

## Fossil and Subfossil Findings of Brown Bears from selected Localities in Slovakia

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**Abstract.** The fossil remains of bears from the Late Pleistocene are very frequently found in the caves of the Western Carpathians. Occasionally, besides of the fossil remains of cave bears the remains of representatives of brown bears are also found in Slovak karst sediments dated from the Late Pleistocene Period to the start of the Holocene Period. Some of them belong to the taxa *Ursus arctos priscus* GOLDFUSS, 1822 (from the Last Glacial) and *Ursus arctos arctos* LINNÉ, 1758 (especially from the Holocene).

This paper gives a more detailed description of metric and morphologic characteristics of brown bear fossil and subfossil remains (especially teeth and skulls) from six Slovak karst localities: the Lisková Cave, the Lukáč Abyss, the Psie diery Cave, the Šípová Cave, the Važec Cave and the Vyvieranie Cave.

**Key words:** brown bears, metric and morphologic analysis, Last Glacial, Holocene, Slovak caves

### Introduction

The fossil remains of bears from the Late Pleistocene are very frequently found in the caves of the Western Carpathians. The greatest number of these bear remains belongs to the species *Ursus spelaeus* ROSENMÜLLER & HEINRICH, 1794. Occasionally, the remains of representatives from the arctoid branch of the ursid phylogeny are also found in Slovak cave sediments dating from the Late Pleistocene Period to the start of the Holocene Period. These findings belong to the taxa *Ursus taubachensis* (RODE, 1931) (especially from the Eem Interglacial), *Ursus arctos priscus* GOLDFUSS, 1822 (from the Last Glacial) and *Ursus arctos arctos* LINNÉ, 1758, which has been present in our territory from the start of the Holocene or by the end of the Last Glacial Period.

This article gives a more detailed description of metric and morphologic characteristics of brown bear fossil and subfossil remains (especially teeth and skulls) from six Slovak karst locations: the Lisková Cave, the Lukáč Abyss, the Psie diery Cave, the Šípová Cave, the Važec Cave, and the Vyvieranie Cave.

### Localities

#### The Lisková Cave (Fig. 1).

The cave is situated in the Lisková quarry in the Liptov depression near village of Lisková in the Ružomberok district. The cave opening, today filled is situated at 535 m above sea level. It is a small cave, only 40-m long.

#### The Lukáč Abyss (Fig. 1).

The Lukáč Abyss, also known as Lukáč Cave, is a small karst formation, situated in the Volovské vrchy

Mountains, at Kojšovská hoľa hill near village of Kojšovo in the Gelnica district. This 33-m deep chasm is situated at 725 m above sea level.

#### The Psie diery Cave (the Dog's Holes Cave) (Fig. 1).

The Psie diery Cave belongs to the 21 000-m long Stratená cave system in the Slovenský raj Mountains. This is the most extensive cave system in Slovakia. The opening of this inactive through-cave is situated above an unnamed creek in the Tiesniny at Duča hill. It is a 194-m deep cave and is formed of the tectonic-broken Middle Triassic limestone. The Psie diery Cave was discovered by V. Košel and J. Volek in 1972 (Dub et al., 1977 – 1982).

#### The Šípová Cave (the Arrow Cave) (Fig. 1).

The Šípová Cave is situated under Dubná skala hill in the Strážovské vrchy Mountains near the village of Čierna Lehota. The osteological remains of brown bear were found here.

#### The Važec Cave (Fig. 1).

The Važec Cave, significant with its dripstone decoration, is situated on the south-western border of Važec village in the Liptovský Mikuláš district, in the Liptov depression, at 784 m above sea level. During the Pleistocene the cave was formed by the fluvial and chemical erosion of the Biely Váh River on the grey-blue Middle Triassic Guttenstein limestone that have been strongly affected by tectonic movement. These limestone alternate with the lighter dolomite. A quantity of cave bear bones have accumulated among the underground river gravel that have filled the cave, in some places as high as the



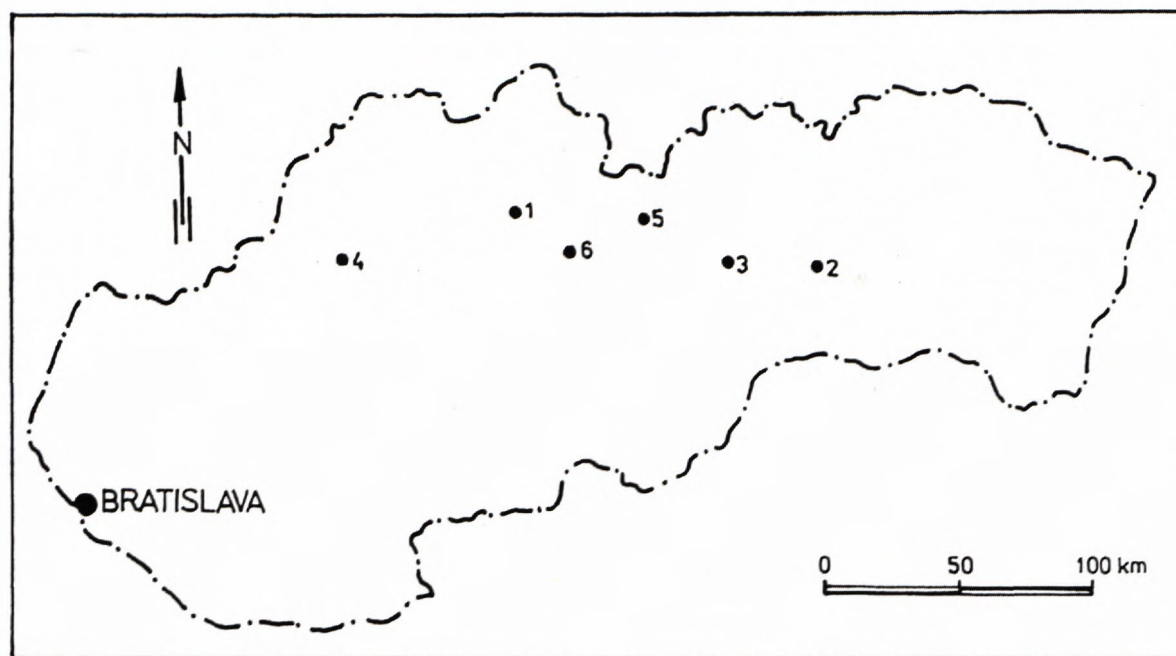


Fig. 1. Location of the individual localities

1 – Lisková Cave, 2 – Lukáč Abyss, 3 – Psie diery Cave, 4 – Šípová Cave, 5 – Važec Cave, 6 – Vyvieranie Cave.

ceiling. This 400 meter long cave is an inactive through-cave, which has collapsed. A student, Ondrej A. Húska, discovered the Važec Cave 8<sup>th</sup> July 1922, and in 1968 the cave was established as a protected site (Dub et al., 1977 - 1982; Kučera et al., 1981).

