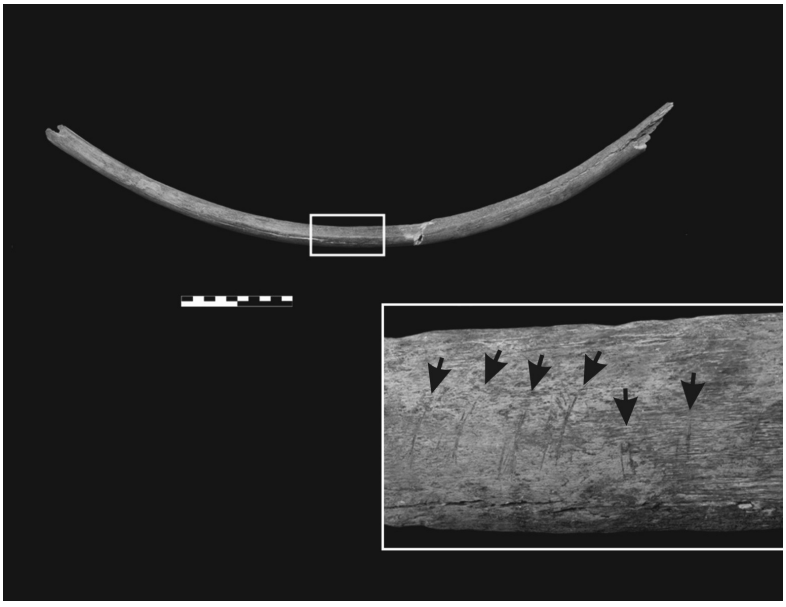

Fig. 6. Borsuka Cave, woolly mammoth *Mammuthus primigenius* fragment of the rib with numerous, parallel cut marks (scale bar: 10 cm).

Perrisodactyls (Perrisodactyla)

The remains of the Perrisodactyl animals are present only in layer VI (Table IX). They are represented by 14 bone fragments belonging to a minimum of one horse *Equus* sp. individual and the single upper premolar tooth of a woolly rhinoceros *Coelodonta antiquitatis* (Fig. 7). Horse remains are represented mainly by limb bones and the whole jaw with traces of gnawing marks made by carnivores.

Table IX

Perissodactyls (Perissodactyla) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Equus ferus BODDAERT, 1785	–	–	–	–	–	–	–	–	14	1	–	–	14
Coelodonta antiquitatis (BLUMENBACH, 1807)	–	–	–	–	–	–	–	–	1	1	–	–	1
Total	0	0	0	0	0	0	0	0	15	2	0	0	15

