Opera Instituti Archaeologici Sloveniae

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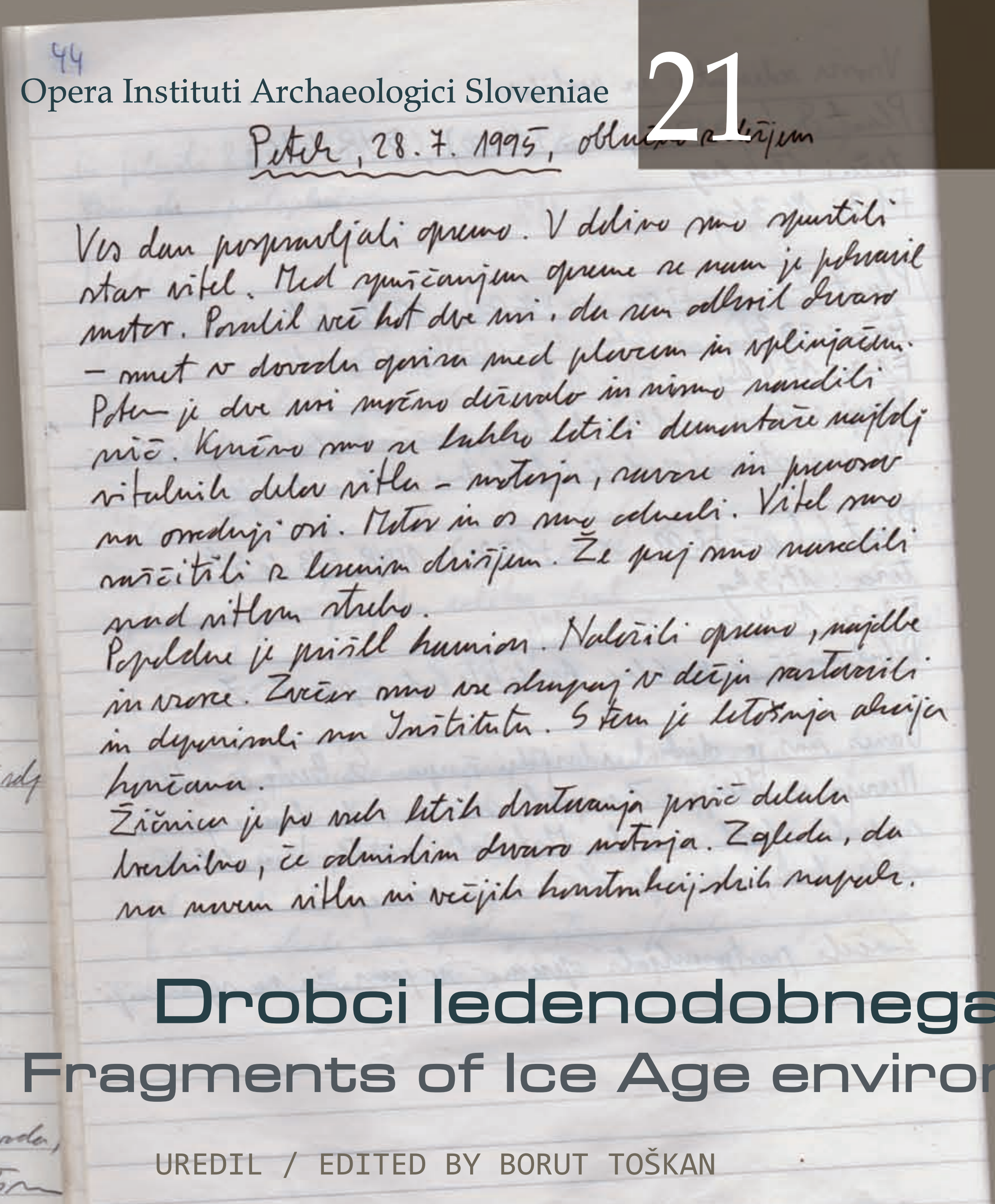

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Petek, 28. 7. 1995, oblačno z dežjem

Ves dan pospravljali opremo. V dolino smo spustili star vitel. Med spuščanjem opreme se nam je pokvaril motor. Porabil več kot dve uri, da sem odkril okvaro – smet v dovodu goriva med plovcem in uplinjačem. Potem je dve uri močno deževalo in nismo naredili nič. Končno smo se lahko lotili demontaže najbolj vitalnih delov vitla – motorja, zavore in prenosa na osrednji osi. Motor in os smo odnesli. Vitel smo zaščitili s lesenim ohišjem. Že prej smo naredili nad vitlom streho.
Popoldne je prišel kamion. Naložili opremo, najdbe in vzorce. Zvečer smo vse skupaj v depoju raztovorili in deponirali na Institutu. S tem je letošnja akcija končana.
Žičnica je po vseh letih obratovanja prvič delala brezhibno, če odmislim okvaro motorja. Zgleda, da na novem vitlu ni večjih konstrukcijskih napak.

Drobci ledenodobnega okolja
Fragments of Ice Age environments

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Uredil / Edited by
Borut Toškan

ZALOŽBA
Z R C

LJUBLJANA 2011

Ivanu!

VSEBINA

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Ivan Turk

SPOŠTOVANEMU KOLEGU DR. IVANU TURKU OB JUBILEJU

TO OUR DEAR COLLEAGUE DR IVAN TURK ON HIS JUBILEE

Anton VELUŠČEK

Redko kdaj se v življenju raziskovalca zgodi, da dobi priložnost napisati uvodne besede v zbornik, posvečen vrhunskemu znanstveniku ob njegovem življenjskem jubileju. Ker sva bila s slavljencem nekaj časa tudi sodelavca, si to štejem še posebej v zelo veliko čast.

Ivan Turk se je rodil v Ljubljani, v težkem obdobju takoj po drugi svetovni vojni. V Ljubljani je končal tudi vse šole na nižjih ravneh, in se sredi šestdesetih let vpisal na enopredmetni študij arheologije ter ga dokončal v roku. Zaradi spleta različnih okoliščin je razmeroma pozno dosegel doktorat. To čast, za katero mu v svoji morda že pretirani skromnosti ni bilo preveč mar, je bolj zaradi kadrovskih potreb kot na lastno željo dosegel šele v zadnjem desetletju minulega tisočletja na Univerzi v Ljubljani.

Slavljenec je zanimanje za najstarejše kulture pokazal že med študijem. S prijateljem in kasneje nepogrešljivim sodelavcem Janezom Dirjecem sta navezala stike s pomembnimi raziskovalci stare kamene dobe v Sloveniji in nekdanji skupni državi Jugoslaviji ter tujini. Tako sta aktivno sodelovala pri arheoloških izkopavanjih, ki sta jih vodila prof. dr. Franc Osole in prof. dr. Đuro Basler. Pod budnim strokovnim vodstvom prof. Osoleta sta v praksi izvedla tudi vsa tedanja sondiranja (iskanja novih najdišč s pomočjo poskusnih vkopov). Ivan je v ta namen sam pregledal celoten seznam kraških jam v Sloveniji in izbral več vodoravnih jam, v katerih bi po njegovem poizkusne arheološke raziskave dale pozitivne rezultate. Posebej zanimivi sta se mu zdeli dve jami: Matjaževe kamre pri Rovtah in Divje babe pri Cerknem. Zaradi lažjega dostopa so se nato odločili za prvo, a raziskave v drugi so veliko kasneje dale pečat slavljenčevi karieri.

Ljudski rek pravi: “Človek obrača, Bog obrne!” Perspektivnega študenta Ivana je po končanem študiju arheologije pot najprej zanesla v matično knjižnico na Filozofski fakulteti, urejanju katere se je posvetil z vsem srcem in delovno vnemo. Z arheologijo, kot sam piše, se takrat ni ukvarjal. Delo v ozadju – dokumentalistika, je bila njegova glavna zadolžitev, tudi ko je nastopil novo službo na Inštitutu za arheologijo pri Slovenski akademiji znanosti in umetnosti, kjer pa je to zahtevno opravilo vedno bolj nadgrajeval s poglabljanjem v arheološko

It rarely happens to a researcher be given the chance to write introductory words to proceedings dedicated to a top-level scientist on his birthday jubilee. Ivan and I were co-workers for some time and therefore I consider this a particularly great honour.

Ivan Turk was born in Ljubljana, during a difficult period immediately after World War II. He completed elementary and secondary education in Ljubljana. During the mid-sixties, he enrolled in the single-subject study of archaeology in Ljubljana and graduated on time. Due to various circumstances, he obtained his doctorate degree relatively late. Ivan received this honour at the University of Ljubljana as late as the 1990s. Being exceedingly modest, he did not care much about it and earned a PhD more because of staffing needs rather than his own desire.

Ivan started showing his interest towards the oldest cultures during his student years. With his friend, and later his vital colleague, Janez Dirjec they made contacts with Palaeolithic researchers from Slovenia and wider. They both played an active role in archaeological excavations, carried out under the supervision of Prof. Dr Franc Osole and Prof. Dr Đuro Basler. Under the watchful expert guidance of Prof. Osole they also carried out all the probing (searching for new sites with sample trenching) that was done back then. Ivan examined the complete list of caves in Slovenia for this purpose and selected several horizontal ones, which would be appropriate to explore archaeologically. Two caves were particularly interesting: Matjaževe kamre near Rovte, and Divje babe near Cerkno. For ease of access, the first cave was chosen for excavation. However, research of the latter, which was done many years later, became the highlight of his career.

As the popular saying goes: “A doctor administers the cure, but nature heals!” After graduating from archaeology, as a promising student Ivan started his job in the Central Library of the Department of Archaeology at the Faculty of Arts, where his heart and working enthusiasm were devoted to organising the Library. As he himself says, he was not directly involved in archaeology at the time. Doing background work, i.e. documentation work, remained his main task when he started a new job at the Institute of Archaeology of the Slovenian Academy of topografijo, predvsem s sondiranji v jamskih najdiščih, tokrat pod strokovnim vodstvom dr. Mitje Brodarja. V poklicnem obdobju sta z Dirjecem izkopavala v več kot petdesetih jamah v Sloveniji. Med njimi so se nekatere uvrstile na seznam starokamenodobnih najdišč, druge pa so zaradi eminentnih objav postale referenčna najdišča za mlajša obdobja, kot je primer najdišča Podmol pri Kastelcu nad Kraškim robom v jugozahodni Sloveniji.

V osemdesetih letih je vodilni inštitutski raziskovalec stare kamene dobe dr. Mitja Brodar odšel v pokoj in na izpraznjeno mesto je bil predlagan Ivan Turk, ki je ponujeno priložnost sprejel kot velik izziv. Leta 1988 je prevzel nase tudi odgovornost vodenja raziskav v jamskem najdišču Divje babe I. Kot piše, jih je pri izkopavanju v jami ves čas spremljala sreča, čeprav so delali v objektivno zelo nevarnih razmerah; kako zelo nevarnih, se je pokazalo v tragični nesreči, ko je na poti v jamo življenje izgubil šolski ravnatelj v pokoju iz Cerknega.

Pod Ivanovim vodstvom so raziskave v jami dobile nov zagon. Lotil se jih je sistematično in v marsičem zelo izvirno, predvsem pa na vrhunski ravni. Najprej so ob podpori znancev in darovalcev ter s prostovoljnim delom v dveh letih napeljali 800 m električnega voda, zgradili 400 m dolgo žičnico z višinsko razliko 230 m in v jami postavili železne odre za odvoz odkopanega materiala. Sledilo je več kot desetletje dela na način, ki ga dotlej doma niso imeli priložnosti preizkusiti. Vse nakopane usedline so po žičnici spravili v dolino, jih z vodo sprali na sitih in temeljito pregledali. Kljub številnim tehničnim težavam so vztrajali pri raziskovanju leto za letom, celo tako, da so sami načrtovali in izdelali nov vitel.

Natančno delo, ki je bilo sprva spričo redkih najdb paleolitskih orodij videti nesmiselno, se je ob tako pomembnih odkritjih, kot so fosilne dlake jamskega medveda in piščal, bogato obrestovalo. Izdelana je bila kronostratigrafija jamskih sedimentov. Bržčas najpomembnejši in strokovno najzahtevnejši dosežek dolgoletnih raziskav v Divjih babah I.

Vsi natančno zbrani podatki za plasti so jim prišli še kako prav. Del kritične svetovne znanosti je predvsem odkritje še vedno domnevne, a iz dneva v dan prepričljivejše piščali, oziroma rečemo lahko najstarejšega pravega glasbila na svetu, sprejel s skepso. Posamezni eminentni raziskovalci, ne zdi se potrebno, da jih imenujem, so se spustili na raven "gostilniškega" obračunavanja z drugačnim in argumenti podprtim razmišljanjem. V osebnih srečanjih z Ivanom je bilo slutiti, da se ob takih napadih, onemogočanjih itd., s kančkom grenkobe sprašuje o dejanskem pomenu znanosti v današnji družbi in njeni zlorabi za kakršen koli namen. Ivan ni bil in tudi danes, pokončen, svež petinšestdesetletnik, ni zamerljiv. Vedno je bil in je tudi še, čeprav danes v zasluženem pokoju, odprt za sodelovanje in pripravljen pomagati.

Ivan Turk je s svojim delom pomembno vplival tudi na razvoj slovenske arheologije. Vedno je zago-

Sciences and Arts. However, he was constantly upgrading this difficult task with additional research on the archaeological topography, especially with sample trenching of cave sites, this time under the expert guidance of Dr Mitja Brodar. During his professional career, Ivan Turk together with Janez Dirjec excavated over fifty caves in Slovenia. Some of them were listed as Palaeolithic sites, while others, such as Podmol near Kastelec in south-western Slovenia, became reference sites for more recent periods, mainly due to their outstanding publications.

In the 1980s, the Institute's leading researcher of the Palaeolithic, Dr Mitja Brodar, retired and Ivan Turk was proposed to take his place. He embraced this opportunity as a major challenge. In 1988, the excavation of the cave site of Divje babe I continued under his supervision. As he writes, they were accompanied by good luck during the excavation of the cave, although they worked under objectively dangerous circumstances, as was demonstrated in a tragic accident when a retired headmaster from Cerkno passed away on his way to the cave.

Ivan's supervision of the excavation of the cave gave new impetus to the research. He undertook the research systematically and originally in many ways, but what is most important is that the research was conducted at the highest level of expertise. Firstly, with the support of friends, donors and volunteers, an 800-m-long power line, a 400-m-long material ropeway with an altitude difference of 230 m and iron scaffolding in the cave were erected in order to remove the excavated sediments. What followed was more than a decade of research, which was different from any other research previously done at Slovenian sites. All excavated sediments were – using the material ropeway – transported to the valley below the site, where they were wet-sieved and thoroughly examined. Despite several technical difficulties, they carried on with the research year after year, and even designed and made a new winch.

Detailed work, which initially – due to few finds of Palaeolithic tools – appeared meaningless, was richly rewarded with such important finds as fossilised cave bear hairs and a bone flute. Chronostratigraphy of cave sediments was established. This is probably the most important and most difficult achievement that resulted from the many years of research at Divje babe I.

All carefully collected data from different layers proved to be very useful. Part of the critical world of science was sceptical about the discovery of the still alleged, but from day to day more convincing find of a flute or, as we may say, the oldest music instrument ever discovered. Individual eminent researchers – it does not seem necessary to name them individually – descended to the level of pub squabble, as they did not embrace the importance of looking at things from a new perspective, which was also supported by sound arguments. Personal conversations with Ivan revealed that when varjal interdisciplinarnost v raziskovanju ter se zaradi kadrovskih zmožnosti sam ukvarjal tudi z arheozoologijo. Postal je dober poznavalec jamskega medveda (*Ursus spelaeus*). Zagotovo je bil tudi eden izmed prvih raziskovalcev pri nas, ki je razumel pomen radiometričnih metod datiranja v arheologiji. V Divjih babah I je radiokarbonsko datiranje v sodelovanju z Bonnie Blackwell nadgradil z ESR-datiranjem, ki je za obdobje pred petdeset tisoč leti veliko bolj zanesljivo in natančno. V slovensko arheologijo je torej vpeljeval natančno in interdisciplinarno obravnavanje sedimentov in drugih ostankov, ki nam veliko povedo o nekdanjem okolju, o gospodarstvu takratnega človeka itd. Mokro sejanje, ki ga je izvajal pri raziskovanju Divjih bab I, se je razširilo tudi v preučevanje mlajših arheoloških obdobij, sprva le na Ljubljanskem barju, danes pa je stalnica pri raziskovanju vseh arheoloških najdišč. Slavljenčev velik dosežek je bilo tudi sprotno objavljanje rezultatov posameznih raziskovalnih sezon v Divjih babah I in rezultatov sondiranj po številnih jamah, kar je v slovenski arheologiji, na žalost, bolj izjema kot pravilo. Ivan se je namreč predobro zavedal, da uvajanje novih tehnologij ne koristi, če se rezultati raziskav dobro ne premislijo in se razmišljanje ne objavi ter se tako ne da v presojo najširši strokovni javnosti. Vedno se je zavzemal za znanstveni pristop do dela, kjer sta odliki jasna, razumljiva beseda in preverljivost razlage.

Ivan Turk je bil vse svoje poklicno obdobje tudi borec za ohranjanje domače kulturne dediščine. Pri znanstvenih projektih je tako trdno zagovarjal načelo recipročnosti. Tujim raziskovalcem možnosti delovanja v Sloveniji ni odrekal, jim je pa postavljal enake pogoje, kot so veljali za domače arheologe, kar je bilo za nekatere silno moteče. Razumljivo, Ivan je bil trd pogajalec, a vedno sta ga vodili privrženost in ljubezen do arheologije. V tem pogledu se je boril tudi za razvoj in ohranjanje slovenske strokovne besede. Pri nekaj več kot dvomilijonskem narodu je to nujno potrebno.

Še bi lahko naštevali, kaj vse je Ivan prispeval v slovensko in tudi evropsko arheologijo, a posvetimo nekaj besed tudi zborniku, ki je izšel slavljencu v čast in zahvalo, v zahvalo za njegov prispevek k arheologiji, znanstvenemu raziskovanju in tovariškemu odnosu.

Zamisel o zborniku je nastala na Inštitutu za arheologijo ZRC SAZU, v domači hiši, kjer je slavljenec dosegel največje poklicne uspehe. Zanje je dobil tudi številne nagrade bodisi matične inštitucije bodisi Slovenskega arheološkega društva.

Glavno breme zbornika je prevzel dr. Borut Toškan. Zbral je lepo število domačih in tujih raziskovalcev, ki so pripravili znanstvene prispevke v čast Ivanovi petinšestdesetletnici. Njihova vsebina vsaj približno odraža področja, s katerimi se je slavljenec večino poklicne kariere bodisi neposredno ukvarjal bodisi so bile predmet njegove znanstvene vedoželjnosti.

such “assaults” appeared, he was, with a hint of bitterness, asking himself about the true meaning of science in today’s society and its misuse. Ivan was not then, and even today – as a vigorous sixty-five-year-old – is still not resentful. Now, enjoying his well-deserved retirement, he remains – as always – ready to assist and help.

Ivan Turk and his researches significantly influenced the development of Slovenian archaeology. He has always supported interdisciplinary research and had the opportunity to engage in archaeozoology himself. He became an expert on the cave bear (*Ursus spelaeus*). He was most definitely also one of the first Slovenian researchers who understood the importance of radiometric methods of dating in archaeology. The radiocarbon dating of Divje babe I, in collaboration with Bonnie Blackwell, was upgraded with far more reliable and precise dating for periods earlier than fifty thousand years ago, called the ESR dating. As mentioned above, he introduced precise and interdisciplinary handling of sediments and other residue, which represent an important source of information about past environments, economy etc. for Slovenian archaeology. Wet sieving, implemented in the exploration of Divje babe I, was later used in researches on later archaeological periods, initially only on the Ljubljansko barje, but is now a routine procedure in the exploration of all archaeological sites. Ivan’s great achievement is also the up-to-date publishing of the results of each excavation season at Divje babe I and the results of sample trenching in a number of other caves, which is, unfortunately, more the exception than the rule in Slovenian archaeology. Indeed, Ivan was aware that the introduction of new technologies is of no use if the results are not carefully thought out and published so that they are available for assessment by the wider public. He has always been committed to a scientific approach to work, where the main hallmarks is plain, understandable language and verifiable interpretation.

Ivan Turk has always defended preservation of Slovenian cultural heritage. This can clearly be seen from scientific projects, in which he defended the principle of reciprocity. He did not refuse foreign researchers the opportunity to work in Slovenia, but they had to work under conditions that were identical to those applied to local archaeologists, which was greatly annoying to some. Understandably, Ivan was a tough negotiator, but he has always been led by dedication and love towards archaeology. He has therefore also strongly encouraged the development and preservation of Slovenian scientific vocabulary. Considering the population of barely two million, this is indeed necessary.

We could continue writing about Ivan’s contributions to Slovenian and European archaeology, but we will now devote a few words to this collection of papers, published on his anniversary to honour and acknowledge his contribution to archaeology, scientific research and collaboration with his colleagues.

V zahvalo za tvoj prispevek k arheologiji ti, spoštovani slavljenec dr. Ivan Turk, v svojem imenu, v imenu tvojih nekdanjih sodelavcev, vseh slovenskih arheologov, v imenu urednika, avtorjev, prevajalcev, lektorjev in drugih tehničnih sodelavcev zbornika želimo ob jubileju veliko zdravja, življenjske energije, novih odkritij in še na mnoga leta!

V Ljubljani, februarja 2011

We came up with an idea of publishing proceedings at the Institute of Archaeology, his second home, where he attained his greatest professional success. He also received numerous awards, from his home institution as well as from the Slovenian Archaeological Society.

The editor, Dr Borut Toškan, contacted a good number of local and foreign researchers, which resulted in a collection of papers compiled in honour of Ivan Turk on the occasion of his sixty-fifth birthday. The content generally reflects areas to which Ivan's career was dedicated, or which have been the subject of his scientific curiosity.

To acknowledge your contribution to archaeology, dear Dr Ivan Turk, on behalf of your former colleagues, all Slovenian archaeologists, editor, authors, translators, assistants and other technical staff of this collection of papers and myself, we wish you good health, plenty of life energy, new discoveries and many years to come!

Ljubljana, February 2011

(Translation: Nives Kokeza)

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NAJDBA MASTODONTA IZ KICARJA BLIZU PTUJA

THE MASTODON FIND FROM KICAR NEAR PTUJ

Vasja MIKUŽ, Jernej PAVŠIČ

Izvleček

V prispevku so obravnavani ostanki mastodontovega okla vrste *Anancus arvernensis* (Croizet et Jobert, 1828), ki so bili v letu 1997 najdeni v starejših villafranchijskih klastitih na širšem območju Kicarja blizu Ptuja. V tem delu Slovenije je že registriranih več ostankov omenjene vrste trobčarja.

Ključne besede: okel, mastodont, starejši villafranchij, Kicar pri Ptuju

Abstract

This contribution deals with the remains of a mastodon tusk from the species *Anancus arvernensis* (Croizet et Jobert, 1828). The remains were discovered in 1997 in the Early Villafranchian clastites in the broader area of Kicar near Ptuj. So far quite a few mastodon remains have been registered in this part of Slovenia.

Keywords: tusk, mastodon, Early Villafranchian, Kicar near Ptuj

UVOD

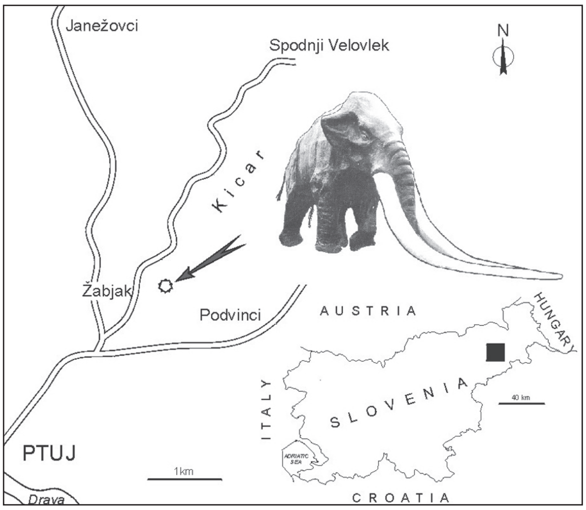
Po podatkih Franca Goloba s Ptuja sta bila dela okla najdena 5. aprila 1997 v konglomeratu ob gozdni cesti na širšem območju Kicarja, dobrih pet kilometrov severnovzhodno od Ptuja, nekako med krajema Spodnji Velovlek na severu in Podvinci na jugu. Dne 21. julija 2004 nam je gospa Katarina Krivic, kustodinja Prirodoslovnega muzeja Slovenije, prinesla sliko najdišča in manjši ostanek ohranjenega okla v silikatnem konglomeratu. Večji ostanek okla istega primerka, dolg okrog 25 cm in s premerom od 10 do 12 cm, smo prejeli nekoliko kasneje.

Ker pravega najdišča nismo poznali, smo novembra 2008 znova prosili najditelja, da nam na karto vriše točno lokacijo najdenih delov trobčarjevega okla. Dne 20. novembra 2008 nam je najditelj poslal nove fotografije najdišča in označeno mesto na topografski karti v merilu 1:25.000. Izkazalo se je, da okel ne izvira iz severnega dela Kicarja, temveč z zahodnega roba

INTRODUCTION

According to the data passed on by Franc Golob from Ptuj the two parts of the tusk were found on 5th April 1997 in a conglomerate alongside a forest route in the broader area of Kicar, just over five kilometres to the northeast of Ptuj, somewhere between Spodnji Velovlek in the north and Podvinci on the south. On 21st July 2004, Mrs. Katarina Krivic, the custodian of the Slovenian Museum of Natural History brought a picture of the site and a smaller remain of the preserved tusk in silicate conglomerate. Somewhat later we received the larger remain (approximately 25 cm long and with a diameter measuring between 10 and 12 cm) of the tusk belonging to the same specimen.

As we did not know the exact location of the finds, we asked the finder to draw the precise location of the discovered parts of the Proboscidea tusk onto a map (in November 2008). On 20th November 2008 he sent us new photographs of the site and marked the spot



Sl. 1: Geografski položaj najdišča okla na območju Kicarja.
Fig. 1: Geographical position of the tusk site on the Kicar territory.

južnega dela, okrog 700 m vzhodno od zaselka Žabjak, ki leži na nadmorski višini 229,1 m in približno 600 m severnozahodno od zaselka Podvinci (*sl. 1*). Deli okla so bili izkopani neposredno iz profila trdno sprijetega konglomerata z vmesnimi lečastimi vložki peščenjaka, ki so rečnega porekla. Po podatkih F. Goloba najdba izvira iz peščeno konglomeratne stene, kakšnih 6 do 8 m nad ravnino Žabjaka, tj. na nadmorski višini okrog 236 m. Pečina se dviga še okrog 15 m nad mestom najdbe, zadnja dva metra pod vrhom stene je plast slabo sprijetega rumenkastega peščenjaka.

Ostanki okla so trenutno na ljubljanskem Oddelku za geologijo Naravoslovnotehniške fakultete Univerze v Ljubljani, Privoz 11. Kasneje jih nameravamo posredovati geološko-paleontološki zbirki Prirodoslovnega muzeja Slovenije.

GEOLOŠKA ZGRADBA KICARJA IN OKOLICE

Po podatkih Žnidarčiča in Mioča (1988) na Osnovni geološki karti SFRJ, lista Maribor in Leibnitz v merilu 1:100.000, izdanjajo na območju najdišča Kicar pliocenske kamnine: pesek, prod, konglomerat in peščenjak z vložki gline. Na obrobju vodoravno ležečih pliocenskih in pliokvartarnih plasti so v nižinskem delu v okolici Kicarja kvartarne usedline: peščena glina in soliflukcijski deluvijalno-proluvijalni material. Vse kaže, da je bil del trobčarjevega okla najden v pliocenskih usedlinah. Prodniki v konglomeratu so zelo različnih velikosti in iz različnih metamorfnih kamnin ter kremena.

Žnidarčič in Mioč (1989, 29 s) pišeta, da ležijo pliocenske plasti v okolici Ptuja superpozicijsko na sarmatijskih in panonijskih skladih. Starost pliocenskih

on a topographic map at a scale 1:25,000. This showed us that the tusk did not originate from the northern part of Kicar, but from the south-western part, around 700 m east of the hamlet Žabjak (that lies 229.1 m a.s.l.) and approximately 600 m northwest from the hamlet Podvinci (*Fig. 1*). Parts of the tusk were dug out from the layer of the closely held together conglomerate (that includes sandstone particles) which came from the river. According to the data given by F. Golob the find originates from the sand conglomerate wall, approximately 6 to 8 m above the plain of Žabjak, i.e. at an altitude of approximately 236 m. The cliff rises approximately 15 m above the location of the find, and the last two metres to the top of the wall are formed by a layer of poorly stuck together sandstone.

The tusk remains are currently located at the Department of Geology, Faculty of natural sciences and engineering, University of Ljubljana, Privoz 11. We plan to pass them on to the geological and Palaeontological collection at the Slovenian Museum of Natural History.

THE GEOLOGY STRATA OF KICAR AND ITS SURROUNDINGS

According to the data provided by Žnidarčič and Mioč (1988) on the Basic geological map of SFRJ, sheet Maribor and Leibnitz (scale 1:100,000), the following Pliocene rocks can be found in the Kicar area: sand, gravel, conglomerate and sandstone with clay inserts. On the area covered by the horizontally lying Pliocene and Plio-Quaternary layers, the following Quaternary sediments can be found in the lowland area in the vicinity of Kicar: sand clay and solifluctional, deluvial-proluvial material. All of this indicates that the part of the Proboscidea tusk was found in the Pliocene sediments. The pebbles found in the conglomerate are of various sizes and from various metamorphic rocks and quartz.

Žnidarčič and Mioč (1989, 29 f) wrote that the Pliocene layers in the vicinity of Ptuj lie on top of Sarmatian and Pannonian bases. The age of the Pliocene layers was established with the aid of the ostracoda found in the clay layers. There are no mentions of mammalian remains discovered in Pliocene or Plio-Quaternary layers. According to these two authors Kicar and its surroundings belong to the Pesnica tectonic trench, or to the tectonic unit of Slovenske gorice.

THE RESEARCH INTO MASTODONS IN SLOVENIA SO FAR

Numerous researchers have written about Mastodon remains in Slovenia: Rakovec (1954; 1968; 1997), Pohar (1963–1964), Drobne (1967; 1983), Brezigar (1997), Po-plasti je določena s pomočjo ostrakodov, najdenih v glinenih plasteh. Iz pliocenskih skladov ne omenjata nobenih ostankov sesalcev. Tudi iz pliokvartarnih skladov ne omenjata nikakršnih najdb takratnih sesalcev. Po podatkih istih avtorjev sodi Kicar z okolico k Pesniškemu tektonskemu jarku oziroma k tektonski enoti Slovenskih goric.

DOSEDANJE RAZISKAVE MASTODONTOV V SLOVENIJI

O ostankih mastodontov na Slovenskem so pisali številni raziskovalci: Rakovec (1954; 1968; 1997), Pohar (1963–1964), Drobne (1967; 1983), Brezigar (1997), Pohar, *et al.* (1997), Lenardić, Pohar (1997), Mikuž (1998) in drugi.