#### The Vyvieranie Cave (the Cave of Spring) (Fig. 1).

The Vyvieranie Cave is situated south-west from the Okno Cave in the Demänová valley. Its opening is 719 m above sea level. This through-cave is 1 538 m long and is a ground water discharge of Demänovka creek (Kučera et al., 1981).

#### Material and Methods

The studied material is for the most part deposited in the Slovak Museum of Nature Protection and Speleology in Liptovský Mikuláš. An exception being the fossil material taken from sediments of the Lisková Cave, which are deposited in the Liptov Museum in Ružomberok. Unfortunately, the circumstances regarding their discoveries are not known; we only know that these fossil cave bear remains came from older excavations in these caves or they were found on the surface in caves. Altogether 38 teeth, 7 mandibles and 5 skulls have been studied metrically and morphologically. The following works were used during the study of these fossil remains: Musil (1962, 1964, 1965, 1969, 1991), Erdbring (1953), Feriancová-Masárová and Hanák (1965), Sabol (1998, *in press*) and Sládek (1991). From the metric point of view, the material was compared with findings from other caves and sites, especially in Slovakia and Moravia.

#### Systematic Part

##### System

Class MAMMALIA LINNAEUS, 1758  
Order CARNIVORA BOWDICH, 1821  
Suborder CANIFORMIA KRETZOI, 1945  
Infraorder ARCTOIDEA FLOWER, 1869  
Order-group taxon ARCTOMORPHA WOLSAN, 1993  
Superfamily URSOIDEA GRAY, 1825  
Family URSIDAE GRAY, 1825  
Subfamily URSINAE VIRET, 1955  
Genus URSUS LINNAEUS, 1758

##### Species *Ursus arctos* LINNAEUS, 1758

Type locality: Sweden

Geological age: Middle Pleistocene – Recent

Distribution: Europe (Middle Pleistocene – Recent), Asia (Middle Pleistocene – Recent), Northern America (Late Pleistocene – Recent), Africa (Late Pleistocene).

The studied fossil material was evaluated without regard to the circumstances of their discovery. All measurements in the tables are in millimetres.

#### The Lisková Cave

The studied material consists of two upper jaw fragments with I<sup>3</sup> dex. and sin., C sup. dex. and sin., P<sup>4</sup> dex. and sin., M<sup>1</sup> dex. and sin., M<sup>2</sup> dex., and with I<sup>1</sup>, I<sup>2</sup>, P<sup>1</sup>, P<sup>2</sup>, P<sup>3</sup> dex. and sin., and M<sup>2</sup> sin. alveoli (Photo 1), the fragment of skull and four mandible fragments. The colour of the teeth crowns is white-brown and yellow-brown, the colour of roots is yellow and yellow-brown and the colour



Photo 1. *Ursus arctos* cf. *priscus* GOLDFUSS, 1822 – the upper jaw of the adult individual (No. 751/2 and 751/3), Lisková Cave, the Last Glacial, 1/2 – 1/3 of the natural size (a – palate view, b – lateral view) (photo: V. Klimešová).

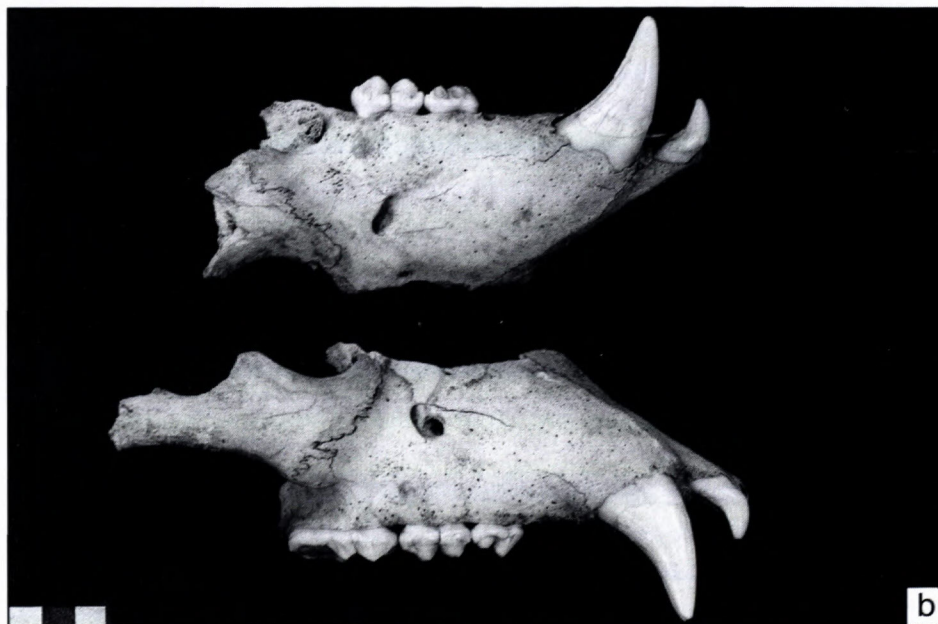
of cranium fragments is yellow, yellow-brown, brown and grey-white.

The both right (No. 751/2) and left (No. 751/3) third upper incisors are still situated in two fragments of upper jaw, probably belongs to brown bear male. Their crowns are damaged, especially on the base; abraded on the top of the main cusps; and with distinct cingulum on the antero-lingual side. The measurements of these incisors are as follows: the crown height is 16 mm (right incisor) and 16.2 mm (left incisor); the lengthwise crown average is 15.1 mm (right incisor) and 15 mm (left incisor); and the transverse crown average is 15.2 mm (right incisor) and 15.2 mm for left incisor.

The right upper canine (No. 751/2; see Tab. 3) has crown damaged and abraded, but the one of the left upper canine (No. 751/3; see Tab. 3) is only damaged at its surface, especially in the crest area.

The crown of the fourth right upper premolar (No. 751/2; see Tab. 4) faintly damaged and abraded. The paracone is damaged on the top together with the metacone, which has one accessory cusp at the back. The deutercone has not developed an accessory cusp. The cingulum is distinct. The fourth left upper premolar (No. 751/3; see Tab. 4) has a damaged and unabraded crown. The paracone together with metacone are damaged on the outside. One accessory cusp is situated behind the metacone. The distinct deutercone is undamaged and unabraded, without an accessory cusp. The walls of main cusps are smooth. The cingulum is distinctly developed, especially at the back and in the front.