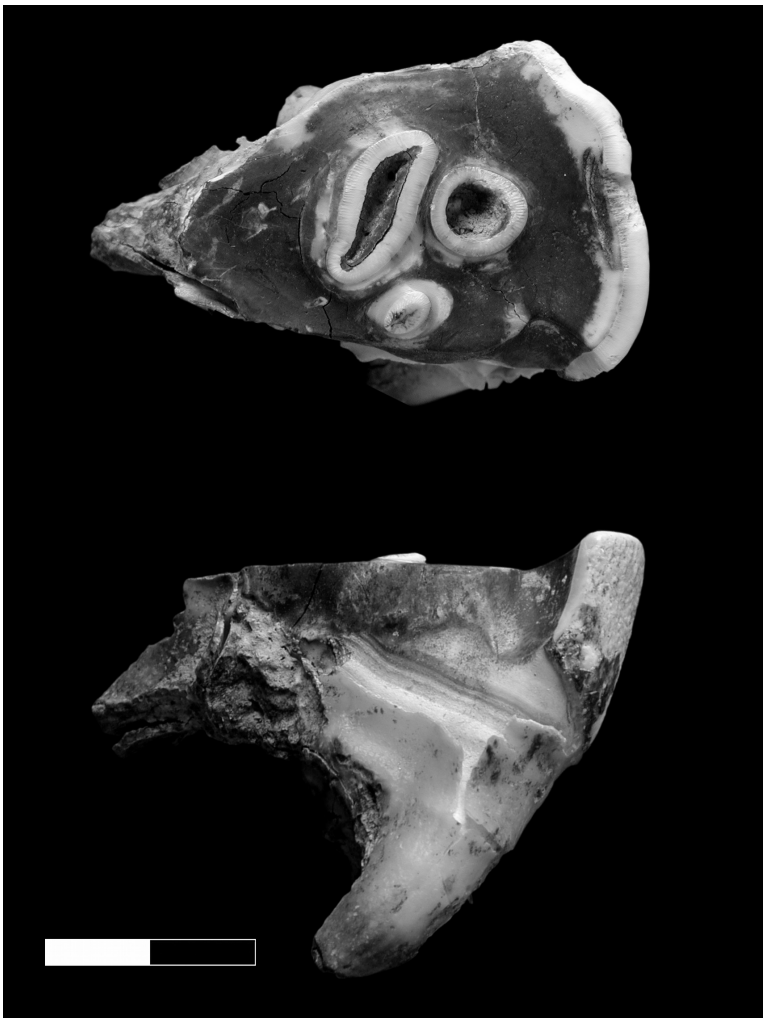

Fig. 7. Borsuka Cave, upper premolar tooth of woolly rhinoceros *Coelodonta antiquitatis* from layer VI (scale bar: 2 cm).

Artiodactyls (Artiodactyla)

Artiodactyls are represented by nine taxa. Among them the most abundant remains belong to a reindeer *Rangifer tarandus* and steppe wisent or aurochs *Bos primigenius/Bison priscus* discovered in layer VI (Table X). Other species are represented by single bones.

In the Holocene layers (I-IV) bones of goat/sheep *Capra* sp./*Ovis* sp., cattle *Bos* sp., roe deer *Capreolus capreolus* and red deer *Cervus elaphus* were discovered. These sparse materials are predominantly related with human occupation of the site.

Unusual material was discovered in layer VI. Within it, at the depth of 160-220 cm, 112 pendants made from the incisors and canines of steppe wisent or aurochs *Bison priscus/Bos primigenius* and European elk *Alces alces* were found. Unfortunately it is impossible to distinguish to which taxon the incisors of *Bison priscus/Bos primigenius* belong. It may be assumed that the pendants are the remains of a necklace. In layer VI single bones of aurochs determined on the basis of BOESSNECK et al. (1963) and MARTIN (1987) were found. Among them were assigned four small fragments of horncorns, proximal and distal fragments of radius, metacarpus and phalanx II, all of them belonging to adult individual.

Table X

Artiodactyls (Artiodactyla) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Capreolus capreolus (LINNAEUS, 1758)	1	1	–	–	–	–	1	1	–	–	–	–	2
Rangifer tarandus (LINNAEUS, 1758)	–	–	–	–	–	–	–	–	44	1	–	–	44
Cervus elaphus LINNAEUS, 1758	–	–	–	–	1	1	–	–	–	–	–	–	1
Alces alces (LINNAEUS, 1758) (pendants)	–	–	–	–	–	–	–	–	35	7	–	–	35
Alces alces (LINNAEUS, 1758)	–	–	–	–	–	–	–	–	1	1	–	–	1
Capra/ Ovis	5	1	8	1	–	–	–	–	–	–	–	–	13
Bos taurus BOJANUS, 1827	2	1	3	1	–	–	–	–	–	–	–	–	5
Bos primigenius/ Bison priscus (pendants)	–	–	–	–	–	–	–	–	78	13	–	–	78
Bos primigenius (BOJANUS, 1827)	–	–	–	–	–	–	–	–	12	1	–	–	12
Total	8	3	11	2	1	1	1	1	170	23	0	0	191

In layer VI reindeer *Rangifer tarandus* remains are quite numerous. Mainly limb bones were found, as well as antlers, carpals, tarsals and sesamoids belonging to a single individual. Furthermore, in the bone assemblage from Borsuka Cave a distal fragment of phalanx II from an European elk was found (Fig. 8).

Fig. 8. Borsuka Cave, fragment of phalanx II of European elk *Alces alces* from layer VI (left), with the whole modern phalanx for comparison (right); scale bar: 2 cm.

Rodents (Rodentia)

The rodent material recovered from layers in Borsuka Cave comprises 15 species (Table XI). Most of the remains are isolated teeth or teeth in mandible fragments. Among rodents the most abundant species were voles: the root vole *Microtus oeconomus* (27% remains), voles from *Microtus arvalis/agrestis* group (23%) and bank vole *Clethrionomys glareolus* (14% of remains). The fossils are not regularly distributed in the sediment. The most numerous sample (79% of all remains) comes from level VI and represents various ecological groups of rodents.