V severnovzhodni Sloveniji so najdbe trobčarjev ali proboscidov redke, v primerjavi z drugimi slovenskimi območji pa razmeroma pogostne. Največ je ostankov mastodontov (Mastodontoidea), kar je razvidno iz podatkov Lenardićeve in Poharjeve (1997). Po stopnji specializacije mastodontskih molarjev sta jih isti avtorici (1997) starostno uvrstili v zgornji pliocen. Tudi v širši okolici Ptuja je bilo že najdenih nekaj ostankov mastodontov. Lenardićeva in Poharjeva (1997, 107) omenjata najdbe anankusa iz najdišč v okolici Ljutomera, sv. Andraža in Vitomarcev ter Lahoncev. Mikuž (1998) opisuje iz okolice Ptuja del tretjega spodnjega levega meljaka (M_3) trobčarja plio-pleistocenske vrste *Anancus arvernensis* (Croizet et Jobert, 1828). Predvideva, da je bil ostanek molarja najden v kamninah villafranchijske starosti (1998, 130). Isti avtor (2007) je tukaj obravnavano najdbo iz Kicarja sprva pomotoma pripisal mamutu. Do neljube pomote je prišlo zato, ker nismo poznali pravega najdišča. Prepričani smo bili, da najdba izvira iz pleistocenskih prodnatih nanosov, ki so v bolj ravninskem delu. Izkazalo pa se je, da izvira iz starejših pliocenskih kamnin z obrobnega območja južnozahodnega dela Kicarja, ki so nad mlajšimi ravninskimi deli.

PALEONTOLOŠKI DEL

Sistematika po: R. Vaufreyju, 1958
Razred Mammalia Linné, 1758
Red Proboscidea Illiger, 1811
Podred Mastodontoidea Osborn, 1921
Družina Tetralophodontidae Vaufrey, 1958
Poddružina Anancinae Hay, 1922
Rod *Anancus* Aymard, 1855.

Thenius (1969) ima nekoliko drugačno sistematiko trobčarjev (Proboscidea). Anankuse oziroma rod *Anancus* uvršča k skupini Elephantoidea in nadalje k manjši skupini Mastodontidae. Iz podatkov navedenega avtorja

har *et al.* (1997), Lenardić, Pohar (1997), Mikuž (1998) and others.

Proboscidea finds are rare in northeast Slovenia, however they are relatively common when compared to other parts of Slovenia. The most common are mastodon (Mastodontoidea) remains, and this can be clearly seen in the data provided by Lenardić and Pohar (1997). Judging by the specialisation level of the mastodon's molars the mentioned authoresses (1997) placed them into Late Pliocene. So far several mastodon finds have been discovered in the broader surroundings of Ptuj. They (1997, 107) mentioned *Anancus* finds discovered at sites in the vicinity of Ljutomer, Sv. Andraž, Vitomarci and Lahonci. Mikuž (1998) described a part of the third lower left molar (M_3) of a Proboscidea belonging to the Pliocene-Pleistocene species *Anancus arvernensis* (Croizet et Jobert, 1828) that was discovered in the Ptuj surroundings; he (Mikuž 1998, 130) assumed that the molar remain found in the rocks belonged to the Villafranchian period. The same author (Mikuž 2007) also initially wrongfully ascribed the here presented find from Kicar as a mammoth find. The mistake was a result of not knowing the precise location of the site. We were convinced that the find originated from the Pleistocene gravel deposits that can mainly be found in the plain. However, it has been discovered that the find came from the older Pliocene rocks on the southwest edge of Kicar, located on top of the earlier plain parts.

PALAEONTOLOGICAL PART

Classification according to: R. Vaufrey (1958)
Class Mammalia Linné, 1758
Order Proboscidea Illiger, 1811
Suborder Mastodontoidea Osborn, 1921
Family Tetralophodontidae Vaufrey, 1958
Subfamily Anancinae Hay, 1922
Genus *Anancus* Aymard, 1855

Thenius (1969) classifies Proboscidea in a slightly different way. He places the genus *Anancus* into the group Elephantoidea and further into the smaller group Mastodontidae. According to Thenius (1969, 601) the species *Anancus arvernensis* is characteristic merely for the late Pliocene and early Pleistocene. Thenius (1969, 604, Fig. 697) compares various mastodon genera amongst each other. The picture shows that the species *Anancus arvernensis* had relatively straight and extremely long tusks and that they could be found only in the upper jaw. A reduction of this incisor took place in the lower jaw.

There are a number of more up to date Proboscidea classifications that do not differ greatly one from another. We will take this opportunity to state newer data as regards the classification of Proboscidea. According to

(Thenius 1969, 601) izvemo, da je vrsta *Anancus arvernensis* značilna za zgornji pliocen in starejši pleistocen. Thenius (1969, 604, sl. 697) primerja med seboj različne rodove mastodontov. Iz slike je razvidno, da je imela vrsta *Anancus arvernensis* okle samo v zgornji čeljusti in da so bili ti razmeroma ravni in zelo dolgi. V spodnji čeljusti je prišlo do redukcije tega sekalca.

Obstajajo tudi številne sodobnejše sistematike proboscidov, ki se med seboj bolj malo razlikujejo. Navajamo nekaj novejših podatkov o sistematiki trobčarjev. Po Maierju (1993) je sistematska razvrstitev naslednja: razred Mammalia Linné 1758, podrazred Theria Parker in Haswell 1897, nižji razred Eutheria Gill 1872, red Proboscidea Illiger 1811, podred Euelephantoidea, družina Gomphotheriidae Cabrera 1929 (Trilophodontidae Simpson 1931), rod *Anancus* Aymard 1855.

Colbert in Morales (1994) imata sistematiko takšno kot Maier (1993), le da upoštevata še naddružino Gomphotherioidea, ki je pri Maierju ni. Njuna razvrstitev je: deblo Chordata, poddeblo Vertebrata, razred Mammalia, podrazred Theria, nižji razred Eutheria, red Proboscidea, podred Euelephantoidea, naddružina Gomphotherioidea.

Dubrovo (1997, 165 s) je mnenja, da rod *Anancus* danes nima naslednikov, filogenetske prednike pa ima v rodovih *Tetralophodon* in miocenskem Gomphotheriumu.

Rakovec (1954, 105 ss) poroča, da je vrsta *Anancus arvernensis* živela v srednjem in zgornjem pliocenu in starejšem pleistocenu. Značilna je za evropski prostor (najdena je bila v številnih državah), najdlje pa se je zadržala na Pirenejskem in Apeninskem polotoku. Isti avtor (1954, 107) tudi piše, da so bili mastodonti prilagojeni na toplo in razmeroma vlažno podnebje.

Anancus arvernensis (Croizet et Jobert, 1828)
(*t. 1–3*)

1912 *Mastodon arvernensis* Cro. et Job. – Gorjanović-Kramberger, 14, tab. 1, 7, 7a

OPISI OHRANJENIH OSTANKOV ANANKUSOVEGA OKLA

Ohranjenih je pet različno velikih delov trobčarjevega okla vrste *Anancus arvernensis* in zelo veliko majhnih in drobnih ostankov zobovine ali dentina, ki so preostanek zdrobljenih delov okla.

Največji, okrog 200 mm dolg ostanek okla je na določenih delih zlepljen s konglomeratom in peščenjakom (*t. 1:* 1a–1b). Manjša površina okla je razkrita. Večji premer okla na sredini meri 122 mm in manjši 119 mm, njegov obseg je okrog 400 mm. V preseku je ostanek ovalne oblike (*t. 1:* 1b). Vse druge strukturne

Maier (1993) they are classified as follows: class Mammalia Linné 1758, subclass Theria Parker et Haswell 1897, infraclass Eutheria Gill 1872, order Proboscidea Illiger 1811, suborder Euelephantoidea, family Gomphotheriidae Cabrera 1929 (Trilophodontidae Simpson 1931), genus *Anancus* Aymard 1855.

Colbert and Morales (1994) use the same classification as Maier (1993), with the only difference being that they included the superfamily Gomphotherioidea, which cannot be found in Maier's classification. Their classification goes as follows: phylum Chordata, subphylum Vertebrata, class Mammalia, subclass Theria, infraclass Eutheria, order Proboscidea, suborder Euelephantoidea, superfamily Gomphotherioidea.

According to Dubrovo (1997, 165 f) the genus *Anancus* does not have any successors today, while the phylogenetic predecessors can be found in the genus *Tetralophodon* and the Miocene genus *Gomphotherium*.

Rakovec (1954, 105 ff) reported that the species *Anancus arvernensis* lived in the Mid and Late Pliocene and the Early Pleistocene. The species is characteristic of the European territories, and was found in a number of countries; however it persisted the longest on the Iberian and Apennine peninsulas. The same author (1954, 107) wrote that the mastodons were adjusted to a warm and relatively damp climate.

Anancus arvernensis (Croizet et Jobert, 1828)
(Pl. 1–3)

1912 *Mastodon arvernensis* Cro. et Job. – Gorjanović-Kramberger, 14, Pl. 1, 7, 7a

DESCRIPTION OF THE PRESERVED REMAINS OF THE ANANCUS TUSK

Five different sized samples of the Proboscidea tusk of the species *Anancus arvernensis* and a number of small and very small remains of dentine (remains of crushed tusk parts) have been discovered.

The largest – approximately 200 mm long – tusk remain is in some parts stuck to the conglomerate and sandstone (*Pl. 1:* 1a-1b). A small surface of the tusk can be seen. The larger diameter of the tusk measures 122 mm in the centre while the smaller one measures 119 mm, and has a circumference of approximately 400 mm. The tusk remain has an oval cross-section (*Pl. 1*: 1b). All other structural characteristics of the dentine and the orientation of certain materials is the same as with the smaller parts belonging to this tusk. The find is in poor condition, for the dentine (hydrophosphate) and the surrounding rock are disintegrating. The binding includes quite a lot of carbonate, thus the individual silicate pebbles are poorly bound. This is a značilnosti dentina in usmerjenost določenih mineralov so takšne kot pri manjših delih istega okla. Najdba je v slabem stanju, saj zobovina (hidrofosfat) in okolišna kamnina razpadata. V vezivu je precej karbonata, zato je zlepljenost posameznih silikatnih prodnikov slaba. V bistvu gre za zelo slabo vezan konglomerat z lečami peščenjaka, ki razpada v prod in pesek. Velikost dela je 250 x 165 x 133 mm.

Drugi ostanek istega okla je predstavljen na *tabli 2:* 1. Velikost kosa konglomerata in peščenjaka je 165 x 126 x 80 mm. Ohranjen je del okla, katerega premer meri 124 mm. Tretji, manjši kos peščenjaka in konglomerata meri 103 x 89 x 45 mm. Na omenjeni kamnini je tanka zunanja plast zobovine, ki je prav tako del največjega kosa najdbe. Ostanek zobovine je velik 90 x 60 x 3–5 mm (*t. 2:* 2). Na *tabli 2:* 3 je četrti, manjši delček okla, velik 95 x 87 mm, ki je z delom primarne zobne površine pritrjen na konglomerat. V bistvu so ohranjeni skromni ostanki rumenkastega zelo higroskopičnega dentina. Na dentinu sta opazni radialna in koncentrična struktura. V prečnem preseku okla je v dentinu opazen "Schregerjev strukturni vzorec" (*t. 2:* 3), ki je značilen za proboscide (Ábelová 2008). V radialni in krožni smeri so številni temni vključki, najverjetneje manganovih raztopin. Ponekod so vidni lepi dendriti psilomelana, sem in tja se najdejo tudi posamezni kristalčki pirita. Nekateri deli okla so limonitizirani, najmočneje tisti ob stiku s konglomeratom oziroma zunanji deli okla. Prodniki v konglomeratu so zelo različnih velikosti in oblik. Po sestavi pripadajo kremenu in metamorfnim kamninam, v vezivu so znova manjši prodniki kremena in drugih kamnin ter številne luskice sljude. Zadnji kos (*t. 2:* 4) konglomerata je velik 143 x 105 x 107 mm. Na njem je prilepljena tanka zunanja plast zobovine, ki meri 120 x 78 x 5 mm. Plast zobovine je odtrgana od največjega dela okla.

PRIMERJAVA

Gorjanović-Kramberger (1912, tab. 1, sl. 7, 7a) predstavlja del okla iz zgornjepliocenskih plasti najdišča Bratovština pri Petrinji na Hrvaškem, ki je po obliki prereza in velikosti podoben našemu primerku iz najdišča Kicar. Prerez hrvaškega primerka je nekoliko manjši od našega, kar je lahko povezano tudi s položajem odlomljenega fragmenta v celem oklu. Prerezi in velikosti okla se razlikujejo v distalnem, srednjem in proksimalnem delu. V Sloveniji je bilo največ delov anankusovih oklov najdenih v Šaleški kotlini. Okli anankusa so bili zelo dolgi in precej izravnani. Sicer pa je primerjava manjših ostankov okla z drugimi bolje ohranjenimi okli zelo težavna. Determinacija vrste z ostankom okla iz Kicarja je nezanesljiva, povsem zanesljiva bi bila, če bi našli določene dele ostalega anankusovega zobovja.

poorly bound conglomerate with sandstone particles that keep disintegrating into gravel and sand. The size of the piece measures 250 x 165 x 133 mm.

The second remain of the same tusk is presented in *plate 2:* 1. The size of the conglomerate and sandstone piece measures 165 x 126 x 80 mm. Preserved is a part of the tusk with a diameter of 124 mm. This is followed by the third – smaller – sandstone and conglomerate piece that measures 103 x 89 x 45 mm. On the aforementioned rock we can find a thin layer of dentine which is also a part of the largest piece. The dentine remain measures 90 x 60 x 3-5 mm (*Pl. 2*: 2). *Plate 2:* 3 depicts the fourth, even smaller, piece of the tusk that measures 95 x 87 mm, and which is attached to the conglomerate with a part of the primary dental surface. In essence we are dealing with modest remains of yellowish and extremely hygroscopic dentine. The dentine reveals a radial and concentric structure. The cross section of the tusk reveals a clearly visible 'Schreger structural pattern' (*Pl. 2*: 3), which is typical for Proboscidea (Ábelová 2008). The tusk reveals numerous dark inclusions in the radial and circular direction, most likely these are manganese solutions. Psilomelane dendrites are clearly visible in certain places, while in others one can even find individual pyrite crystals. Some parts of the tusk are limonitized; this is most noticeable on parts that are in contact with the conglomerate or the outer parts of the tusk. The pebbles within the conglomerate differ greatly as regards their size and shape. According to their composition they consist of quartz or metamorphic rocks, while the binding includes smaller quartz pebbles and other rocks as well as numerous mica flakes. The last piece (*Pl. 2*: 4) is a conglomerate piece measuring 143 x 105 x 107 mm. A thin outer layer of dentine measuring 120 x 78 x 5 mm is stuck to the conglomerate. The dentine layer has been torn from the largest part of the tusk.

COMPARISON

Gorjanović-Kramberger (1912, Pl. 1: Figs. 7, 7a) described a part of a tusk from the Late Pliocene layers at the site Bratovština near Petrinje in Croatia, which is according to the shape of its cross-section and size similar to our sample from Kicar. The cross-section of the Croatian specimen is somewhat smaller than ours, however this could be linked to the position of the fragment within the tusk. Cross-sections and tusk sizes differ in the distal, central and proximal part. In Slovenia most *Anancus* tusks were found in the Šaleška valley (Šaleška dolina). Their tusks were long and rather straight. It is extremely difficult to compare the smaller tusk remains with other better preserved tusks. It is hard to determine the species merely from the tusk remain from Kicar, however this process would be reliable in we also had some of the remaining *Anancus*' teeth at our disposal.

Ker se je velik del okla dobesedno razletel, so ostali le številni manjši in zelo majhni luskasti in iverasti fragmenti zobovine (*t. 3:* 2–3), ki jih ne moremo umestiti na ustrezno mesto oklovega ostanka. To zobovino bomo ohranili in uporabili za preostale mikroskopske in kemične raziskave.

SKLEPI

Klastične kamnine, v katerih je bil najden del okla v širši okolici Kicarja, točneje na njegovem jugozahodnem robu nasproti zaselka Žabjak, so pliocenske starosti (Žnidarčič, Mioč 1988; 1989). Po našem mnenju so slabo vezani konglomerati in peščenjaki iz starejšega villafranchija. Najdeni ostanek zoba je skromen in problematičen, najverjetneje pripada mastodontu vrste *Anancus arvernensis*. Ostanek okla je razpadel na večji del (*t. 1:* 1a–1b) in štiri manjše dele (*t. 2:* 1–4). Vsi predstavljeni deli so sestavni del istega dela okla. Veliko zobovine, ki je zelo higroskopična, je razpadlo na številne manjše delce in zelo majhne iveri in luske, ki jih ni mogoče znova zlepiti v celoto. V prečnem preseku je pri posameznih delih okla opaziti za proboscide značilen “Schregerjev strukturni vzorec” (*t. 3:* 1–3). Posamezni fragmenti okla so pritrjeni na prodnike oziroma na slabo vezan kremenovo-silikatni konglomerat, ponekod tudi na pesek in peščenjak.

Okel je bil najverjetneje prenesen z rečnim tokom in razlomljen, njegovi posamezni deli so se ohranili na določenih mestih skupaj z naplavljenimi in akumuliranimi prodniki in peščenimi delci. Dokler je bil fragment okla v sprijetem sedimentu, je ostal v enem delu, po izkopu in odvzemu iz profila je začel razpadati na večje, manjše in vse manjše delce.

Preostanek v prod in pesek povsem razpadle kamnine smo temeljito sprali in pregledali njihovo sestavo. Ugotovljeno je bilo, da je med debelejšo frakcijo (prodniki velikosti od 87 x 45 mm do 9 x 4 mm) manj kot polovica kremenovih prodnikov, prevladujejo pa silikatni prodniki, pretežno različnih metamorfnih kamnin. Prodniki so valjasti, ploščati in kroglasti. Prevladujejo ploščati, manj je valjastih in najmanj kroglastih prodnikov. V zelo drobni prodni in peščeni frakciji prevladujejo kremenova zrna, pogostna so tudi zrna drugih kamnin, pirita, luskice sljude in delci drugih mineralov. V vezivu klastitov je razmeroma veliko kalcijevega karbonata, saj je bila reakcija na ustrezno razredčeno in hladno klorovodikovo kislino burna oziroma zelo odzivna.

As a large part of the tusk has literally fallen to bits a number of smaller and very small flakes and splinter like teeth fragments remain (*Pl. 3*: 2-3), and these cannot be placed back into their position within the tusk remain. However, this dentine will be preserved and used for microscopic and chemical research.

CONCLUSIONS

The clastic rocks, in which a part of the tusk from the broader vicinity of Kicar (or to be more exact from its south-western edge opposite the hamlet of Žabjak) was found, belong to the Pliocene period (Žnidarčič, Mioč 1988; 1989). In our opinion the poorly bound conglomerates and sandstones belong to the older Villafranchian period. The discovered tooth remain is modest and problematic, and most likely belongs to a mastodon of the species *Anancus arvernensis*. The tusk remain disintegrated into one large (*Pl. 1:* 1a-1b) and four smaller parts (*Pl. 2:* 1-4). All of the presented pieces are a part of the same tusk. A large portion of the highly hygroscopic dentine has disintegrated into a number of smaller parts and very small splinters and flakes that can no longer be glued back into a whole. In the cross-section individual pieces reveal the ‘Schreger structural pattern’ that is characteristic of Proboscidae (*Pl. 3:* 1-3). Individual tusk fragments are attached to pebbles or to the poorly bound quartz-silicate conglomerate, in some places also on sand or sandstone.

The tusk was most likely transported by the river and it was during this journey that we assume it was broken into smaller parts. In certain places the individual tusk parts remained together and stuck onto accumulated pebbles and sand particles. As long as the tusk fragment remained within the sediment it was preserved in a single piece, however once it was dug out it began to disintegrate into large, small and minute parts.

The remnants of the rock that disintegrated into gravel and sand was thoroughly washed and its composition was studied. It was ascertained that the thicker fraction (pebbles measuring between 87 x 45 mm and 9 x 4 mm) consisted of less than 50 % of quartz pebbles, and that the majority was represented by silicate pebbles, mainly from various metamorphic rocks. The pebbles are cylindrical, flat or round in shape. Most of them are flat, slightly poorer represented are cylindrical pebbles and the round ones are the rarest. Quartz granules prevail in the minute pebble and sand fraction, however rock granules, pyrite, mica flakes and parts of other minerals are also common. The clastic rocks binding includes a relatively high share of calcium carbonate, for the reaction onto the appropriate diluted and cold Hydrochloric acid is turbulent i.e. highly reactive.

Zahvale

Najditelju okla gospodu Francu Golobu s Ptuja se iskreno zahvaljujemo za darovane najdbe in za koristne podatke o najdišču. Kustosinji Prirodoslovnega muzeja Slovenije, geologinji Katarini Krivec se zahvaljujemo za posredovanje najdbe v določitev, za tehnično in fotografsko pomoč pa sodelavcu Marijanu Grmu.

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Translation: Sunčan Patrick Stone

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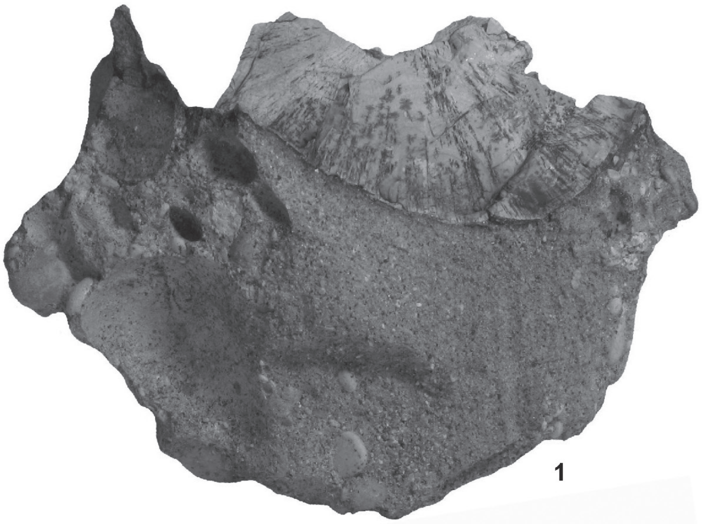
1a

1b

T. 1: **1a** – največji ostanek okla vrste *Anancus arvernensis* (Croizet et Jobert, 1828) v zgornjepliocenskem (spodnjevillafranchijskem) konglomeratu iz južnozahodnega dela Kicarja oziroma z območja med Kicarjem na severu in Podvinci na jugu; najditelj Franc Golob s Ptuja, velikost 200 x 122 x 119 mm; **1b** – isti primerek v prečnem preseku z radialno in koncentrično strukturo. Premera okla 122 x 119 mm, obseg meri ~400 mm. (Foto: Marijan Grm.)

Pl. 1: **1a** – The largest tusk remain of *Anancus arvernensis* (Croizet et Jobert, 1828) in the Late Pliocene (Early Villafranchian) conglomerate from southwest part of Kicar, i.e. from the area between Kicar in the north and Podvinci in the south; finder Franc Golob from Ptuj, size 200 x 122 x 119 mm; **1b** – Cross section of the same specimen, with radial and concentric structure. Diameters 122 x 119 mm, circumference of the tusk ~400 mm. (Photo: Marijan Grm.)


1

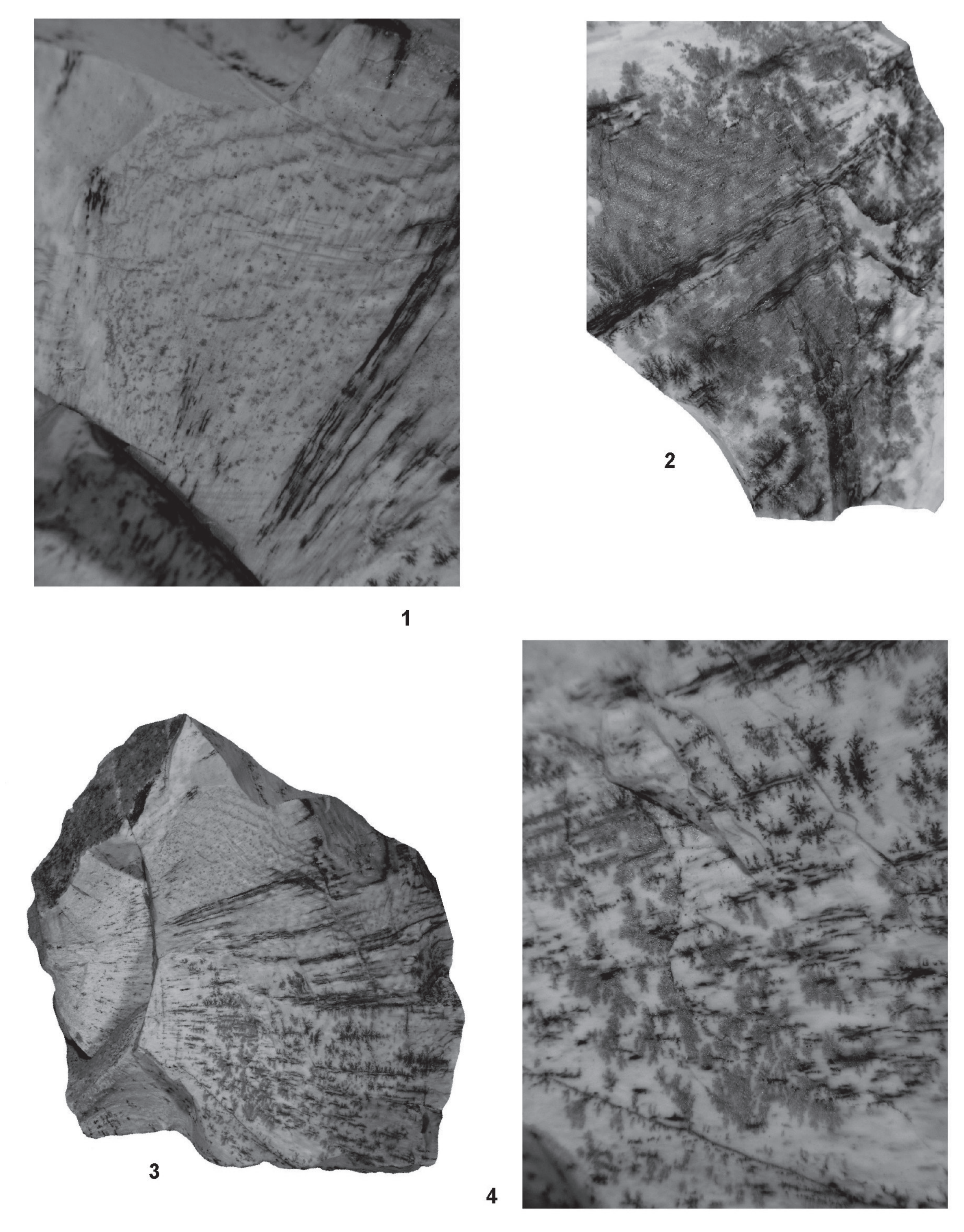

2


3


4

T .2: **1** – Prečni presek okla vrste *Anancus arvernensis* (Croizet et Jobert, 1828) v peščenjaku in konglomeratu, Kicar, velikost kosa 165 x 126 x 80 mm; **2** – del oklove površine v debelozrnatem peščenjaku in konglomeratu, Kicar, velikost kosa 103 x 89 x 45 mm; **3** – del istega okla v konglomeratu, velikost zobovine 95 x 87 mm; **4** – del istega okla v konglomeratu, velikost kosa 143 x 105 x 107 mm. (Foto: Marijan Grm.)

Pl. 2: **1** – Cross section of tusk *Anancus arvernensis* (Croizet et Jobert, 1828) in the sandstone and conglomerate, Kicar, size of sample 165 x 126 x 80 mm; **2** – part of tusk area in coarse-grained sandstone and conglomerate, Kicar, size of sample 103 x 89 x 45 mm; **3** – part of the same tusk in conglomerate, size of dentine 95 x 87 mm; **4** – part of the same tusk in conglomerate, size of sample 143 x 105 x 107 mm. (Photo: Marijan Grm.)



T. 3: **1** – “Schregerjev strukturni vzorec” na zobovini trobčarja vrste *Anancus arvernensis* (Croizet et Jobert, 1828), Kicar, velikost detajla 25 x 23 mm z vzorca [**3**]; **2** – manjši kos zobovine s “Schregerjevim strukturnim vzorcem”, velikost kosa 30 x 23 mm; **3** – večji kos zobovine s “Schregerjevim strukturnim vzorcem” in radialno-koncentričnimi psilomelanovimi dendriti, velikost kosa 61 x 55 x 22 mm; **4** – detajl psilomelanovih dendritov z vzorca [**3**], velikost detajla 18 x 14 mm. (Foto: Marijan Grm.)
Pl. 3: **1** – “Schreger structural pattern” on the proboscidean dentine of *Anancus arvernensis* (Croizet et Jobert, 1828), Kicar, detail size 25 x 23 mm from sample[**3**]; **2** – smaller piece of dentine with “Schreger structural pattern”, size of piece 30 x 23 mm; **3** – larger piece of dentine with “Schreger structural pattern” and radial-concentrically dendritic psilomelane, size of sample 61 x 55 x 22 mm; **4** – detail of dendritic psilomelane from sample [**3**], size of detail 18 x 14 mm. (Photo: Marijan Grm.)

FOSSIL AND SUBFOSSIL REMAINS OF *Capra ibex,* L. FROM SALZOFENHÖHLE (UPPER AUSTRIA) AND THE EASTERN ALPINE REGION

FOSILNI IN SUBFOSILNI OSTANKI VRSTE *Capra ibex,* L. IZ NAJDIŠČA SALZOFENHÖHLE (ZGORNJA AVSTRIJA) IN Z VZHODNOALPSKEGA PROSTORA

Martina PACHER

Abstract

Fossil and subrecent *Capra ibex* is proved in many Austrian and Eastern Alpine caves but usually only few specimens were recovered. Salzofenhöhle (2005 m a.s.l.) provided a larger assemblage of ibex remains which was excavated between 1924 and 1964. The material containing 221 specimens is presented in detail for the first time and compared to ibex remains from the Drachenhöhle near Mixnitz, Styria and the Upper Palaeolithic loess site of Willendorf, Lower Austria. Since the volume is dedicated to one of the leading scientists for the Palaeolithic research in Slovenia, Ivan Turk, remains of ibex from sites in Slovenia are included. *Capra ibex* is mentioned here for the first time from Potočka zijalka.

At Salzofenhöhle, carnivore activity is detected on the ibex remains whereas there is no proven evidence of human hunting. Three horn cores bear modern hacking marks and fire traces which suggest an actual input of these remains. In the absence of direct radiocarbon dates, the chronological position of the finds stays unclear. Morphometrical comparison speaks in favour of the assemblage from Salzofenhöhle consisting mainly of females and younger individuals. The comparison of values shows that the fossil specimens lie at the upper range of size distribution of modern ibex in both, males and females. More detailed studies are needed to detect the degree of size differences between the sexes but also between modern and fossil ibex populations. More direct radiocarbon dates are needed to assess the chronological distribution and the role of ungulates at high Alpine cave sites.