The first right upper molar (No. 751/2; see Tab. 6) has crown damaged and abraded. The both paracone and metacone are damaged on the top, and their accessory cusps (parastyle and metastyle) are abraded together with



the protocone and cusp, which is situated between the protocone and hypocone (metaconuluse). The hypocone is still distinct together with the crown cingulum. The middle part of this molar is abraded. The crown of the first left upper molar (No. 751/3; see Tab. 6) is damaged too, and faintly abraded. The paracone is damaged on the top, smooth on the inside, with a parastyle in the front, and separated from the metacone by a notch. As well, the metacone is damaged on the top, smooth on the inside, and with little metastyle at the back, forming the end of the posterior crest. The protocone is not divided and faintly abraded. The hypocone is without accessory cusps, and is faintly abraded, similarly the lesser metaconuluse. The middle part of crown is smooth, without cusps. The cingulum is developed on both lateral sides, but the lingual one is more robust.

Tab. 1. Measurements and counted indices of the fossil and subfossil brown bear skulls from some studied localities.

skulls	<i>Ursus arctos arctos</i> Lukáč Abyss (4525)
skull length (from the anterior-most point of skull to the posterior border of occipital condyles)	334.2
max. skull length	357.0
skull length (from the anterior-most point of skull to the lower border of foramen magnum)	316.6
length of the face part of the skull	261.7
length of the cerebral part of the skull	115.3
medium length of the nasal bones	-
lateral length of the nasal bones	-
palate length	177.9
length (from the posterior border of the palate to the posterior border of the pterygoid hamulus)	69.0
rostrum width	87.4
zygomatic width	226.2
interorbital width	80.7
postorbital width	-
mastoid width	161.8
skull height	190.4
	(with mandible)
height of the upper canines	-
length from the upper P4 to the upper M2: dex.	74.8
length from the upper P4 to the upper M2: sin.	73.7
the same in % of the max. skull length: dex.	21.0
the same in % of the max. skull length: sin.	20.6
frontal width	120.0
length from the upper canine to the upper M2: dex.	131.0
length from the upper canine to the upper M2: sin.	135.0
the same in % of the max. skull length: dex.	36.7
the same in % of the max. skull length: sin.	37.8

skulls	<i>Ursus arctos priscus</i> Važec Cave (570/77)
skull length (from the anterior-most point of skull to the posterior border of occipital condyles)	314.2
max. skull length	347.7
skull length (from the anterior-most point of skull to the lower border of foramen magnum)	294.4
length of the face part of the skull	258.0
length of the cerebral part of the skull	108.0
medium length of the nasal bones	81.0
lateral length of the nasal bones	87.5
palate length	171.5
length (from the posterior border of the palate to the posterior border of the pterygoid hamulus)	70.4
rostrum width	76.3
zygomatic width	-
interorbital width	-
postorbital width	68.5
mastoid width	172.9
skull height	-
height of the upper canines	48.4 (dex.)
length from the upper P4 to the upper M2: dex.	70.4
length from the upper P4 to the upper M2: sin.	72.4
the same in % of the max. skull length: dex.	20.3
the same in % of the max. skull length: sin.	20.8
frontal width	112.0
length from the upper canine to the upper M2: dex.	120.0
length from the upper canine to the upper M2: sin.	118.6
the same in % of the max. skull length: dex.	34.5
the same in % of the max. skull length: sin.	34.1



skulls	<i>Ursus arctos cf. priscus</i> Vyvieranie Cave (321)
skull length (from the anterior-most point of skull to the posterior border of occipital condyles)	402.3
max. skull length	415.0
skull length (from the anterior-most point of skull to the lower border of foramen magnum)	390.0
length of the face part of the skull	336.4
length of the cerebral part of the skull	101.8
medium length of the nasal bones	-
lateral length of the nasal bones	-
palate length	230.0
length (from the posterior border of the palate to the posterior border of the pterygoid hamulus)	-
rostrum width	100.0
zygomatic width	-
interorbital width	-
postorbital width	89.2
mastoid width	-
skull height	-
height of the upper canines	-
length from the upper P4 to the upper M2: dex.	97.0
length from the upper P4 to the upper M2: sin.	97.0
the same in % of the max. skull length: dex.	24.1
the same in % of the max. skull length: sin.	24.1
frontal width	126.9
length from the upper canine to the upper M2: dex.	176.0
length from the upper canine to the upper M2: sin.	176.0
the same in % of the max. skull length: dex.	43.8
the same in % of the max. skull length: sin.	43.8

Tab. 2. Measurements and counted indices of the fossil and subfossil brown bear mandibles from some studied localities  
(\* - measured only to m1, (a) – alveolusly measured).

mandibles	<i>Ursus arctos arctos</i> , Lukáč Abyss (4526)		<i>U. arctos cf. arctos</i> Šípová Cave (6310)
mandible length	245.7 (dex.)	247.5 (sin.)	183.6
height of the C inf.	-	-	30.7
length of the P4 - M3	82.1 (dex.)	80.8 (sin.)	75.0 (a)
length of the P4 - M3 in % of the mandible length	33.4 (dex.)	32.7 (sin.)	40.8
length of the C inf. - M3	147.0 (dex.)	147.3 (sin.)	118.3 (a)
length of the C inf - M3 in % of the mandible length	59.8 (dex.)	59.5 (sin.)	64.4
max. mandible height	-	-	79.8
upper mandible width		143.5	-
lower mandible width		179.0	-

mandibles	<i>Ursus arctos ssp.</i> , Psie diery Cave	
	5815/dex.	5815/sin.
mandible length	107.4	104.4
height of the C inf.	10.2	-
length of the P4 - M3	31.0*	59.6 (a)
length of the P4 - M3 in % of the mandible length	28.9*	57.1
length of the C inf. - M3	53.4*	80.0 (a)
length of the C inf - M3 in % of the mandible length	49.7*	76.6
max. mandible height	41.0	-
upper mandible width	-	-
lower mandible width	-	-



The brown crown of the second right upper molar (No. 751/2; see Tab. 7) is undamaged and nearly un-abraded. The paracone has developed one accessory cusp on the front side, but the metacone is without an accessory cusp. The protocone is divided into two cusplets, the metaconuluse is distinct and the hypocone coincides with the back border of the crown. The middle part of the crown is faintly abraded.

The seams of the damaged skull fragment (No. 751/1) are fully grown and knitted together (adult individual). The occipital shield is damaged in the upper part of the nuchal crest, on the base and in the area of the jugular processes. The basisphenoid is broken off. The temporals are damaged, especially on the base and in the area of the mastoid processes, but both right and left mandible fossa are undamaged. The parietals are damaged; the sagittal crest, that is beginning most on the skull end, is very faint and short. Only posterior part of the frontals has been preserved. Also, the lateral parts fragments of the pterygoid are preserved only. The measurements of this skull fragment are as follows: the braincase width is 120.6 mm and the mastoid width is 161.5 mm.

Only posterior parts of two right and two left mandible branches have been studied (No. 582/1-2 and No. 583/1-2). They have broken off coronoid process and damaged the condylar process. The angular process is either damaged or broken off; with two distinct length-wise crests in the inside. One mandible fragment with  $M_2$  dex. and  $M_3$  dex. alveoli has both undamaged the mandible foramen and the subangular process. The length between the coronoid process and angular process of the mandible fragment No. 582/1 is 49.5 mm and of the mandible fragment No. 583/1 is 52.6 mm.