Lagomorphs (Lagomorpha)

During excavations nearly 130 remains of hare were discovered (Table XII). Unfortunately their state of preservation makes impossible to distinguish to which taxa they belong – mountain hare *Lepus timidus* or the European hare *Lepus europaeus*. The hare remains occur in the Holocene layers (I-IV), and are particularly numerous in the Pleistocene layer VI. They represent all parts of the skeleton. In layer I also the remains of a single rabbit were discovered. Single teeth of the steppe pika *Ochotona pusilla* occurred only in layer VI.

Table XI

Rodents (Rodentia) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Spermophilus superciliosus KAUP, 1839	–	–	–	–	–	–	–	–	–	–	1	1	1
Sciurus vulgaris LINNAEUS 1758	–	–	1	1	–	–	–	–	–	–	–	–	1
Castor fiber LINNAEUS, 1758	–	–	–	–	1	1	–	–	1	1	–	–	2
Cricetus cricetus (LINNAEUS, 1758)	–	–	2	1	6	2	–	–	9	9	–	–	17
Dicrostonyx gulielmi (SANFORD, 1870)	–	–	–	–	–	–	–	–	89	73	–	–	89
Lemmus lemmus (LINNAEUS, 1758)	1	1	–	–	–	–	1	1	91	64	6	5	99
Clethrionomys glareolus (SCHREBER, 1780)	5	3	–	–	–	–	1	1	147	105	47	24	200
Arvicola terrestris (LINNAEUS, 1758)	16	9	11	8	–	–	1	1	47	37	3	2	78
Microtus subterraneus (DE SALYS-LONGSCHAMPS, 1836)	2	2	1	1	–	–	–	–	–	–	–	–	3
Microtus arvalis/agrestis	11	7	16	9	–	–	3	2	208	145	89	50	327
Microtus gregalis (PALLAS, 1779)	–	–	–	–	–	–	–	–	153	106	15	8	168
Microtus oeconomus (PALLAS, 1776)	2	1	2	2	–	–	3	2	323	207	80	44	410
Apodemus sylvaticus/ flavicollis	3	2	3	2	–	–	–	–	2	2	–	–	8
Mus musculus LINNAEUS, 1758	1	1	–	–	–	–	–	–	–	–	–	–	1
Glis glis (LINNAEUS, 1766)	2	1	1	1	–	–	–	–	–	–	–	–	3
Total	43	27	37	25	7	3	7	9	1070	749	241	134	1407

Indeterminate Remains of Mammals

Among discovered faunal assemblage numerous indeterminate fragments of bones were found. Its small dimensions make it very difficult, and sometimes impossible, to determine the taxon or even the kind of bone or tooth to which they belong. Nevertheless some of them were possible to divide, on the basis of their dimensions, and were assigned

as belonging to small, medium and large size animals (Table XIII). Numerous bone fragments from layer III were burned (NISP 66). Most of these specimens are smaller than 2 cm and come from a large-sized animal. The length of the larger fragments does not exceed 5 cm. They were burnt to a black color and it is possible that were used as fuel in camp fires (BUIKSTRA & SWEGLE 1989).

Table XII

Lagomorphs (Lagomorpha) from the Borsuka Cave – number of identified specimens (NISP) and minimum number of individuals (MNI)

Taxon	Holocene								Pleistocene				Total NISP
	Layer I		Layer II		Layer III		Layer IV		Layer VI		Layer VII		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Lepus sp.	29	2	14	2	3	1	1	1	82	4	–	–	129
Oryctolagus cuniculus (LINNAEUS, 1758)	2	1	–	–	–	–	–	–	–	–	–	–	2
Ochotona pusilla (PALLAS, 1769)	–	–	–	–	–	–	–	–	18	4	–	–	18
Total	31	3	14	2	3	1	1	1	100	8	0	0	149

Table XIII

Number of indeterminate remains of mammals from the Borsuka Cave (NISP)