Keywords: *Capra ibex*, Salzofenhöhle, Willendorf, Eastern Alpine region, metrical analysis

Izvleček

Fosilni in subrecentni ostanki vrste *Capra ibex* so znani iz več avstrijskih in vzhodnoalpskih jam, vendar je število najdenih kosti in zob običajno pičlo. Salzofenhöhle (2005 m n. m.) ponuja drugačno sliko, saj je bilo v tej jami med letoma 1924 in 1964 izkopanih 221 kozorogovih ostankov. Gre za razmeroma obsežen vzorec, ki je prvič detajlneje predstavljen na tem mestu. Osrednji del predstavitve je namenjen metrični analizi, kjer so kot primerjalni material služili kozorogi iz jame Drachen pri Mixnitzu (Drachenhöhle), z avstrijske Štajerske ter iz mlajšepleistocenskega najdišča Willendorf v Spodnji Avstriji. Ker je zbornik posvečen Ivanu Turku, enemu vodilnih raziskovalcev paleolitskega obdobja v Sloveniji, so v prispevku obravnavane tudi kozorogove najdbe s Slovenskega, z na tem mestu prvič omenjenim ostankom iz Potočke zijalke vred. Na gradivu iz jame Salzofen so opazne sledi zverske aktivnosti, medtem ko na dokaze o človekovem lovu izkopavalci niso naleteli. Trije primerki rožnice so delno ožgani, kažejo pa tudi sledi novodobnih urezov, zato gre najbrž za alohtone najdbe. Žal neposrednih radiokarbonskih datacij ni na razpolago, tako da ostaja natančnejša kronološka opredelitev najdb nejasna. Iz rezultatov morfometrične študije izhaja, da obsega gradivo iz jame Salzofen predvsem ostanke samic in mlajših živali. Pri tem je že osnovna primerjava velikosti pokazala, da se pleistocenski primerki pri obeh spolih umeščajo na sam zgornji rob razpona vrednosti za recentne kozoroge. Za detajlnejše preučevanje razlik v velikosti med samci in samicami oz. med populacijami iz različnih geoloških obdobij bi potrebovali bolj poglobljen analitičen pristop. Prav tako bi bilo treba za popolnejše razumevanje kronološke razporeditve in vloge kopitarjev v alpskih visokogorskih jamskih najdiščih nujno pridobiti dodatne radiokarbonske datacije.

Ključne besede: *Capra ibex*, Salzofenhöhle, Willendorf, vzhodnoalpski prostor, metrična analiza

INTRODUCTION

Capra ibex is one of the symbols of the modern Alpine wild life. Nearly driven to the edge of extinction, in Austria latest 1710 (Bauer, Spitzenberger 2001), its number recovered considerably since the re-introduction of colonies starting in Switzerland 1911, and Austria 1924 (Bauer, Spitzenberger 2001) thanks to protection, breeding, and further re-introduction of animals in various parts of the Alps.

The Late Pleistocene cave site of Salzofenhöhle in Upper Austria provided a 221 specimen assemblage of fossil and subfossil ibex remains. The cave, known as a high Alpine cave bear den (Döppes *et al*. 1997; Döppes 2001) lies at 2005 m above sea level in the mountain range of the Totes Gebirge in Upper Austria (*Fig. 1*).

The first fossils were found in 1924 and led to continuing excavations by the local school inspector Otto Körber until 1944. Kurt Ehrenberg from the University of Vienna started systematic excavations in 1939 which lasted until 1964, with an interruption from 1954 until 1955. The 3,588 m long cave system consists of large chambers, corridors, fissures and shafts at several levels (Pfarr, Stummer 1988). The sediments provided a rich

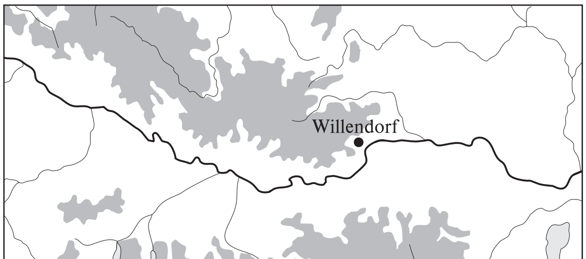


Fig. 1: Ibex sites included in the study.
Sl. 1: V prispevku omenjena najdišča s kozorogovimi ostanki.

UVOD

Kozorog velja za enega od simbolov današnje alpske favne. V začetku 18. stoletja je bila vrsta na robu izumrtja (zadnji podatek za Avstrijo iz tistega obdobja je iz leta 1710; Bauer, Spitzenberger 2001), s ponovnima naselitvama v Švici leta 1911 ter v Avstriji leta 1924 (Bauer, Spitzenberger 2001) pa se je stanje začelo postopoma izboljševati. K temu so prispevali tudi odločitev o zavarovanju vrste, aktivna politika vzreje ter več novih poskusov ponovne naselitve v različne dele Alp.

Na mlajšepleistocenskem jamskem najdišču Salzofenhöhle v Zgornji Avstriji je bilo najdenih 221 ostankov vrste *Capra ibex*. Jama, ki je sicer znana kot visokogorski brlog jamskega medveda (Döppes *et al.* 1997; Döppes 2001), se odpira na gorskem grebenu Totes Gebirge na nadmorski višini 2.005 m (*sl. 1*). Prve fosilne najdbe so bile odkrite leta 1924 in so botrovale odločitvi lokalnega šolskega inšpektorja Otta Körberja k nepretrganemu terenskemu raziskovanju najdišča vse do leta 1944. Leta 1939 je Kurt Ehrenberg z dunajske univerze zastavil še sistematična izkopavanja, ki so s prekinitvijo v letih 1954–55 potekala do leta 1964.

Razvit, 3.588 m dolg jamski sistem sestavljajo velike dvorane, rovi, razpoke in brezna na več ravneh (Pfarr, Stummer 1988). V obsežnem favnističnem gradivu, ki sicer obsega tudi najdbe mehkužcev in malih sesalcev, močno prevladujejo ostanki jamskega medveda in drugih zveri (npr. volka, lisice, kune zlatice, rjavega medveda, jamskega leva, rosomaha). Ker celoten korpus najdb še nikoli ni bil natančneje obdelan, je na seznam v jami zastopanih rastlinojedov za zdaj mogoče vključiti zgolj srno, gamsa in kozoroga. Gradivo je najbrž kronološko heterogeno; neposredne radiokarbonske datacije so razpoložljive zgolj za ostanke jamskega medveda (> 49.100 pred sedanjostjo (= p. s.); Döppes 2003) in rosomaha (neobjavljeni podatki). V nadaljevanju so podrobneje predstavljeni ostanki kozoroga.

GRADIVO

Kozorogovi ostanki iz jame Salzofen so bili deloma pobrani, deloma izkopani na več različnih mestih, a žal brez beleženja natančnejših stratigrafskih podatkov. Danes je tako nemogoče rekonstruirati mesto najdbe vsake posamezne kosti oz. zoba, čeprav je nekaj takšnih mest v jami vendarle znanih. Tako Ehrenberg (1949) poroča, da je Körber na lokaciji t. i. brezna žrtev ("Opferschacht") odkril ostanke najmanj dveh odraslih in ene mlade živali. O najdbi več kot enega kozoroga poročajo z območja vhodne dvorane (Vorraum), nadaljnjih sedem kosti pa je bilo pobranih/izkopanih tudi v rovu Rundzug, povezanem z njo. Po Ehrenbergu (1964) je šest najdb ležalo na območju med vhodno dvorano in rovom Rundzug, posamezni ostanki pa izvirajo tudi z lokacij faunal assemblage, including micro fauna and molluscs, dominated by cave bear and various carnivores, like wolf, red fox, pine marten, brown bear, cave lion, and wolverine. Among herbivores, roe deer, deer, chamois and ibex are proved but a detailed faunal analysis is missing, so far. The material is probably chronologically heterogeneous and direct dates are available for cave bear (> 49,100 BP; Döppes 2003) and wolverine (unpublished data). The sample from ibex is presented in the following study.

MATERIAL

Ibex remains were partly collected, partly excavated at several places within the cave. No details about its stratigraphy are known. It is not possible to reconstruct the origin of each single element but several localities can be detected from the literature. From the "Opferschacht" (shaft of victims) a steep debris slope with bone remains, Körber recovered at least two adult and one juvenile individual (Ehrenberg 1949). Within the Vorraum (entrance hall) remains of more than one animal were found. The following corridor called Rundzug provided seven ibex bones (Ehrenberg 1965). An additional six bones are listed from an area between the entrance hall (Vorraum) and the corridor (Rundzug) after Ehrenberg (1964). The Vp110 locality provided additional remains (Ehrenberg 1965). Several bones came from areas called "Schrammelgang", "Graf Kesselstattdom", and "Löwenschacht" (lion's shaft), and a further small number of specimens were recovered in 1963 in a passage towards the "Opferschacht".

The analyzed material consists of 221 remains housed at the Kammerhofmuseum in Bad Aussee, Styria (*Tab. 1*). A minimum number of three juvenile and nine adult individuals is presented.

The ibex material from Salzofenhöhle seems to be heterogeneous in terms of its phylogenetic level. Mottl (1950, 34) referred them to a small form of ibex without exception, contrary to Ehrenberg (1956), who mentioned also larger remains of a so-called *Ibex priscus*-type. In the actual study, in order to compare the size range of the ibex assemblage from the Salzofenhöhle, the material from Drachenhöhle near Mixnitz (Sickenberg 1931) and the Palaeolithic open air site of Willendorf (Thenius 1959, 156) is included.

The ibex remains from Willendorf come from the Willendorf I, I/N, and II localities and comprise approx.

Vp110, "Schrammelgang", "Graf Kesselstattdom" ter t. i. levjega brezna ("Löwenschacht"; Ehrenberg 1965). Manjše število najdb je bilo leta 1963 pobranih tudi na enem od dostopov k t. i. breznu žrtev ("Opferschacht").

Skupno je bilo v jami Salzofen najdenih 221 kozorogovih ostankov, ki jih hrani Kammerhofmuseum v Bad Ausseeju na avstrijskem Štajerskem (*tab. 1*). Najmanjše število živali (MNI; *Minimum Number of Individuals*) za mlade živali je tri, za odrasle pa devet.

Najdbe vrste *C. ibex* iz jame Salzofen se zdijo filogenetsko heterogene. Mottl (1950, 34) jih je sicer vse pripisal isti majhni obliki kozoroga, vendar pa Ehrenberg (1956) omenja tudi večje primerke t. i. tipa *Ibex priscus*. V okviru metrične analize, ki se ji posvečamo v nadaljevanju, je bilo primerjalno upoštevano tudi gradivo iz najdišč Drachenhöhle pri Mixnitzu (Sickenberger 1931) ter Willendorf (Thenius 1959, 156).

Kozorogovi ostanki iz Willendorfa izvirajo z lokacij Willendorf I, I/N ter II in obsegajo pribl. 270 kosti in zob. Najbolj znana lokacija je Willendorf II z devetimi kulturnimi horizonti, obsegajočimi najdbe orinasjenske in gravetjenske kulture, ter s serijo radiokarbonskih datacij v razponu od 41.700 p. s. do 23.180 p. s. (Nigst *et al.* 2008). Kozorogi iz Willendorfa po velikosti praviloma presegajo recentne primerke, zato so bili opisani kot *Capra ibex prisca*, Woldřich (Thenius 1959, 156).

Tab. 1: Ibex remains from Salzofenhöhle at the Kammerhofmuseum (Bad Aussee) according to body side and age. Abbreviations: ad. – adult; juv. – juvenile.
Tab. 1: Kozorogovi ostanki iz jame Salzofen, ki jih hrani Kammerhofmuseum (Bad Ausee), po anatomski orientiranosti in starosti. Kratici: ad. – odrasel; juv. – mlad.

Element	**sin (ad. / juv.)**	**dex (ad. / juv.)**	**indet (ad. / juv.)**	**Total / skupaj**
Cranium+horn			12 / 4	16
Mandibula	3 / -	3 / 3		9
Costae			16 / 3	19
Sternum			1 / -	1
Cerv. vertebrae			11 / 2	13
Thor. vertebrae			10 / 13	23
Lum. vertebrae			11 / 7	18
Vertebrae			4 / -	4
Sacrum			3 / -	3
Scapula	4 / -	4 / -	- / 1	9
Humerus	5 / 2	3 / -	- / 2	12
Radius/ulna	3 / 2	8 / -		13
Metacarpalia	1 / 2			3
Carpalia		3		3
Pelvis	7 / 1	4 / -		12
Femur	5 / 1	9 / 1		16
Tibia	3 / 3	5 / 2		13
Os maleolare		1		1
Patella		1		1
Metatarsalia	5 / -	4 / -		9
Astragalus	1	1		2
Calcaneus	2	1		5
Tarsalia	1			1
Metapodia			1	1
Phalanx 1		2 / -		2
Phalanx 2	4 / -	4 / -		8
Phalanx 3			4 / -	4

270 bones. The most famous site is locality II with nine cultural horizons of Aurignacian and Gravettian provenience and a series of radiocarbon dates ranging from 41,700 BP up to 23,180 BP. (Nigst *et al.* 2008). The ibex individuals from Willendorf are on average larger than modern Alpine ibex and therefore described as *Capra ibex prisca*, Woldřich (Thenius 1959, 156).

The ibex assemblage from Drachenhöhle near Mixnitz consists of 64 remains, among them 44 bones of one single juvenile individual (Sickenberg 1931). The material is ascribed to *Capra ibex alpinus*. Most of the fauna remains from Drachenhöhle were collected during phosphate mining. Therefore only rough information about the stratigraphy of finds is known. One radiocarbon date from charcoal gave an age of 25,040 BP (Fladerer 1997) and one cave bear tooth resulted at 39,420 BP (Pacher, Stuart 2009). The ibex remains are either unstratified remains or came from the upper layers (Fladerer 1997).

In Slovenia, nine cave sites and one fluviatile gravel pit yielded ibex remains (*Tab. 2*). So far, one metatarsal from Potočka zijalka, Slovenia, is the only evidence of ibex at this site. *Capra ibex* was not mentioned in the first monograph by Brodar, S. & M. (1983) and no specimen was found during the new excavations (Pacher *et al.* 2004), but the metatarsal, housed in the Geological Institute in Ljubljana, is clearly labelled with Potočka zijalka.

Mokriška jama, only 17 km air distance away from Potočka zijalka, yielded three remains of *Capra ibex*. A humerus, a cervical vertebra and a juvenile maxilla fragment come from cultural layer 7 within the entrance part (Brodar 1960). One distal and one middle phalanx of the anterior extremities came from layer 2 of Jama pod Herkovimi pečmi (Pohar 1981). Črni kal yielded one second upper molar and one third upper molar from stratum 8, attributed to the Late Pleistocene (Rakovec 1958). The Late Glacial assemblage from Poljšiška cerkev contains a second lower molar, a third upper molar, and one astragalus (Pohar 1991). Only one posterior distal phalanx is proven from the Late Glacial horizon

Kozorogovih ostankov iz jame Drachen pri Mixnitzu je 64, od tega jih 44 pripada isti mladi živali (Sickenberg 1931). Najdbe so bile pripisane podvrsti *Capra ibex alpinus*. Večina ostankov je bila pobranih med kopanjem fosfatov, zato so stratigrafski podatki znani le v grobem. Radiokarbonsko datiranje vzorca oglja je pokazalo na starost 25.040 p. s. (Fladerer 1997), zoba jamskega medveda pa na 39.420 p. s. (Pacher, Stuart 2009). Najdbe kozoroga so bodisi nestratificirane bodisi izvirajo iz zgornjih plasti (Fladerer 1997).

Na Slovenskem so ostanki vrste *C. ibex* znani iz devetih jamskih najdišč in ene prodne jame (*tab. 2*). Primerek stopalnice iz Potočke zijalke je za sedaj edina znana najdba te vrste z navedenega najdišča. Kozorog namreč ni omenjen niti v monografijai iz leta 1983 (Brodar, S. in M. 1983) niti niso bili njegovi ostanki najdeni med novejšimi izkopavanji (Pacher *et al.* 2004). Povezava zgoraj omenjene stopalnice v hrambi ljubljanskega Geološkega inštituta z navedenim najdiščem je kljub temu zanesljiva, saj je na kosti lepo razviden napis Potočka zijalka.

V Mokriški jami, ki leži zgolj 17 km zračne razdalje od Potočke zijalke, so bili najdeni trije ostanki vrste *C. ibex*: nadlahtnica, vratno vretence in odlomek zgornje čeljustnice mlade živali. Vsi trije izvirajo iz vhodnega dela jame in so ležali v kulturni plasti 7 (Brodar 1960). V plasti 2 jame pod Herkovimi pečmi sta bili najdeni po ena druga in tretja prstnica prednjih nog (Pohar 1981), v mlajšepleistocenski plasti 8 na Črnem kalu pa drugi in tretji zgornji meljak (Rakovec 1958). V prav tako mlajšepleistocenskem gradivu iz Poljšiške cerkve so drugi spodnji in tretji zgornji meljak ter skočnica (Pohar 1991), medtem ko sta bila v prodni jami pri Trbonjah ter v jami nad Rašico najdena odlomka lobanje (Pohar 1993). Iz poznoglacialnega horizonta Lukenjske jame izvira tretja prstnica zadnjih nog (Pohar 1983). Nekoliko več kozorogovih ostankov je bilo najdenih v Divjih babah I, in sicer devet. Primerek drugega spodnjega meljaka izvira iz plasti 6, po en tretji spodnji meljak in spodnji podočnik, ena prva ter dve drugi prstnici, stegnenica mlade živali

Tab. 2: Ibex remains from cave sites and the gravel pit at Trbonje in Slovenia.
Tab. 2: Kozorogovi ostanki iz slovenakih jamskih najdišč ter iz prodne jame pri Trbonjah.

Site / najdišče	**NISP**	**MNI**	**Chronology of the site / kronologija najdišča**	**Reference / viri**
Divje babe I	9	1	layer 2-5, layer 6, Late Pleistocene / plasti 2–5, pozni pleistocen	Toškan 2007
Herkove peči	2	1	layer 2, Pleistocene / plast 2, pleistocen	Pohar 1981
Črni kal	2	1	stratum 8, Late Pleistocene / plast 8, pozni glacial	Rakovec 1958
Poljšiška cerkev	3	1	Late Glacial, Epigravettian / pozni glacial, epigravetjen	Pohar 1991
Lukenjska jama	1	1	Late Glacial, Epigravettian (12,580 BP) / pozni glacial, epigravetjen (12.500 p. s.)	Pohar 1983
Mokriška jama	3	1	layer 7 / plast 7	Brodar 1960
Potočka zijalka	1	1	Late Pleistocene (26,840-35,720 BP) / pozni pleistocen (26.840-35.720 p. s.)	Pacher *et al.* 2004
Jama treh bratov	11	3	Late Pleistocene / pozni pleistocen	Rakovec 1940
Trbonje	1	1	Late Pleistocene / pozni pleistocen	Pohar 1993
Jama nad Rašico	1	1	Late Pleistocene / pozni pleistocen	Pohar 1993

Tab. 3: Measurements of horn cores from *Capra ibex* (in mm). Abbreviations: oroab – oroaboral breadth; lat-med – lateral-medial breadth; diam – greatest diameter at the base; NHMW – Natural History Museum Vienna.
Tab. 3: Velikost rožnic pri vrsti *Capra ibex* (v mm). Kratice: oroab – oroaboralna širina; lat-med – lateralno-medialna širina; diam – največji obseg baze; NHMW – Prirodoslovni muzej Dunaj.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**oroab**	**lat-med**	**diam**
Salzofen	114/3 subadult?	32.9	26.2	
	115/3 subadult?	34.6	29.0	96
	115/2 subadult?	34.3	29.6	93
	115/1 subadult?	28.3	25.2	95
	117	45.2	27.7	
	1661	51.8	36.7	140
	1661	48.2	33.0	126
Willendorf	Wi-II-8	79.0	65.8	235
	Wi-II-5	84.5		
	Wi-II-5	39.7	31.6	120
	Wi-V	75.5	59.0	233
Modern male	NHMW 2550	69.7	60.7	
Modern female	NHMW 13529	35.9	29.8	
Jama treh bratov[1]	dex	84.0	71.5	253
Jama treh bratov[1]	dex	87.8	65.0	245
Jama treh bratov[2]		44.6	33.5	122
Trbonje[1]	dex	76.5	64.0	236

[1] after / po Pohar (1993), [2] after / po Rakovec (1940)

at Lukenjska jama (Pohar 1983). Both the gravel pit at Trbonje and Jama nad Rašico provided one skull fragment each (Pohar 1993). Divje babe I provided nine ibex remains. One second lower molar comes from layer 6, while one lower third molar, one lower canine, two middle phalanges, one proximal phalanx, one femora of a juvenile individual, and two tibia fragments – one from a subadult individual – are from layers 2-5 (Toškan 2007). Remains of at least three individuals come from Jama treh bratov (Rakovec 1940; Pohar 1993).

METRICAL ANALYSIS

Measurements were taken according to von den Driesch (1976). Comparison of size ranges was possible for several skeletal elements while – for others – only measurements are given.

A comparison of the size of horn cores at its base results in two groups (*Fig. 2*). The sample from the Salzofenhöhle and one specimen from Willendorf fall

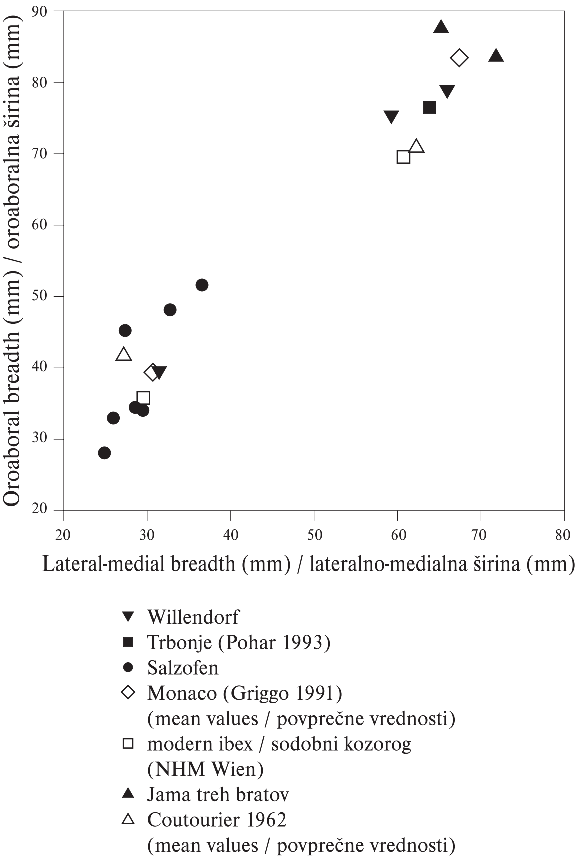


Fig. 2: Oroaboral and lateral-medial breadth of horn cores from *Capra ibex* (in mm). Data after Grigo (1991), Coutourier (1962), Pohar (1993), and own data.
Sl. 2: Oroaboralna in lateralno-medialna širina rožnic pri vrsti *Capra ibex* (v mm). Vir podatkov: Grigo (1991); Coutourier (1962); Pohar (1993) ter lastni podatki.

in dva odlomka golenice – od tega eden od subadultnega kozoroga – pa so bili pobrani iz sklopa plasti 2–5 (Toškan 2007). O ostankih vsaj treh živali poročajo tudi iz Jame treh bratov (Rakovec 1940; Pohar 1993).

METRIČNA ANALIZA

Metrični podatki so bili zbrani v skladu s smernicami, ki jih podaja von den Driescheva (1976). Pri številčno bolje zastopanih skeletnih elementih mednajdiščne primerjave temeljijo na vzporejanju variacijskih širin za posamezne dimenzije, drugod smo bili prisiljeni primerjati zgolj posamezne metrične podatke.

Rožnice je mogoče po velikosti bazalnega dela razvrstiti v dve skupini (*sl. 2*). Prva obsega razmeroma majhne primerke rožnic iz jame Salzofen ter eno od treh iz Willendorfa, medtem ko sta preostali dve rožnici bistveno večji. Največji od tukaj obravnavanih rožnic sta pripadali samcema iz Jame treh bratov, pri čemer povprečje recentnih kozorogov presega tudi samcu within the smaller size group, whereas two individuals from Willendorf are considerably larger. The two males from Jama treh bratov are the largest specimens, and the male from Trbonje lies also above the modern male sample (*Fig. 2*). In females, the fossil sample lies slightly above the modern ibex horn core measurements. The four smallest specimens from Salzofenhöhle could be from subadult individuals, as indicated by the small diameter of the horn cores at its base (*Tab. 3*).

The large material of fossil ibex from Monaco after Griggo (1991) and the modern dataset given by Coutourier (1962) document the considerable sexual dimorphism in size. The mean values are included in *figure 2*. Mean values (x), size range and number of specimen (n) are given below:

<u>Oroaboral breadth:</u>
Monaco male (n = 31; 59.2-92.5 mm; x = 83.5 mm), female (n = 44; 25.5-48.5 mm; x = 39.6 mm)
Modern male (n = 85; 58.9-88.0 mm; x = 71.0 mm), female (n = 45; 30.0-43.0 mm; x = 42.0 mm)

<u>Lateral-medial breadth:</u>
Monaco male (n = 31; 49.2-76.4 mm; x = 67.3 mm), female (n = 45; 21.4-38.7 mm; x = 31.5 mm)
Modern male (n = 85; 51.0-74.0 mm; x = 62.2 mm), female (n = 45; 24.0-31.0 mm; x = 27.5 mm)

The comparison shows that horn cores of modern *Capra ibex* lie at the lower end of the size range of fossil specimens. Considerably large values are obtained by single fossil individuals. This fact results in higher mean values in males and females as shown by the comparison of the fossil material from Monaco (Griggo 1991) and the modern sample from Coutourier (1962).

Mandibles are preserved only as fragments. The few measurements are listed in *table 4*. The premolar length

pripisan primerek iz Trbonj (*sl. 2*). Večje dimenzije pleistocenskih primerkov nasproti recentnim so bile ugotovljene tudi pri samicah. Majhen obseg baze štirih najdb iz jame Salzofen bi lahko kazal na to, da gre za ostanke subadultnih živali (*tab. 3*).

Bogato gradivo fosilnih kozorogov iz Monaka (Griggo 1991) – enako pa izhaja tudi iz podatkov za recentne primerke (Coutourier 1962) – kaže na obstoj očitnega spolnega dimorfozma v velikosti teh živali. Povprečne vrednosti (x) so prikazane na *sliki 2*, skupaj s podatki o variacijski širini in velikosti vzorca (n) pa so podane tudi spodaj:

<u>Oroaboralna širina:</u>
Monako: samci (n = 31; 59,2–92,5 mm; x = 83,5 mm); samice (n = 44; 25,5–48,5 mm; x = 39,6 mm)
Recentni primerki: samci (n = 85; 58,9–88,0 mm; x = 71,0 mm); samice (n = 45; 30,0–43,0 mm; x = 42,0 mm)

<u>Lateralno-medialna širina:</u>
Monako: samci (n = 31; 49,2–76,4 mm; x = 67,3 mm); samice (n = 45; 21,4–38,7 mm; x = 31,5 mm)
Recentni primerki: samci (n = 85; 51,0–74.0 mm; x = 62,2 mm); samice (n = 45; 24,0–31,0 mm; x = 27,5 mm)

Iz predstavljene primerjave izhaja, da se rožnice recentnih kozorogov umeščajo na spodnji rob razpona vrednosti fosilnih živali, pri čemer posamezni pleistocenski primerki izstopajo po svojih očitno večjih dimenzijah. Slednje botruje višjim povprečnim vrednostim za samce in samice pleistocenske starosti, kar nazorno kaže tudi primerjava med fosilnim gradivom iz Monaka (Griggo 1991) in vzorcem recentnih živali, ki ga je analiziral Coutourier (1962).

Spodnje čeljustnice so ohranjene zgolj fragmentarno. Peščica razpoložljivih metričnih podatkov je podana v *tabeli 4*. Dolžina niza predmeljakov kozorogov

Tab. 4: Measurements of mandibles from *Capra ibex* (in mm). Abbreviations: tl – length of the cheekteeth row; ml – length of the molar teeth row; pl – length of premolar teeth row; p2-c – length of the diastema; hm1 – height of mandible mesial of m1; hp2 – height of mandible mesial of p2.

Tab. 4: Velikost spodnjih čeljustnic pri vrsti *Capra ibex* (v mm). Kratice: tl – dolžina niza predmeljakov in meljakov; ml – dolžina niza meljakov; pl – dolžina niza predmeljakov; p2c – dolžina diasteme; hm1 – višina spodnje čeljustnice mezialno od m1; hp2 – višina spodnje čeljustnice mezialno od p2.

Site / najdišče	**Inv. no. or locality / inv. št. oz. lokaliteta**	**tl**	**ml**	**pl**	**p2-c**	**hm1**	**hp2**
Salzofenhöhle	1657			19.1		27. 1	20.7
	1657-123/1		50.3	23.3			
	1658			25.5	44.6	26.1	17.7
	1658	76.0	52.4	23.6	51.4	25.8	20.3
Willendorf	Wi-II-9			37.3			
	Wi-II-9			24.4			
	Wi-I-N			27.0			
	Wi-I-N			22.7			

Tab. 5: Measurements of scapulae from *Capra ibex* (in mm). Abbreviations: slc – smallest length of the collum; glp – greatest length of processus articularis; la – length of articulation facet; ba – breadth of articulation facet.
Tab. 5: Velikost lopatic pri vrsti *Capra ibex* (v mm). Kratice: slc – najmanjša dolžina vratu (*collum scapulae*); glp – največja dolžina sklepnega odrastka (*processus artucularis*); la – dolžina sklepne ponvice; ba – širina sklepne ponvice.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**slc**	**glp**	**lg**	**bg**
Salzofenhöhle	1645 dex	22.2	39.0	32.0	25.3
	1645 sin	25.9	41.7	34.6	28.0
	1637 sin	26.5	41.2	34.5	28.5
	1637 dex	26.5	40.9	33.5	28.3
	1637 sin	25.4			27.7
	1664	24.6	38.6	28.7	26.4
	1625-2	25.8	40.4	31.1	28.1
	1625-2	25.7	40.0	30.9	27.3
Willendorf	Wi-II-5	24.6	39.2	35.4	25.9
	Wi-II-5	23.2			
	Wi-II-5	27.3			
	Wi-II-8	30.0			

of ibex from Willendorf is partly larger than and partly of similar length to those from Salzofenhöhle.

Several scapulae are preserved at Salzofenhöhle (*Tab. 5*). The scapulae are partly of similar size to those

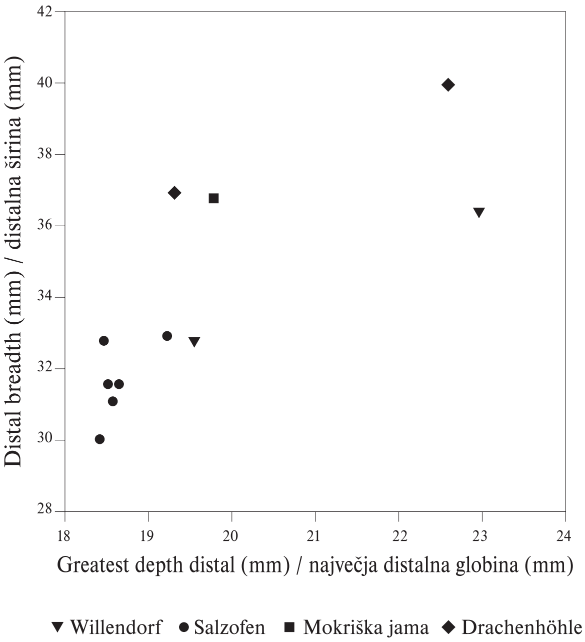


Fig. 3: Distal breadth and breadth of the trochlea of humeri from *Capra ibex* (in mm). Source: own data.
Sl. 3: Širini distalnega konca in nadlahtničnega valja (*trochlea humeri*) pri vrsti *Capra ibex* (v mm). Vir podatkov: lastni podatki.

iz Willendorfa deloma presega, deloma pa se ujema s primerki iz tukaj obravnavanega najdišča Salzofenhöhle.