The studied findings belong to five to six adult individuals. One of them was probably male. On the basis of the metric and morphologic characteristics of these bear fossil remains, especially fragments of upper jaw with  $P^1$ ,  $P^2$  and  $P^3$  alveoli, they were placed into the taxon *Ursus arctos* cf. *priscus*.

### The Lukáč Abyss

The skull (No. 4525 (18/86); see Photo 2) and mandible (No. 4526; see Photo 2) from the Lukáč Abyss belong to a subfossil representative of the brown bear. The measurements of the both skull and mandible are situated in the tables No. 1 and 2.

There are preserved only the fourth upper premolars and the first and second upper molars in the upper jaws (see Tabs. 4, 6 and 7). In the mandible, both the fourth both right and left lower premolars (see Tab. 5), the first left lower molar, both the second right and left lower molars (see Tab. 8), and the third right lower molar have been preserved there.

The first left lower molar (No. 4525) is very damaged. The length of this tooth is 21.2 mm, and the width at the back narrow of this one is 5.4 mm. The measurements of the abraded third right lower molar (No. 4525) are as follows: the tooth length is 19.4 mm; the width in the

frontal part is 15.4 mm; the width at the back part is 15.2 mm; and crown height at the place of the paraconid is 4.2 mm.

As well, four free canines (1 C sup. dex., 1 C sup. sin., 1 C inf. dex., and 1 C inf. sin.; see Tab. 3) have been studied. The colour of their crowns is yellow-white and yellow-brown, the colour of their roots is yellow and yellow-brown.

The crown of the right upper canine (No. 4547/1; see Tab. 3) is damaged. Root is preserved entirely and faintly damaged on the surface. The left upper canine (No. 4547/2; see Tab. 3) has its crown abraded on the top and damaged on the surface. Root is preserved entirely and damaged on the surface.

The crown of the right lower canine (No. 4546/2; see Tab. 3) is abraded on the top and damaged on the surface. Root is preserved entirely and faintly damaged on the surface. The left lower canine (No. 4546/1; see Tab. 3) has its crown very damaged, especially on lingual side. Its root is also preserved entirely and damaged on the surface.

All these subfossil bear findings belong to subspecies *Ursus arctos arctos* and probably they belong to old individual, which skeleton have been found in the sinter deposits at the bottom of this abyss. F. Pomorský has partly studied these remains (1986).

### The Psie diery Cave

Only one incomplete skull and mandible of the brown bear cub (No. 5815) has been studied from this location. The skull consists only of braincase and the damaged facial part. The width of the brow is 67 mm. This is an only measurement, measured at the damaged skull.

The right branch of the mandible (see Tab. 2) is faintly abraded and damaged on the inner side. This mandible contained one lower canine and a still ingrown permanent first lower molar together with the incisor, and  $P_1$ ,  $P_3$  and  $P_4$  alveoli.

The left branch of this mandible (see Tab. 2) is also faintly abraded, with a broken off the coronoid process. The  $P_3$ ,  $P_4$  and  $M_3$  alveoli and, still ingrown, both of the permanent first and second lower molars have been situated here.

On the basis of the presence of the  $P_1$  dex., and  $P_3$  dex. and sin. alveoli, this finding probably belongs to the species *Ursus arctos* LINNÉ.

### The Šípová Cave

One fragment of right upper jaw (No. 6311 (114/94)) with the C sup. dex. (see Tab. 3),  $P^4$  dex. (see Tab. 4) and  $M^1$  dex. (see Tab. 6), and the right branch of mandible with C inf. dex. and  $P_4$  dex. from the Šípová Cave probably belongs to subfossil representative of the brown bear.

The light-yellow mandible (No. 6310; see Tab. 2) is faintly damaged on the surface. The sinter crust covers the part of this one. Three chin openings (*foramina mentalia*) are developed in the front mandible part – two of



