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Nerubajskoe, a New Cave Bear Site in the Old Nordmann Territory

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Abstract

The cave near Nerubajskoe village is one of several karstic elements in this area. Some of these caves contain Pleistocene material. Nordmann (1849) was the first to excavate in this area. Only a few new sites have been found since then. The Austrian-Ukrainian research group recovered new Pleistocene material from a cave ruin near Nerubajskoe in 2003. The cave bear belongs to the *U. ingressus* group with plesiomorphic morphological features. While morphological different from the modern cave bear from the Alpine region, the results of the fossil DNA analyses clearly places them in the same evolutionary line as the findings from the Gamssulzen and Potočka Cave. New Radiocarbon dates place the fauna into the middle part of the Upper Pleistocene.

Zusammenfassung

Die Höhle in der Nähe des gleichnamigen Dorfes Nerubajskoe ist eine von vielen Karstelementen dieser Gegend. Einige dieser Höhlen beinhalten pleistozänes Material. Nordmann (1860) war der erste, der dort Ausgrabungen machten. Nur wenige neue Fundstellen sind seit damals bekannt geworden. Die Österreichische-Ukrainische Forschungsgruppe konnte 2003 neues pleistozänes Material aus der Höhle nahe Nerubajskoe bergen. Die Höhlenbären dieser Gegend gehören zur so genannten *U. ingressus* Gruppe, tragen aber immer noch plesiomorphe Merkmale. Obwohl sie morphologisch unterschiedlich zu den modernen Höhlenbären der Alpen sind, gehören sie auf Grund der Analyse der fossilen DNA zu der selben Entwicklungslinie, wie die Funde aus der Gamssulzen- und Potočka Höhle. Neue Radiokarbon Datierungen stellen die Fauna in den mittleren Abschnitt des Jungpleistozäns.

1. Introduction

The Nordmann caves have been known since 1849 when Nordmann taught at the Lyceum of Odessa and excavated in the Odessa region (Nordmann 1949, 1858-1860, Gromova 1948). Most of the investigation took place near Nerubajskoe ("Nerubajskie hutorá" Lehmann, 1933). The majority of the fossil material is now stored at the Department of Geology and Palaeontology of the University of Helsinki. Other material is in St. Petersburg and of course Odessa.

These caves are karstic elements in the Pontian limestone. Unfortunately, this limestone has been used as construction material for the surrounding area and therefore most of the localities are lost today. Only Ilinka cave has remained more or less intact, situated in the waste area of the village. The fossil material is stored at the Natural History Museum in Kiev and the Paleontological Museum of Odessa University. In 2003, Konstanin Pronin from the Department of Geology, Odessa University became aware of a new site opened by an excavator near the village Nerubajskoe (fig. 1). The cave top was already destroyed and sediments and bones were exposed. Small quarries like this are soon refilled with trash and shut again. Therefore a rescue excavation was undertaken to recover as much material from this Pleistocene cave ruin as possible by the Austrian-Ukrainian excavation team: a cooperation between the Department of Palaeontology (University of Vienna), the Paleontological Museum of Odessa (Odessa

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Figure 1: Map of the Odessa area. Cave ruin near Nerubajskoe and the cave near Ilinka.

Figure 2: Excavation site near Nerubajskoe. The pit was made by the excavator and the team is cleaning the area for further investigation.

University) and the National History Museum of Kiev (Ukrainian Academy of Sciences). Over 450 specimens were found, among them *Ursus ingressus*, *Canis* cf. *lupus*, *Crocuta crocuta* ssp., *Bison* sp., *Equus* sp., *Spalax* sp. and *Lepus* sp. The material was preserved and is stored in the Paleontological Museum of Odessa.

2. Excavation

The excavation pit opened by the excavator was cleaned of debris and a frame of 5 x 5 m applied. Vertically a depth of -140 cm below the current surface was reached. The section started with fossiliferous sand between 10 to 30 cm thick, lying on compressed material of the same texture in some places about 10 to 15 cm in thickness. Below this layer fossils were again found and no indication of a change in sedimentation could be seen. At ca 50 cm below the surface an organic layer appeared and below this only small bone fragments were recovered (fig. 2). The fossil material was excavated under very dry conditions and had

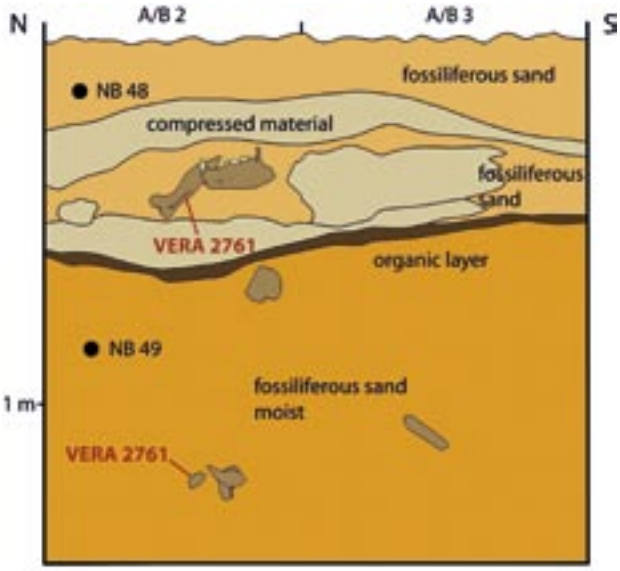

Figure 3: Profile of the cave ruin from Nerubajskoe. Austrian-Ukrainian excavation 2003. NB 48 and NB 49 geological samples. ^{14}C-Dates (Vienna Environmental Research Accelerator): > 52.450 cal. a BP (VERA 2761), 16.700 cal. a BP (VERA 2762).