Taxon	Holocene				Pleistocene		Total NISP
	Layer I	Layer II	Layer III	Layer IV	Layer VI	Layer VII	
Small size animals (fox/hare)	49	33	23	4	76	3	188
Medium size animals (roe deer, wolf)	7	4	21	8	13	–	53
Large size animals (horse/elk)	5	5	41	5	35	2	93
Indeterminate	9	2	4	1	216	1	233
Total	70	44	89	18	358	6	585

V. RESULTS AND DISCUSSION

The discovered material can be divided into two different faunal assemblages: a younger one including the Holocene layers I-IV, with the other including older layers of Pleistocene age (layers VI-VII). The bone assemblage from the younger layers is less numerous (both in terms of quantity of described taxa, as well as the number of remains) and

could be associated both with animal and human activities (during Eneolithic/Early Bronze and Middle Ages or even modern times). The older assemblage (layers VI and VII) has provided a very rich and diverse fauna. Composition of the fauna, single signs of carnivore activity marks (gnawing marks and digested bones) and lack of traces of human activity on the animal remains (e.g., cut marks, burnt bones etc.) confirm that this bone accumulation is the result of natural factors. More problematic are the mammoth bones, especially the rib with cut marks. Because during archaeological excavation no bones of this species were found, its hard to define their relationship with the discovered accumulation.

In layers I and II the remains of domestic animals (sheep/goat and cattle) are present, which were accumulated during the late Middle Ages and modern times. There were also found numerous red fox remains, along with isolated bones of wildcat and badger. Remains of the latter taxa (especially wildcat) indicate the presence of deciduous forests in the surroundings of the cave during accumulation of the sediments. The presence of the Aesculapian snake remains in layers I and II should also be noted. This taxon is considered a good indicator of palaeoclimates, in particular of mean air temperatures in late spring to summer. The Aesculapian snake, being a highly thermophilous species, nowadays inhabits the southern half of the European continent with the northern range of its geographic distribution reaching southernmost Poland (GASC et al. 1997). In the past, however, its distribution expanded northwards, and in the Holocene it reached the coast of the Baltic Sea (cf. SZYNDLAR 1984, and references therein). The younger layers (I-II), apart from species characteristic of forest stands (grouse, woodcock) and open areas (partridge), also contain the remains of birds associated with a moist or wet meadow environment (the white-fronted goose, corncrake, ducks). But we have to consider that these conclusions are based on a small number of bird remains, which could be deceptive; in these layers (I-III) domestic fowl are also found.

In layer III badger remains were mainly found. Their accumulation appears to have been natural. Among undeterminated remains, 66 fragments of large animals bones bear traces of fire on their surfaces. Radiocarbon dates indicate that this bone assemblage should be referred to the subboreal period.

Layer IV represents a younger phase of sediment accumulation, too. On the basis of sediment characteristic and cultural assignation of archaeological finds it is possible to state that they accumulated during Holocene. This layer contains only isolated bone remains, mainly small indeterminate fragments. Probably they represent a younger admixture. Mesolithic flint artefacts were discovered, characteristic for the Komornica culture. This culture was present in Europe since the Boreal to the Atlantic Period.

Layer V corresponds with the significant cooling of the climate connected with the period of the Last Glacial Maximum. Within this layer no archaeological or paleontological material has been found.

The faunal composition and number of taxa represented is most numerous in layer VI. There are two known radiocarbon dates for remains from this layer. The first date (26,430±180 BP; Poz-38237) was made from a reindeer metatarsus and the second date (27,350±450 BP; Poz-32394) from a European elk tooth pendant. They are close to the date of the mammoth bone (24,850±200 Poz-26124). All dates allow us to estimate the time of accumulation of the remains from this assemblage at the end of the Upper Plenivistulian.

In the paleontological material from layer VI the remains of snails, fish, amphibians, birds and mammals (primarily rodents) are present. It is very possible that all the animal remains found in layer VI (except Artiodactyl teeth from a necklace) are the result of natural accumulation – the activity of carnivore predators. It should be noted that among the taxa associated with colder climates, also the remains of animals of a warmer, forest environment were found.