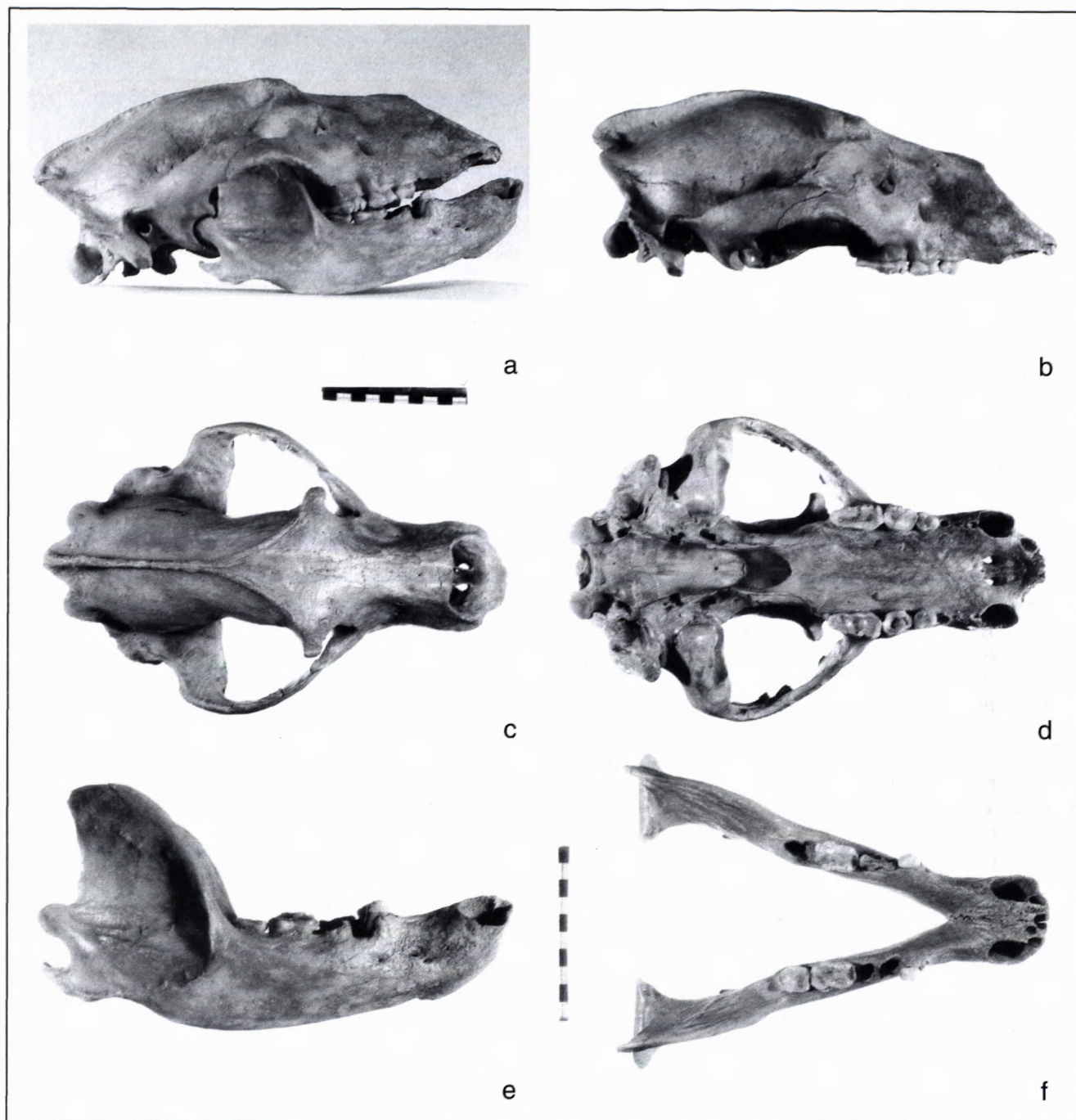


Photo 2. *Ursus arctos arctos* LINNÉ, 1758 – the skull and mandible from the Lukáč Abyss, the end of the Pleistocene (?) and start of the Holocene, 1/3 – 1/4 of the natural size (a – complete view; b – skull, lateral view; c – skull, dorsal view; d – skull, ventral view; e – mandible, lateral view; f – mandible, dorsal view) (photo: L. Osvald).

these are situated below the space between C inf. dex. and P<sub>4</sub> dex., and one small chin opening sits below P<sub>4</sub> dex. This mandible branch with incisors, P<sub>1</sub> dex. and molar alveoli belongs probably to young male individual.

The white and yellow-white crown of the lower right canine of this mandible (No. 6310, see Tab. 3) is damaged on the surface and unabraded. The colour of root is yellow.

The colour of the P<sub>4</sub> crown from the described mandible branch (No. 6310, see Tab. 5) is yellow-white. Its crown is damaged, especially at the back; and only faintly

abraded. The protoconid is distinct, faintly abraded at the back, with a distinct anterior cingulum, and with a small accessory cusp on the posterior side where it has developed a low crest. This crest continues to the little cusp (probably hypoconid), situated at the distinct posterior cingulum. The colour of the both roots is yellow.

#### The Važec Cave

Only one skull of a fossil brown bear was metrically and morphologically studied from this cave. The major



Tab. 3. Measurements and counted indices of the fossil and subfossil brown bear upper and lower canines from some studied localities.

the upper and lower canines sample	<i>U. arctos cf. priscus</i> , Lisková Cave		<i>U. a. cf. arctos</i>
	751/2	751/3	Šípová C. (6311)
tooth length measured from tip to root tip (not along the length of the tooth)	-	-	-
lengthwise average of the crown base	22.7	21.8	17.6
transverse average of the crown base	16.6	15.2	12.0
transverse average of the crown base in % of the lengthwise average of the crown base	73.1	69.7	68.2
crown height	38.0	34.0	27.6
max. lengthwise root average	-	-	-
max. transverse root average	-	-	-
max. transverse root average in % of the lengthwise root average	-	-	-
root length in front	-	-	-
root length at the back	-	-	-
lengthwise root average in % of the root length at the back	-	-	-
transverse root average in % of the root length at the back	-	-	-

the upper and lower canines sample	<i>U. arctos priscus</i> Važec C. (570/77)
tooth length measured from tip to root tip (not along the length of the tooth)	85.8
lengthwise average of the crown base	20.0
transverse average of the crown base	15.2
transverse average of the crown base in % of the lengthwise average of the crown base	76.0
crown height	24.4
max. lengthwise root average	28.0
max. transverse root average	17.6
max. transverse root average in % of the lengthwise root average	62.9
root length in front	67.0
root length at the back	56.4
lengthwise root average in % of the root length at the back	49.7
transverse root average in % of the root length at the back	31.2

the upper and lower canines sample	<i>U. a. cf. arctos</i> Šípová C. (6310)	<i>U. arctos, arctos</i> , Lukáč Abyss	
		4547/1	4547/2
tooth length measured from tip to root tip (not along the length of the tooth)	-	90.7	90.4
lengthwise average of the crown base	19.6	20.0	20.4
transverse average of the crown base	14.7	16.0	16.2
transverse average of the crown base in % of the lengthwise average of the crown base	75.0	80.0	79.4
crown height	30.8	31.5	29.2
max. lengthwise root average	-	22.8	22.8
max. transverse root average	-	16.4	16.7
max. transverse root average in % of the lengthwise root average	-	71.9	73.3
root length in front	-	69.2	70.0
root length at the back	-	56.0	58.0
lengthwise root average in % of the root length at the back	-	40.7	39.3
transverse root average in % of the root length at the back	-	29.3	28.2



the upper and lower canines		<i>U. arctos arctos</i> , Lukáč Abyss	
sample		4546/1	4546/2
tooth length measured from tip to root tip (not along the length of the tooth)		84.8	83.0
lengthwise average of the crown base		21.0	20.3
transverse average of the crown base		16.5	16.4
transverse average of the crown base in % of the lengthwise average of the crown base		78.6	80.8
crown height		31.7	28.8
max. lengthwise root average		22.6	22.5
max. transverse root average		16.4	16.0
max. transverse root average in % of the lengthwise root average		72.6	71.1
root length in front		64.5	65.0
root length at the back		52.2	52.0
lengthwise root average in % of the root length at the back		43.3	43.3
transverse root average in % of the root length at the back		31.4	30.8

Tab. 4. Measurements and counted indices of the fossil and subfossil brown bear P<sup>4</sup> from the some studied localities.

the fourth upper premolars	<i>U. arctos cf. priscus</i> , Lisková Cave		<i>U. arctos arctos</i> , Lukáč Abyss	
	751/2	751/3	4525/dex.	4525/sin.
sample				
max. length	17.2	18.0	16.9	17.6
max. width	13.0	13.6	13.5	12.5
max. width in % of the max. length	75.6	75.6	79.9	71.0
crown height at the place of the paracone	10.5	-	8.7	7.0
max. width in % of the paracone length	118.2	138.8	129.8	125.0
paracone length	11.0	9.8	10.4	10.0
metacone length	8.4	4.7	7.4	7.2
deuterocone length	7.6	7.8	8.3	9.2
metacone length in % of the paracone length	76.4	48.0	71.2	72.0
deuterocone length in % of the paracone length	69.1	79.6	79.8	92.0
deuterocone length in % of the metacone length	90.5	166.0	112.2	127.8

the fourth upper premolars	<i>U. arctos cf. arctos</i> Šípová C. (6311)	<i>U. a. priscus</i> Važec C. (570/77)	<i>U. a. cf. priscus</i> Vývveranie C. (321)
sample			
max. length	15.4	17.2	22.4
max. width	10.1	12.6	13.8
max. width in % of the max. length	65.6	73.3	61.6
crown height at the place of the paracone	8.4	8.3	7.4
max. width in % of the paracone length	113.5	126.0	-
paracone length	8.9	10.0	-
metacone length	5.6	7.3	-
deuterocone length	7.5	8.0	-
metacone length in % of the paracone length	62.9	73.0	-
deuterocone length in % of the paracone length	84.3	80.0	-
deuterocone length in % of the metacone length	133.9	109.6	-