to be recovered rapidly, otherwise the bones cracked and crumbled. Members of the excavation team were (arranged by institution and ordered alphabetically):
Nadja Kavcik, Doris Nagel, Irene Pytlik, Wolfgang Raba, Gernot Rabeder (Department of Palaeontology, Vienna), Christoph Urbanek (Department of Geosciences, Vienna), Konstantin Pronin, Nikolai Orlov (Paleontological Museum, Odessa), Dmitry Ivanoff, Yuriy Semenov (Natural History Museum, Kiev).

3. Geological results (Huijer)

Two geological samples were taken (NB48, NB49, fig. 2) and examined (sieved, x-ray measurements). The main components are quartz and calcite (shell components from the surrounding rocks). The sediments show no signs of transportation indicated by angular shaped grains and poorly sorted. They are a product of weathering of the surrounding Pontian limestone. X-ray measurements of both samples show almost no clay minerals, NB 48 contains some gypsum, whereas NB 49 shows none.

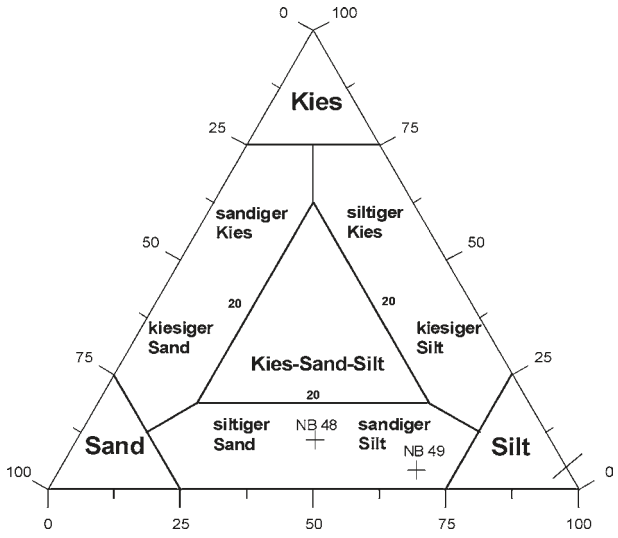

Figure 4: Distribution of grain size from the sediments of the cave ruin near Nerubajskoe. Diagram after Shepard (1954), modified.

4. Palaeontology (Nagel, Rabeder & Withalm)

4.1. Material

Most of the material recovered belongs to *Ursus spelaeus* (95%) and only 5% is from other animals. Over 450 specimens were collected and prepared in the Paleontological Museum Odessa. Due to the dry conditions, larger parts such as pelvis and scapula fragmented and had to be restored. If possible elements were refitted. The material is inventoried with the abbreviation PMONU 3948 and then consequently labelled NB for Nerubajskoe and numbered. Therefore the first specimen's collection number is PMONU 3948/NB1. To keep it simple in the text we only refer to NB and the number. Measurements were taken with a caliper to the nearest of 0.1 mm. P and M refer to the upper premolars and molars and p and m to the lower premolars and molars.

Order: Carnivora

***Ursus ingressus* Rabeder et al. 2004**

Material: NB 108 1 atlas, NB 109 1 axis, 49 vertebrae, 7 humeri, 5 ulnae, 6 radii, 2 femora, 6 tibiae,1 fibula, 2 scapulae, 5 sterna, 2 pelves, 6 costae, 1 patella, 1 baculum, 2 hyalia, 4 scapholunata, 6 calcanei, 8 astragali, 16 carpalia and tarsalia, 46 metapodial bones, 44 phalanges. 9 lower jaws: NB 101 sin., with p4, alveolus for m1, m2 – m3; NB 42 dext., p4-m3; NB 16 sin., p4-m3; NB 24 dext., p4-m1; NB103-96 sin., m2-m3 (juvenile), NB 110 sin., NB 111 sin., NB 112 dext., NB 144 dext., NB 100-2 maxillar fragment with M1-M2, NB 142 cranium fragment; isolated teeth: 3 I1, 4 I2, 7 I3, 5 Csup., 5 P4, 16 M1, 9 M2, 4 i1, 4 i2, 2 i3, 7 Cinf., 5 p4, 9 m1, 8 m2, 5 m3. The material is partly fragmented. MNI = 7 adults and 2 juveniles. Measurements in Appendix 1a-c. Only complete or meassurable specimens are listed here. Most of the material is partly fragmented.
Two lower jaws (NB 16 and NB 24, fig. 5 a+b) still retain the plesiomorphic p1. Unfortunately, the present number of teeth from the cave bear is too low for a taxonomic allocation. We compared the material with the type faunas from the three new taxa from the Alpine area (Rabeder et al. 2004): Gamssulzen Cave, Conturines Cave and Ramesch Bone Cave (fig. 6). The molars are all within the length and breadth distribution of these three taxa with one excep-

Figure 5a, b: a – juvenile lower jaw (NB 103/96) of *U. ingressus* from Nerubajskoe with m3 in eruption; b – lower jaws of *U. ingressus* from Nerubajskoe still retaining the alveolus for p1 (NB 16 and NB 24).