V okviru gradiva iz jame Salzofen je bilo mogoče metrično obdelati tudi osem lopatic (*tab. 5*). Sodeč po

Tab. 6: Measurements of humeri from *Capra ibex* (in mm). Abbrevitions: gl – greatest length; glc – greatest length from *caput humeri*; bp – proximal breadth; dp – proximal depth; sd – smallest breadth of diaphysis; bd – distal breadth; bt – breadth of the trochlea.
Tab. 6: Velikost nadlahtnic pri vrsti *Capra ibex* (v mm). Kratice: gl – največja dolžina; glc – največja dolžina merjena od sklepne glave; bp – širina proksimalnega konca; dp – globina proksimalnega konca; sd – najmanjša širina diafize; bd – širina distalnega konca; bt – širina nadlahtničnega valja (*trochlea humeri*).

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**glc**	**bp**	**dp**	**kd**	**bd**	**bt**
Salzofenhöhle	1642 LH	206.6			61.0	20.9	43.0	40.1
	1642 DaII			49.1	61.0			
	1642 KE					17.2		36.0
	1642 KE						40.8	38.7
	1642							37.9
	1640	145.5				17.7	42.9	38.8
	1630	208.0	180.4	54.0	60.1	22.5	43.0	
	1630	202.9	178.2	51..04	56.7	21.0	42.0	38.9
Mokriška jama		225.0	205.0		64.8	32.6	46.0	41.0
Willendorf	Wi-II-9						45.7	46.3
	Wi-II-9							46.4
	Wi-I-N						46.1	
	Wi-I-N						45.0	
	Wi-I-N						42.9	40.6
	Wi-I-N							47.1
Drachenhöhle	sin– ad?					25.6	48.4	45.7
	sin			55.7	60.4	21.1	46.1	40.2

Tab. 7: Measurements of radii from *Capra ibex* (in mm). Abbreviations: pl – physiological length; bpa – breadth of the proximal articulation; for other abbreviations see *table 6*.
Tab. 7: Velikost koželjnic pri vrsti *Capra ibex* (v mm). Kratice: pl – fiziološka dolžina; bpa – širina sklepa na proksimalnem koncu; za ostale okrajšave glej pripis k *tabeli 6*.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**pl**	**bp**	**bpa**	**sd**	**Bd**
Salzofenhöhle	1866 dex	188.8		41.2		24.5	37.7
	1639 dex	178.9	170.8	40.7		22.0	38.0
	1639 sin	190.7	179.5	42.3		22.8	38.1
	1639 sin	179.8	168.3	40.6		22.0	37.3
	1639 dex	195.0	184.4	40.6		24.6	37.9
	1633 sin	194.0	183.6	41.7		23.7	39.6
	1633 dex	182.6	172.1	41.5		22.1	36.5
	1633 dex	191.5	185.1	40.6		22.3	38.7
Willendorf	Wi-I-N			45.6	43.5		
	Wi-I-N			46.0	44.4		
	Wi-I-N			47.3	43.5		
	Wi-II-4			40.6	38.6		
	Wi-II-9						38.4
	Wi-II-9			45.0	41.9		
	Wi-II-5			39.0	37.2		
Drachenhöhle	sin, ad					21.0	38.0

Tab. 8: Measurements of metacarpals of *Capra ibex* (in mm). Abbreviations: dd – distal depth of the articulation; for other abbreviations see *table 6*.
Tab. 8: Velikost dlančnic pri vrsti *Capra ibex* (v mm). Kratice: dd – globina sklepa na distalnem koncu; za ostale okrajšave glej pripis k *tabeli 6*.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**bp**	**dp**	**sd**	**bd**	**dd**
Salzofenhöhle	1635 sin		30.6	20.4	18.6		
	1635 sin	121.2	30.1	21.7	19.1	32.8	20.1
Drachenhöhle		127.0	30.0	22.3	21.0	34.0	21.1
Willendorf	Wi-II-8					41.4	21.2
	Wi-II-8					42.4	23.9
	Wi-II-9					42.5	
	Wi-II-9					49.0	23.0
	Wi-II-5		32.6	22.0			
	Wi-I-N					39.2	
Modern female[1]	n=12	109-133	27-32	18-23	15-19	30-35	17-21
Modern male[1]	n=23	124-146	30-36	20-24	18-24	34-41	17-24

[1] after / po Bosold (1968)

Tab. 9: Measurements of femora from *Capra ibex* (in mm). Abbreviations: dc – depth of the *caput*; for other abbreviations see *table 6*.
Tab. 9: Velikost stegnenic pri vrsti *Capra ibex* (v mm). Kratice: dc – globina sklepne glave; za ostale okrajšave glej pripis k *tabeli 6*.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**glc**	**bp**	**dc**	**sd**	**Bd**
Salzofenhöhle	1866 dex						49.9
	1866 sin						49.8
	1908	227.6	223.8	57.3	27.5	22.2	48.2
	1631 dex	217.5	210.4	53.8	25.6	19.2	43.9
	1631 sin	229.9	226.7	58.6	27.1	21.0	45.9
	1631 dex			59.2	28.4	22.5	

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**glc**	**bp**	**dc**	**sd**	**Bd**
	1631 sin	217.7	213.3	52.9	26.6	20.7	46.8
	1631 sin		216.0		26.4	19.5	44.4
	1641					21.6	46.9
	1652						54.3
	1925-1			59.5	28.5	21.1	48.0
	1925-1			56.0	28.1	21.1	48.6
	1814			58.5	27.3		
Drachenhöhle	sin, ad	230.0	223.0	56.1	27.8	21.6	45.9
	dex, ad?					25.5	49.0

Tab. 10: Measurements of tibiae from *Capra ibex* (in mm). For abbreviations see *tables 6 and 8*.
Tab. 10: Velikost golenic pri vrsti *Capra ibex* (v mm). Kratice: glej pripisa k *tabelama 6* in *8*.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**bp**	**sd**	**bd**	**dd**
Salzofenhöhle	1642 KE			18.5	31.1	24.8
	1813	270.0		20.0	33.2	25.3
	1858			18.9	32.5	25.2
	1907	266.5	52.8	18.7	33.2	25.5
	1643-279	251.2	51.2	19.9	30.2	25.1
	1643-280	251.1	52.6	20.0	30.2	25.2
	1632 dex	251.2	50.3	18.4	29.7	24.8
	1632 sin	249.1	51.3	19.0	32.3	25.8
Willendorf	Wi-I-N 1			25.8	37.7	30.7
	Wi-I-N 2				373	32.0
	Wi-I-N 3				32.4	
	Wi-I-N					
	Wi-I-N 4				37.0	28.7
	Wi-II-8			27.7	39.6	30.8
Divje babe[1]	D.b.1091				34.0	26.5
	D.b.1520				31.0	23.0

[1] after / po Toškan (2007)

from Willendorf and partly smaller as based on the smallest length of the collum.

Most metacarpals (*Tab. 8*) from Willendorf are larger than those from Salzofenhöhle and lie in the upper range of modern males, respectively above them. Due to this, the specimens from Salzofen rather correspond to females.

In long bones (*Figs*. 3-4; *Tabs*. 6-7, 9-10) the material from Salzofenhöhle forms a group of small-sized individuals. Only one humerus from Willendorf is small (*Fig. 3*), while one specimen from Drachenhöhle and the one from the Mokriška jama lie in between. The majority of radii (*Tab. 7*) from Willendorf is considerably larger than from Salzofenhöhle. In femora (*Tab. 9*), the values are similar for the Salzofenhöhle and the Drachenhöhle, whereas no data from Willendorf are available. The tibia case represents again two distinct groups (*Fig. 4*; *Tab. 10*). The larger one includes specimens from Willendorf and Drachenhöhle, the smaller one comes from Salzofenhöhle. The sample from Divje babe I falls into

dolžini vratu so te bodisi podobno velike bodisi manjše od tistih iz Willendorfa.

Večina stopalnic iz Willendorfa je večja od tistih iz jame Salzofen in je na zgornjem robu variacijske širine za recentne kozoroge oz. te celo presega. Glede na navedeno se zdi primerke iz jame Salzofen utemeljeno pripisati samicam.

Dolge kosti iz jame Salzofen (*sl. 3–4*; *tab. 6–7* in *9–10*) oblikujejo enotno skupino razmeroma majhnih primerkov. Podobno izstopajoča je po svoji majhnosti zgolj še ena izmed nadlahtnic iz Willendorfa, medtem ko imata ostanka enakega skeletnega elementa iz jam Drachen in Mokriške jame v tem smislu vmesno lego (*sl. 3*). Kar zadeva koželjnice, večina willendorfskih primerkov po velikosti močno presega tiste iz tukaj obravnavanega najdišča (*tab. 7*). Medtem ko pri stegnenicah ni opaznejših razlik med najdbami iz jam Salzofen in Drachen ni (*tab. 9*), pa tovrstni podatki za Willendorf žal manjkajo. Obstoj dveh velikostnih skupin je potrdila metrična analiza golenic (*sl. 4*; *tab. 10*); med večje

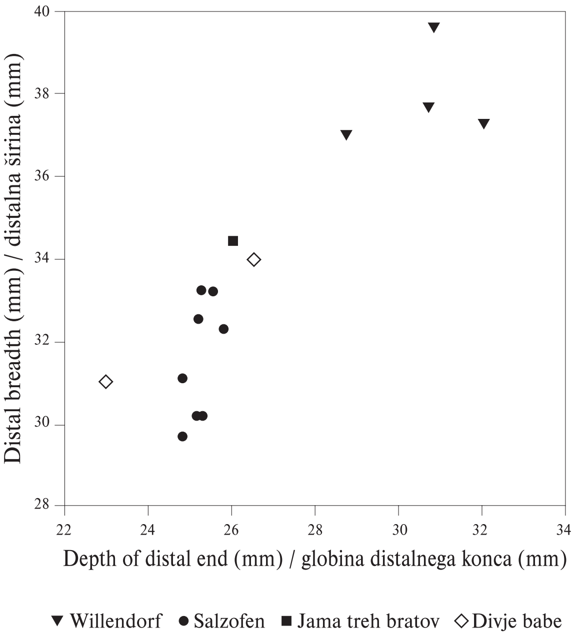


Fig. 4: Distal breadth and depth of distal end of tibiae from *Capra ibex* (in mm). Data after Toškan (2007) and own data.
Sl. 4: Širina in globina distalnega konca golenice pri vrsti *Capra ibex* (v mm). Vir podatkov: Toškan (2007) ter lastni podatki.

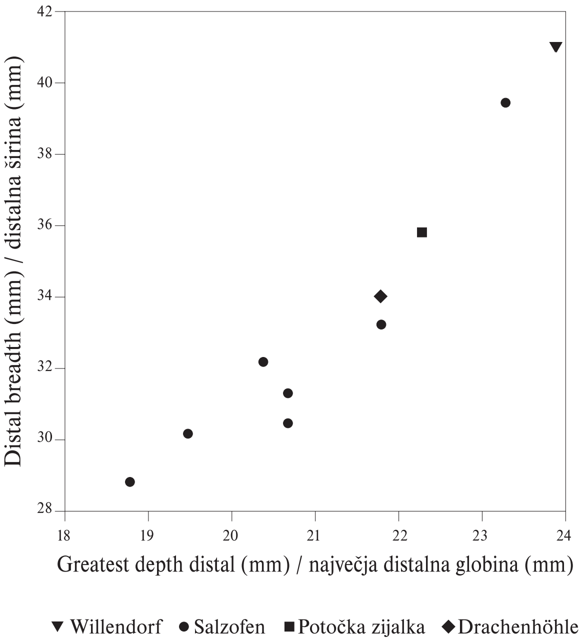


Fig. 5: Distal breadth and greatest depth of distal end of metatarsi from *Capra ibex* (in mm).
Sl. 5: Širina in največja globina distalnega konca stopalnice pri vrsti *Capra ibex* (v mm).

Tab. 11: Measurements of the pelvic bone from *Capra ibex* (in mm). Abbreviations: gl – greatest length; ls – length of symphysis; la – length of acetabulum including labium; sh – smallest height of ileum; sb – smallest breadth of ileum; lfo – inner length of *foramen obturatum*.
Tab. 11: Velikost medenic pri vrsti *Capra ibex* (v mm). Kratice: ls – dolžina simfize; la – dolžina kolčne ponvice (*acetabulum*) vključno z obodom; sh – najmanjša višina črevnice; sb – najmanjša širina črevnice; lfo – notranja dolžina zadelane odprtine (*foramen obturatum*).

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**ls**	**la**	**sh**	**sb**	**lfo**
Salzofenhöhle	1636 dex			33.7	18.8	12.3	50.0
	1636 dex			33.2	19.3	12.3	
	1636 sin			32.4	19.4	11.0	44.0
	1644 sin			34.2	21.5	13.1	
	1644 dex			33.3			
	1644 sin				20.5	11.5	
	1925-3	240.0	73.5	33.8	20.8	12.2	51.3
	1925-3	240.0	72.3	32.3	18.4	12.4	46.9

Tab. 12: Measurements of metatarsals from *Capra ibex* (in mm). For abbreviations see *tables 6* and *8*.
Tab. 12: Velikost stopalnic pri vrsti *Capra ibex* (v mm). Kratice: glej pripisa k *tabelama 6* in *8*.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**bp**	**dp**	**sd**	**bd**	**dd**
Salzofenhöhle	1635 sin	135.1	25.9		15.7	30.5	20.7
	1635 dex	135.3	25.7		15.4	30.2	19.5
	1635 sin	136.5	26.3		16.1	28.8	18.8
	1635 sin	141.3	25.5		16.2	32.2	20.4
	1909	143.8	27.7		18.4	33.2	21.8
	1646	158.4	32.6		21.3	39.4	23.3
	1635		26.2		15.4	31.3	20.7

Site / najdišče	Inv. no or locality / inv. št. oz. lokaliteta	gl	bp	dp	sd	bd	dd
	1910		26.7		17.3	28.8	18.8
Drachenhöhle[1]	1635	151.2	28.3	24.5	18.5	34.0	21.8
Potočka zijalka	Pz 36	162.0	29.5	25.2	21.2	35.8	22.3
Modern female[2]	n=12	116-141	21-26	20-23	13-16	26-31	17-20
Modern male[2]	n=23	131-156	25-30	21-25	15-20	26-36	18-22

[1] after / po Sickenberg (1931) and own measurements / in lastni podatki, [2] after / po Bosold (1968)

Tab. 13: Measurements of proximal phalanges from *Capra ibex* (in mm). For abbreviations see *table 6*.
Tab. 13: Velikost prvih prstnic pri vrsti *Capra ibex* (v mm). Kratice: glej pripis k *tabeli 6*.

Site / najdišče	Inv. no or locality / inv. št. oz. lokaliteta	element	gl	bp	sd	bd
Salzofenhöhle	1653	phal 1 ant	48.2	18.2	15.7	17.5
	1651 dex	phal 1 ant	43.7	17.2	15.1	16.6
	1651 sin	phal 1 ant	43.6	17.7	15.4	16.6
Jama pod Herkovimi pečmi[1]		phal 1 ant	44.4	15.0		14.6
Willendorf		phal 1 ant	52.0	21.3	17.7	20.2
		phal 1 ant	55.0	22.5	18.1	21.5
		phal 1 post	51.1	18.6	16.5	18.6
		phal 1 post	53.8	21.0	16.0	
		phal 1 post	52.0	20.3	18.1	
Lukenjska jama[2]		phal 1 post	~39.0	~13.0		12.5
modern[3]	male (n=21)	phal 1 ant	41-50	16-21	12.5-17	15-20
modern[3]	female (n=12)	phal 1 ant	36-45	14-18	11.5-14	13.5-17
modern[3]	male (n=21)	phal 1 post	41-50	14-16	13-15	14-19
modern[3]	female (n=12)	phal 1 post	37-44	13-16	12-15	10-13

[1] after / po Pohar (1981), [2] after / po Pohar (1983), [3] after / po Bosold (1968)

Tab. 14: Measurements of middle phalanges from *Capra ibex* (in mm). Abbreviations: glpe – greatest length at peripher side; for other abbreviations see *table 6*.
Tab. 14: Velikost drugih prstnic pri vrsti *Capra ibex* (v mm). Kratice: glpe – največja dolžina na periferni strani; za ostale okrajšave glej pripis k *tabeli 6*.

Site / najdišče	Inv. no or locality / inv. št. oz. lokaliteta	element	glpe	bp	sd	bd
Salzofenhöhle	1651 sin	phal 2 ant	27.9	17.3	13.9	13.9
	1651 sin	phal 2 ant	27.4	17.1	13.5	13.9
	1651 dex	phal 2 ant	28.5	17.0	13.7	13.4
	1651 dex	phal 2 ant	26.8	17.1	13.4	13.8
	1651 dex	phal 2 post	28.1	15.1	12.3	11.8
	1651 dex	phal 2 post	27.4	14.9	12.1	11.6
	1651 sin	phal 2 post	27.3	15.0	12.2	11.8
	1651 sin	phal 2 post	27.9	14.7	12.1	11.1
Jama pod Herkovimi pečmi [1]		phal 2 ant	33.1	16.9		15.3
Willendorf		phal 2	32.1	20.0	16.8	
		phal 2	34.8	17.8	14.4	
		phal 2	34.6	20.0		
Divje babe[2]	D.b.1162	phal 2		18.0		
	D.b.1317	phal 2		16.0		

[1] after / po Pohar (1981), [2] after / po Toškan (2007)

Tab. 15: Measurements of astragali from *Capra ibex* (in mm). Abbreviations: gll – greatest length lateral; glm – greatest length medial; dl – depth lateral; dm – depth medial; bd – breadth distal.
Tab. 15: Velikost skočnic pri vrsti *Capra ibex* (v mm). Kratice: gll – največja dolžina na lateralni strani; glm – največja dolžina na medialni strani; dl – globina na lateralni strani; dm – globina na medialni strani; bd – širina na distalnem koncu.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gll**	**glm**	**dl**	**dm**	**bd**
Salzofenhöhle	1650 dex	38.1	36.3	21.3	21.0	25.4
	1650 sin		38.8	23.0	23.5	26.5
Drachenhöhle*		39.2	38.0	21.7	21.8	27.4
Willendorf	Wi-II-2	42.3		21.6		
	Wi-II-9	42.5	40.3	22.1		30.5
Poljšiška cerkev.[1]		~38.0				25.8

*probably part of one complete juvenile individual / verjetno del ohranjenega okostja mlade živali, [1] after / po Pohar (1991)

the smaller size group, with the subadult specimen being rather small in its distal depth.

Measurements for pelvic bones from Salzofenhöhle are given in *table 11*. The pelvis material from Willendorf is more fragmented and no meaningful measurements could be taken.

Concerning the metatarsal bones the assemblage from Salzofenhöhle – generally speaking – forms a small-sized group with the exception of one metatarsal (*Fig. 5*). The size values of metatarsals fall clearly within the distribution range of values for modern female individuals (*Tab. 12*) given by Bosold (1968). The large specimen from Salzofenhöhle and the metatarsal from Potočka zijalka fall within the modern male group. Their greatest length even exceeds values given for modern males.

Two proximal phalanges from Salzofenhöhle fall into the range of modern female individuals given by Bosold (1968) and one into the range of modern males. The sample from Willendorf clearly exceeds those values (*Tab. 13*). The material from Willendorf was measured again by the author, since the values published by Thenius (1959, 156) seem to be taken in a slightly different way. The middle phalanges from Willendorf are larger than those from Salzofenhöhle (*Tab. 14*).

Few additional measurements are available from astragali and calcanei (*Tabs. 15-16*). In astragali, the sample from Willendorf is of larger size than the specimens from Salzofenhöhle.

Tab. 16: Measurements of calcanei from *Capra ibex* (in mm). Abbreviations: gl – greatest length; gb – greatest breadth.
Tab. 16: Velikost petnic pri vrsti *Capra ibex* (v mm). Kratici: gl – največja dolžina; gb – največja širina.

Site / najdišče	**Inv. no or locality / inv. št. oz. lokaliteta**	**gl**	**gb**
Salzofenhöhle	1650 sin	71.3	25.4
	1650 sin	74.8	27.1
Willendorf	Wi-II-5		27.6
	Wi-II-9	~71.0	

primerke sodijo tisti iz Willendorfa ter iz jame Drachen, medtem ko so oni iz najdišča Salzofenhöhle opazno manjši. K slednjim se umešča tudi vzorec iz Divjih bab I, pri čemer golenica subadultne živali izstopa po razmeroma majhni globini distalnega dela.

Metrični podatki za ostanke medenice iz najdišča Salzofenhöhle so podani v *tabeli 11*. Primerjave z najdbami iz Willendorfa v tem primeru žal ni bilo mogoče opraviti, saj so te v zelo fragmentarnem stanju.

Podobno kot v primeru ostalih skeletnih elementov je bilo tudi z analizo stopalnic iz jame Salzofen ugotovljeno, da je te – z eno izjemo – mogoče združiti v enotno skupino razmeroma majhnih primerkov (*sl. 5*). Razpoložljivi metrični podatki se namreč lepo umeščajo v variacijsko širino za recentne samice, kot jo podaja Bosold (1968; *tab. 12*). Večji primerek iz jame Salzofen ter edini iz Potočke zijalke se po svojih dimenzijah ujemata s podatki za recentne samce, po največji dolžini pa te celo presegata.

Od treh izmerjenih prvih prstnic iz jame Salzofen se dve dimenzijsko ujemata s primerki recentnih samic (*cf.* Bosold 1968), ena pa s primerki recentnih samcev. Najdbe iz Willendorfa te vrednosti očitno presegajo (*tab. 13*). Naj k temu dodamo, da je bilo gradivo iz navedenega najdišča v okviru tukaj predstavljene študije podvrženo ponovnemu merjenju, saj naj bi Thenius (1959, 156) metrične podatke zajemal nekoliko drugače. Podobno kot pri prvih prstnicah tudi v primeru drugih najdbe iz Willendorfa po velikosti presegajo tiste iz jame Salzofen (*tab. 14*).

Zajetih je bilo tudi nekaj dodatnih metričnih podatkov o skočnicah in petnicah (*tab. 15–16*).

Pri skočnicah najdbe iz Willendorfa po velikosti presegajo tiste iz jame Salzofen.

REZULTATI

Tako mlajšepleistocenski kot tudi recentni primerki vrste *C. ibex* sestavljajo dve velikostni skupini, ki ju običajno povezujemo s samci in samicami. Primerjalni

RESULTS

Late Pleistocene and modern *Capra ibex* show two size groups commonly concluded as males and females. Comparative data from modern ibex were available for horn cores, metapodials and phalanges. The comparison of values shows that the fossil specimens lie at the upper range of size distribution in both males and females, and there is evidence of very large individuals during the Late Pleistocene that even exceed values of large modern males. Nonetheless, the number of specimens included in this study is too low to draw assured conclusions. Size differences between modern and fossil assemblages need to be studied in more detail.

Because of the measured values, it is supposed that the assemblage from Salzofenhöhle consists mainly of female individuals, whereas the ibex remains from Willendorf are predominantly from males. Sexing of longbones is not clear for each single specimen due to a number of middle sized individuals in the studied assemblage. One metatarsus from Salzofenhöhle, the specimen from Potočka zijalka and Mokriška jama and a few bones from Drachenhöhle are close to the larger specimens from Willendorf. These specimens probably represent male individuals.

In the absence of direct radiocarbon dates on the ibex material of the studied sites and due to the probable chronological heterogeneity of the cave assemblages, which may include Late Pleistocene as well as Holocene finds, more refined results are not possible.

DISCUSSION

Remains of ungulates in caves are present but often rare. As an important fact, different preservation patterns can be observed. Ungulates may be only presented by small skeletal elements (eg. carpals, tarsals, teeth), and heavily fragmented pieces often reveal gnaw marks and corrosion due to gastric acids. They may be either introduced by carnivores as their prey or were brought into the cave by human hunters and afterwards the bones were scavenged by carnivores. Spatial distribution analyses of bones and artefacts suggest *Capra ibex* as human hunting prey at Gamssulzenhöhle 1300 m a.s.l.), Upper Austria (Kühtreiber, Kunst 1995). At Nixloch-cave (770 m a.s.l.), Upper Austria, ungulates probably also correlate with the human use of this site although an input by carnivores is also possible, because of severe gnawing damage (Kunst 1992). The material of these two sites was recovered by modern excavations, while Salzofenhöhle and Drachenhöhle are "old roughly excavated sites". Because of the high selective sampling method, small skeletal elements were not collected. However, the material from these sites is much better preserved, with nearly all skeletal

metrični podatki za recentne kozoroge so bili razpoložljivi v primeru rožnic, metapodijev in prstnic. Vzporejanje obeh nizov podatkov je pokazalo, da se fosilni primerki umeščajo na zgornji rob variacijske širine za recentne živali tako pri samcih kot tudi pri samicah. Pri tem posamezni izrazito veliki fosilni ostanki dimenzije velikih recentnih samcev očitno presegajo. Seveda se je pri tem treba zavedati, da je tukaj predstavljena študija zajela zgolj pičlo število najdb; za pridobitev zanesljivejših podatkov o razlikah v velikosti med fosilnimi in recentnimi kozorogi bi bile tako nujne detajlnejše študije bogatejših vzorcev. Na podlagi razpoložljivih metričnih podatkov se sicer zdi, da med najdbami iz jame Salzofen prevladujejo kosti samic, medtem ko naj bi v Willendorfu prevladovali samci. V primeru nekaterih najdb tem zaradi "vmesnih" dimenzij ni bilo mogoče določiti spola. Največja stopalnica iz jame Salzofen, najdbi iz Potočke zijalke in Mokriške jame ter posamezne kosti iz jame Drachen se po svoji velikosti umeščajo k večjim primerkom iz Willendorfa. Te kosti gre najbrž pripisati samcem.

Ovira na poti do detajlnejših rezultatov je domnevna kronološka heterogenost analiziranega gradiva, ki morda obsega najdbe tako mlajšepleistocenske kot tudi holocenske starosti. Pri tem je dodatna ovira tudi to, da do sedaj še ni bila opravljena nobena neposredna radiokarbonska datacija katere od kozorogovih najdb.

RAZPRAVA

Ostanki kopitarjev so v jamskih najdiščih sicer prisotni, a njihovo število je povečini skromno. Samosvoj je tudi vzorec zastopanosti posameznih skeletnih elementov z očitno prevlado majhnih kosti (npr. zapestne oz. nartne kosti, zobje), na odlomkih praviloma močno fragmentiranih večjih kosti pa so pogosto tudi odtisi zverskih zob oz. je vidna korozija zaradi delovanja želodčne kisline. V jamo so jih lahko prinesle zveri kot lasten plen, lahko pa je to storil tudi človek in so zveri do njih prišle šele naknadno. Prostorska porazdelitev kozorogovih najdb v jamskem najdišču Gamssulzenhöhle (1300 m n. m.) v Zgornji Avstriji je pokazala, da bi za njihovo kopičenje dejansko lahko bil odgovoren človek, ki naj bi jih tudi uplenil (Kuhtreiber, Kunst 1995). Enaka domneva je bila postavljena za jamsko najdišče Nixloch (770 m n. m.), ki prav tako leži v Zgornji Avstriji, čeprav bi številne močno obgrizene najdbe v tem primeru lahko razumeli tudi kot indic, da so jih tja prinesle zveri (Kunst 1992). Favnistično gradivo iz navedenih dveh najdišč je bilo pobrano med modernimi arheološko-paleontološkimi izkopavanji, medtem ko veljata jami Salzofen in Drachen za "na star, dokaj površen način izkopani najdišči". Čeprav zaradi selektivnega vzorčenja najdb ostanki manjših skeletnih elementov pogosto sploh niso bili pobrani, pa je gradivo iz navedenih dveh jamskih elements represented and a considerable number of complete long bones.

The material from Salzofenhöhle reveals clear traces of carnivore activity. Three humeri, four femora, three tibiae, two horn cores, and one pelvic bone show biting marks and spiral fractures. One tibia shows traces of rodent gnawing. With an intensity of 28 %, gnawing traces are rather frequent. There are no traces of damage due to gastric acids on the preserved small elements like phalanges.

Evidence of a nearly complete juvenile skeleton at Drachenhöhle argues for a natural death in single cases, and the two skeletons found in the "Opferschaft" in Salzofenhöhle represent natural trap victims.

There is no proven evidence of human activity on the bones from the two sites with the exception of three horn cores from Salzofenhöhle revealing hacking marks by a metal tool and traces of fire of unknown origin. These specimens are modern ibex individuals. One of them shows bite impressions at the tip of the horn core. The observed modifications argue for heterogeneous material and the question of chronological position of the finds.

Besides proven actual input, ibex is determined as Late Glacial / Early Holocene component of Alpine cave sites by direct dates. One conventional radiocarbon date for *Capra ibex* from Gamssulzenhöhle is 10,180 ± 160 BP (VRI-1327; Kühtreiber, Kunst 1995) and corresponds well to an AMS date from Neue Laubensteinbärenhöhle in Bavaria of 11,350 ± 50 BP (GrA-13377; Rosendahl, Grupe 2001). For the Swiss Alps, direct dated remains of ibex up to now fall into the Holocene period (e.g. Blättler *et al.* 1995; Imhof 2003; 2004). There are no direct radiocarbon dates for ibex from Slovenian and Italian Alpine sites. Ibex remains from the loess area are of Late Pleistocene age due to its presence in the Early Upper Palaeolithic context. So far, no Late Pleistocene ibex remains from Alpine sites are proved by direct dating.

More direct dates would be needed to detect possible Late Pleistocene finds and to reconstruct the role of ungulates at high Alpine cave sites. Additional material is needed to test if the degree of size differences differs in various skeletal elements not only between the sexes but also between modern and fossil ibex populations.

najdišč precej bolje ohranjeno, obsega najdbe praktično vseh skeletnih elementov, neprimerno znatnejše pa je tudi število celih dolgih kosti.

Na mnogih (tj. 28 %) najdbah iz jame Salzofen so vidne sledi zverske aktivnosti. Odtisi zob in spiralni lomi so tako prisotni na treh nadlahtnicah, štirih stegnenicah, treh golenicah, dveh rožnicah ter eni medenici. Ob tem so bile na eni od golenic prepoznane tudi sledi glodanja s strani neznanega glodavca. Po drugi strani nobena od najdb manjših skeletnih elementov (npr. prstnice) ni kazala poškodb, ki bi nastale zaradi korozivnega delovanja želodčne kisline.

Najdba skoraj celotnega skeleta mladega kozoroga v jami Drachen priča o posameznih primerih naravne smrti, medtem ko bi lahko okostji iz brezna žrtev ("Opferschaft") v jami Salzofen pripadali živalma, ki sta se ponesrečili pri padcu v brezno.

Na gradivu iz navedene jame sicer ni opaziti nikakršnih sledi, ki bi se dale povezati s človekom. V tem smislu edino izjemo predstavljajo tri zgoraj že omenjene delno ožgane rožnice, na katerih so med drugim vidni urezi s kovinskim predmetom, eden od primerkov pa ima tudi obgrizen terminalni del. Glede na navedeno se zdi torej utemeljeno sklepati, da gre za ostanke recentnih kozorogov, kar le še podkrepljuje domnevo o kronološko heterogeni sestavi obravnavanega gradiva.