The malacofauna assemblage from the layer VI includes both woodland or shade-loving snail species and typical cold-tolerant elements. Woodland snails are represented by *Ena montana*, *Aegopinella pura* and *Perforatella incarnata* whereas the remaining species live in both woodland biotopes and in other shaded habitats e.g. thickets, parks, humid rocks. *Pupilla loessica* and *Columella columella* are characteristic for the cold climatic stages of the Pleistocene. The former species was thought to become extinct in Europe at the end of the Pleistocene but recently it has been found living in the Altai Mountains (Central Asia) (HORSÁK et al. 2010). The latter species, at present, is distributed in northern Europe and mountains of central Europe (POKRYSZKO 1990).

Fish remains were found only in sediments of layer VI. The taxa represented in the fossil material of Borsuka cave can now be found in fresh water bodies and are considered as cold adapted. From cyprinids family the genus *Leuciscus* fits this trend, e.g. the chub *Leuciscus cephalus* occurs in that region also nowadays, however the roach *Rutilus rutilus* is also known from the Pleistocene find locations. *Coregonus* group fish have disappeared from southern Poland, but during Pleistocene they were present in the Ice Age lakes and rivers (LÕUGAS et al. 2012).

The amphibian and reptilian species (except the Aesculapian snake) have little potential for reconstructing palaeoenvironmental conditions. The brown frogs, grass snakes, and adders are widely distributed in the European continent and well adapted to their existence in different habitats and variable climates, as well as severe weather conditions (SPELLERBERG 1976, 2002). In Europe, the present-day latitudinal ranges of these species extend from the Mediterranean coasts in the South to subarctic regions in the North (brown frog and adder occur north of the polar circle) (GASC et al. 1997).

Bird species occurring in the Pleistocene layers (VI, VII) – the willow grouse, ptarmigan, black grouse and red-backed shrike – are characteristic of overexposed forests and open areas with clumps of trees and shrubs. The willow grouse, black grouse and goshawk are now typical tundra forest residents.

Among insectivores from layer VI *Sorex runtonensis, Neomys anomalus* and *Neomys fodiens* are of interest. The extinct *S. runtonensis* was one of the most abundant and most widely (from Spain to Russia) distributed species of the genus *Sorex* in the Pleistocene of Europe (AGADZHANYAN 2009; RZEBIK-KOWALSKA 2009). It is very similar in morphology to the recent Asiatic *Sorex tundrensis* MERRIAM, 1900, inhabiting different biotopes from arctic tundra to steppe and preferring open and arid territories. According to OSIPOVA et al. (2006) *S. runtonensis* may have the same ecological requirements as *S. tundrensis* and serve as the indicator of an arid and relatively open paleobiotope. The most abundant species in layer VI is *S. araneus*, which occupies a large area of almost all Europe and continental Asia north of the steppe zone. It lives in forests, scrubs, old parks etc., both in mountains and lowlands. The oldest fossil remains of this species are mentioned from the Early Pleistocene (Q1) localities. Today, *Neomys anomalus* inhabits Europe from

Spain to Eastern Russia but in Central Europe its range is insular. Isolated populations e.g. in Poland indicate the relict character of its recent range. The oldest data on *N. anomalus* come from the Middle Pleistocene of Europe. A larger species of this genus, *N. fodiens*, inhabits a large area over the entire northern and central Palaearctic. Its oldest fossil remains come from the Middle Pleistocene of Europe and the Late Pleistocene of Asia. Both species of *Neomys* are associated with water-bodies. In layer VI and VII remains of *Talpa europaea* are also present. This species lives throughout temperate Europe (including Britain) to the Ob and Irtysh Rivers in Asia. The oldest remains of *T. europaea* were collected in Early Pleistocene (MN17) European localities (RZEBIK-KOWALSKA 2009).

In sediments of layer VI numerous remains of arctic fox were found. Its occurrence could indicate cool conditions and a steppe-tundra and/or tundra-open boreal forest biome near the site during accumulation of this layer. The arctic fox is a circumpolar species, well adapted to cold conditions, usually tundra-living but may penetrate into boreal forest zones during winter migratory movements (SHELDON 1992; KAHLKE 1999). The present range of the arctic fox in Europe is restricted to the tundra regions of Fennoscandia (AUDET et al. 2002). During the Weichselian the species was widespread in Europe (KAHLKE 1999), occasionally reaching the north part of the Iberian Peninsula in the southwest (ÁLVAREZ-LAO & GARCÍA 2011). The fossil remains of arctic fox are recorded from many late Pleistocene localities in the Kraków-Częstochowa Upland (e.g., WOLSAN 1989; CYREK et al. 2000; NADACHOWSKI et al. 2009).