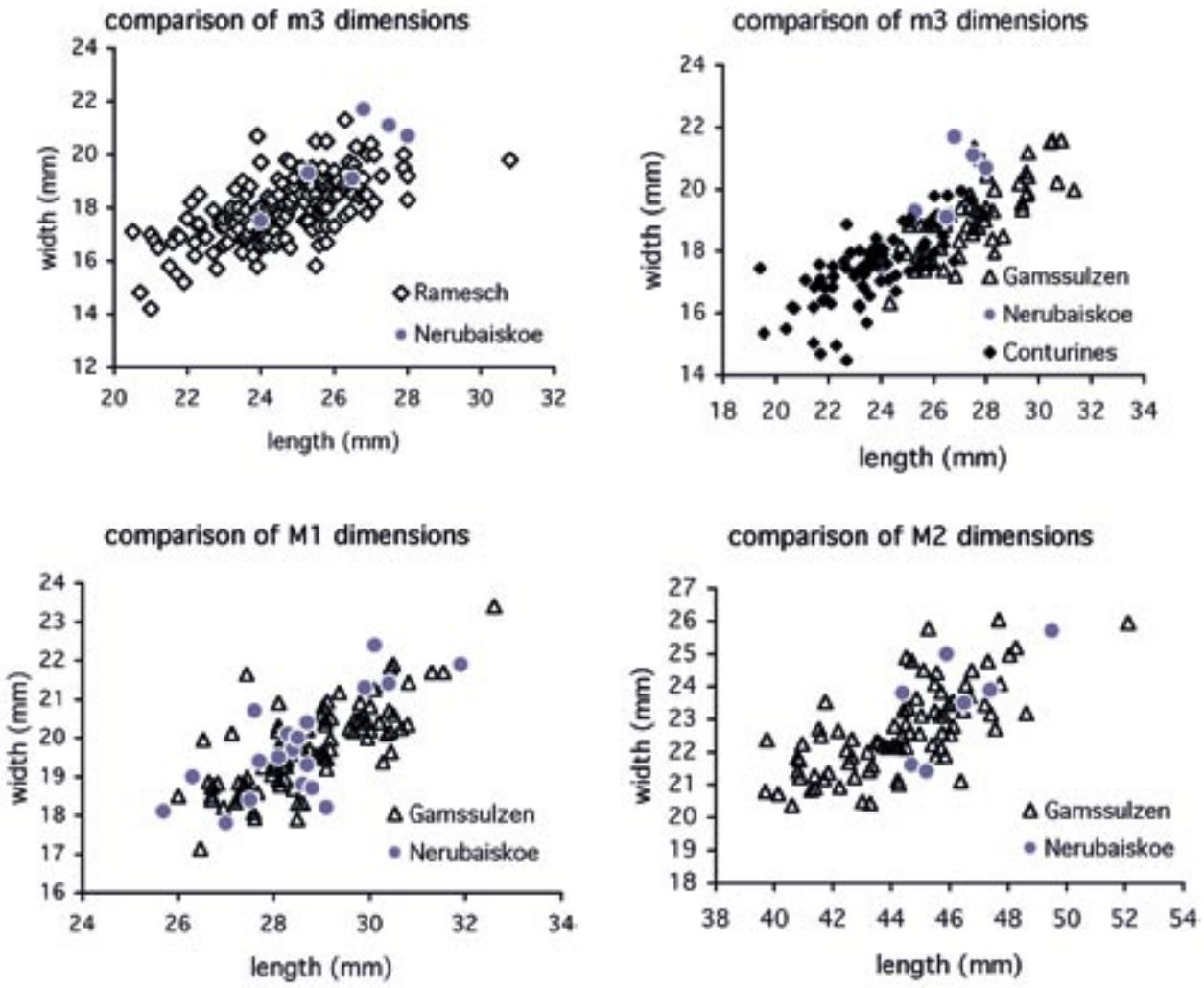

Figure 6: Scatter diagrams of m3, M1 and M2 from *U. ingressus* from Nerubajskoe in comparison with *U. ingressus* from Gamssulzen cave, *U. sp. eremus* from Ramesch bone cave and *U. sp. ladinicus* from Conturines cave.

tion the m3. The evolution of the m3 diverged in the three evolutionary lines. The m3 from Nerubajskoe are larger than the one from Ramesch and Conturines (three out of six) and they are equally broad but shorter compared to the material from the Gamssulzen Cave.