Z izjemo dokazano recentnih vnosov lahko na podlagi peščice razpoložljivih neposrednih radiokarbonskih datacij gledamo na kozoroga kot na element alpskih jamskih tafocenoz poznoglacialne/zgodnjeholocenske starosti. Konvencionalno pridobljen radiokarbonski datum za eno od najdb vrste *C. ibex* iz jame Gamssulzen se tako s svojimi 10.180 ± 160 BP (VRI-1327; Kühtreiber, Kunst 1995) lepo ujema z AMS-datumom konspecifičnega primerka z bavarskega najdišča Neue Laubensteinbärenhöhle (tj. 11.350 ± 50 BP; GrA-13377; Rosendahl, Grupe 2001). Vse doslej pridobljene datacije za kozorogove ostanke iz švicarskih Alp sodijo v holocen (npr. Blättler *et al.* 1995; Imhof 2003; 2004), medtem ko tovrstnih podatkov za gradivo iz slovenskih oz. italijanskih Alp ni. Ostanki vrste *C. ibex* z območja puhlice so mlajšepleistocenske starosti, o čemer priča njena prisotnost v zgodnjem mlajšem paleolitiku. Na takšno (tj. mlajšepleistocensko) starost sicer doslej še ni pokazal noben radiokarbonski datum, ki bi bil pridobljen neposredno z analizo katere od kozorogovih kosti z območja Alp.

Za pridobitev zanesljivejših podatkov o eventualni prisotnosti mlajšepleistocenskih najdb vrste *C. ibex* v visokoalpskih jamskih najdiščih ter za boljše poznavanje vloge tam najdenih kopitarjev nasploh bi bilo tako nujno treba pridobiti dodatne neposredne radiokarbonske datacije. Jasnejši odgovor o obstoju razlik v velikosti med obema spoloma oz. med fosilnimi in recentnimi živalmi pa bi lahko dale tudi analize novih obsežnih vzorcev.

Prevod: Borut Toškan

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OSTANKI MAMUTOVEGA OKLA IZ PRODNE JAME KAMNICA PRI DRNOVEM V KRŠKI KOTLINI

THE MAMMOTH TUSK REMAINS FROM THE KAMNICA GRAVEL PIT NEAR DRNOVO IN THE KRKA RIVER BASIN

Jernej PAVŠIČ, Vasja MIKUŽ

Izvleček

Znova sta predstavljena dva večja dela trobčarjevega okla, ki sta bila najdena v prodni jami Kamnica pri Drnovem v Krški kotlini. Po velikosti in morfoloških značilnostih okla, strukturnih posebnostih zobovine in starosti prodnega zasipa reke Save ostanke okla pripisujemo mlajšepleistocenski vrsti *Mammuthus primigenius* (Blumenbach). Najdbe te vrste so na širšem območju Krške kotline izredno redke.

Ključne besede: okel, mamut, mlajši pleistocen, prodna jama Kamnica, Drnovo, Krška kotlina

UVOD

V paleontološki zbirki Oddelka za geologijo Univerze v Ljubljani sta že dolgo razstavljena dva večja fragmenta mamutovega okla. Najdba je iz prodne jame Kamnica pri Drnovem v Krški kotlini (*sl. 1*). Zgornji rob prodne jame Kamnica je na nadmorski višini 159 m. Ostanka okla sta bila najdena nekaj metrov nižje, na desnem robu ali pobočju prodne jame, v desetletju med 1970 in 1980, najverjetneje pa v letu 1976. Na ostanke mamutovega okla nas je opozoril arheolog dr. Mitja Guštin, ki je bil takrat še kustos muzeja v Brežicah. Ko smo si najdbi ogledali, smo že vedeli, da gre za ostanke mamutovega okla. Ostanki mamuta so v Sloveniji zelo redki, iz Krške kotline pa še toliko bolj. Ostanka okla iz Kamnice sta že bila predstavljena (Lenardić, Pohar 1995), vendar smo se znova odločili za njuno doku-

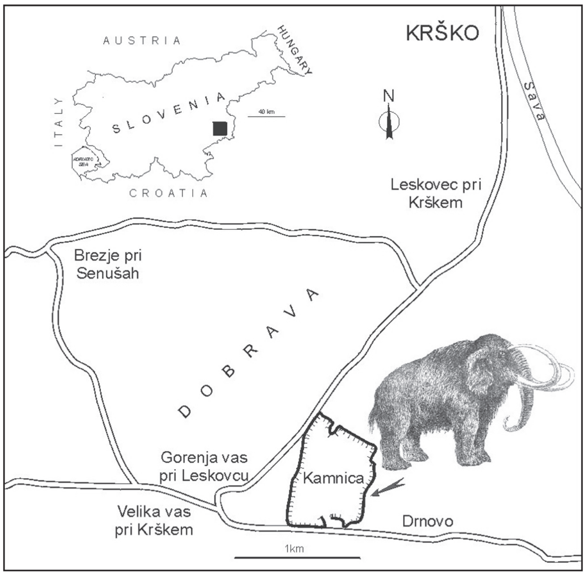
Abstract

The two larger parts of the mammoth tusk that were discovered in the Kamnica gravel pit near Drnovo in the Krka river basin are presented once again. Taking into account the size and morphologic characteristics of the tusk, the structural characteristics of the dentine and the age of the gravel deposit of the Save river, the tusk remains are ascribed to the Late Pleistocene species *Mammuthus primigenius* (Blumenbach). Such finds are extremely rare in the broader area of the Krka river basin.

Keywords: tusk, mammoth, Late Pleistocene, Kamnica gravel pit, Drnovo, Krka river basin

INTRODUCTION

The Palaeontology collection at the Department of Geology, University of Ljubljana, has had two large mammoth tusk fragments on display for quite a while now. The find originates from the Kamnica gravel pit near Drnovo in the Krka river basin (*Fig. 1*). The upper edge of the Kamnica gravel pit stands at 159 metres above sea level. In the 1970s (most likely in 1976) the tusk remains were discovered a few meters lower, on the right edge or slope of the gravel pit. The mammoth tusk was brought to our attention by the archaeologist Phd Mitja Guštin, who was a curator at the Brežice museum at the time. As soon as we laid our eyes on the finds we knew that we were dealing with the remains of a mammoth tusk. Mammoth remains are very rare in Slovenia and even more so in the Krka river basin. Even



Sl. 1: Geografski položaj najdišča mamutovega okla v prodni jami Kamnica pri Drnovem.
Fig. 1: Geographical position of site of the mammoth tusk in Kamnica gravel pit at Drnovo.

mentiranje zaradi konkretnejših podatkov o starosti terase in njenih sedimentih, geološke zgradbe okolice najdišča in drugih dopolnilnih merskih podatkov. Tako je omogočena boljša časovna umestitev najdbe v prostor.

DOSEDANJE NAJDBE IN RAZISKAVE OSTANKOV MAMUTA V KRŠKI KOTLINI

Najdišča mamutovih ostankov v Krški kotlini in na njenem obrobju so zelo redka. Večina raziskovalcev omenja ostanke mamuta iz najdišča Kostanjevica na Krki, ki so ga odkrili med letoma 1936 in 1938. Tam so bili najdeni deli mamutovega okla, posamezne zobne lamele in kosti metapodijev. Med prvimi, ki sta opisala te najdbe, sta Rakovec (1954; 1973) in Brodar (1955), medtem ko Osole (1955–1956) in Ramovš (1974) samo omenjata najdbe mamuta iz tega najdišča. Tudi Pleničar in Premru (1977, 32) pišeta o najdbah ostankov mamuta iz mlajših würmskih plasti Kostanjevice ob Krki in navajata, da so jih raziskovali Rakovec v letu 1954, Brodar 1955. leta in Šercelj v letu 1963. Lenardićeva in Poharjeva (1995, 138, t. 2, sl. 1) sta prvi, ki sta predstavili ostanke mamutovega okla iz prodne jame Kamnica, ki so shranjeni v šolski paleontološki zbirki Oddelka za geologijo. Merski podatki Lenardićeve in Poharjeve (1995) so pomanjkljivi in zavajajoči, saj so v tabeli 4 podani podatki za samo en del okla, na tabli 2, sliki 1, pa sta prikazana dva dela istega okla. Torej sta na merske podatke drugega dela okla pozabili? Mikuž (2007, 162) samo omenja ostanke mamutovega okla iz Kamnice v Krški kotlini.

though the tusk remains from Kamnica have already been presented (Lenardić, Pohar 1995), we decided to document them once more due to the new data as regards the age of the terrace and its sediments, the geological pattern of the site surroundings and other additional data. This provided us with the opportunity to more precisely position the finds into the space.

THE FINDS SO FAR AND THE RESEARCH OF THE MAMMOTH REMAINS IN THE KRKA RIVER BASIN

Sites with mammoth remains are very rare in the Krka river basin and its surroundings. Most researches mention the mammoth remains from the site Kostanjevica na Krki, which was discovered between 1936 and 1938. This location revealed parts of a mammoth tusk, individual dental lamellas and metapode bones. One of the first to describe them were Rakovec (1954; 1973) and Brodar (1955). Osole (1955–1956) and Ramovš (1974) merely mention the mammoth finds at this site. Pleničar and Premru (1977, 32) also wrote about the mammoth remains discovered in the Late Würm layers at Kostanjevica na Krki and stated that they were researched by Rakovec in 1954, Brodar in 1955 and Šercelj in 1963. Lenardić and Pohar (1995, 138, T. 2, Fig. 1) were the first to present the remains of the mammoth tusk from the Kamnica gravel pit that are kept in the school Palaeontological collection at the Department of Geology. The metric data provided by Lenardić and Pohar (1995) is incomplete and misleading, as the data provided in table 4 belongs to a single part of the tusk, and plate 2, Fig. 1 depicts two parts of the same tusk. Does this mean that they forgot to give us the metric data for the second part of the tusk? Mikuž (2007, 162) merely mentions the remains of the mammoth tusk from Kamnica in the Krka river basin.

THE GEOLOGY STRATA OF THE DRNOVO SURROUNDINGS

Drnovo lies on Quaternary sediments and sediment rocks. On the Basic geologic map for Novo mesto Pleničar *et al.* (1976) marked that Holocene gravel and sand cover the surface of the Drnovo surroundings. The map also depicts a number of terrace sections. The tusk find most likely originates from the lower lying Pleistocene gravel deposits. Pleničar and Premru (1977, 33) mention a belt of gravel alluvium between Malo Mraševo and Drnovo. In the south part of this belt one can find gravel deposited by the river Krka and on the north that of the river Sava. In the tectonic sense the site is in the area of the late Krka river depression or the Krka river syncline (Pleničar, Premru 1977, 36). In

GEOLOŠKA ZGRADBA OKOLICE DRNOVEGA

Drnovo je zgrajeno oziroma leži na kvartarnih sedimentih in sedimentnih kamninah. Na Osnovni geološki karti lista Novo mesto so Pleničar *et al.* (1976) na površju okolice Drnovega označili holocenski prod in pesek. Na karti je vrisanih tudi več terasnih odsekov. Najdba okla najverjetneje izvira iz nižje ležečih pleistocenskih prodnih nanosov. Pleničar in Premru (1977, 33) omenjata pas prodnih naplavin med Malim Mraševim in Drnovim. V južnem delu omenjenega pasu je prod reke Krke, na severu pa Save. V tektonskem smislu je najdišče na območju mlade krške udorine oziroma krške sinklinale (Pleničar, Premru 1977, 36). Nadalje ista avtorja pišeta, da je prod Krke drobnejši in bolj pravilno zaobljen, medtem ko je savski prod zelo različnih velikosti. Iz teh skladov ne omenjajo nobene favne. Šikić *et al.* (1978) so kvartarne plasti v podaljšku Krške udorine razdelili na območja treh savskih teras (a1–a3). Najvišjo pleistocensko teraso (a3) sestavljajo apnenčevi konglomerati, holocensko srednjo (a2) in najnižjo (a1) pa konglomerati proda, peska in gline. Neposredno ob Savi so označene aluvijalne naplavine. Šikić *et al.* (1979) pri opisih pleistocenskih skladov na območju krške udorine ne omenjajo nikakršnih najdb ostankov mamuta. Verbič (2004; 2005) prikazuje in ponazarja, da so severno in severovzhodno od Drnovega holocenski zasipi in holocenske erozijske površine. Samo Drnovo in območje, ki leži severozahodno in južno od njega, pa sestavljajo velike zasipne površine, ki pripadajo Drnovski aloformaciji. V bistvu gre za zgornjepleistocensko savsko teraso ali zasip, katere starost je ocenjena od 16.000 do 18.000 let pred sedanjostjo.

PALEONTOLOŠKI DEL

Sistematika po: Maier (1993); Lenardić, Pohar (1995)

Red Proboscidea Illiger, 1811
Družina Elephantidae Gray, 1821
Poddružina Elephantinae Gill, 1872
Rod *Mammuthus* Burnett, 1830

Vaufrey (1958) mamute uvršča v podred Elephantoidea Osborn 1921, nadalje k družini Elephantidae Gray 1821 in poddružini Elephantinae Bonaparte 1858 ter k rodu *Elephas* Linné 1758. Vaufrey (1958, 260) vrsto *Elephas primigenius* Blumenbach pripisuje k posebni skupini rodu *Mammuthus* Burnett 1830. Ob tem zapiše (Vaufrey 1958, 270), da je bila ta vrsta mamuta značilna za pleistocen Evrope in Azije.

Thenius (1969) uvršča mamute k večji skupini proboscidov Elephantoidea in podrobneje še k manjši družini Elephantidae. Pri tem zanje uporablja rodovno ime

the continuation both authors wrote that the Krka river gravel is smaller and more rounded, while the gravel from the Sava river can be found in different sizes. No fauna from these layers is mentioned. Šikić *et al.* (1978) have divided the Quaternary layers in the continuation of the Krka river depression into three Sava river terraces (a1-a3). The highest lying Pleistocene terrace (a3) is composed from lime conglomerates. The middle, Holocene one (a2) is composed from gravel and sand while the lowest (a1) is composed from gravel, sand and clay. Alluvial sediments are marked next to the Sava river. In their descriptions of the Pleistocene layers in the area of the Krka river depression Šikić *et al.* (1979) did not mention any mammoth remains. Verbič (2004; 2005) indicated that there were Holocene deposits and Holocene erosion surfaces to the north and northeast of Drnovo. Drnovo and the area that lies to the northwest and south of it are large deposit surfaces that belong to the Drnovo alloformation. This is an Upper Pleistocene Sava terrace or deposit that is believed to be approximately between 16,000 and 18,000 years old.

PALAEONTOLOGICAL PART

Classification according to: Maier (1993) and Lenardić, Pohar (1995)

Order Proboscidea Illiger, 1811
Family Elephantidae Gray, 1821
Subfamily Elephantinae Gill, 1872
Genus *Mammuthus* Burnett, 1830

Vaufrey (1958) placed mammoths into the subordo Elephantoidea Osborn 1921, family Elephantidae Gray 1821, subfamily Elephantinae Bonaparte 1858 and genus *Elephas* Linné 1758. Vaufrey (1958, 260) classifies the species *Elephas primigenius* Blumenbach as a special group of the genus *Mammuthus* Burnett 1830. Vaufrey (1958, 270) wrote that this mammoth species was characteristic of the European and Asian Pleistocene.

Thenius (1969) categorised mammoths into the larger group of proboscid Elephantoidea and more detailed into the smaller Elephantidae family. Thenius (1969, 608 f) used the genus name *Mammonteus,* which is supposedly a synonym for the genus *Mammuthus*. The species *Mammuthus primigenius* is believed to be typical for the Late Pleistocene in Europe.

Ábelová, one of the few researchers to quote the sixth reprint of Blumenbach's work (2008, 231), researched the structure of the mammoth tusks. From this edition we can learn that Blumenbach defined the species *Mammuthus primigenius* in 1799 and not in 1803 as most researchers (including Lenardić and Pohar, even though they do not state any work by Blumenbach) state.

Mammonteus, ki naj bi bilo sinonim rodu *Mammuthus* (Thenius 1969, 608 s). Vrsta *Mammuthus primigenius* naj bi bila po njegovem mnenju značilna za mlajši pleistocen v Evropi.

Ábelová (2008) je raziskovala strukturo mamutovih oklov in je ena izmed redkih raziskovalcev, ki citirajo šesto izdajo Blumenbachovega dela (*cf.* Ábelová 2008, 231). Odtod izvemo, da je Blumenbach vrsto *Mammuthus primigenius* določil leta 1799 in ne leta 1803, kot navaja večina raziskovalcev, z Lenardićevo in Poharjevo vred, čeprav sicer ne navajata nobenega Blumenbachovega dela.

Po našem mnenju je tudi ta letnica določitve vrste (tj. 1799) sporna, saj Thenius (1969, 638) med svojimi citati uporabljenih virov navaja četrto izdajo Blumenbachovega dela z letnicama 1791 in 1797. V delu Theniusa sicer podatka o konkretni letnici določitve vrste *Mammuthus primigenius* ne najdemo. Prava letnica avtorstva vrste ostaja torej še vedno vprašljiva, zato je ne bomo uporabili.

Mammuthus primigenius (Blumenbach)
T. 1: 1, 2a–2b; *t. 2*: 1, 2a–2b

1884 *Elephas primigenius* Blumb. – Gorjanović-Kramberger, 23
1895 *Elephas primigenius* Blumb. – Zittel, 852, sl. 1912–1913
1912 *Elephas primigenius* Blumenbach. – Gorjanović-Kramberger, 21
1960 *Mammuthus primigenius* Blumenbach – Termier, H. in G., 452, sl. 3323–3324
1995 *Mammuthus primigenius* (Blumenbach), 1803 – Lenardić, Pohar, 138, tab. 2, sl. 1.

MATERIAL

Dva večja dela mamutovega okla oziroma primerka 1 in 2 (*t. 1* in *t. 2*) sta iz prodne jame Kamnica pri Drnovem. Ostanka okla iz Krške kotline sta danes shranjena v vitrini paleontološke zbirke Oddelka za geologijo Naravoslovnotehniške fakultete Univerze v Ljubljani, na Privozu 11 v Ljubljani.

OPIS NAJDB

Ostanki okla so bili v zelo slabem, zmehčanem in fragmentiranem stanju. Vsi deli mamutovega zoba so bili kasneje impregnirani in primerno restavrirani ter sestavljeni oziroma zlepljeni v dve večji celoti. Vsem fragmentom ni bilo mogoče najti ustreznega mesta. Oba ostanka kažeta v preseku ovalno obliko (*t. 2:* 1) v vzdolžni smeri pa rahlo ukrivljenost (*t. 1–2*: 2a–b). V bistvu sta sestavna dela istega okla, vendar brez vmesnih

In our opinion even the year 1799 should be placed under question (as the year in which the species was described) for in his quotes of used sources Thenius (1969, 638) referes to the fourth edition of Blumenbach's work printed in 1791 and 1797. Thenius' work does not provide data on an actual year in which the species *Mammuthus primigenius* was described. As the true year in which the species was established remains questionable it will not be used in this text.

Mammuthus primigenius (Blumenbach)
Pl. 1: 1, 2a-2b; *Pl. 2*: 1, 2a-2b

1884 *Elephas primigenius* Blumb. – Gorjanović-Kramberger, 23
1895 *Elephas primigenius* Blumb. – Zittel, 852, Figs. 1912, 1913
1912 *Elephas primigenius* Blumenbach. – Gorjanović-Kramberger, 21
1960 *Mammuthus primigenius* Blumenbach – Termier, H. & G., 452, Figs. 3323-3324
1995 *Mammuthus primigenius* (Blumenbach), 1803 – Lenardić, Pohar, 138, Pl. 2, Fig. 1

MATERIAL

Two large parts of the mammoth tusk, i.e. specimens 1 and 2 (*Pl. 1-2*) were discovered in the Kamnica gravel pit near Drnovo. The tusk remains from the Krka river basin are currently kept in the display case of the Palaeontological collection of the Department of Geology, Faculty of natural sciences and engineering, University of Ljubljana, at Privoz 11 in Ljubljana.

DESCRIPTION OF FINDS

The tusk remains are in a very poor, fragmented and softened state. All parts of the mammoth tooth were treated and appropriately restored and then glued into two larger parts, however not all fragments could be placed. Both remains have an oval cross-section (*Pl. 2*: 1) and a slight curve lengthwise (*Pl. 1-2*: 2a-2b). Both parts belong to the same tusk, but the parts in between are missing. The first example is somewhat longer but has a slightly smaller circumference (*Pl. 1*: 2a-2b) and thus belongs to the more frontal (mesial) part, while the second example is shorter and has a larger circumference (*Pl. 2*: 2a-2b) and thus represents the continuation of the frontal or first part, and therefore belongs closer to the back (distal) part of the tusk. On the surfaces of the cross sections we can observe the characteristic (for mammoths and other proboscides) 'Schreger structural pattern' (*Pl. 1*: 1), which is discussed and presented in

Tab. 1: Dimenzije obeh ostankov mamutovega okla (1 in 2) iz prodne jame Kamnica pri Drnovem v Krški kotlini.
Tab. 1: Dimensions of both specimens of mammoth tusk (1 and 2) from Kamnica gravel pit at Drnovo in Krka river basin.

Glavni merski parametri dveh delov mamutovega okla / The main parameters of two parts of mammoth tusk	**Primerek 1 / Specimen 1** (*t. 1:* 2a-2b)	**Primerek 2 / Specimen 2** (*t. 2:* 1, 2a-2b)
Dolžina ostankov okla / Length of tusk remains	540 mm	510 mm
Večji premer Greater diameter	168 mm	250 mm
Manjši premer / Smaller diameter	143 mm	159 mm
Večji obseg okla / Greater extent of tusk	540 mm	610 mm
Manjši obseg okla / Smaller extent of tusk	485 mm	580 mm
Odprtina na sredini okla / Aperture in the centre of tusk	–	55 x 30 mm

elementov, ki manjkajo. Prvi primerek, ki je nekoliko daljši del okla, vendar z manjšim obsegom (*t. 1:* 2a–b) in po položaju pripada bolj sprednjemu (mezialnemu) delu, drugi primerek ali krajši del z večjim obsegom (*t. 2:* 2a–b) je nadaljevanje sprednjega ali prvega dela, torej je bližje zadnjemu (distalnemu) delu okla. Na površinah prečnih presekov mamutovega okla lahko opazimo za mamute in ostale proboscide zelo značilen "Schregerjev strukturni vzorec" (*t. 1*: 1), ki ga temeljito obravnava in nazorno predstavlja Ábelová (2008) na vzorcih iz Moravske na Češkem in Hrvaške.

Gorjanović-Kramberger (1884; 1912) piše, da je mamut živel na območju bivše Jugoslavije predvsem v nižinskih predelih rek Save, Drave in Donave in da so njegovi ostanki razmeroma pogostni.

SKLEPI

Prodna jama Kamnica pri Drnovem je bila izkopana na zgornjepleistocenski savski terasi, katere starost je ocenjena na 16.000 do 18.000 let pred sedanjostjo (Verbič 2004; 2005). V produ jame so tedanji delavci leta 1976 našli ostanke okla večjega trobčarja. Po dimenzijah zobnih ostankov (predvsem po obsegu okla), določenih strukturnih značilnostih zobovine in starosti sedimenta sklepamo, da dela okla pripadata mlajšepleistocenski vrsti *Mammuthus primigenius* (Blumenbach). Oba fragmenta sta predstavljena v tem prispevku na *tabli 1* in *2*. Na manjših površinah prečnega preseka okla (*t. 1*: 1) je na dentinu opaziti izrazit "Schregerjev strukturni vzorec", ki je po Ábeloví (2008) zelo značilen predvsem za zobovino mamutovih oklov.

great detail by Ábelová (2008) on the samples from Moravsko (Czech Republic) and Croatia.

Gorjanović-Kramberger (1884; 1912) wrote that in the territory of former Yugoslavia the mammoth lived mainly in the lowland areas surrounding the Sava, Drava and Danube rivers and that their remains are relatively common.

CONCLUSIONS

The Kamnica gravel pit near Drnovo was excavated on the Late Pleistocene Sava river terrace, which is estimated to be between 16,000 and 18,000 years old (Verbič 2004; 2005). In 1976 the workers working in this gravel pit found the remains of a tusk belonging to a larger Proboscidea. Taking the dimensions of the tooth remains (especially the circumference of the tusk) the certain structural characteristics of the dentine and the age of the sediment into account we assumed that the parts of the tusk belong to the Late Pleistocene species *Mammuthus primigenius* (Blumenbach). Both fragments are presented in this paper in *plates 1* and *2*. On the smaller surfaces of the cross section (*Pl. 1*: 1) the dentine shows a clearly visible 'Schreger structural pattern', which is – according to Ábelová (2008) – characteristic for the dentine belonging to mammoth tusks.

To our knowledge the Kamnica gravel pit near Drnovo is the second site with registered mammoth remains in the Krka river basin and its edge. The first and much

Kolikor nam je znano, je prodna jama Kamnica pri Drnovem drugo najdišče z registriranimi ostanki mamuta v Krški kotlini in na njenem obrobju. Prvo in veliko bolj znano najdišče z mamutovimi ostanki je arheološko in paleontološko najdišče Kostanjevica na Krki.

Zahvale

Ob tej priložnosti se zahvaljujemo profesorju arheologije dr. Mitju Guštinu, ki nas je opozoril na najdbo mamutovega okla, in za takrat podarjene mamutove ostanke šolski paleontološki zbirki Oddelka za geologijo. Sodelavcu Marijanu Grmu se zahvaljujemo za vso drugo tehniško in fotografsko podporo.

better known site with mammoth remains is the archaeological and Palaeontological site Kostanjevica na Krki.

Acknowledgment

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Translation: Sunčan Patrick Stone

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T. 1: **1** – *Mammuthus primigenius* (Blumenbach); primerek 2, prečni presek oklove površine s "Schregerjevim strukturnim vzorcem", prodna jama Kamnica pri Drnovem v Krški kotlini, velikost izseka 90 x 78 mm; **2a–b** – *Mammuthus primigenius* (Blumenbach); primerek 1, sprednji del okla z leve in desne strani, prodna jama Kamnica pri Drnovem v Krški kotlini, dolžina ostanka 540 mm. (Foto: Marijan Grm.)
Pl. 1: **1** – *Mammuthus primigenius* (Blumenbach); specimen 2, cross section of tusk with "Schreger structural pattern" area, Kamnica gravel pit at Drnovo in Krka river basin, sector size 90 x 78 mm; **2a**-**b** – *Mammuthus primigenius* (Blumenbach); specimen 1, anterior part of tusk from the left and right lateral side, Kamnica gravel pit at Drnovo in Krka river basin, length of remain 540 mm. (Photo: Marijan Grm.)

T. 2: **1** – *Mammuthus primigenius* (Blumenbach); prečni presek največjega dela okla, prodna jama Kamnica pri Drnovem v Krški kotlini, premera 250 x 159 mm; **2a–b** – *Mammuthus primigenius* (Blumenbach); primerek 2, zadnji večji del okla z leve in desne strani, prodna jama Kamnica pri Drnovem v Krški kotlini, dolžina ostanka 510 mm. (Foto: Marijan Grm.)
Pl. 2: **1** – *Mammuthus primigenius* (Blumenbach); cross section of the largest part of tusk, gravel pit Kamnica near Drnovo in the Krka river basin, diameters 250 x 159 mm; **2a-b** – *Mammuthus primigenius* (Blumenbach); specimen 2, posterior largest part of tusk from the left and right lateral side, Kamnica gravel pit near Drnovo in the Krka river basin, length of remain 510 mm. (Photo: Marijan Grm.)

LATE PLEISTOCENE LION *Panthera leo spelaea* (GOLDFUSS 1810) SKULL AND OTHER POST-CRANIAL REMAINS FROM THE SLOUP CAVE IN THE MORAVIAN KARST, CZECH REPUBLIC

LOBANJA IN POSTKRANIALNI OSTANKI MLAJŠE-PLEISTOCENSKEGA LEVA *Panthera leo spelaea* (GOLDFUSS 1810) IZ JAME SLOUP NA MORAVSKEM KRASU, ČEŠKA REPUBLIKA

Cajus G. DIEDRICH

Abstract

A male lion skull of *Panthera leo spelaea* (Goldfuss 1810) and postcranial remains from the Sloup Cave, Moravian Karst, Czech Republic are described, together with a partial historical find of a skeleton. These are the few known steppe lion records from the mentioned famous European cave bear and hyena den. The lion material from Sloup was found partly with some postcranial bones at a hyena den area with other accumulated hyena prey bones, but also with a skull and limb bones deeper in the cave among many cave bear remains in the cave bear den area. The absence of juvenile lion material proves again that these extinct carnivores were imported by hyenas as prey or carcasses. Such taphonomic situation of adult lion remains found deep in cave bear hibernation den caves explains more and more on the presence of lion skeleton remains in Europe. Those steppe lions were cave dwellers who were stealing their prey at hyena commuting den cave entrances, and were hunting down cave bears during their hibernation, especially in winter times. The antagonistic battle between lions and hyenas/cave bears must have ended fatally in some cases in the cave itself for the lions.

Keywords: *Panthera leo spelaea* (Goldfuss 1810), Sloup Cave, Czech Republic, cave bear and hyena den, palaeoecology, Late Pleistocene

Izvleček

V prispevku so opisani lobanja samca vrste *Panthera leo spelaea* (Goldfuss 1810) ter posamezne kosti trupa, ki izvirajo iz jame Sloup na Moravskem krasu (Češka republika). Del članka je posvečen drugemu, zgolj delno ohranjenemu skeletu iste vrste, ki je bil že pred časom najden v isti jami. Gre za edine znane ostanke stepskega leva iz navedenega najdišča, sicer evropsko znanega brloga jamskega medveda in hijene. Levje kosti so bile najdene na več krajih v jami. Del jih je bil pomešan z nakopičenimi ostanki hijeninega plena na prostoru, ki so ga živali te vrste uporabljale kot brlog. Kar nekaj najdb, s primerkom lobanje vred, pa je skupaj z obilico medvedjih kosti ležalo globlje v jami, kjer so sicer prezimovali jamski medvedi. Odsotnost ostankov mladih levov govori proti tezi, da naj bi kosti te izumrle zveri v jamo prinesla hijena – bodisi kot lasten plen bodisi kot mrhovino. Verjetneje se namreč zdi, da so odrasli stepski levi med svojim zahajanjem v jame iz vhodnih delov, ki (ko) so služili kot brlog hijen, tem izmikali tam nakopičene ostanke plena oz. mrhovine, predvsem v klimatsko neugodnem delu leta pa z vpadi v globlje dele jam plenili tam prezimovajoče jamske medvede. Pri tem so se, kot vse kaže, ti antagonistični boji med levi in hijenami ali jamskimi medvedi v jamskem okolju včasih končali tudi s poginom prvih.