Tab. 5. Measurements and counted indices of the subfossil brown bear P<sub>4</sub> from the some studied localities.

the fourth premolars	<i>U. arctos arctos</i> , Lukáč Abyss			<i>U. a. cf. arctos</i> Šípová Cave (6310)
	4525/dex.	4525/sin.	average	
samples				
max. length	12.6	12.0	12.3	11.3
max. width	7.7	8.0	7.9	5.8
max. width in % of the max. length	61.1	66.7	63.9	51.3
crown height at the place of the protoconid	5.5	6.0	5.8	6.2



Tab. 6. Measurements and counted indices of the fossil and subfossil brown bear M<sup>1</sup> from the some studied localities

the first upper molars		<i>U. arctos</i> cf. <i>priscus</i> , Lisková Cave		<i>U. a. arctos</i> , Lukáč A.
sample		751/2	751/3	4525/d
max. length		24.6	23.4	24.6
width of the frontal part		16.0	15.8	15.5
width of the frontal part in % of the max. length		65.0	67.5	63.0
width of the back part		15.6	18.0	17.8
width of the back part in % of the max. length		63.4	76.9	72.4
width of the back part in % of the width of the frontal part		97.5	113.9	114.8
width of the middle part		-	15.4	15.8
length of the frontal part measured at the middle		9.6	10.2	11.2
length of the back part measured at the middle		12.4	12.4	12.3
length of the back part in % of the length of the frontal part		129.2	121.6	109.8
width of the frontal part in % of the length of the frontal part		166.7	154.9	138.4
width of the back part in % of the length of the back part		125.8	145.2	144.7
paracone length		9.0	8.8	8.8
paracone length in % of the tooth length		36.6	37.6	35.8
metacone length		8.9	10.3	10.1
metacone length in % of the tooth length		36.2	44.0	41.1
metacone length in % of the paracone length		98.9	117.1	114.8
crown height at the place of the paracone		9.0	9.0	4.5
crown height at the place of the paracone in % of the tooth length		36.6	38.5	18.3
crown height at the place of the metacone		9.7	10.2	6.1
crown height at the place of the metacone in % of the tooth length		39.4	43.6	24.8

the first upper molars		<i>U. a. arctos</i> , Lukáč's A.	<i>U. arctos</i> cf. <i>arctos</i>	<i>U. a. priscus</i> , Važec C.
sample		4525/s	Šípová C. (6311)	570/77/dex.
max. length		22.0	21.2	22.0
width of the frontal part		13.7	14.4	16.2
width of the frontal part in % of the max. length		62.3	67.9	73.6
width of the back part		17.0	16.4	17.3
width of the back part in % of the max. length		77.3	77.4	78.6
width of the back part in % of the width of the frontal part		124.1	113.9	106.8
width of the middle part		15.1	14.6	16.0
length of the frontal part measured at the middle		8.9	9.0	10.0
length of the back part measured at the middle		13.0	11.8	11.2
length of the back part in % of the length of the frontal part		146.1	131.1	112.0
width of the frontal part in % of the length of the frontal part		153.9	160.0	162.0
width of the back part in % of the length of the back part		130.8	139.0	154.5
paracone length		6.2	9.3	9.2
paracone length in % of the tooth length		28.2	43.9	41.8
metacone length		11.4	9.4	9.0
metacone length in % of the tooth length		51.8	44.3	40.9
metacone length in % of the paracone length		183.9	101.1	97.8
crown height at the place of the paracone		-	8.6	6.8
crown height at the place of the paracone in % of the tooth length		-	40.6	30.9
crown height at the place of the metacone		5.7	9.2	7.4
crown height at the place of the metacone in % of the tooth length		25.9	43.4	33.6



the first upper molars	<i>U. a. priscus</i> , Važec C. 570/77/sin.	<i>U. arcus</i> cf. <i>priscus</i> 321/dex.	Vyvieranie Cave 321/sin.
sample			
max. length	21.2	31.5	31.8
width of the frontal part	15.8	21.8	21.5
width of the frontal part in % of the max. length	74.5	69.2	67.6
width of the back part	16.4	20.8	21.6
width of the back part in % of the max. length	77.4	66.0	67.9
width of the back part in % of the width of the frontal part	103.8	95.4	100.5
width of the middle part	15.9	20.5	20.5
length of the frontal part measured at the middle	11.0	-	14.5
length of the back part measured at the middle	11.5	-	16.0
length of the back part in % of the length of the frontal part	104.6	-	110.3
width of the frontal part in % of the length of the frontal part	143.6	-	148.3
width of the back part in % of the length of the back part	142.6	-	135.0
paracone length	9.0	12.3	12.6
paracone length in % of the tooth length	42.5	39.1	39.6
metacone length	8.4	11.6	12.2
metacone length in % of the tooth length	39.6	36.8	38.4
metacone length in % of the paracone length	93.3	94.3	96.8
crown height at the place of the paracone	7.0	-	-
crown height at the place of the paracone in % of the tooth length	33.0	-	-
crown height at the place of the metacone	7.0	-	-
crown height at the place of the metacone in % of the tooth length	33.0	-	-

Tab. 7. Measurements and counted indices of the fossil and subfossil brown bear M<sup>2</sup> from the some studied localities.

the second upper molars	<i>U. arctos</i> cf. <i>priscus</i> Lisková C. (751/2)	<i>U. a. arctos</i> , Lukáč Abyss 4525/dex.	4525/sin.
sample			
max. tooth length	38.4	36.0	37.5
width at the place of the paracone (with cingulum)	18.0	18.6	19.2
width at the place of the hypocone	14.3	13.7	14.4
paracone length	10.5	11.0	12.3
metacone length	10.7	11.4	11.0
width at the place of the paracone in % of the max. tooth length	46.9	51.7	51.2
metacone length in % of the paracone length	101.9	103.6	89.4

the second upper molars	<i>U. a. priscus</i> . 570/77/dex.	Važec Cave 570/77/sin.
sample		
max. tooth length	32.3	35.0
width at the place of the paracone (with cingulum)	18.5	18.2
width at the place of the hypocone	11.8	13.0
paracone length	13.0	10.2
metacone length	7.6	9.9
width at the place of the paracone in % of the max. tooth length	57.5	52.0
metacone length in % of the paracone length	58.5	97.0

the second upper molars	<i>U. a. cf. priscus</i> 321/dex.	Vyvieranie Cave 321/sin.
sample		
max. tooth length	46.2	46.8
width at the place of the paracone (with cingulum)	24.2	25.0
width at the place of the hypocone	19.4	19.8
paracone length	13.6	13.9
metacone length	9.9	-
width at the place of the paracone in % of the max. tooth length	52.4	53.4
metacone length in % of the paracone length	72.8	-



part of this skull (No. 570/77; see Tab. 1) is covered by the sinter crust. The left zygomatic arch of this grey skull is broken off and its sagittal crest is good developed. Only C sup. dex., P<sup>4</sup> dex., M<sup>1</sup> dex. and sin., M<sup>2</sup> dex. and sin.; and P<sup>1</sup> dex. and P<sup>3</sup> dex. alveoli are preserved. The presence of these front upper premolar alveoli indicates the subspecies of brown bear from the Last Glacial (*Ursus arctos priscus* GOLDFUSS). The white crowns of the teeth are abraded. The measurements of canine, premolar and molars are situated in the table No. 3, 4, 6 and 7.