Age and sex distribution: One jaw fragment is from a juvenile individual, three mandibles show worn teeth and are therefore from older individuals, the remaining five are from adults. There are size differences in the astragali and calcanei, which can be explained by sexual dimorphism. The dimorphism is best seen on the canines, which are too few for an exact determination (Rabeder, 1999).

Only a small number of metapodial bones from this site were undamaged and therefore measurable. Thus the results are only of preliminary character and can change significantly with the acquisition of new material. An overview of the material is given in table 1. All measurements were taken and the indices calculated according to Withalm (2001:177), the diagrams in Appendix 2 refer to the diagrams in Withalm (2001:231 ff.)

There are some peculiarities concerning the proportions of metacaralss and metatarsals, which closely resemble the situation that can be found in the bears (*U. sp. ladinicus*, Rabeder et al. 2004) from Conturineshöhle in South Tyrol. These similarities can be found in the proportions of the K-index and of the index of plumpness. The K-values of metacarpus of the bear from Nerubajskoe even exceeds those from *U. sp. ladinicus*. In the metatarsus it is more

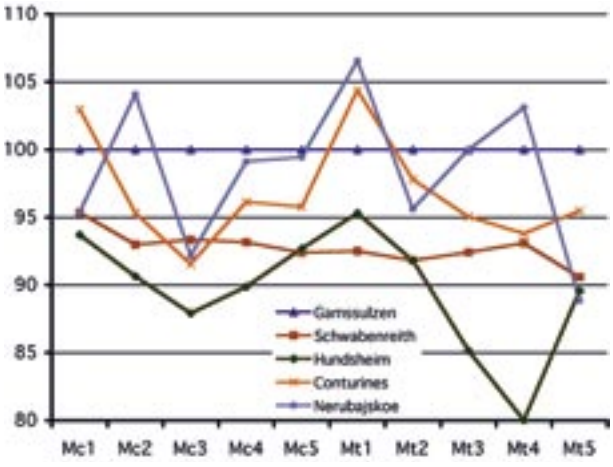

Figure 7: The metapodials from *U. ingressus* from Nerubajskoe in comparison with *U. ingressus* from Gamssulzen cave, *U. sp. eremus* from Ramesch bone cave and *U. sp. ladinicus* from Conturines cave.

Element	n	gl	pw	sdw	dw	dew	pd	sdd	dd	da	pa	sda	ip	K
Mc1	3	65.0	24.3	11.9	19.0	18.6	19.0	9.8	18.4	350.6	462.5	117.1	28.76	7.10
Mc2	4	76.2	20.3	19.5	23.5	27.0	30.3	16.1	22.1	523.2	619.7	313.8	35.62	8.10
Mc3	1	86.1	21.6	17.7	23.0	26.3	30.0	13.1	21.1	485.3	648.0	231.9	30.55	7.53
Mc4	9	84.5	23.4	18.9	23.3	28.2	32.4	13.7	23.6	555.9	762.0	261.3	33.33	8.98
Mc5	5	90.0	33.0	20.0	30.4	31.8	39.5	16.0	23.4	712.4	1308.2	322.8	35.33	14.53
average		80.3	24.5	17.6	23.8	26.4	30.2	13.8	21.7	525.5	760.1	249.4	32.72	9.25
Mt1	2	58.7	25.5	13.6	19.2	20.0	27.1	10.9	17.4	334.1	690.0	147.1	34.06	11.8
Mt2	5	69.8	15.0	13.4	18.9	21.2	22.5	9.94	17.4	331.5	343.2	134.8	30.28	4.87
Mt3	7	77.9	19.7	16.0	20.2	23.6	31.5	12.9	19.7	396.1	623.3	208.5	30.28	8.20
Mt4	3	90.5	24.0	18.3	24.0	27.1	31.5	15.0	21.2	507.9	755.7	275.7	29.93	8.34
Mt5	7	91.7	28.3	12.9	23.4	23.4	29.6	12.4	18.8	439.7	842.5	160.9	25.51	9.16
average		77.7	22.5	14.8	21.1	23.0	28.4	12.2	18.9	401.9	650.9	185.4	30.01	8.47
Σ	46													

Table 1: Averaged measurements and indices of metapodial bones from Nerubajskoe (Ukraine), Abbreviations: gl – greatest length, pw – proximal width, sdw – smallest diaphyseal width, dw – distal width, dew – distal epicondyleal width, pd – proximal depth, sdd – smallest diaphyseal depth, dd – distal depth, da – distal area, pa – proximal area, sda – smallest diaphyseal area, ip – index of plumpness and K – K-index.

similar to this subspecies of cave bear, with exception of the 1st metatarsal bone, which shows a much higher K-value than the Conturines-bear. The 2nd metapodial bones tend to be slender and place themselves between those of *U. deningeri* and the smaller members of the cave bear group, see fig. 7. As the K-value of the 2nd metatarsal bone is correlated with age it is to be expected that the bears from Nerubajskoe are between 50 and 60 ky old. Based on the facts mentioned above and taking into account the small number of bones, a taxonomic allocation is not possible on morphological ground alone but only after a genetic investigation.