Ključne besede: *Panthera leo spelaea* (Goldfuss 1810), jama Sloup, Češka republika, brlog jamskega medveda in hijene, paleoekologija, mlajši pleistocen

INTRODUCTION

From the Czech Republic, Late Pleistocene steppe lions *Panthera leo spelaea* (Goldfuss 1810) were first described by Wankel from the Sloup Cave. He dealt with a partial skeleton (Wankel 1868), which is at present

UVOD

Prva opisana najdba mlajšepleistocenskega stepskega leva *Panthera leo spelaea* (Goldfuss 1810) z območja današnje Češke republike je bil delno ohranjen skelet iz jame Sloup (Wankel 1868). Danes je to gradivo skupaj z

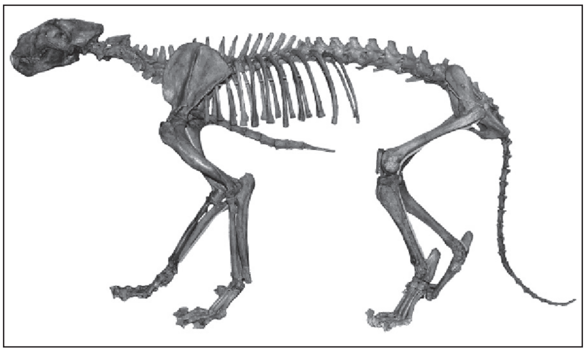

Fig. 1: Late Pleistocene lion *Panthera leo spelaea* (Goldfuss 1810) skeleton composed of different male and female individuals – as well as casts (about 50% original bones) – from the Sloup Cave, with some pedal bones from the Výpustek Cave, Moravian Karst, Czech Republic (NHMW No. 1885/0014/4302).

Sl. 1: Skelet mlajšepleistocenskega leva *Panthera leo spelaea* (Goldfuss 1810), sestavljen iz kosti več samcev in samic iz jame Sloup ter iz približno enakega števila ulitih primerkov. Nekatere izmed kosti okončin izvirajo iz jame Výpustek na Moravskem krasu, Češka republika (NHMW, št. 1885/0014/4302).

exposed as a composite of Sloup Cave, Výpustek Cave and casted bone material in the Natural History Museum Vienna (*Fig. 1*). Other lion remains were mentioned from the open air loess site Prague-Podbaba (Kafka 1903; Diedrich 2007). These materials, skeleton remains, were recently re-described as were many other isolated bones, a skull and teeth from several open air sites around Prague, whereas also a first overview was given about lion material from cave sites of the Bohemian Karst (Diedrich 2008).

Only from the Chlupáčovy Sluje Cave in the Bohemian Karst were other lion remains reported (Zázvorka 1954). The most complete recently known lion skeleton of the Czech Republic was derived from the Srbsko-Chlum-Komin Cave in the Bohemian Karst (Diedrich, Žák 2006). Lions from the Moravian Karst have not yet been studied at all in an overview and in detail; they were listed mainly by Wankel (1868), and later by Musil (1956), especially for the two caves of Sloup and Výpustek. From the latter, two skeletons were mounted, composed of different individuals and both being only half complete (after own observations). One skeleton is presented in the Natural History Museum Vienna (*Fig. 1*), the other is in the Anthroposmuseum Brno. The one composed skeleton from Vienna was bought by the Prince of Lichtenstein and was later thought to be singularly from the Sloup Cave, but many included pedal bones have historical graffiti on the bones with the cave locality of Výpustek.

MATERIAL AND METHODS

Historically collected lion material from the Sloup Cave housed in the Natural History Museum Vienna (= NHMW) and new remains excavated by L. Seitl in 1998 housed in the Anthroposmuseum Brno (= AMB) are described. The postcranial lion material of his excavations was labelled as "*Ursus spelaeus*". The few postcranial bones in the collection of the NHMW have the old stamp-like labels sticking with the running numbers, typical of all the Sloup Cave collection from Wankel. The Sloup Cave megafauna of the Wankel collections material was received in 1885 as one of the

nekaj kostmi iz jame Výpustek in posameznimi ulitimi primerki kot sestavljen skelet razstavljeno v Prirodoslovnem muzeju na Dunaju (*sl. 1*). O skeletnih ostankih stepskega leva so poročali tudi z najdišča na prostem Praga-Podbaba (Kafka 1903; Diedrich 2007). Gre za gradivo, ki je bilo pred nedavnim ponovno obdelano in objavljeno tako kot ne nazadnje tudi več drugih izoliranih najdb kosti, lobanj in zob s posameznih praških planih najdišč. Leta 2008 je tako izšla tudi prva sinteza vseh najdb stepskega leva s Češkega krasa (Diedrich 2008).

Najpopolnejši pred nedavnim odkrit levji skelet iz Češke republike izvira iz jamskega najdišča Srbsko-Chlum-Komin (Diedrich, Žák 2006) s Češkega krasa, vrsta pa je zastopana tudi med živalskimi ostanki iz jame Chlupáčovy (Zázvorka 1954). Poznavanje ostankov stepskega leva z Moravskega krasa je bistveno slabše, saj ti povečini še niso bili predmet poglobljenih znanstvenih študij. Sam popis najdb in lokacij podajata Wankel (1868) in Musil (1956), ki pa se posvečata predvsem ostankom iz jam Sloup in Výpustek. Najdbe iz slednje so bile sestavljene v dva (po avtorjevem opažanju) nepopolna skeleta, od katerih enega razstavlja Prirodoslovni muzej na Dunaju (*sl. 1*), drugega pa Antropološki muzej v Brnu (Anthroposmuseum). Za prvega je dolgo veljalo zmotno mišljenje, da vsi vanj vključeni ostanki izvirajo iz jame Sloup; kot namreč nedvoumno dokazujejo originalni zapisi na posameznih kosteh šap del kosti vendarle izvira iz jamskega najdišča Výpustek.

GRADIVO IN METODE

Prispevek obravnava historične najdbe stepskega leva iz jame Sloup, ki jih hrani dunajski Prirodoslovni muzej (= NHMW), ter novejše ostanke iste vrste iz istega najdišča, ki jih je leta 1998 izkopal L. Seitl in jih danes hrani Antropološki muzej v Brnu (= AMB). Kosti trupa iz brnske zbirke so zmotno označene kot "*Ursus spelaeus*", na sicer pičlem številu postkranialnih najdb z dunajskega NHMW pa so še vedno ohranjene etikete z zaporednimi inventarnimi številkami, ki jih je za gradivo iz jame Sloup uporabljal Wankel. NHMW je najdbe iz Wanklove zbirke sesalske megafavne iz jame Sloup pridobil leta 1885 kot eno svojih prvih paleontoloških

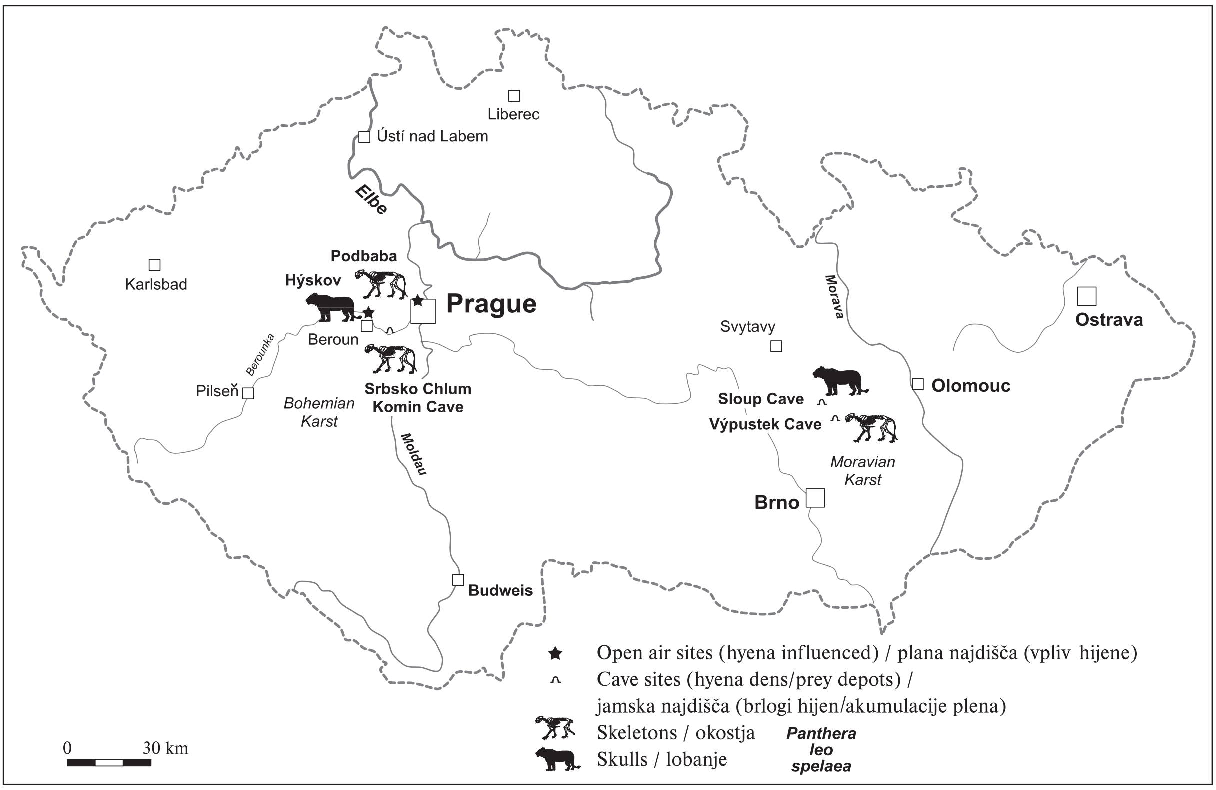

*Fig. 2***:** Compared Late Pleistocene lion skull and skeleton remains from caves and open air sites in the Czech Republic (composed after Diedrich 2005; Diedrich 2007, and new data).

Sl. 2: Jamska in plana najdišča v Češki republiki z najdbami levjih lobanj oz. kosti trupa mlajšepleistocenske starosti (sestavljeno iz Diedrich 2005; Diedrich 2007 ter iz novih podatkov).

first palaeontological collections of the Natural History Museum Vienna, but was excavated in 1881-1882 by Sedlak who sold this collection. This collection from the Sloup Cave was donated by the Anthropologische Gesellschaft (*cf.* Diedrich 2009b), whereas the here figured lion skeleton was a gift to the Vienna Museum by the Prince of Liechtenstein. A single atlas bone labelled with "Geologische Lehrkanyel Technische Hochschule Wien 1935" was also identified as a cave bear bone, and was finally found in-between those "*Ursus spelaeus*" vertebrae. None of those historical labels were found on bones of the displayed lion skeleton in the show case of the Natural History Museum Vienna (*Fig. 1*), which was believed to originate from the Sloup Cave.

For a sex identification of the lion skull from the Sloup Cave, all recently known skulls from Czech Republic (*cf. Fig. 2*) were compared to other skeleton and skull remains in Europe. The postcranial bones are too incomplete for such a male/female identification, also a metapodial comparison overview is still lacking.

The cave was explored during the cave bear symposium in 2007 to identify the historical excavation areas of Sedlak and the new ones of Seitl and to understand the cave morphology and different use by hyenas, cave bears and the presence of lions (*Fig. 3*).

zbirk, sama izkopavanja pa so pod Sedlakovim vodstvom potekala že v letih 1881–1882. Navedeno gradivo je dunajskemu Prirodoslovnemu muzeju podarilo združenje Anthropologische Gesellschaft (*cf.* Diedrich 2009b), medtem ko predstavlja skelet s *slike 1* dar liechtensteinskega princa. Eno od levjih najdb z Dunaja – gre za nosač – označuje napis "Geologische Lehrkanyel Technische Hochschule Wien 1935", sama kost pa je bila pomešana med nosače jamskega medveda. Enake označbe ni bilo opaziti na nobeni od kosti razstavljenega levjega skeleta (*sl. 1*), ki naj bi izvirale iz jame Sloup.

Pri ugotavljanju spola živali, ki je bila v gradivu iz jame Sloup zastopana s skoraj v celoti ohranjeno lobanjo, je bila ta primerjana z vsemi ostalimi znanimi levjimi lobanjami iz Češke republike (*cf. sl. 2*) ter s številnimi primerki iz drugih evropskih najdišč. V primeru kosti trupa podobno razvrščanje med spola ni bilo mogoče, saj je bila stopnja ohranjenosti teh kosti preskromna. Podobno velja tudi za metapodije.

V okviru simpozija o jamskem medvedu je bila leta 2007 jama Sloup cilj strokovne ekskurzije, katere namen je bil prepoznati izkopavališča Sedlaka in Seitla ter poglobiti razumevanje morfologije jame in razlik v vzrokih za njeno obiskovanje med hijenami, jamskimi medvedi in levi (*sl. 3*).

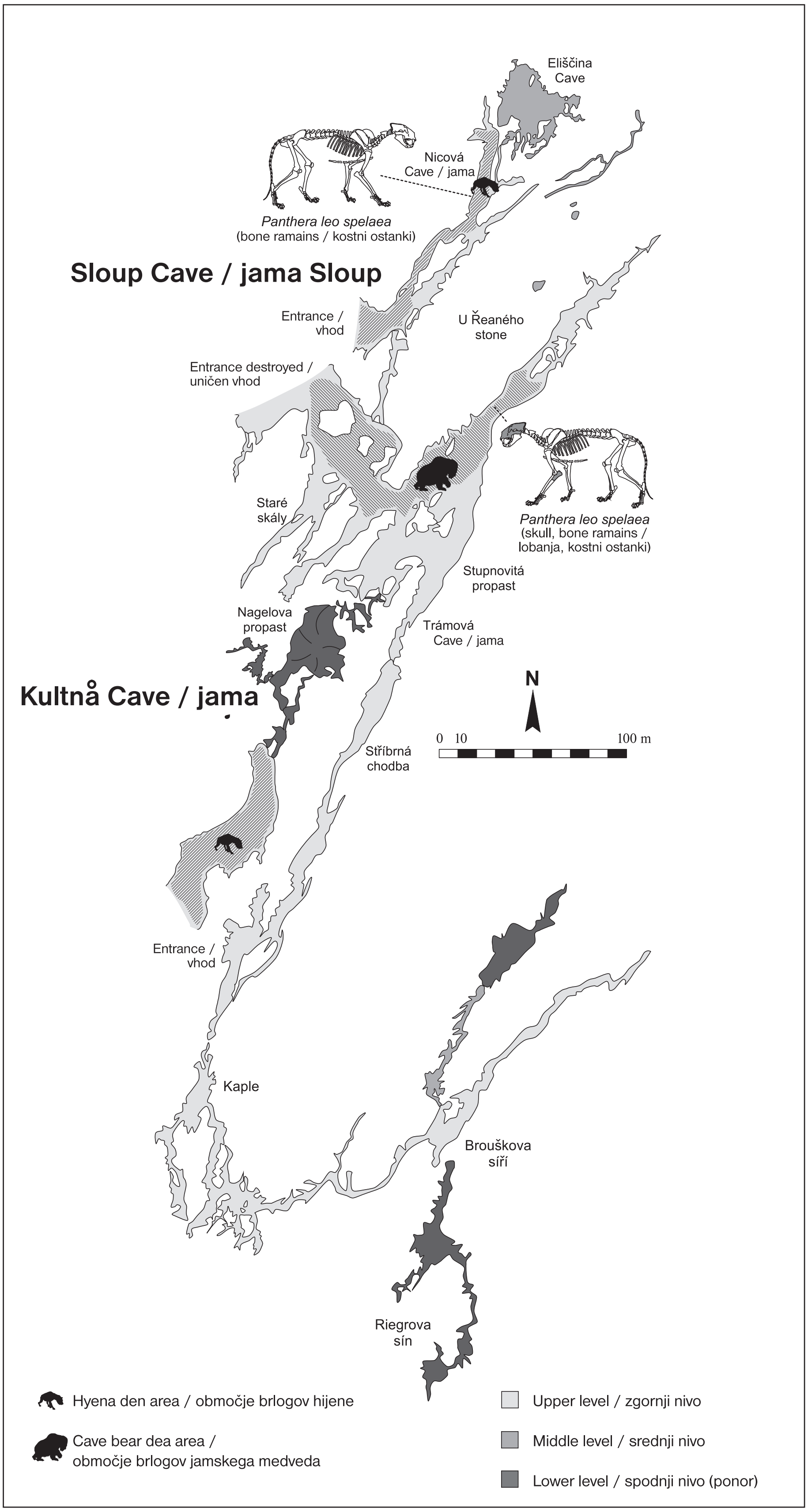

Fig. 3: Cave map of the Sloup Cave and area where the lion material was found (map redrawn after Zajíček *et al.* 2007).
Sl. 3: Načrt jame Sloup z označenimi deli, kjer so bili najdeni levji ostanki (načrt modificiran po Zajíček *et al.* 2007).

Fig. 4: Skull of a male steppe lion *Panthera leo spelaea* (Goldfuss 1810) from the Sloup Cave, Moravian Karst, Czech Republic (AMB No. OK 130570): 1a – dorsal.

Sl. 4: Lobanja samca stepskega leva *Panthera leo spelaea* (Goldfuss 1810) iz jame Sloup na Moravskem krasu, Češka republika (AMB, št. OK 130570): 1a – dorzalni pogled.

Family: Felidae Gray 1821
Genus: *Panthera* Oken 1816
Panthera leo spelaea (Goldfuss 1810)

Skull: The skull (*Figs. 4-6.1*) is incomplete. Parts of the right parietal, the left praemaxillary and other smaller parts, such as of the left frontal are missing. From the dentition only the fourth premolars are preserved (right one incomplete), though all other teeth must have been present originally. The main measurements for sex identification are: total length = 378 mm, and condylus width = 72 mm. The skull is from the Seitl excavations and was found in the deeper part of the cave during excavations in 1998 (Stríbrná chodba branch).

Postcranial bones: Within the Seitl excavations a half proximal left ulna (*Fig. 6.3*) and a half distal right fibula (*Fig. 6.4*) were found. The pedal bones, historically excavated by Svedlak in 1881-1882, consist of the right and the left metacarpus II (*Figs. 6.6-7*) and the left metacarpus V (*Fig. 6.5*) and have the typical Wankel labels. Finally an incomplete atlas (*Fig. 6.2*) is unclear in its origin or finding position, and is the only find of the Geologische Lehrkanyel Technische Hochschule Wien.

Družina: Felidae Gray 1821
Rod: *Panthera* Oken 1816
Panthera leo spelaea (Goldfuss 1810)

Lobanja: Lobanja (*sl. 4–6.1*) je delno poškodovana. Manjkajo deli desne temenice, leve medčeljustnice ter še nekaj drugih manjših delov (npr. delček leve čelnice). Od zob sta ohranjena zgolj oba četrta predmeljaka (od tega desni primerek le delno), čeprav je moralo biti zobovje ob izkopu popolno. Ključni dimenziji za ugotavljanje spola sta kondilobazalna dolžina (= 378 mm) in širina zatilničnih čvršev (= 72 mm). Lobanja je bila najdena med Seitlovimi izkopavanji leta 1998 v enem izmed globljih delov jame (t. i. Stríbrná chodba).

Kosti trupa: Med Seitlovimi izkopavanji sta bila najdena proksimalni del leve komolčnice (*sl. 6.3*) in distalni del desne piščali (*sl. 6.4*), medtem ko Svedlakova zbirka iz let 1881–1882 vključuje po eno levo in eno desno dlančnico II (*sl. 6.6–7*) ter levo dlančnico V (*sl. 6.5*), vse tri z značilnimi Wanklovimi etiketami. Na tem mestu velja omeniti še najdbo nepopolno ohranjenega nosača (*sl. 6.2*) iz neznanega najdišča, ki ga edinega od tukaj obravnavanih levjih najdb označuje napis "Geologische Lehrkanyel Technische Hochschule Wien 1935".

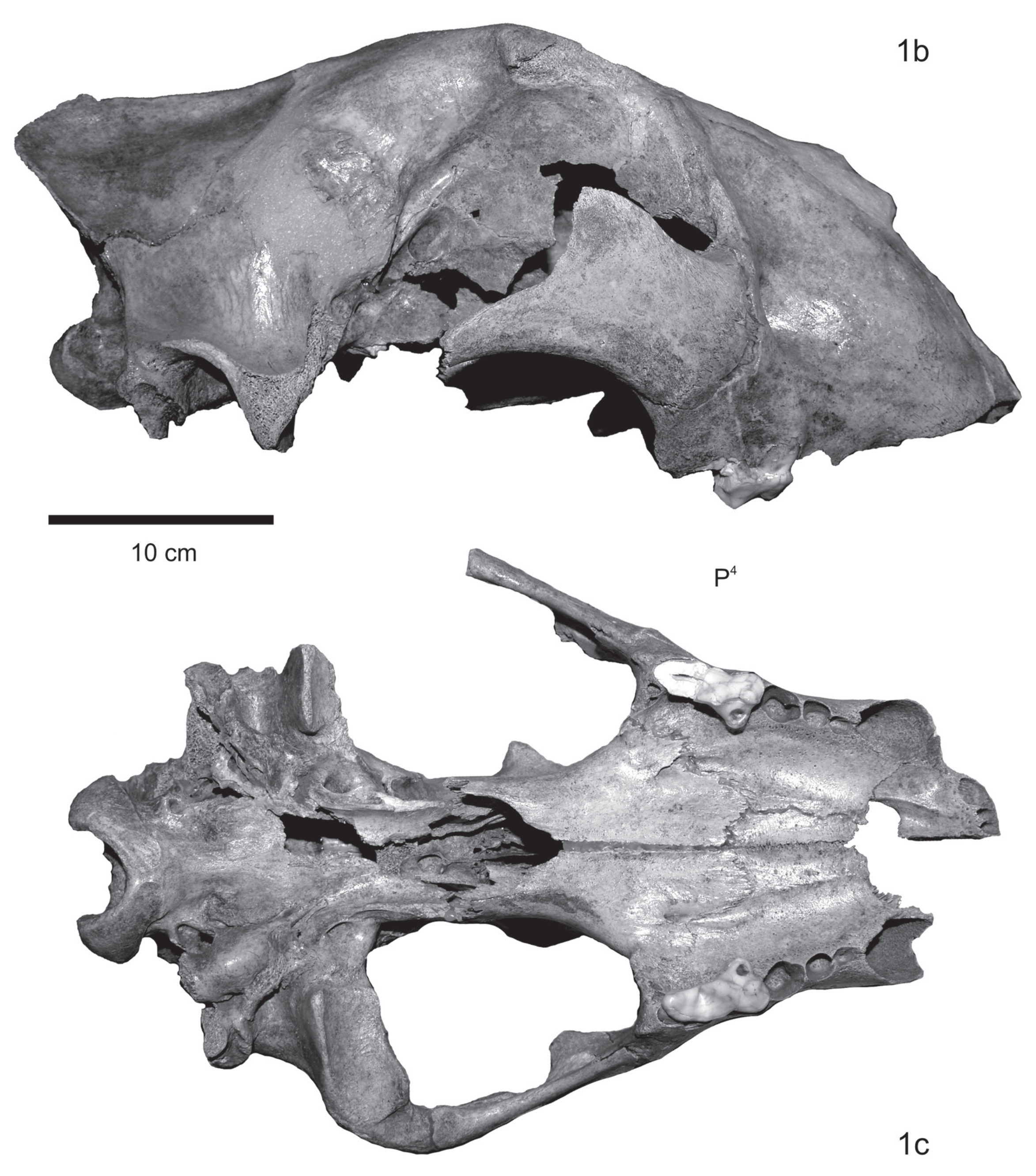

Fig. 5: Skull of a male steppe lion *Panthera leo spelaea* (Goldfuss 1810) from the Sloup Cave, Moravian Karst, Czech Republic (AMB No. OK 130570): 1b – lateral; 1c – ventral.

Sl. 5: Lobanja samca stepskega leva *Panthera leo spelaea* (Goldfuss 1810) iz jame Sloup na Moravskem krasu, Češka republika (AMB, št. OK 130570): 1b – lateralni pogled; 1c – ventralni pogled.

DISCUSSION

The lion *Panthera leo spelaea* material seems to be from the Late Pleistocene Weichselian age, to which other material of *Ursus spelaeus*, *Crocuta crocuta spelaea, Gulo gulo*, *Canis lupus*, *Mammuthus primigenius*,

RAZPRAVA

V prispevku obravnavano gradivo leva vrste *Panthera leo spelaea* najverjetneje sodi v obdobje zadnje poledenitve mlajšega pleistocena (t. i. weichselianska poledenitev). V isti čas gre najbrž datirati tudi najdbe ostalih

Fig. 6: Skull and postcranial bones of grown up animals of the steppe lion *Panthera leo spelaea* (Goldfuss 1810) from the Sloup Cave, Moravian Karst, Czech Republic: **1** – Skull (AMB No. OK 130570): **1d** – frontal, **1e** – occipital; **2** – Atlas (NHMW No. 2008z0089/0001): dorsal; **3** – Left proximal ulna fragment (AMB No. Sloup 80/80-1): lateral; **4** – Right distal half of the fibula (AMB No. Sloup 80/80-2): lateral; **5** – Left metacarpus V (NHMW No. 2008z0089/0004): dorsal; **6** – Right metacarpus II (NHMW No. 2008z0089/0003): dorsal; **7** – Left metacarpus II (NHMW No. 2008z0089/0002): dorsal.

Sl. 6: Lobanja in kosti trupa odraslih primerkov stepskega leva *Panthera panthera spelaea* (Goldfuss 1810) iz jame Sloup na Moravskem krasu, Češka republika: **1** – lobanja (AMB, št. OK 130570): **1d** – frontalni pogled, **1e** – okcipitalni pogled; **2** – nosač (NHMW, št. 2008z0089/0001): dorzalni pogled; **3** – proksimalni odlomek leve komolčnice (AMB, št. Sloup 80/80-1): lateralni pogled; **4** – distalni odlomek desne piščali (AMB, št. Sloup 80/80-2): lateralni pogled; **5** – leva dlančnica V (NHMW, št. 2008z0089/0004): dorzalni pogled; **6** – desna dlančnica II (NHMW, št. 2008z0089/0003): dorzalni pogled; **7** – leva dlančnica II (NHMW, št. 2008z0089/0002): dorzalni pogled.

Coleodonta antiquitatis, *Bison priscus*, *Bos primigenius*, *Equus ferus przewalskii*, *Megaloceros giganteus*, *Rangifer tarandus*, *Capra ibex* and possibly *Saiga tatarica* fits (*cf.* Diedrich 2009b).

Wankel's large bone collection mostly consisted of several hundred famous and in many cases pathological cave bear bones (Wankel 1868; Musil 2002), which have not yet been redescribed. This large bone collection was historically excavated from the cave at different places (*cf.* Wankel 1868; Musil 2002).

There were only about 139 non-cave bear bones, including four lion specimens described here, and 23 only briefly restudied hyena coprolites (*cf.* Diedrich 2009b); the latter were incorrectly identified as "cave bear excrements". All similar coloured and preserved bones of the non-cave bear fauna were found in one small area of the cave, the "Nicová Cave" part. This is where the hyena remains, its prey and coprolites were also discovered (*cf.* Wankel 1858; 1868), which indicates an area of hyena den use (Diedrich 2009b). Three pedal bones and possibly one atlas were found in this hyena den area and might reflect lion carcass remains imported by hyenas; a similar situation is represented by the lion bones at the Perick Caves hyena den, Germany (Diedrich 2009a). Also one wolverine from the "Nicová Cave" part was most likely imported as a complete carcass or prey by the Ice Age spotted hyenas (Diedrich 2009b). This cave part was clearly used as a hyena den, as is also proved by many hyena bone remains, including skulls, juvenile material and even several coprolites.

Other lion remains were found in the recent excavations deeper in the cave, in the branch of the Stríbrná chodba. Here generally only cave bear remains were found in high amounts, therefore postcranial lion bones were mixed with cave bear bones. The only lion skull of this cave and the long bone material do not prove any hyena activities. On the basis of its proportions and comparisons to many other skulls from Czech Republic and other European sites, the skull from Sloup Cave seems to belong to a male lion (*Fig. 7*; Diedrich 2009c).

The presence of lion skulls and skeleton remains deeper in caves has most recently produced new taphonomic interpretations. New skeleton finds of lions 800 metres deep in the Romanian Urşilor Cave on cave bear hibernation plateaus (Diedrich *et al.* 2009) indicate an active cave bear hunt by steppe lions (Diedrich 2009d). Also in the Sloup Cave the lion bone presence seems to have two reasons: hyena import and cave bear predations. Without good systematic excavations and exact taphonomic studies of large cave bear dens and hyena caves, it is not possible to decide about the lion bone origin. As seen here in the Sloup Cave, and recently shown for the Srbsko-Chlum-Komin Cave, often single skulls and bones from complete skeletons of lions are destroyed by misidentifications especially of postcranial bones.

v jami zastopanih vrst: jamski medved ("*Ursus spelaeus*"), jamska hijena (*Crocuta crocuta spelaea*), rosomah (*Gulo gulo*), volk (*Canis lupus*), dlakavi mamut (*Mammuthus primigenius*), dlakavi nosorog (*Coleodonta antiquitatis*), stepski bizon (*Bison priscus*), przewalskijev konj (*Equus ferus przewalskii*), orjaški jelen (*Megaloceros giganteus*), severni jelen (*Rangifer tarandus*), kozorog (*Capra ibex*) ter morda tudi sajga (*Saiga tatarica*; *cf.* Diedrich 2009b).

Bogato Wanklovo zbirko je večinoma sestavljalo nekaj tisoč pogosto patoloških kosti jamskega medveda (Wankel 1868; Musil 2002). Najdbe so bile izkopane v 19. stoletju na več različnih krajih v jami (*cf.* Wankel 1868; Musil 2002) in doslej še niso bile predmet moderne znanstvene revizije.

Poleg kosti in zob jamskega medveda vsebuje Wanklova zbirka tudi 139 najdb drugih vrst, med njimi štiri tukaj opisane levje kosti ter 23 koprolitov hijene (*cf.* Diedrich 2009b); slednje so v preteklosti zmotno pripisali jamskemu medvedu. Vsi podobno obarvani in ohranjeni ostanki nemedvedje favne so bili najdeni v istem, prostorsko razmeroma skromnem delu jame, imenovanem Nicová jama. Tam so bile nakopičene tudi najdbe hijene, z ostanki njenega plena in zgoraj že omenjenimi koproliti vred (*cf.* Wankel 1858; 1868). Slednje nedvoumno priča o tem, da je navedena vrsta ta del jame uporabljala kot brlog (Diedrich 2009b). Med drugim naj bi tako ledenodobne lisaste hijene na navedeno lokacijo prinesle tudi cel kadaver rosomaha (Diedrich 2009b). Pri tem dejstvo, da so bili med tam najdenimi ostanki vrste *Crocuta crocuta spelaea* tudi lobanje, kosti in zobje mladičev, tezo o uporabi tega dela jame za brlog le še dodatno podkrepljuje.

Ostanki jamskega leva so bili najdeni tudi globlje v jami, v rovu, imenovanem Stríbrná chodba. Gre za lokacijo, kjer so sicer prevladovale kosti jamskega medveda, mednje pa so bile pomešane tudi posamezne levje. Pri tem je zanimivo, da na slednjih niso bile zapažene nikakršne sledi obgrizovanja, ki bi ga lahko pripisali hijenam. Enako velja tudi za edino levjo lobanjo iz tukaj obravnavane jame. Po primerjavi z drugimi primerki iste vrste, ki so bili najdeni bodisi na območju Češke republike bodisi v kateri od drugih evropskih jamskih najdišč, je bila lobanja pripisana samcu (*sl. 7*; Diedrich 2009c).

Prisotnost ostankov stepskega leva v globljih delih evropskih jam je bila v zadnjem času na novo interpretirana. Najdbe tudi do 800 m globoko v notranjosti romunske jame Urşilor na kraju, ki so ga sicer za prezimovanje uporabljali jamski medvedi (Diedrich *et al.* 2009), je mogoče namreč razumeti kot posreden dokaz, da je stepski lev aktivno plenil te največje zveri (Diedrich 2009d). Prav to naj bi bil – ob kopičenju hijen – tudi eden od razlogov za prisotnost levjih ostankov v jami Sloup. Moderna sistematska izkopavanja in natančne študije pomembnejših brlogov medveda in hijene bodo to problematiko gotovo dodatno osvetlili.