Remains of Mustelidae adapted to cool and/or snowy climatic conditions are represented in osteological material from layer VI. The most noteworthy occurrence is the wolverine bone. This animal is known only from a few Late Pleistocene Polish localities (WOJTAL 2007). The wolverine is purely defined as a northern element of boreal (taiga-type) forests; but in modern times it also lives in open tundra lowlands as well as highly in mountains, which allows the possibility that it has lived in open steppe-tundra too (PASITSCHNIAK-ARTS & LARIVIÈRE 1995). Among Mustelidae ermine and least weasel are recognized as eurytypic species; ermine prefers cooler climates than the weasel (ABRAMOV & BARYSHNIKOV 2000; HERNÁNDEZ FERNÁNDEZ 2001). Pine marten and, to a lesser extent, badger are also strongly associated with deciduous forests, but the pine marten is known from taiga-type forests as well (HERNÁNDEZ FERNÁNDEZ 2001).

The brown bear, recorded from the few late Pleistocene localities in Poland (NADACHOWSKI et al. 2010), is a species occupying a wide range of habitats, including both coniferous and deciduous forests, grasslands, arctic shrublands and tundra, alpine-tundra, semi-deserts and deserts (WILSON & MITTERMEIER 2009).

The most noteworthy presence in layer VI is the lynx bone. Remains of this taxon are very rare in the Pleistocene of Poland (NADACHOWSKI et al. 2009). The lynx lives in old-growth taiga, mixed or deciduous forests, and wooded steppe up to an elevation of 2,500 m (TUMLISON 1987).

Reindeer inhabits forest-tundra and northern subarctic taiga (HEPTNER et al. 1988), and together with horse remains discovered in layer VI, fits with Pleniglacial period in southern Poland.

Single remains of the European elk and aurochs, like other taxa from layer VI (lynx, pine marten or beaver) show that forest environment in some part of the Upper Pleniglacial

occured in the vicinity of the site. The most noteworthy occurrence is of the remains of beaver in layer VI, which are very rare in Late Quaternary of Poland and characteristic of warmer climatic stages of Pleistocene (NADACHOWSKI 1982). The remains of European elk from the Upper Pleniglacjal site of Poland have not previously been discovered. Previous records in the literature of this taxon in the late nineteenth and early twentieth century represent an admixture of Holocene taxa (KOWALSKI 1959). Similar controversies apply to the assemblages coming from the Carpathian Basin and Moravian sites. Among the sites in which were found undoubted remains of European elk from Upper Pleniglacial are open air sites like Bodrogkeresztúr-Henye – dated to 28-26 ka BP (VÖRÖS 2000) and Předmostí – dated to 27-26 ka BP (MUSIL 2010) or cave sites like Mladeč Caves – dated to ~31 ka BP (PACHER 2006; WILD et al. 2005), and Istállóskő Cave – were human remains are dated to 39,700 BP (VÖRÖS 1984; ALLSWORTH-JONES 1990). It is worth mentioning that in the Mladeč Cave pendants made from European elk teeth analogous to those from Borsuka Cave were found (OLIVA 2006).

The most abundant rodents in layer VI are eurytopic taxa (47%), such as the root vole *Microtus oeconomus* which occurs along streams, rivers, inhabits swamps or damp forests, and voles from *Microtus arvalis/agrestis* group, which live in woodland and bushy/open areas, as well as members of the typical tundra-steppe community (33%) such as the narrow-skulled vole *Microtus gregalis*, the collared lemming *Dicrostonyx gulielmi* and the Norway lemming *Lemmus lemmus*. Various forest species (14%) are represented by bank vole *Clethrionomys glareolus*, mouse *Apodemus sylvaticus/flavicollis* and beaver *Castor fiber* (Fig. 9). The remains of beaver are very rare in Late Quaternary of Poland and characteristic for warmer climatic stages of the Pleistocene (NADACHOWSKI 1982).