4.2. Fossil DNA results (Hofreiter)

The cave bear samples from Nerubajskoe were extracted as described as well as primers and PCR conditions used for cave bear mtDNA amplification (HOFREITER et al., 2002). Altogether, only 90 bp of mitochondrial control region were amplified. Nevertheless, the sequence is very close to the ones from Vindija (Croatia), Potočka zijalka and Križna jama (Slovenia), Gamssulzen, Liegloch, Hartlesgraben and Nixloch (Austria). The results are closest to *Ursus ingressus* known from the sites mentioned above.

4.3. Additional fauna

Order: Carnivora

Canis* cf. *lupus

Material: NB 5, right lower jaw fragment (surface find) with m1 (31.7:11.4) and m2 (12.4:8.9), alveolus for m3. The teeth suffered almost no abrasion and are from a young adult. NB 103-34, atlas; MNI=1.

***Crocuta crocuta* ssp.**

Material: NB 21, left radius fragment (-35 cm below surface), adult individual; MNI=1.

Order: Artiodactyla

***Bison* sp.**

Material: NB 6-2, thoracal vertebra, NB 29-4, scapula fragment, NB 103-31, axis; MNI=1.

Order: Perissodactyla

***Equus* sp.**

Material: NB 1-4, upper molar; NB 17 right metatarsal fragment; NB 4-31 and NB 1-7, carpalia, NB 27, tibia fragment; NB 103-72, right calcaneus; NB 14-4, scaphoid; NB 1-27, cuboid; MNI=1.

Order: Rodentia

***Spalax* sp.**

Material: NB 18, left lower jaw fragment with cinf, m1-m3; right lower jaw with cinf broken, m1-m2; left upper jaw fragment with M1-M3; left humerus with proximal articulation surface missing; left and right ulnae. The remains are probably from one individual.

Order: Lagomorpha

***Lepus* sp.**

Material: NB 34-19, tibia fragment; NB36-43, femur fragment; NB 103-78, metapodial fragment; MNI=1.

5. Discussion

The cave ruin near Nerubajskoe was never investigated before. Pleistocene material from the area around Nerubajskoe was already investigated and published by NORDMANN (1858-1860) and later on mentioned in EICHWALD (1860). He described *Ursus spelaeus major* and erected additionally *U. sp. minor*, from caves of this area. LEHMANN (1933) argued that *U. sp. minor* is conspecific with *U. rossicus*. He also mentioned the tendency in the premolars to develop additional cusps. MUSIL (1980) pointed out the primitive morphology of this cave bear and assigned the specimens to the *U. deningeri* group. A number of subspecies of *U. deningeri* were described by BORISSIAK (1932) and BARYSHNIKOV (1998) from the Caucasus area. The latter also included material from the Nerubajskoe area in his study and found them typical for *spelaeus*-but distinct from the smaller *deningeri*-group from the Caucasus caves. The material from the Odessa-Nerubajskoe area, stored in Helsinki, was included in GRANDAL-D'ANGLADE's work (1993) about cave bears from Galicia (Spain). Again, the Ukrainian cave bears were identified as an outgroup to the Spanish *U. spelaeus*. In the Alpine region, four different evolutionary lineages were identified (HOFREITER et al. 2002, RABEDER et al., 2004). The bears from Nerubajskoe would fit into the *U. ingressus* as well as *U. sp. ladinicus* group. The morphodynamic analyses (RABEDER, 1999) needs a statistically valid number of teeth, which unfortunately is not possible from the latest findings. The taxonomic allocation is mainly based on the ancient DNA results.

Although the morphological investigation yielded no exact taxonomic allocation of the cave bear from the Odessa region, due to plesiomorphic and apomorphic features, it is important to remember that the *U. ingressus* and *U. spelaeus* lines split approximately 150.000 years BP and the ancestor of the modern *U. ingressus* from the Alpine region probably came from the eastern region, maybe Ural Mountains or Caucasus area. The Ukrainian cave bears are therefore of special interest in the investigation of cave bear history. KURTÉN (1969) made an initial attempt to date bones from the Odessa area. At that time a relatively large amount of material was needed for a Radiocarbon date and therefore "several different fragments of long bone were submitted and used". The date, 26.930 ± 980 a BP (Laboratoriet för radioaktiv datering, Stockholm) must be considered as an average age.

In 2003, two Radiocarbon dates were carried out by VERA (Vienna Environmental Research Accelerator) in the course of the Austrian-Ukrainian excavation in Nerubajskoe. The cave bear yielded an age of > 52.450 a BP (VERA-2761), a rib fragment from disturbed sediments was dated as 16.700 a BP (VERA-2762, calibrated age). This indicates two different sedimentation periods and probably two faunal periods documented in the Nerubajskoe cave.

The faunal elements from the Odessa-Nerubaj Caves were published by NORDMANN (1858-1860) and summarized in KURTÉN (1969). All elements found in 2003 are also represented in the former works. There is no indication whether the fossil material was from one or two different time periods. It is possible that *Spalax*, *Equus* and maybe *Canis* were fossilised during a younger period but the sedimentation of the different horizons give no hint whatsoever as to how to separate the material.