Kot se je pokazalo v primeru jame Sloup, nedavno pa tudi v primeru jame Srbsko-Chlum-Komin, se

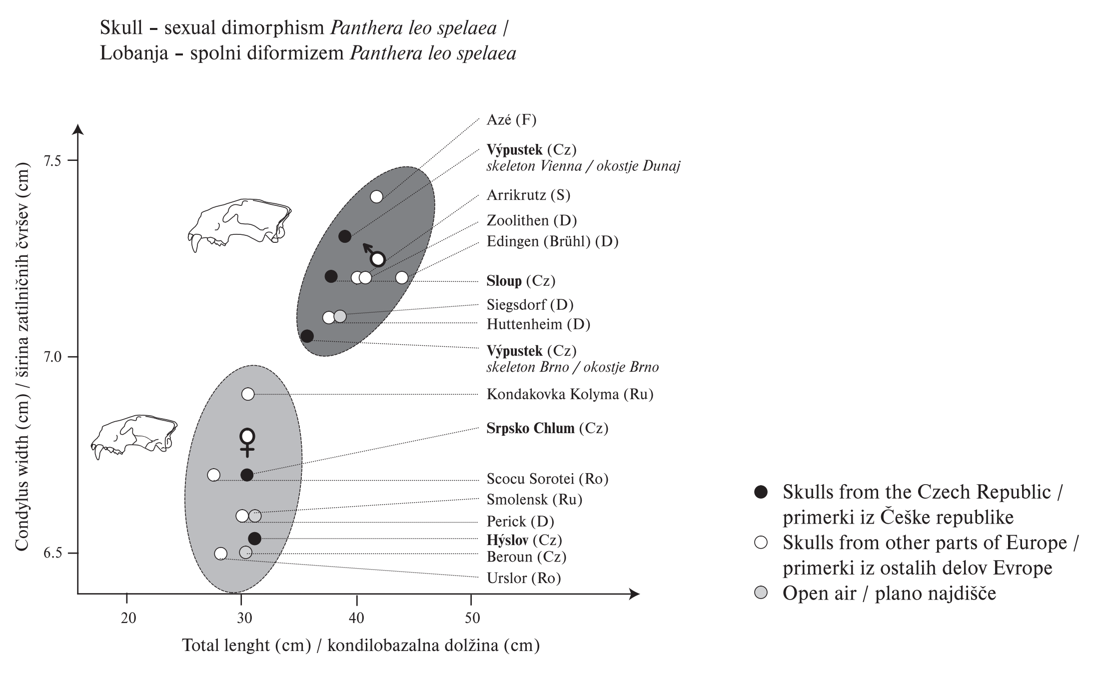

Fig. 7: Cranial sexual dimorphism in the lion *Panthera leo spelaea* (Goldfuss 1810) including the skulls from the Czech Republic. The male skulls are much larger than the female ones. The skull from Sloup Cave falls within the male lions (data from Altuna 1981; Argant 1988; Gross 1992; Diedrich 2009c).
Sl. 7: Na lobanji izražen spolni dimorfizem pri stepskem levu *Panthera leo spelaea* (Goldfuss 1810). Lobanje samcev so značilno večje od samičjih. Primerek iz jame Sloup se umešča k lobanjam samcev (podatki povzeti po: Altuna 1981; Argant 1988; Gross 1992; Diedrich 2009c).

The selective collection of bones, which are easier to identify as lion bones (skulls, jaws and teeth), has resulted – sadly not only in the past – in the destruction of taphonomic information as well as of entire skeletons. The skeleton from Srbsko-Chlum-Komin is one of the best negative examples (*cf.* Diedrich, Žák 2006), but there are other lion skeletons being similarly destroyed. In some caves the skeletons must have been articulated or partly scattered disarticulated. The latter situations were both recently documented in the Urşilor Cave on three lion skeletons. One of those was completely articulated and another was scattered on a plateau by carnivore scavenging activities (Diedrich *et al.* 2009). Especially this latter situation explains the anthropogenous skull and bone selection and presence of "skulls" in collections, the postcranial material of which is possibly still in the caves. Here in the Sloup Cave, therefore, more lion material can be expected in collections or in the cave itself.

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sledi za levjimi ostanki prevečkrat izgubijo že zavoljo napačne taksonomske določitve (predvsem) kosti trupa. O tem pričajo mnoge (muzejske) zbirke z očitno porušenim razmerjem v zastopanosti posameznih skeletnih elementov, in to na način, da v njih prevladujejo predvsem taksonomsko razmeroma lahko določljivi lobanje, čeljustnice in zobje. Gre za pomanjkljivost, ki ne le da nepovratno oklesti tafonomsko informacijo, ki je zajeta v dani tafocenozi, marveč ob najdbi popolnoma ohranjenih skeletov uniči njihovo celovitost. Okostje iz jame Srbsko-Chlum-Komin je eden najočitnejših primerov takšne prakse (Diedrich, Žák 2006), ki pa jih je žal še veliko več. Zgodi se, da do takšnih napak pride pri odkritju še v celoti artikuliranih skeletov, večinoma pa se to seveda vendarle dogaja takrat, kadar so posamezne kosti že nekoliko razmetane (obe situaciji sta bili npr. dokumentirani v jami Urşilor; Diedrich *et al.* 2009). Takšna "razmetanost" namreč pogosto botruje selektivnemu pobiranju najdb, s tem pa v končni fazi tudi bolj ali manj očitni prevladi lobanj v levjih zbirkah iz posameznih najdišč. Tako lahko tudi v primeru tukaj obravnavane jame Sloup pričakujemo, da se posamezne napačno taksonomsko določene najdbe stepskega leva še vedno skrivajo v muzejskih depojih, marsikatero kost pa bi bilo zagotovo mogoče najti še tudi v jami sami.

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Prevod: Borut Toškan

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LATE PLEISTOCENE HYAENA *Crocuta crocuta spelaea* (GOLDFUSS, 1823) FROM BARANICA CAVE (SOUTHEAST SERBIA): COMPETITION FOR A DEN SITE

MLAJŠEPLEISTOCENSKA HIJENA *Crocuta crocuta spelaea* (GOLDFUSS, 1823) IZ JAME BARANICA (JUGOVZHODNA SRBIJA): TEKMOVANJE ZA BRLOG

Vesna DIMITRIJEVIĆ

Abstract

The majority of caves in Serbia that contain Pleistocene deposits were "bear caves". The only hyaena den cave up to now recognized is Baranica Cave (southeast Serbia, valley of the river Trgoviški Timok, near Knjaževac). It is a composite cave with two parts designated as Baranica I and Baranica II with an entrance into Baranica II some 20 m above Baranica I. Faunal remains show similar composition and taphonomy in both parts. There is a wealth of herbivorous and carnivorous species remains, but hyaena remains predominate. Bone fragmentation is high, mostly due to damage made by hyaena teeth. There was competition for the living space among cave hyaena and other carnivores, as well as humans, but hyaena had taken on a major role in Baranica I and kept an inviolable den site in Baranica II.

Keywords: Cave hyaena, Late Pleistocene, Baranica Cave, Serbia, den site, competition

Izvleček

Večina srbskih jam z živalskimi ostanki pleistocenske starosti je "medvedjih", medtem ko je doslej znano jamsko najdišče s prevladujočim deležem hijene le eno – Baranica (JV Srbija, dolina reke Trgoviški Timok v bližini Knjaževca). Gre za kompleksen jamski sistem, katerega del sta tudi jami Baranica I in II, pri čemer leži vhod v slednjo kakih 20 m nad vhodom v prvo. Tafocenozi iz obeh navedenih lokacij sta si podobni tako po vrstni sestavi kot po stopnji ohranjenosti. Gradivo obsega ostanke številnih rastlinojedov in zveri, prevladujejo pa najdbe hijene. Prav omenjena vrsta je tudi odgovorna za visoko stopnjo fragmentiranosti kostnega gradiva. Kot vse kaže, je bil obravnavani jamski sistem kot življenjski prostor v pleistocenu predmet ostre konkurence med hijeno, nekaterimi drugimi zvermi ter človekom. Na območju Baranice I je bila pri tem očitno najuspešnejša prav hijena, to pa še toliko bolj velja za Baranico II, kjer je bila navedena vrsta domnevno sploh edina stalna obiskovalka.

Ključne besede: jamska hijena, mlajši pleistocen, jama Baranica, Srbija, brlog, tekmovanje

INTRODUCTION

Caves provided an important natural shelter for both humans and animals in the course of the Pleistocene. The most successful among representatives of the order Carnivora in the competition for the living space in caves were cave bear and cave hyaena due to, on the one hand, their resolute urge to den in caves and, on the other, to competitive efficiency in comparison with other

UVOD

Jame so bile v pleistocenu pomembno naravno zavetišče tako za človeka kot za živali. Med zvermi sta bila v tekmovanju za ta zavetja najuspešnejša jamski medved in jamska hijena, v veliki meri prav zaradi njune nujne potrebe po ureditvi primernega brloga. Pri tem sta vrsti izkoriščali svoje očitne kompetititvne prednosti. Če je jamski medved v jamskem okolju predvsem prezimoval, Carnivora. Both species made their lairs or dens in caves, cave bear hibernating in winter months, while cave hyaena nursing their cubs possibly throughout the year.

The majority of caves in Serbia that contain Pleistocene deposits were “bear caves”. Cave bear remains have been found in each of the 29[1] caves with Pleistocene mammal remains recorded up today, and they constitute more than 90 % of large mammal remains of these sites (e.g. Risovača, Petnička Cave, Ceremošnja, Prekonoška and Ledena Cave of the Ušac Cave system; Rakovec 1965; Lazarević *et al.* 1988; Dimitrijević 1992; 1994; 1997b). At some of these locations cave bear was the sole representative of large mammals (e.g. Popšička, Kovačevića, Ravanička, Ošljarska and Velika Cave in Duboka near Kučevo; Dimitrijević 1997b; 1998, Tab.4; Dimitrijević *et al.* 2001). Abundant remains of cave bear have been found even at sites that yielded Palaeolithic artifacts, like in Pećurski Kamen, Smolućka or Prekonoška Caves (Malez, Salković 1988; Dimitrijević 1991; 1997b), where humans must have interrupted bears’ dominion, even if this accounted only for short episodes of occupation. An exception to this preponderance of cave bear remains in Serbian caves is noticeable at those sites that were inhabited more intensively by humans, and where humans accumulated remains of their prey, like at the Paleolithic sites of Šalitrena Cave in the valley of the Ribnica River, or Mala Balanica in the Sićevo Gorge, where excavations are in progress (Mihailović B. 2008; Mihailović D. 2008).

Another exception from the dominance of cave bear remains in Serbian caves is Baranica, which is now recognized as the only hyaena den cave in Serbia. Remains of hyaena have also been found in several other sites, but mostly with quite a few remains in comparison with abundant cave bear bones and teeth. A single bone is recorded from Petnička Cave and Golema Dupka Cave (Dimitrijević 1992; 1994; 1997b), and a coprolite from Ceremošnja Cave (Lazarević *et al.* 1988). A few bones or teeth have been found in Smolućka Cave (Dimitrijević 1991), Pećurski Kamen (Malez, Salković 1988), and Ledena Cave (Dimitrijević 1997b), while somewhat more numerous hyaena remains characterize the cave of Risovača (Rakovec 1965; Dimitrijević 1997b). The presence of hyaena is also claimed for Jerinina Cave (Gavela 1988). But none of these sites match Baranica with regard to the abundance of hyaena remains and this species’ contribution to prey remains accumulation.

pa je bila pri hijenah potreba po varnem brlogu vezana predvsem na skrb za mladiče in so zato jamo po možnosti uporabljale vse leto.

Večina srbskih jam z živalskimi najdbami pleistocenske starosti je “medvedjih”. Ostanki navedene vrste so bili namreč najdeni v vsaki od 29[1] doslej odkritih jam z ostanki ledenodobnih sesalcev in predstavljajo več kot 90 odstotkov vseh ostankov velikih sesalcev v teh jamah (npr. Risovača, Petnička jama, Ceremošnja, Prekonoška in Ledena jama v okviru jamskega sistema Ušac; Rakovec 1965; Lazarević *et al.* 1988; Dimitrijević 1992; 1994; 1997b). V nekaterih od navedenih najdišč je bil jamski medved celo edini predstavnik velikih sesalcev v tamkajšnjih tafocenozah (npr. Popšička, Kovačevića, Ravanička, Ošljarska in Velika jama v Duboki pri Kučevem; Dimitrijević 1997b; 1998, Tab. 4; Dimitrijević *et al.* 2001). Številni ostanki jamskega medveda so bili najdeni celo v jamah, od koder so znani tudi paleolitski artefakti. Takšni primeri so npr. Pećurski Kamen, Smolućka ali Prekonoška jama (Malez, Salković 1988; Dimitrijević 1991; 1997b), kjer so ljudje očitno vsaj za krajše obdobje prekinili kontinuiteto prisotnosti jamskega medveda. Izjema med srbskimi jamami z izrazito prevlado ostankov vrste *U. spelaeus* so tiste, kjer je dokumentirana intenzivna prisotnost človeka, ki je v jamo prinašal svoj plen. Takšna najdišča so npr. Šalitrena jama v dolini reke Ribnice ali Mala Balanica v soteski Sićevo, kjer trenutno potekajo arheološka izkopavanja (Mihailović B. 2008; Mihailović D. 2008).

Druge vrste izjema med srbskimi jamami z živalskimi ostanki pleistocenske starosti je Baranica, ki je edini doslej znan jamski brlog ledenodobnih hijen v državi. Navedena vrsta je bila sicer zastopana tudi v več drugih jamah, vendar povečini z zgolj skromnim številom najdb v primerjavi s prevladujočimi ostanki jamskega medveda. Po ena kost je bila tako najdena v jamah Petnička in Golema Dupka (Dimitrijević 1992; 1994; 1997b), koprolit pa v Ceremošnji jami (Lazarević *et al.* 1988). O najdbi nekaj kosti in zob poročajo še iz Smolućke jame (Dimitrijević 1991), Pećurskega Kamna (Malez, Salković 1988) ter Ledene jame (Dimitrijević 1997b), nekoliko večje število ostankov pa je znanih iz Risovače (Rakovec 1965; Dimitrijević 1997b). Hijena naj bi bila zastopana tudi v favni Jerenine jame (Gavela 1988), vendar pa nobeno od naštetih najdišč ne prekaša Baranice po številčnosti najdb njenih ostankov in njenem prispevku k akumulaciji tafocenoze.

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[1] The list of 25 caves with Pleistocene vertebrate remains is given in Dimitrijević (1998); in addition, Pleistocene fossil remains have been discovered in Brezovica (Trifunović 2004), Velika pećina in Duboka near Kučevo (Dimitrijević *et al.* 2001), Hadži-Prodanova Cave (Mihailović, D. & B. 2003) and Mala Balanica (Mihailović D. 2008).

[1] Seznam 25 jam z ostanki vretenčarjev iz pleistocenskega obdobja podaja Dimitrijević (1998); poleg navedenih najdišč so tovrstne najdbe znane tudi iz Brezovice (Trifunivić 2004), Velike pećine in Duboke pri Kučevem (Dimitrijević *et al.* 2001), Hadži-Prodanove jame (Mihailović, D. in B. 2003) ter Male Balanice (Mihailović D. 2008).

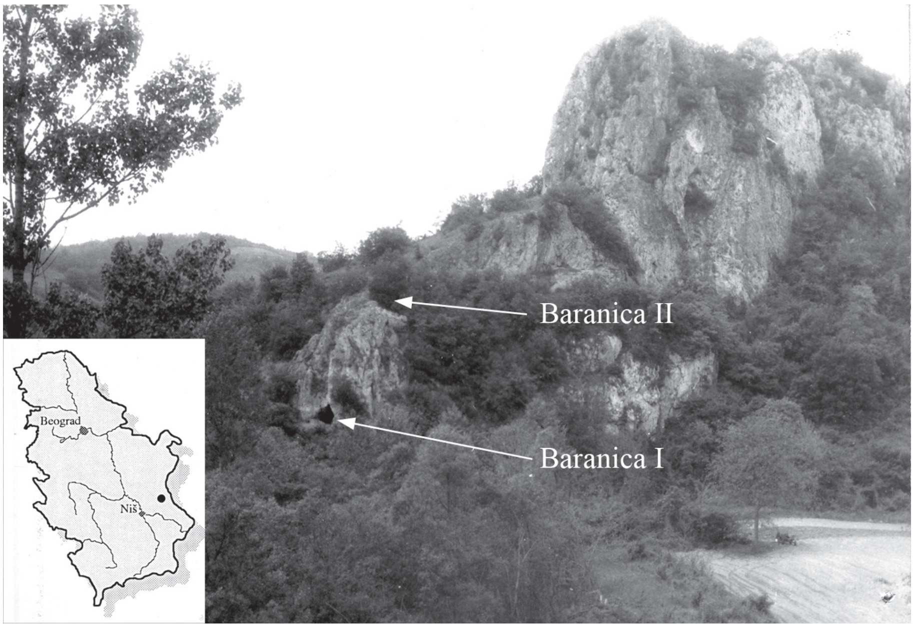

Fig. 1: Baranica Cave and its geographical position.
Sl. 1: Jama Baranica in njena geografska lega.

BARANICA CAVE: GEOGRAPHICAL POSITION, STRATIGRAPHY, PALAEOLITHIC ARTIFACTS AND FAUNAL REMAINS

Baranica Cave is situated in southeast Serbia, in the valley of the river Trgoviški Timok, about 5 km southeast of Knjaževac. It is a composite cave that consists of many narrow cave passages approachable through several entrances. One entrance is positioned 15 m above the riverbed (260 m a.s.l.) and it opens into a chamber 5 m wide. This part of the cave is named Baranica I. Another one is positioned some 20 m above the first, and this part of the cave is named Baranica II (*Fig. 1*).

Archaeological excavations were first performed in 1994 in Baranica I (Sladić, Jovanović 1995). Interest in the site was sparked since many excavated bones seemed like bone implements. Subsequent research established that hyaenas' gnawing produced these "modifications". Yet, human-made chipped stone implements were found in the course of 1995 and 1997 excavation campaigns in the cave.

Four geological layers were distinguished in Baranica I: surface humus layer with mixed material of the Holocene and Pleistocene age (layer 1), and three layers of the Pleistocene age (layers 2-4; Mihailović *et al.* 1997). Excavations were stopped at the depth of 2.2 m, without reaching the floor of the cave. Layers 2 and 4 contained abundant large mammal remains and a few lithic implements, while layer 3, characterized as a homogeneous gray silt, contained only rare small

JAMA BARANICA: GEOGRAFSKA LEGA, STRATIGRAFIJA, PALEOLITSKI ARTEFAKTI IN ŽIVALSKI OSTANKI

Jama Baranica leži v jugovzhodnem delu Srbije v dolini reke Trgoviški Timok, približno 5 km JV od Knjaževca. Gre za sestavljen jamski sistem, ki ga tvori več ozkih hodnikov, do katerih je mogoče priti skozi več različnih vhodov. Ena takšnih vstopnih točk leži 15 m nad strugo (260 m n. m.) in se odpira v 5 m široko dvorano. Ta del jame se imenuje Baranica I. Približno 20 m nad tem vhodom leži še eden, kjer je dostop do t. i. Baranice II (*sl. 1*).

Prva arheološka izkopavanja na tej lokaciji so bila izvedena leta 1994, in sicer na območju Baranice I (Sladić, Jovanović 1995). K odločitvi za terensko raziskovanje je prispevalo dejstvo, da so številni kostni odlomki spominjali na orodja; kot se je izkazalo kasneje, je šlo za posledice aktivnosti hijen. V letih 1995 in 1997 so arheologi vendarle našli tudi kamnito orodje.

V Baranici so bile prepoznane štiri geološke plasti: površinski humus z najdbami iz obdobja pleistocena in holocena (tj. plast 1) ter tri plasti pleistocenske starosti (tj. plasti 2 do 4; Mihailović *et al.* 1997). Izkopavanja so bila prekinjena na globini 2,2 m, še preden je bilo doseženo dno jame. V plasteh 2 in 4 je bilo najdenih veliko živalskih ostankov in nekaj kamnitih orodij, medtem ko je plast 3 – označena kot homogen siv melj – vsebovala zgolj posamezne ostanke malih sesalcev (Dimitrijević 1997a). To plast je najbrž v zelo kratkem časovnem ob-mammal remains (Dimitrijević 1997a). This layer was probably deposited in a short episode by a water torrent through cave channels. In layer 3, there is no cave rubble, which is abundant in layers 2 and 4, neatly separating these layers. A blade, a side-scraper, and a bladelet were found in layer 2, and an end-scraper, two fragmentary blades and two flakes in layer 4, all attributable to the early Upper Palaeolithic period (Mihailović D. 1998).

Baranica II is a small rear cave chamber that remained after the construction of the road had destroyed the anterior portion of the cave space of unknown extension and proportions. It is approximately 4 m deep and 2 m wide, with an entrance only 1.5 m high. Reddish-brown silty clay with limestone rubble was deposited on the floor of Baranica II. The top of the sediment was in places cemented by cave sinter into bone breccias.

The faunal composition differs slightly in Baranica I and II (*Tab. 1*), mostly by the presence of particular carnivorous species, represented by only a few remains, such as badger and weasel, present in Baranica I and absent in Baranica II, as well as snow leopard and wild cat that are, by contrast, present in Baranica II and absent from Baranica I. In addition, mammoth remains were only found in Baranica II. Cave hyaena remains account for 28 % of identified specimens in Baranica I, and 28.5 % in Baranica II.

Three dates are available from Baranica thanks to the NERC-funded project related to the Late Quaternary large-mammal extinctions in northern Eurasia conducted by A. Stuart and A. Lister (Lister, Stuart 2008). A lower canine of cave hyaena from Baranica II (BAR II 97/16/12; OxA - 13946) gave the age > 53,100 BP (δ ^{13}C - 18.069). A second phalanx of a giant deer (BAR 97/19/16; OxA - 13827) dated layer 2 in Baranica I to 23,520 ± 110 BP (δ^{13}C - 19.415), while a third molar of a cave bear (BAR 97/80/1; OxA - 13828) dated layer 4 to 35,780 ± 320 BP (δ^{13}C - 20.980).

CAVE HYAENA REMAINS IN BARANICA CAVE

Cave hyaena remains in Baranica I-II caves are mostly unweathered, bone and teeth structure well preserved but highly fragmented. The colour of the bones and teeth is mostly pale yellow, with black mineral oxides spotted in places on the surface of the bone and retracing crevices in the teeth enamel.

Cranial remains are presented exclusively with fragmented maxillae and mandibles. There are numerous isolated teeth, while postcranial remains are less abundant (*Tab. 2*).

There are two left maxillae: one with P^3 and fragmented P^4 (BAR II 1/24) and one with second and third incisor and alveolus for the first incisor (BAR II

Tab. 1: Baranica Cave I and II, faunal composition.
Tab. 1: Jami Baranica I in II, sestava favnističnega vzorca.

	BAR I	BAR II
Castor fiber	5(1)	3(1)
Lepus sp.	8(2)	7(4)
Canis lupus	17(2)	3(1)
Vulpes vulpes	17(2)	14(2)
Ursus spelaeus	11(3)	13(3)
Meles meles	2(1)	/
Martes martes	3(2)	2(1)
Mustela nivalis	1(1)	/
Crocuta crocuta spelaea	51(9)	137(12)
Panthera spelaea	1(1)	1(1)
Panthera pardus	/	2(1)
Felis silvestris	/	1(1)
Mammuthus primigenius	/	10(3)
Coelodonta antiquitatis	1(1)	21(6)
Equus ferus	12(3)	84(7)
Equus hydruntinus	1(1)	13(2)
Megaloceros giganteus	9(3)	44(5)
Cervus elaphus	3(2)	6(2)
Bison priscus	31(4)	72(11)
Capra ibex	9(2)	45(11)
Rupicapra rupicapra	1(1)	2(1)

dobju naplavil vodotok, ki je v nekem trenutku (s)tekel skozi jamo. V plasti 3 ni grušča, ki ga je sicer v plasteh 2 in 4 veliko. Nabor kamnitih artefaktov, ki vsi sodijo v zgodnji mlajši paleolitik (Mihailović D. 1998), je naslednji: po en primerek kline, strgala in klinice izvira iz plasti 2, praskalo ter po dva odbitka in odlomka klin pa iz plasti 4.

Baranica II je majhna nekdaj terminalna dvorana, ki se je edina ohranila, potem ko je med izgradnjo ceste prišlo do uničenja vhodnega dela jame neznanih razsežnosti. Dimenzije ohranjenega dela jame znašajo 4 x 2 m, sam vhod pa v višino meri poldrugi meter. Na tleh se je odložila rdečkastorjava meljasta glina s posameznimi apnenčastimi kosi grušča. Vrhnji del sedimentnega zaporedja je bil skupaj s kostmi mestoma cementiran v brečo s siginim vezivom.

Razlike v sestavi favnističnih vzorcev iz Baranice I in II so majhne (*tab. 1*); večinoma gre za to, da so posamezne zveri z nekaj najdbami zastopane v zgolj eni od obeh jam. Tak primer sta jazbec in podlasica, katerih ostanki so bili najdeni le v Baranici I, ali pa snežni leopard in divja mačka, ki sta zastopana zgolj v gradivu iz Baranice II. Ostanki jamske hijene predstavljajo 28 odstotkov vseh favnističnih najdb iz Baranice I ter 28,5 odstotka tistih iz Baranice II.

Po zaslugi preučevanja mlajšekvartarnih izumrtij velikih sesalcev v severni Evraziji, projekt vodita A. Stuart in A. Lister (Lister, Stuart 2008), financira pa ga NERC, so bile za Baranico pridobljene tri radio-

Tab. 2: Baranica Cave, *Crocuta crocuta spelaea* remains.
Tab. 2: Jama Baranica, ostanki vrste *Crocuta crocuta spelaea*.

2x Maxillae	2 sin.: fr. max. with/s P^3, fr. P^4 (BAR II 1/24); fr. max. with/z I^2, I^3, alveolus for/za I^1 (BAR II 97/24/3).
16x Mandibulae	11 sin.: fr. mand.with/z P_2-M_1 (BAR II 1/1); fr. mand. with/z C, alveolus for/za P_1, root frgments of / odlomka korenin P_1, P_2 (BAR II 97/16/11); fr. mand. with/z C alveolus, root fragments of /odlomki korenin P_2, P_3, P_4 (BAR II 97/7/28); fr. mand. with/s P_4, M_1 (BAR II 97/17/4); fr. mand. with/s P_3, P_4 (BAR II 97/11/30); fr. mand. with/s P_2, P_3 (BAR II 97/12/10); 2 fr. mand. with/s P_3 (BAR II 97/22/1, BAR II 97/17/6); fr. mand. with/s P_2 (BAR II 97/11/36); fr. mand. with/z M_1 (BAR 21/2); fr. mand. with/s fr. P_4 alveolus, fr. M_1 root/korenino (BAR II 97/8/40). 4 dext.: fr. mand. with/s P_3-M_1, root fragment of/odlomek korenine P_2 (BAR II 97/14/2); fr. mand. with/s C alveolus, root fragment of/odlomek korenine P_2, fr. P_3 (BAR II 97/29/16); fr. mand. with/s P_3, P_4 (BAR II 97/24/2); fr. mand. with/s fr. P_3 (BAR II 97/11/34). 1 indet. side/stran: fr. mand. with/s fr. P_3 (BAR II 97/20/6).
4x I^1	3 sin. (BAR 95/4/2, BAR 97/29/1, BAR II 97/19/11). 1 dext. (BAR II 97/31/1).
6x I^2	5 sin. (BAR 24/1, BAR 95/16/1, BAR II 97/31/2, BAR II 97/31/3, BAR II 97/3/12). 1 dext. (BAR II 97/8/7).
4x I^3	1 sin. (BAR II 97/9/7). 3 dext. (BAR 27/1, BAR 95/60/1, BAR II 97/21/12).
7x C^1	1 sin. (BAR 8/1). 6 dext. (BAR II 97/7/2, BAR II 97/11/33, BAR II 97/3/15, BAR II 97/25/8, BAR II 97/3/8, BAR 21/4).
2x P^1	1 sin. (BAR II 1/34). 1 dext. (BAR 95/47/1)
3x P^2	3 dext. (BAR II 97/4/4, BAR 14/2, BAR II 1/29).
13x P^3	10 sin. (BAR II 97/2/1, BAR II 97/25/5, BAR II 97/16/14, BAR II 97/11/35, BAR II 97/17/8, BAR 97/2/10, BAR 97/37/2, BAR II 1/33, BAR II 1/35, BAR II 97/21/15). 3 dext. (BAR II 97/25/3, BAR II 97/9/24, BAR II 97/17/9).
17x P^4	10 sin. (BAR II 97/1/11, BAR II 97/9/4, BAR II 97/21/8, BAR II 97/25/2, BAR II 97/5/6, BAR II 97/19/14, BAR II 97/29/20, BAR II 97/19/7, BAR II 97/19/16, BAR 95/37/1). 7 dext. (BAR 97/15/1, BAR II 97/11/31, BAR II 97/19/15, BAR 97/721/1, BAR II 97/7/16, BAR II 97/3/23, BAR II 97/24/5).
1x P/M sup.	a root fragment/odlomek korenine (BAR II 3/5)
2x I_1	1 sin. (BAR 97/2/14). 1 dext. (BAR II 2/2).
2x I_2	2 dext. (BAR II 97/19/12, BAR 97/16/2).
8x I_3	6 sin. (BAR II 97/29/21, BAR II 97/19/13, BAR II 97/7/11, BAR II 97/7/1, BAR 5/10, BAR 6/3). 2 dext. (BAR II 97/19/10, BAR 97/30/1).
14x C_1	10 sin. (BAR II 97/15/4, BAR II 97/7/22, BAR II 97/7/4, BAR II 97/6/10, BAR 6/2, BAR II 1/2, BAR II 1/3, BAR 18/1, BAR 95/21/1, BAR II 1/4). 4 dext. (BAR II 97/15/5, BAR II 97/6/1, BAR II 97/16/12, BAR 1/6).
1x P_2	1 dext. (BAR II 97/32/2).
8x P_3	5 sin. (BAR II 97/12/11, BAR II 97/19/6, BAR II 97/19/5, BAR 97/2/12, BAR 95/47/2). 3 dext. (BAR II 97/7/5, BAR 97/2/13, BAR 10/14).
13x P_4	9 sin. (BAR II 97/7/14, BAR II 97/3/6, BAR II 97/24/4, BAR II 97/3/18, BAR II 97/3/11, BAR II 97/19/8, BAR 23/1, BAR 9/1, BAR 10/1). 4 dext. (BAR II 97/9/2, BAR II 97/3/17, BAR II 97/31/4, BAR 1/7).
15x M_1	10 sin. (BAR II 97/25/4, BAR II 97/17/5, BAR II 97/9/22, BAR II 97/3/7, BAR II 97/28/1, BAR II 97/8/9, BAR II 97/11/32, BAR II 97/21/7, BAR II 97/9/23, BAR 11/5). 5 dext. (BAR II 97/16/13, BAR II 97/3/31, BAR 97/16/1, BAR II 3/1, BAR 10/3). 1 D4 inf. sin. (BAR 10/18).
17x fr. C indet.	BAR II 1/9, BAR II 97/21/10, BAR II 97/21/11, BAR II 97/20/5, BAR II 97/18/6, BAR II 97/17/7, BAR II 97/15/3, BAR II 97/10/11, BAR II 97/10/12, BAR II 97/7/12, BAR II 97/4/5, BAR II 97/3/28, BAR II 97/3/25, BAR II 97/1/12, BAR 97/17/1, BAR 97/19/12, BAR II 1/36.