### The Vyvieranie Cave

Only one skull of a fossil brown bear from this cave was studied metrically and morphologically. The skull (No. 321, see Tab. 1) is incomplete and very damaged. The zygomatic arches together with the back part of the cranium base are broken off and the external narial aperture is damaged. Only P<sup>4</sup> sin., M<sup>1</sup> dex. and sin., and M<sup>2</sup> dex. and sin. have been preserved of the upper teeth (see Tabs. 4, 6 and 7). Their white and brown crowns are very abraded. The cave bears have found their third upper premolars only exceptionally. Therefore, the presence of the alveolus of this upper premolar at the left part of studied skull indicated that this one probably is a fossil representative of the brown bear from the Last Glacial (*Ursus arctos* cf. *priscus*).

### Discussion and conclusions

On the basis of the metric and morphologic analyses of the described remains from the studied locations, we are able to discuss and draw conclusions on the findings.

The fossil findings from the Lisková Cave belong to brown bears, probably from the Last Glacial Period. The evidence of it is the arctoid morphology of the cranium (presence of P<sup>1-3</sup> alveoli, low and short sagittal crest etc.) and mandibles fragments together with morphology and measurements of the teeth. These teeth are similar to the bear teeth from the Lukáč Abyss and they correspond metrically to the findings from the Hundsheim (*Ursus deningeri*) (Musil, 1972), Předmostí (*Ursus arctos priscus*) (Musil, 1964), Važec Cave (*Ursus arctos priscus*) and Kupčovie izbička Cave (*Ursus arctos* cf. *priscus*) (see Tab. 9). However, the measurements of these teeth are larger than teeth measurements of the recent brown bears from Europe (*Ursus arctos arctos*). On the basis of it, we can assume that this studied material belongs to the representatives of the species *Ursus arctos*, probably of the subspecies *priscus* (*Ursus arctos* cf. *priscus*).

From the metrical and morphological point of view, the skull from the Lukáč Abyss belongs to the subfossil subspecies *Ursus arctos arctos* LINNÉ. The morphology and teeth measurements also confirm this result. From the metrical point of view these teeth correspond to the measurements of bear teeth from the Važec Cave (*Ursus arctos priscus*) and the Lisková Cave. We can also see some metric similarity in the findings from Bilzingsleben (Musil, 1991), Žernavá (Musil, 1969), and the Bear Cave in Slovenský raj Mountains (Sabol, *in press*) (see Tab. 9).

These findings probably belong to individual, which skeleton has partly studied by Pomorský (1986). It was relatively large, but older and sick male too (there have been ascertained spondylosis, fractures and other pathological phenomena on its bones). These osteological remains is possible to date probably to the period from the end of the Pleistocene (?) to the beginning of the Holocene.

The damaged skull together with mandible from the Psie diery Cave belongs probably to a cub of the taxon *Ursus arctos* ssp. In this case, skull morphology played the decisive role in the species determination, especially due to the presence of P<sub>1</sub> and P<sub>3</sub> alveoli in both mandible branch only (P<sub>1</sub> was developed in the right branch of mandible only), though the presence of front premolars is known from findings of cave bear juveniles too. This bear cub must have perished in the first year of its life. The evidence of this is presence in the still ingrown permanent lower molars.

From the metrical point of view, the teeth (C sup., P<sup>4</sup> and M<sup>1</sup>) situated in the fragment of right upper jaw from the Šípová Cave correspond to the findings from the Pod hradem Cave (Musil, 1965), the Bear Cave under Sivý hill (= „v Sypkých skalách“ Cave), also, these teeth correspond to tooth measurements of the subspecies *Ursus arctos priscus* from the Važec Cave (see Tab. 9). However, the typical arctoid morphology of molar was an important finding for the final determination of the species. Also, the morphology and measurements of the right mandible and its teeth (C inf. dex. and P<sub>4</sub> dex.) indicate a typical representative of the brown bears. On the basis of this, the findings have been placed in the species *Ursus arctos* LINNÉ, probably subspecies *arctos*.

The measurements of the skull (No. 570/77) from the Važec Cave correspond to the observed range of the species *Ursus arctos*. However from the morphological point of view, this bear skull shows arctoid features as well as speleoid ones such as a weakly vaulted brow and a distinctly developed sagittal crest, typical for cave bears. From the morphological point of view, the teeth correspond to the morphology of teeth of bears from the arctoid branch of the ursid phylogeny. On the other hand, from the metric point of view the skull teeth correspond to the measurements of *Ursus spelaeus* teeth as well as the measurements of *Ursus arctos* teeth, though some correspond more to the measurements of brown bear teeth. The metrical similarity with findings from the Lukáč Abyss, the Bear Cave under Sivý hill and the Lisková Cave (see Tab. 9) is evidence of this. On the basis of these signs it was determined that this bear skull belongs to a representative of the subspecies *Ursus arctos priscus* GOLDFUSS.

Besides speleoid features, the bear skull from the Vyvieranie Cave shows features, which are typical for the arctoid branch of ursid phylogeny. From the morphologic and metric point of view, the teeth of this skull have a speleoid character and they correspond to the measurements of findings from the Pod hradem Cave (Musil, 1965) and Švédův stůl Cave (Musil, 1962) in Moravia (see Tab. 9). However, on the basis of presence of the P<sup>3</sup>



Tab. 8. Measurements and counted indices of the subfossil brown bear *M<sub>2</sub>* from the Lukáč Abyss.