6. Conclusion

The faunal material from Nerubajskoe is probably from two different time periods but the cave bear clearly belongs to the older part (> 52.450 a BP) and still retain plesiomorphic features, such as the presence of p1 and slender metapodials, similar to the ones from *U. sp. ladinicus*. The analyses based on morphological features indicate an age between 50 to 60 ka BP which correlates with the results from the Radiocarbon dating. The material yield no indication that two different cave bear species were present. The taxonomic allocation is uncertain and the assignment to *U. ingressus* is only based on DNA results.

Future works will focus on the Ilinka cave because the new Radiocarbon dates indicate the same age for the cave bears as from Nerubajskoe. It will also be necessary to obtain new dates from the material in Helsinki to incorporate the results from the old Nordmann caves material.

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APPENDIX

Appendix 1a: Measurements of teeth from *U. ingressus* from Nerubajskoe. L – length; W – width.

Inv.no.	element	L	W	Inv.no.	element	L	W
NB1-35	p4	13.7	9.7	NB148	P4	19.5	14
NB114	p4	15.5	10	NB28/6	P4	20.5	13
NB145	p4	14.1	10	NB33/3	P4	20.2	13.5
NB146	p4	15	9.3	NB149	M1	28.5	20
NB147	p4	16.8	12.7	NB150	M1	27.7	19.4
NB114	m1	30.4	13.3	NB151	M1	28.6	18.8
NB156	m1	30.5	13.8	NB152	M1	27	17.8
NB157	m1	31.3	14.8	NB153	M1	28.8	18.7
NB103/2	m1	28.1	12.8	NB103/143	M1	29.1	18.2
NB35/10	m1	31.8	15	NB35/9	M1	29.9	21.3
NB35/11	m1	31.8	14.4	NB13/3	M1	25.7	18.1
NB103/92	m1	29.4	15.2	NB43/1	M1	28.1	19.5
NB17/1	m1	29.2	15.1	NB103/136	M1	28.4	19.7
NB34/13	m1	28.3		NB103/86	M1	26.3	19
NB1/11	m2	30.5	18.3	NB103/94	M1	27.5	18.4
NB2/2	m2	28.3	16.3	NB103/140	M1	30.1	22.4
NB103/82	m2	27.3	17.2	NB35/8	M1	28.7	20.4
NB115	m2	32.1	19.3	NB1/30	M1	27.6	20.7
NB116	m2	28.6	16.1	NB28/8	M1	31.9	21.9
NB117	m2	29.4	16.5	NB154	M2	43.9	22.6
NB113	m2	32.4	20.5	NB155	M2	40.8	20.8
NB1/29	m3	28	20.7	NB13/11	M2	45.3	21.4
NB4/26	m3	26.5	19.1	NB103/132	M2	46.5	23.5
NB115	m3	27.6	20.2	NB103/91	M2	44.7	21.6
NB158	m3	29.5	19.1	NB5/7	M2	44.4	23.8
NB159	m3	23.3	17.5	NB103/85	M2	45.2	21.4
				NB1/32	M2	49.5	25.7
				NB17/7	M2	47.4	23.9

Appendix 1b: Measurements of upper and lower jaws from *U. ingressus* from Nerubajskoe. Abbreviations: ML – mandibular length, Hbm1 – height below m1, TRL – tooth row length, L-dia – length of diapysis; W-con – width of condyles.

Inv.no.	Element	side	TL	Hbm1	TRL	L-dia	H-cor	W-cond	H-cond
NB24	Mandibula	dext.	335	72.4	107	55.7	160	84.7	29.6
NB42	Mandibula	dext.		67.3	99.1	57.5			
NB101	Mandibula	sin.		46.4	96.2	27.7			
NB16	Mandibula	sin	338	76.1	109.6	57.6	158	83.3	30
NB103-7	Mandibula	sin.		63	101.2				
NB110	Mandibula	sin.	328	73.3	106.5	60	142.2	74	26
NB111	Mandibula	sin.	326	72.4	104.8	40.5	147.8	81.7	28.9
NB112	Mandibula	dext.		68.2	102.9	56			
NB144	Mandibula	dext.	309	64.8	113.9	60	138	69.6	24.8

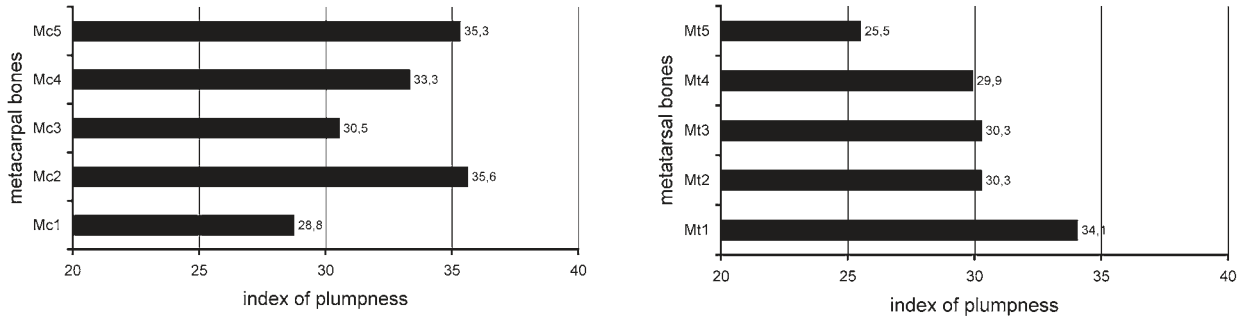
			TRL sin	TRL dext	dia sin	dia dext
NB142	Cranium		93.2	93	45.8	45.7