Layer VII filled the small rocky niches, where numerous amphibians and small mammal remains were found. They belong mainly to species of little value in reconstructing palaeoenvironmental conditions. Only the single remains of a badger could indicate that forest environmental conditions occurred during sedimentation of this layer. Unfortunately, we have no direct radiocarbon dating of these sediments – we can only determine that the materials appearing in this layer are older than 27 ka BP (radiocarbon dates of the layer VI).

VI. CONCLUSIONS

The accumulation of sediments in Borsuka Cave took place from Late Pleistocene up to the present. The remains of different groups of animals give an opportunity to reconstruct the environment in the vicinity of the site during the last 30 thousand years. The most important result of the research is the discovery of forest environment taxa in layers dated ca. 27 to 26 ka BP. There were a few taxa found from different animal groups (snails, pine marten, lynx, elk, beaver) which are clearly connected with warmer conditions and a forest environment. On the other hand there were also animals of cold, tundra-steppe conditions (e.g., snails, arctic fox, horse, woolly rhino, reindeer, lemmings). It should be noted that such a mixture of represented taxa were not found in other caves from the Kraków-Częstochowa Upland in this period (WOJTAL 2007; NADACHOWSKI et al. 2009; STEFANIAK et al. 2009). However, more field work is necessary to confirm whether forest could have covered a larger area, and not only the small area around the Borsuka Cave.

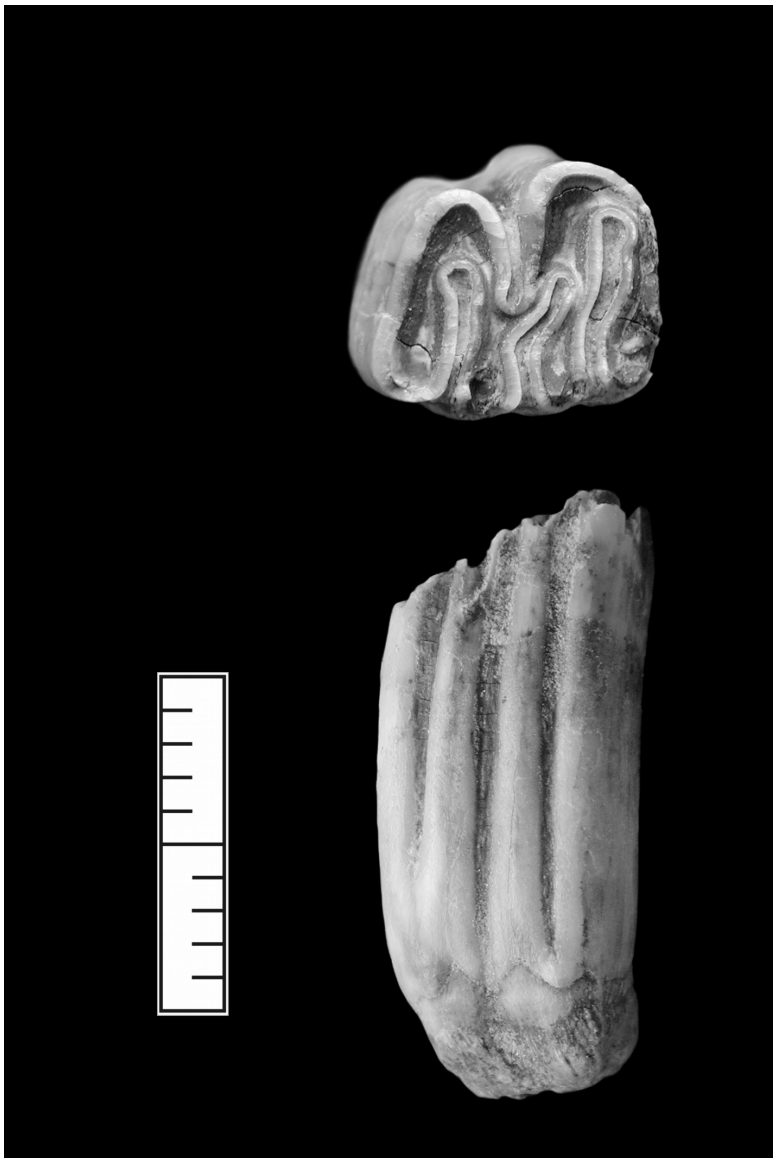

Fig. 9. Borsuka Cave, tooth of beaver *Castor fiber* from layer VI (scale bar: 1 cm).

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