the second lower molars sample	<i>U. a. arctos</i> , Lukáč Abyss	
	4525/dex.	4525/sin.
tooth length	25.4	26.7
width of the frontal part	15.7	15.5
width of the frontal part in % of the tooth length	61.8	58.1
width of the back part	17.4	17.7
width of the back part in % of the tooth length	68.5	66.3
width of the back part in % of the width of the frontal part	110.8	114.2
frontal part length on the lingual side	12.4	12.3
frontal part length on the lingual side in % of the tooth length	48.8	46.1
back part length on the lingual side	13.0	13.2
back part length on the lingual side in % of the tooth length	51.2	49.4
back part length on the lingual side in % of the frontal part length on the lingual side	104.8	107.3
frontal part length on the buccal side	15.8	17.0
frontal part length on the buccal side in % of the tooth length	62.2	63.7
back part length on the buccal side	9.2	9.4
back part length on the buccal side in % of the tooth length	36.2	35.2
back part length on the buccal side in % of the frontal part length on the buccal side	58.2	55.3
crown height at the place of the protoconid	5.0	3.7
crown height at the place of the protoconid in % of the tooth length	19.9	13.9
crown height at the place of the metaconid	6.2	6.2
crown height at the place of the metaconid in % of the tooth length	24.4	23.2
crown height at the place of the hypoconid	5.0	3.8
crown height at the place of the hypoconid in % of the tooth length	19.9	14.2
crown height at the place of the entoconid	5.0	6.2
crown height at the place of the entoconid in % of the tooth length	19.9	23.2

Tab. 9. The comparison of some measurements of bear teeth from described localities with measurements adduced by the other authors.

fossil and subfossil remains of the bears		Bilzingsleben	Hundsheim	Žernavá	Švédův stůl (Musil, 1962)	
		(Musil, 1991)	(Musil, 1972)	(Musil, 1969)	<i>Ursus spelaeus</i>	
		<i>U. deningeri</i>	<i>U. deningeri</i>	<i>U. deningeri</i>	R/W + W1-2	W2
		average	average		average	average
the fourth upper premolars	max. length	18.4	18.1	19.4	20.6	20.9
	max. width	13.2	12.8	14.1	14.0	14.5
the first upper molars	max. length	26.1	-	-	29.2	29.1
	width of the frontal part	18.2	-	-	19.7	19.5
the second upper molars	max. length	42.4	-	42.0	46.1	46.4
	width at the place of the paracone	21.3	-	18.9	23.1	22.5
the fourth lower premolars	max. length	14.2	-	-	-	15.7
	max. width	9.2	-	-	-	10.7
the first lower molars	max. length	28	-	27.3	31.1	31.1
	taloid length	13.9	-	13.2	14.0	14.8
the second lower molars	max. length	29.1	-	-	32.0	31.1
	width of the back part	17.7	-	-	18.9	19.0
the third lower molars	max. length	26	-	-	28.1	28.0
	max. width	18.4	-	-	19.7	20.4



fossil and subfossil remains of the bears		Pod hradem (Musil, 1965) <i>Ursus spelaeus</i>			
		W2 - W3	W1-2		W1
		I.	II.	III.	IV.
		average	average	average	average
the fourth upper premolars	max. length	19.8	20.8	20.7	-
	max. width	14.5	14.4	14.8	-
the first upper molars	max. length	29.2	29.0	27.8	-
	width of the frontal part	20.3	19.6	18.6	-
the second upper molars	max. length	44.4	45.7	44.8	-
	width at the place of the paracone	22.4	23.3	22.5	-
the fourth lower premolars	max. length	15.0	15.8	16.1	15.7
	max. width	10.6	10.8	10.7	10.2
the first lower molars	max. length	30.0	30.7	30.7	29.4
	talonid length	14.2	14.6	14.9	14.2
the second lower molars	max. length	31	31.5	31.2	29.9
	width of the back part	18.3	18.5	18.5	18.4
the third lower molars	max. length	26.7	28.1	27.7	27.2
	max. width	18.9	19.8	20.0	19.1

fossil and subfossil remains of the bears		Předmostí	"v Sypkých skalách"	Kupčovie izbička	Lisková Cave
		(Musil, 1964)			
		<i>U. a. priscus</i>	<i>U. spelaeus</i>	<i>U. a. cf. priscus</i>	<i>U. a. cf. priscus</i>
		average	average	average	average
the fourth upper premolars	max. length	15.0	17.1	16.3	17.6
	max. width	9.0	12.2	12.4	13.3
the first upper molars	max. length	24.2	26.8	25.2	24.0
	width of the frontal part	17.4	17.0	16.4	15.9
the second upper molars	max. length	38.3	42.0	38.3	38.4
	width at the place of the paracone	+20.6	19.8	19.0	18.0
the fourth lower premolars	max. length	-	15.2	-	-
	max. width	-	11.2	-	-
the first lower molars	max. length	27.1	32.8	25.7	-
	talonid length	14.2	-	9.0	-
the second lower molars	max. length	28.8	31.6	25.5	-
	width of the back part	17.9	20.3	16.8	-
the third lower molars	max. length	24.2	-	-	-
	max. width	17.3	-	-	-

fossil and subfossil remains of the bears		Lukáč Abyss	Šípová Cave	Vážec Cave	Vyvieranie
		<i>U. a. arctos</i>	<i>U. a. cf. arctos</i>	<i>U. a. priscus</i>	<i>U. a. cf. priscus</i>
		average		average	
the fourth upper premolars	max. length	17.3	15.4	17.2	22.4
	max. width	13.0	10.1	12.6	13.8
the first upper molars	max. length	23.3	21.2	21.6	31.7
	width of the frontal part	14.6	14.1	16.0	21.7
the second upper molars	max. length	36.8	-	33.7	46.5
	width at the place of the paracone	18.9	-	18.4	24.6
the fourth lower premolars	max. length	12.3	11.3	-	-
	max. width	7.9	5.8	-	-
the first lower molars	max. length	21.2	-	-	-
	talonid length	-	-	-	-
the second lower molars	max. length	26.1	-	-	-
	width of the back part	17.6	-	-	-
the third lower molars	max. length	19.4	-	-	-
	max. width	15.4	-	-	-



alveolus, this fossil remain has been placed into the taxon *Ursus arctos* cf. *priscus*.

In conclusion, we are able to determine that the findings of brown bears from Slovak cave sediments dated from the Last Glacial to the start of the Holocene Period belong to the species *Ursus arctos*, tangibly to the subspecies *Ursus arctos priscus* GOLDFUSS (from the Last Glacial; the Lisková Cave, the Važec Cave and the Vyvieranie Cave), the *Ursus arctos arctos* LINNÉ (the Lukáč Abyss) or *Ursus arctos* cf. *arctos* resp. (the Šípová Cave) and to the nearly undetermined subspecies *Ursus arctos* ssp. (the Psie diery Cave).

The presence of these brown bear taxa in our territory is result of some migration waves of these ursids from the south (probably from the Balkan Peninsula) – the extinct *Ursus arctos priscus* appears at the end of the Pleistocene Period, when lived in the same territory together with cave bears, and the *Ursus arctos arctos* is present in our territory by the start of the Holocene or yet by the end of the Last Glacial Period. However, the subspecies *Ursus arctos priscus* is not a descendant of brown bears (*U. arctos arctos*) from southern Europe (Musil, 1996).

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