		L	W	
NB101	M2 inf.	28	17.8	
NB101	M3 inf.	25.3	17.8	
NB42	P4 inf.	15.1	10.2	manible fragment very worn
NB42	M1 inf.	28.5	14.3	
NB42	M2 inf.	29.5	17.2	
NB42	M3 inf.	25.3	19.3	
NB16	P4 inf.	17.7	11.2	mandible very worn with p1
NB16	M1 inf.	31.5	16	
NB16	M2 inf.	29.5	19.9	
NB16	M3 inf.	27.5	21.1	
NB24	P4 inf.	17.2	11.1	mandible very worn with p1
NB24	M1 inf.	31.2	16.3	
NB24	M2 inf.	30.4	19.9	
NB24	M3 inf.	26.8	21.7	
NB103/96	M2 inf.	30	17.9	juvenile mandible
NB103/96	M3 inf.	24	17.5	
NB100/2	M1 sup.	30.4	21.4	upper jaw fragment
NB100/2	M2 sup.	45.9	25	
NB144	P4 inf.	16.8	10.5	
NB144	M2 inf.	30	19	
NB144	M3 inf.	26.5	20.5	
NB142	C sup.	29.1	24	
NB142	P4 sup.	19.3	12.5	
NB142	P4 sup.	19.1	13.2	
NB142	M1 sup.	28.3	20.1	
NB142	M1 sup.	28.7	19.3	
NB142	M2 sup. sin.	44.6	24.5	
NB142	M2 sup. dext.	46.1	23.6	

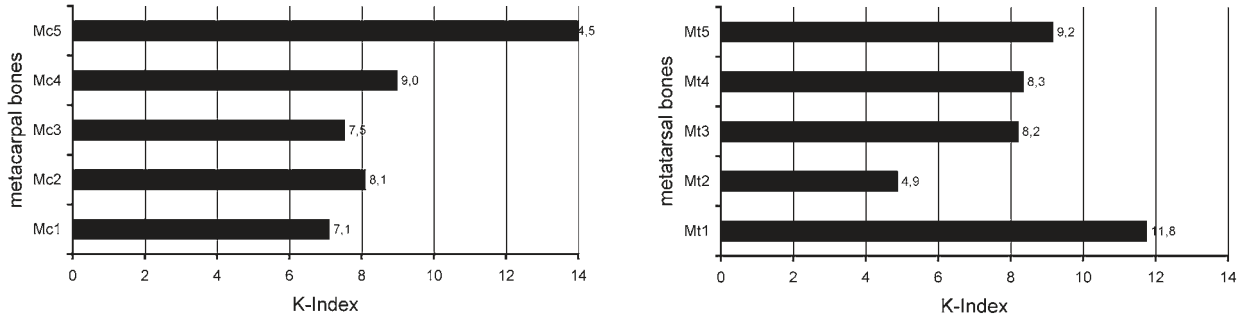
Appendix 1c: Measurements of the postcranial elements from *U. ingressus* from Nerubajskoe. TL – total length, Wp – width proximal, Dp – depth proximal, Wd – width distal, Dd – depth distal, W dia – width diaphysis, D dia – depth diaphysis, TW – total width, TD – total depth, art surf – articulation surface.

Inv.no.	Element	side	TL	Wp	Dp	Wd	Dd	W dia	D dia
NB143	Scapula	sin.	290	113.5	79.6	52.3	74.1		
NB12	Scapula	sin.	330	114	88.7	56.2	78.8		
NB104	Humerus	dext.				112.7	64.5	40.8	37.9
NB105	Humerus	dext.	362	72.2	94.6	104.9	65	49.1	42.1
NB160	Humerus	dext.	377	80.8	78.7	102.3	61.1	42.1	37.5
NB161	Humerus	dext.	417	88.3	106.2	133.2	79.5	60.5	48.4
NB162	Humerus	dext.	375	74.6	93.1	107.9	66.1	54.5	40.3
NB163	Humerus	dext.		87.2	115.4				
NB41	Humerus	dext.	435	96.6	121	139	80	57	48
NB6-1	Radius. subadult	sin.			55			22.5	31.6
NB7-1	Radius	dext.	327	54.5	41.2		45	38	23.7
NB38-2	Radius. subadult	dext.		55.8	39.5			33.1	22.9
NB103-97	Radius	sin.	325		40.6	79	51.7	39.2	32.3
NB107	Radius	dext.	294	47.8	33	66	42.5	19.4	31.3
NB167	Radius	sin.	334	52	38.8	49	78.4	23.4	36.6
NB103-4	Ulna. subadult	dext.	335	48	75.7	26.5	48		
NB103-116	Ulna. subadult	sin.		39.8	77.5				
NB106	Ulna	sin.	385	89.1	47.6	30.8	55.9	30.4	45.3
NB165	Ulna	dext.	334	70.5	33.9	28	46	26.3	38.5
NB166	Ulna	sin.	383	85.3	44.1	33.3	52.5	32.5	42.4
NB40	Femur	sin.				88.3	74	39	29.6
NB164	Femur	sin.	450			100.2	73.5	46.3	35.3
NB36-7	Tibia	dext.				84.1	48.3	33	34
NB19	Tibia	sin.	280	94.1	70.4	81.4	44.3	33.5	30.1
NB34-3	Tibia	sin.	276	90.7	67.8	69.4	39	27.5	29.5
NB103-5	Tibia	sin.	339	112	82	88.5	50	40.4	38.1
NB103-151	Tibia	dext.		98.9	75.3			37.2	33.7
NB168	Tibia	sin.	295	100.5	74.1	80.6	46.4	35.7	36.6
			TL	Wd	art surf				
NB118	Calcaneus	dext.	101.4	69.3	34.3				
NB141	Calcaneus	sin.	103.9	69.9	38.9				
NB11-6	Calcaneus	dext.	92.9	61.7	40				
NB103-73	Calcaneus	sin.	101.7	71.9	43				
NB14-1	Calcaneus	sin.	110	72.9	53.6				
NB103-77	Calcaneus	dext.	111	71.2	53				
			TL	TW	art surf	TD			
NB103-143	Astragalus	sin.	60.5	69	40.1	48.5			
NB4-2	Astragalus	dext.	56.9	59.6	33.6	41.8			
NB33-1	Astragalus	sin.	48.3	52	29.5	40.8			
NB103-29	Astragalus	sin.	60.6	68	40.5	49.5			
NB103-49	Astragalus	dext.	57.7	60	31.4	46.2			
NB13-7	Astragalus	sin.	63	66.5	39	49.1			
NB119	Astragalus	dext.	63.3	68.5	39.3	48.7			
NB120	Astragalus	dext.	63.9	67.2	39.5	48.6			
NB121	Scapholunatum	dext.	34.4	59.3		63.1			
NB1-12	Scapholunatum	dext.	30.5	49.3		55.6			
NB10-5	Scapholunatum	sin.	31.5	47					
NB103-74	Scapholunatum	sin.	29.9	49.8		54			

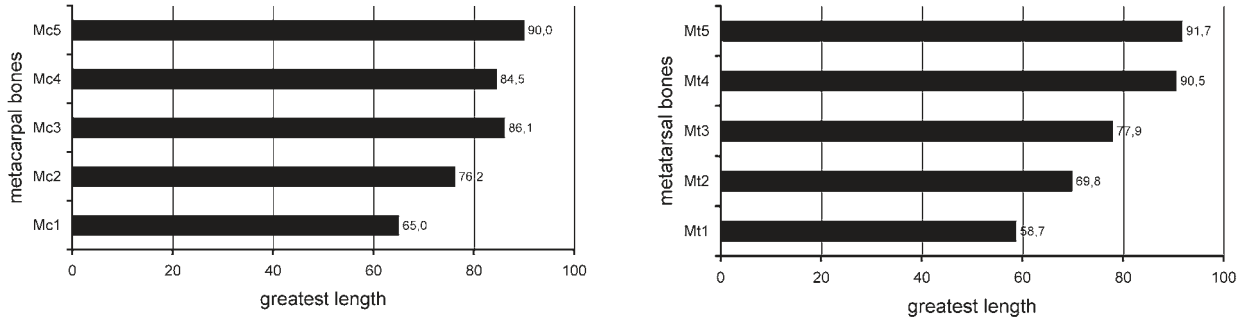
Appendix 2a: Interrelationship of the index of plumpness in metacarpus and metatarsus of the bears from Nerubajskoe (Ukraine). Please note the 2nd metacarpal and the 1st metatarsal bone, which show extreme plumpness. The plumpness of the 1st metatarsal bone even exceeds that of the bears from Vindija (Croatia), layer D/E/F, compare to WITHALM (2005).



Appendix 2b: Interrelationship of the K-index in metacarpus and metatarsus of the bears from Nerubajskoe (Ukraine). Please note the 5th metacarpal and the 1st metatarsal bone, which show extremely high K-values, comparable to those from layer D/E/F from Vindija (Croatia) and even higher than those from Potočka zijalka (Slovenia), compare to WITHALM (2004).



Appendix 2c: Interrelationship of the greatest length in metacarpus and metatarsus of the bears from Nerubajskoe (Ukraine). The picture corresponds to a highly evolved member of the cave bear group, please note the prominence of the 3rd metacarpal bone. The greatest length of the bears from Nerubajskoe fits perfectly well into the range of *U. ingressus* from uppermost layers of Vindija (Croatia).



Appendix 2d: Interrelationship of the smallest diaphyseal are in metacarpus and metatarsus of the bears from Nerubajskoe (Ukraine). Please note the prominence of the 2nd metacarpal and the 4th metatarsal bone. The 2nd metacarpal bone comes very close to the value of the 5th metacarpal bone. A similar pattern is visible in the index of plumpness of the metacarpal bones (see above).