7x fr. P indet.	1 fr. P3 indet. (BAR 10/15), 4 fr. P indet. (BAR II 97/16/15, BAR II 97/19/9, BAR II 97/17/10, BAR II 97/24/7), 2 fr. P/M indet. (BAR 95/40/9, BAR 95/57/1).
7x Milk teeth/ mlečni zobje	1 i3 sup. sin. (BAR II 97/21/16), 1 c sup. (BAR II 97/21/14), 1 D2 sup. (BAR II 97/21/13), 2 D3 sup. sin. (BAR 97/19/13, BAR 97/2/11), 1 c inf. dext. (BAR II 97/32/1), 1 D3 inf. sin. (BAR 25/5).
1x Vertebra cerv.	BAR 97/19/19.
2x Humeri	2 fr. diaphyses: 1 sin. (BAR II 97/10/16), 1 dext. (BAR II 97/26/13).
2x Ulnae	2 fr. prox. dext. (BAR 97/10/14, BAR 97/19/3).
3x Radii	1 sin.: 1 fr.diaphysis (BAR II 97/24/8). 2 dext.: 1 fr. prox. (BAR II 97/10/15), 1 fr. diaphysis (BAR II 97/26/12).
1x Tibia	1 dext. fr. dist. (BAR 97/19/2).
1x Calcaneus	1 dext. (BAR 97/19/6), complete/cel
2x Mt II	2 dext.: 1 almost complete/skoraj cel (BAR 97/7/1), 1 prox. (BAR II 97/7/25).
1x Mc IV	1 dext. (BAR II 97/16/16), complete.
2x Mp indet.	1 dist. (BAR II 1/23), 1 unfused/nezraščena dist. epiphyses (BAR II 97/21/9).
1x Phalanx I	1 dist. BAR II 97/28/4.
1x coprolite/ koprolit	BAR II 97/12/13.

97/24/3). Fifteen fragmented mandibles were found: 11 left and 4 right. The best preserved are a left mandible with complete jugale teeth row P_2-M_1 (BAR II 1/1) and a right mandible with root fragment of P_2 and P_3-M_1 (BAR II 97/14/2; *Fig. 2a*), both with gnawed symphyseal and vertical branch ends. The remaining mandible fragments mostly have gnawed parts of the mandible body containing few teeth and damaged alveoli.

Numerous isolate teeth comprise all classes of teeth, among which 43 % are with complete crown and roots, the remaining 57 % are fragmented. Fragmented teeth often show traces of predators gnawing on the roots. Milk dentition is represented by a deciduous left third incisor, a deciduous canine and a deciduous second upper molar, probably coming from the same jaw together with a third permanent premolar germ, as well as a single lower right deciduous canine, 2 left upper third milk molars, single lower third deciduous molar, and a single lower last deciduous molar.

The postcranial skeleton is represented by a single cervical vertebra, several long bones and few bones of distal extremities. The vertebra belonged to a young animal as indicated by unfused cranial and caudal articular surfaces of the vertebra body. All long bones are fragmented: two humeri, one left (*Fig. 3b*) and one right (*Fig. 3a*), one right ulna (*Fig. 4a*), three radii, one left and 2 right (*Fig. 4b*), and a single right tibia. Judging by the fused epiphyses, or solid bone structure and relative size where epiphyses are damaged, all long bones originate from adults or subadults. Distal extremities bones are represented by a right calcaneus with fused tuber calcanei, two complete and two fragmented metapodials with fused epiphyses, one unfused distal epiphysis of a metapodial and a single fragmented first phalanx.

karbonske datacije. Spodnji podočnik jamske hijene iz Baranice II (BAR II 97/16/12; OxA – 13946) je pokazal na starost > 53.100 BP (δ^{13}C – 18,069). Druga prstnica orjaškega jelena (BAR 97/19/16; OxA – 13827) iz plasti 2 Baranice I je bila datirana v 23.520 ± 110 BP (δ^{13}C – 19,415), tretji meljak jamskega medveda (BAR 97/80/1; OxA – 13828) iz plasti 4 pa v 35.780 ± 320 BP (δ^{13}C – 20,980).

OSTANKI JAMSKE HIJENE IZ BARANICE

Na površini kostnih ostankov jamske hijene iz Baranice I in II večinoma ni opaziti luščenja in razpok, ki bi nastali zaradi izpostavljenosti nihajočim (mikro) klimatskim razmeram. Tudi kostna/zobna struktura je dobro ohranjena, čeprav so najdbe izrazito fragmentirane. Obarvanost ostankov je bledo rumena, mestoma je na površini kosti in zob najti tudi črne mineralne okside.

Od lobanjskih kosti so v vzorcu zastopane izključno fragmentirane zgornje in spodnje čeljustnice. Sicer pa gradivo obsega tudi številne izolirane zobe in posamezne kosti postkranialnega skeleta (*tab. 2*).

Izmed dveh najdenih zgornjih čeljustnic ima ena ohranjena nepoškodovan tretji predmeljak in odlomek četrtega (BAR II 1/24), druga pa drugi in tretji sekalec skupaj z zobno jamico prvega (BAR II 97/24/3). Spodnje čeljustnice so zastopane s 15 primerki: enajstimi levimi in štirimi desnimi. Najbolje ohranjena sta po en levi primerek s celotnim zobnim nizom od P^2 do M^1 (BAR II 1/1) ter en desni z odlomkom korenine P^2 in nepoškodovanimi ostalimi (pred)meljaki (BAR II 97/14/2; *sl. 2a*); pri obeh sta ohranjeni tudi obgrizena simfiza in vertikalna veja mandibule. Med ostalimi primerki

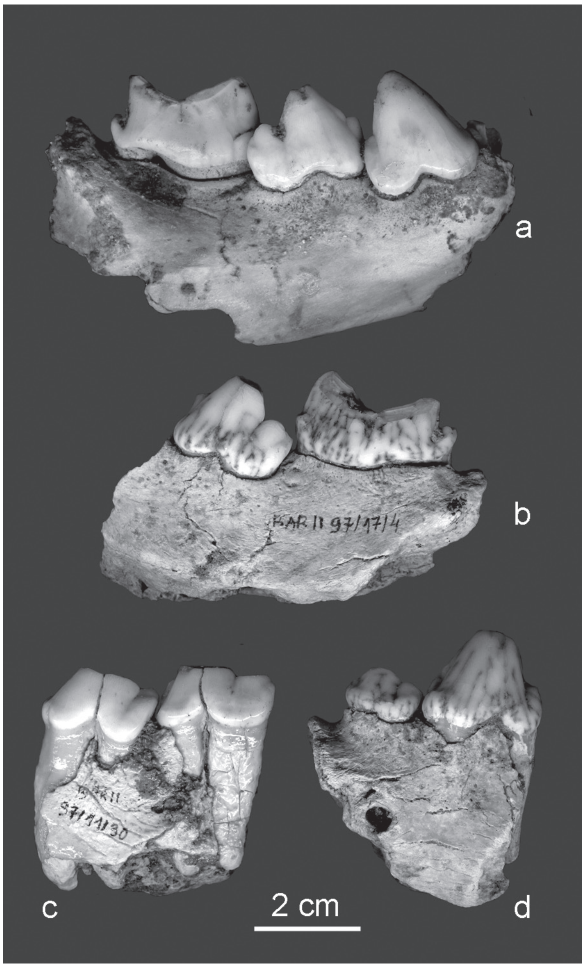

Fig. 2: Baranica Cave, *Crocuta crocuta spelaea*, mandible fragments: a – right mandible with rooth fragment of P_2 and P_3-M_1 (BAR II 97/14/2); b – left mandible with P_4 and M_1 (BAR II 97/17/4); c – left mandible with P_3 and P_4, (BAR II 97/11/30); d – left mandible with P_2 and P_3 (BAR II 97/12/10).
Sl. 2: Jama Baranica, *Crocuta crocuta spelaea*, odlomki spodnjih čeljustnic: a – desni primerek s fragmentom korenine P_2 ter P_3–M_1 (BAR II 97/14/2); b – levi primerek s P_4 in M_1 (BAR II 97/17/4); c – levi primerek s P_3 in P_4 (BAR II 97/11/30); d – levi primerek s P_2 in P_3 (BAR II 97/12/10).

The high fragmentation of hyaena remains both in Baranica I and II is the consequence of hyaena's scavenging and cannibalistic activities. Mostly bones and teeth are severely broken and many bear traces of intensive gnawing. All mandible fragments show traces that indicate that they were broken by powerful hyaena teeth (*Fig. 2*). Isolated teeth frequently show damages on the roots indicating that they are extracted from jaws by the cracking of mandibles. Long bones epiphyses are mostly completely gnawed (*Fig. 3*) or show severe gnawing and nibbling damages (*Fig. 4*), typical for the hyaena-mode of bone destruction. There are few complete bones (calcaneus, metacarpus, and an unfused distal epiphyses of a metapodial). The excellent preservation of several un-

Fig. 3: Baranica Cave, *Crocuta crocuta spelaea*, repetitive pattern of hyaena humeri gnawing: a – right humerus (BAR II 97/26/13); b – left humerus (BAR II 97/10/16).
Sl. 3: Jama Baranica, *Crocuta crocuta spelaea*, ponavljajoč se vzorec hijenjinega obgrizovanja nadlahtnice: a – desna nadlahtnica (BAR II 97/26/13); b – leva nadlahtnica (BAR II 97/10/16).

prevladujejo ogrizeni odlomki spodnječeljustničnih teles (*corpus mandibulae*) s posameznimi zobmi oz. poškodovanimi zobnimi jamicami.

Izmed številnih najdenih zob jih je 43 odstotkov ohranjenih v celoti, tj. s korenino in krono; preostalih 57 odstotkov je bolj ali manj fragmentiranih. Na koreninah slednjih so pogosto vidni odtisi zob plenilcev. Od mlečnih zob so bili v Baranici najdeni levi tretji sekalec, podočnik in drugi zgornji meljak – vsi najverjetneje pripadajo isti čeljustnici z ohranjenim zametkom stalnega tretjega predmeljaka – ter desni spodnji podočnik, dva leva zgornja ter po en tretji in zadnji spodnji meljak.

Od postkranialnih skeletnih elementov je v gradivu iz Baranice primerek vratnega vretenca, več dolgih kosti ter nekaj kosti distalnega dela okončin. Vretence je pripadalo mladi živali, o čemer pričata obe končni ploskvi, ki še nista zraščeni s telesom vretenca. Vse dolge kosti so fragmentirane: dve nadlahtnici – po ena desna (*sl. 3a*) in ena leva (*sl. 3b*), ena desna komolčnica (*sl. 4a*), tri koželjnice – po ena leva in dve desni (*sl. 4b*), ter desna golenica. Sodeč po zraščenosti epi- in diafiz oz. strukturi jedrnate (kompaktne) kosti ter dimenzijah ostankov se zdi, da so vse naštete dolge kosti pripadale bodisi subadultnim bodisi odraslim živalim. Od kosti spodnjih delov okončin so

Fig. 4: Baranica Cave, *Crocuta crocuta spelaea*, disarticulated and gnawed at both ends ulna and radius: a – right ulna; b – right radius.
Sl. 4: Jama Baranica, *Crocuta crocuta spelaea*, izolirana in obojestransko obgrizena komolčnica in koželjnica: a – desna komolčnica; b – desna koželjnica.

damaged specimens shows that physico-chemical conditions in the cave favored preservation of the remains and are not responsible for the fragmentation. Traces of water transport on the bones are not found. Preservation of permanent teeth germs with fragile tooth wall in their initial stages of development, as well as complete milk teeth support the presumption that remains were not transported by physical agencies.

Measurements of lower and upper teeth and a small number of postcranial elements that allowed for the measurements to be taken are shown in *tables 3-5*.

The relative sizes and proportions of carnassials and premolars are consistent with spotted hyaena *Crocuta crocuta*, and are distinctly different from the teeth of

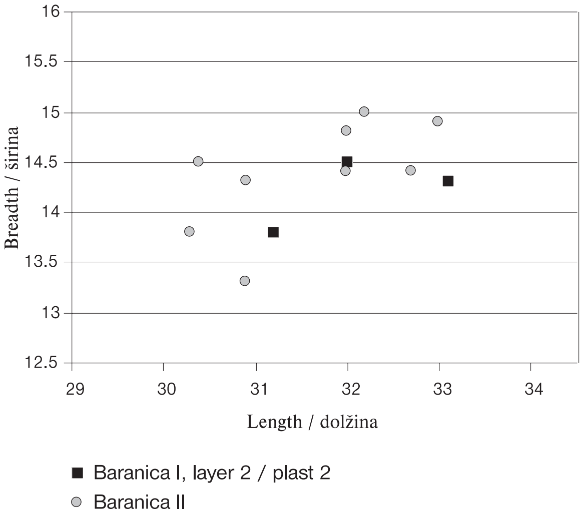

Fig.5: Baranica Cave, *Crocuta crocuta spelaea*, lower carnassial, breadth by lenght (mm), from Baranica II and layer 2 of Baranica I.
Sl. 5: Jama Baranica, *Crocuta crocuta spelaea*, spodnji derači iz Baranice II in plasti 2 Baranice I. Podani so tudi podatki o največji širini oz. dolžini (v mm) navedenih zob.

bili najdeni desna petnica z zraščeno petnično grčo (*tuber calcanei*), po dva v celoti ohranjena in dva fragmentirana metapodija z zraščenimi epifizami, še ne v celoti osificiran metapodij ter odlomek prve prstnice.

Večina kosti in zob hijene iz Baranice I in II je močno fragmentiranih – mnoge so tudi obgrizene, kar gre pripisati mrhovinarskim in kanibalističnim aktivnostim hijen samih. Sledi na odlomkih spodnjih čeljustnic kažejo, da jih je strl prav močan ugriz te živali (*sl. 2*). Na številnih izoliranih zobeh je opaziti poškodbe korenin, ki so očitno nastale med trenjem čeljustnic. Epifize dolgih kosti so bile največkrat povsem uničene (*sl. 3*), redki ohranjeni primerki pa kažejo sledi intenzivnega obgrizovanja, ki ga gre nedvomno pripisati hijeni (*sl. 4*). Nepoškodovanih kosti je zgolj peščica (petnica, dlančnica ter še nezraščena distalna epifiza nekega metapodija), skoraj pri vseh pa je odlično ohranjena kostna substanca. Slednje dokazuje, da fragmentiranosti favnističnega gradiva iz Baranice dejansko ni utemeljeno pripisati neugodnim fizikalno-kemijskim razmeram v obeh jamah, saj so bile te ohranitvi kostne substance očitno naklonjene. Prav tako na kosteh ni opaziti sledi vodnega transporta.

Najdbe zametkov stalnih zob s krhkimi stenami v zgodnji fazi razvoja ter nepoškodovanih mlečnih zob podkrepljujejo zgoraj navedeno tezo o tem, da favnistično gradivo ni bilo transportirano po zaslugi katerega izmed fizikalnih dejavnikov.

Metrični podatki za spodnje in zgornje zobe ter za manjše število dovolj dobro ohranjenih postkranialnih skeletnih elementov so podani v *tabelah 3* do *5*.

Tab. 3: Baranica Cave, *Crocuta crocuta spelaea* upper jaw teeth measurements. Explanation of abbreviations: L – mesio-distal diameter (lenght) of the crown; B – bucco-lingual diameter (breadth) of the crown.
Tab. 3: Jama Baranica, *Crocuta crocuta spelaea*, metrični podatki za zgornje zobe. Obrazložitev simbolov: L – mezo-distalni premer (dolžina) krone; B – buko-lingvalni premer (širina) krone.

		BAR 95/4/2	BAR 97/29/1	BAR II 97/31/1	BAR II 97/19/11
I^1	L	6.9	6.9	6.8	/
	B	8.6	8.9	8.6	8.9

		BAR 24/1	BAR 95/16/1	BAR II 97/24/3	BAR II 97/8/7	BAR II 97/31/2	BAR II 97/31/3	BAR II 97/3/12
I^2	L	7.7	7.5	7.1	7.4	7.6	/	/
	B	10	11	9.7	10	10	10	10

		BAR 27/1	BAR 95/60/1	BAR II 97/24/3	BAR II 97/9/7
I^3	L	11	10	9.8	10
	B	11	/	13	13

		BAR II 97/7/2	BAR II 97/11/33	BAR II 97/3/15	BAR II 97/25/8
C^s	L	15	15	15	14
	B	17	19	/	18

		BAR 95/47/1	BAR II 1/34
P^1	L	8	7.5
	B	7.4	7.2

		BAR 14/2	BAR II 1/29	BAR II 97/4/4
P^2	L	19	19	17
	B	14	15	13

		BAR 97/2/10	BAR II 1/24	BAR II 1/33	BAR II 1/35	BAR II 97/2/1	BAR II 97/25/5	BAR II 97/17/8
P^3	L	26	24	25	25	25	25	24
	B	/	18	18	19	19	/	/

		BAR 97/15/1	BAR II 1/24	BAR II 97/11/31	BAR II 97/1/11	BAR II 97/9/4
P^4	L	39	41	39	42	/
	B	21	24	21	22	22

striped hyaena *Hyaena hyaena*, as compared with the parameters given by Bonifay (1971). By its large size, they are consistent with remains of spotted hyaena in the European Late Pleistocene, most often ascribed to a subspecies *Crocuta crocuta spelaea* (Argant 1991; Davis 2002; Diedrich 2006; Kurtén 1957), the opinion that we here accept with the awareness of the existing discussion on its taxonomic status and recent results of DNA analyses (Rohland *et al.* 2005).

Relativna velikost in proporci deračev ter predmeljakov pri obravnavanem gradivu so skladni s stanjem pri lisasti hijeni *Crocuta crocuta* in odstopajo od podatkov za vrsto *Hyaena hyaena* (*cf.* Bonifay 1971). Po svojih velikih dimenzijah se ti zobje umeščajo v variacijske širine za ledenodobne lisaste hijene iz Evrope, ki se običajno obravnavajo kot samostojna podvrsta *Crocuta crocuta spelaea* (Kurtén 1957; Argant 1991; Davis 2002; Diedrich 2006). Temu sledimo tudi na tem mestu, čeprav velja

Tab. 4: Baranica Cave, *Crocuta crocuta spelaea* lower jaw teeth measurements. Explanation of abbreviations: L – mesio-distal diameter (lenght) of the crown; B – bucco-lingual diameter (breadth) of the crown.
Tab. 4: Jama Baranica, *Crocuta crocuta spelaea*, metrični podatki za spodnje zobe. Obrazložitev simbolov: L – mezodistalni premer (dolžina) krone; B – buko-lingvalni premer (širina) krone.

P_2	L	16	17
	B	12	13

P_3	L	24	/	23	23	23	23	23	22	24
	B	16	18	16	16	16	17	17	15	/

		BAR 23/1	BAR 9/1	BAR II 97/3/6	BAR II 97/3/18	BAR II 97/9/2	BAR II 97/3/17	BAR II 97/14/2	BAR II 97/11/30	BAR II 97/17/4	BAR II 97/24/2	BAR II 97/24/4	BAR II 97/7/14
P_4	L	25	25	24	24	23	25	23	23	23	23	25	26
	B	15	15	15	15	15	15	14	15	15	14	16	17

		BAR 21/2	BAR 11/5	BAR 97/16/1	BAR II 97/14/2	BAR II 97/17/4	BAR II 97/3/7	BAR II 97/17/5	BAR II 97/11/32	BAR II 97/25/4	BAR II 97/16/1	BAR II 97/28/1	BAR II 97/21/7	BAR II 97/8/9
M_1	L	32	31	33	31	32	30	/	33	32	32	30	33	31
	B	15	14	14	13	14	14	14	15	15	15	15	14	14

Tab. 5: Baranica Cave, *Crocuta crocuta spelaea*, postcranial bones measurements. Measurements after von den Driesch (1976): DPA – depth across the processsus anconeus; SD – smallest breadth of diaphysis in humerus and tibia, breadth of diaphysis in the midshaft in radius and metapodials; GL – greatest length. Additional measurements (in calcaneus and distal metapodials): ML breadth – medio-lateral breadth; AP breadth – antero-posterior breadth.
Tab. 5: Jama Baranica, *Crocuta crocuta spelaea*, metrični podatki za postkranialne skeletne elemente. Obrazložitev simbolov (*cf.* von den Driesch 1976): DPA – globina preko ankonealnega podaljška (*processus anconeus*); SD – najmanjša širina diafize pri nadlahtnici in golenici oz. širina diafize na njenem sredinskem delu pri koželjnici in metapodijih; GL – največja dolžina. Dodatni merjeni dimenziji (v primeru petnice in metapodijev): širina ML – mediolateralna širina; širina AP – anteroposteriorna širina.

		BAR 97/19/8
Calcaneus	GL	64.3
	ML breadth / širina	31.4
	AP breadth / / širina	31.5

		BAR II 97/16/16
Mc IV	GL	83.6
	SD	12.6
	Dist. ML breadth / širina	13.7
	Dist. AP breadth / širina	16.1

		BAR II 97/7/25
Mc II	GL	75.4
	SD	13.9
	Dist. ML breadth / širina	15.1
	Dist. AP breadth / širina	14.5

		BAR 97/28/4
Ph I	dist. ML breadth / širina	13.1

opozoriti, da o taksonomskem statusu ledenodobnih lisastih hijen trenutno poteka živahna diskusija, podkrepljena tudi z rezultati analiz DNK (Rohland *et al.* 2005).

Metrična analiza obravnavanega gradiva ni pokazala na obstoj kakršnih koli razlik v velikosti spodnjih deračev hijen iz plasti 2 Baranice I (datacija: 23.520 ± 110 BP, tj. OIS 2) in tistih iz Baranice II, ki so živele pred več kot 50.000 leti, tj. v domnevno toplejšem delu zadnjega glaciala (*sl. 5*). Po mnenju nekaterih avtorjev naj bi nihanje

In the sample from Baranica, there are no visible differences in size of lower carnassials (*Fig. 5*) of hyaenas that lived during the deposition of layer 2 in Baranica I, dated to 23,520 ± 110 BP, i.e. cold isotope stage 2 (OIS 2), and hyaenas from Baranica II, dated to > 50,000 BP, i.e. the supposedly warmer part of the glacial. It is argued that the size of hyaena changes according to the Bergmann rule: they are larger in cold environments and increase with the latitude (Klein, Scott 1989). However, the question remains how sensible to the temperature changes hyaenas really were, and how other factors, for example competition with other species, or constraints in an environment, might have affected their size.

HYAENA AGE STRUCTURE

The age structure of hyaenas inhabiting Baranica Cave is established on the basis of their teeth, as the most abundant remains and most reliable for age determination. There are several methods for age structure identification, based either on teeth rows or isolated teeth. Kruuk (1972), for example, distinguished 5 wear stages on permanent lower jaw teeth. Brugal *et al.* (1997) distinguished six stages including juveniles I and II (with milk teeth), subadults (III) with permanent unworn teeth, young adults (IV) with M_1 light wear, and mature and old adults (V and VI) with worn M_1. Stiner (1994; 2004) distinguished 9 wear stages on P_3, including its milk predecessor. This is also suitable (with minor adjustments) for the upper third premolar.

In Baranica teeth rows are not very numerous, while isolated teeth – including third premolars – are much better represented. Consequently, the latter method has been selected for the identification of the age structure of the Baranica's hyaenas. Stiner's dental eruption and wear sequence I-IX is subdivided into three relative age groups – juvenile (I-III), prime adult (IV-VII) and old adult (VIII-IX). Juveniles encompass deciduous premolars (I), erupted permanent third molars with unworn crown and 10-50 % formed root (II) and slightly worn crowns with more than half root formed (III). Prime adults encompass crowns with elliptical wear mark on prime cones starting with a small wear mark (IV) until the large wear mark touching accessory cusps (VII), while old adults have a large wear mark broadly connecting prime cones and accessory cusp marks (VIII) or are completely worn out (IX).

All Baranica third premolars belong to juveniles and prime adults. Age stage is identified both in the lower and upper, left and right teeth, and the minimum number of individuals (MNI) was established by counting the maximal number of the same side tooth in each stage.

A minimum number of 15 animals was established for the whole site: 5 in Baranica I and 10 in Baranica II. There are 7 juveniles: 2 belonging to stage I and 2 be-

velikosti pri hijeni sovpadalo z Bergmanovim pravilom. To pravi, da so toplokrvne živali, ki živijo na območju s hladnejšim podnebjem, praviloma višje in daljše od njihovih sorodnikov na območjih s toplejšim podnebjem (Klein, Scott 1989). Vendar pa ostaja vprašanje občutljivosti hijen na temperaturna nihanja še vedno odprto, kar velja tudi za potencialni vpliv drugih omejitvenih dejavnikov v okolju, vključno s tekmovanjem z drugimi vrstami.

STAROSTNA STRUKTURA HIJEN

Starostna struktura hijen iz Baranice temelji na rezultatih analize zob, ki kot najštevilčnejše zastopan skeletni element v vzorcu omogočajo tudi najbolj verodostojne rezultate. V literaturi je najti več različnih metodologij za ocenjevanje starostne strukture na podlagi zob. Tako npr. Kruuk (1972) razlikuje med petimi stopnjami obrabe žvekalne površine stalnih spodnjih ličnikov in kočnikov. Po drugi strani Burgal in sodelavci (1997) omenjajo sedem starostnih kategorij, vključno z juvenilnima I in II (živali z mlečnimi zobmi), subadultno (III; stalni zobje še neobrabljeni), mlado odraslo (IV; M_1 kaže prve sledi obrabe žvekalne površine) ter staro odraslo (V in VI; prvi spodnji meljak močno obrabljen). Še več stopenj – devet – navaja Stinerjeva (1994; 2004). Pri tem se osredotoča na spodnji tretji predmeljak, vključno z njegovim mlečnim predhodnikom, podoben pristop pa je z manjšimi popravki primeren tudi za zgornji tretji predmeljak.

V gradivu iz Baranice je število čeljustnic z ohranjenim celotnim zobnim nizom skromno. Bistveno bolje so zastopani izolirani zobje – vključno s tretjimi predmeljaki, zato je bila starostna struktura v našem primeru ocenjena z upoštevanjem smernic Stinerjeve. Pri tem smo devet stopenj obrabe P_3 (tj. I–IX) razvrstili v tri relativne starostne razrede: mladi (I–III), mlajši odrasli (IV–VII) in stari odrasli (VIII–IX). K mladim prištevamo mlečne primerke (I), že izrasle stalne P_3 brez sledi obrabe in z 10–50-odstotno razvito korenino (II) ter primerke z blago obrabljeno žvekalno površino in več kot polovično razvito korenino (III). Mlajše odrasle živali označuje eliptično obrabljen prednji del krone (IV) oz. začetek obrabe stranskih grebenov (VII), medtem ko k starim odraslim prištevamo primerke z napredovano stopnjo obrabe vseh grebenov (VIII) ter popolnoma obrabljene zobe (IX).

Vsi tretji predmeljaki iz Baranice pripadajo mladim oz. mlajšim odraslim živalim. Stopnja obrabe žvekalne površine je bila ugotavljana na vseh zgornjih in spodnjih ter levih in desnih P_3, pri čemer je bilo za vsako od devetih stopenj obrabe izračunano tudi najmanjše število živali (MNI; *Minimum Number of Individuals*).

Najmanjše število živali za celotno gradivo iz Baranice je 15, tj. pet iz Baranice I in deset iz Baranice II. Mladih primerkov je sedem; od tistih iz Baranice I dva izkazujeta stopnjo obrabe I ter dva stopnjo obrabe III, longing to stage III in Baranica I, and one belonging to stages I, II and III, all in Baranica II. There are 8 prime adults: one belonging to stage IV both in Baranica I and Baranica II, while stages V-VII are represented only in Baranica II – 3 in stage V, 2 in stage VI and 1 in stage VII.

The presence of both juveniles and prime adults is consistent with the presumption that Baranica Cave was used by hyaenas as a den for breeding their young. Most probably hyaenas chose Baranica II as their den in this secluded small place at the end of the cave channel[2], and this part of the cave was probably exclusively used by hyaenas. In Baranica I, the excavation that took place at the area close to the entrance, probably did not reach the particular den place, but the area also used by other animals and, occasionally, humans. Hyaenas were certainly present there too, passing on their way to deeper parts of the cave, bringing and scattering bones of animals around the place.

HYAENAS' PREY SELECTION

As a consequence of the cave hyaenas' denning, hyaena adult and cub remains were accumulated in Baranica, but also remains of the animals that hyaenas hunted or scavenged.

There is the expected lack of preference for any particular species of prey in the Baranica assemblage. As a scavenger, the hyaena searches for meat of whatever animal, which died of whatever cause, whether predator, illness, exhaustion or simply advanced age. The selectivity is noticeable concerning the availability and the size of prey. Searching for prey usually in packs, and arriving at the spot often after the main predators (i.e. hunting animals), hyaenas rarely dragged any small animals, such as beavers, or hares. The majority of their prey brought to the cave were very large, large and medium sized herbivores, while the frequency of particular herbivore species remains mostly dependent on its abundance in the region. The Baranica faunal assemblage indicates that giant deer were more abundant in the region than red deer, caballoid horse than hydruntinus, ibex than chamois. In the bone accumulation, sizes of the prey vary, and the fact that Baranica was close to the possible drinking place is of importance, since fragments of very large bones of the largest animals, mammoth and rhino, were brought into the cave.

Prey selection is also reflected in the differential distribution of age classes of various prey animals. Largest animals (like mammoth and rhino) are almost exclusively

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[2] Recent research on caves in Jordan showed that striped hyaenas raise their cubs in dens that are small and narrow, just large enough for the cubs. Although the spotted hyaena is genetically closely allied to the cave hyaena, there is a possibility that the striped hyaena is more similar in its behavior to its Pleistocene relatives since it has a habit of carrying large bones into caves (Kempe *et al.* 2006).

izmed treh tretjih predmeljakov iz Baranice II pa gre po enega pripisati vsaki od prvih treh stopenj obrabe (tj. I–III). Izmed osmih mlajših odraslih primerkov sta dva izkazovala stopnjo obrabe IV (po eden iz Baranice I in II), medtem ko so stopnje V–VII zastopane zgolj v Baranici II (3 x stopnja V, 2 x stopnja VI ter 1 x stopnja VII).

Prisotnost ostankov tako mladih kot mlajših odraslih živali je skladna s tezo, da so hijene v Baranici vzrejale svoje mladiče. Brlog je bil domnevno lociran na območju Baranice II, ki je bila takrat verjetno dobro skrita manjša terminalna dvoranica na koncu ožjega rova.[2] Pri tem se celo zdi, da so ta del jame takrat uporabljale skoraj izključno hijene. V nasprotju z navedenim na območju Baranice I brlogov najbrž nikoli ni bilo. Na tem vhodnem delu nekdanje jame, ki je bil tudi edini podrobneje arheološko raziskan, so se sicer zadrževale različne živalske vrste ter tudi človek. Same hijene so tod mimo prehajale globlje v notranjost, tjakaj prinašale ostanke plena, pri tem pa še razmetavale na tleh ležeče kosti.

IZBOR PLENA PRI HIJENI

Jama Baranica je, kot že večkrat omenjeno, v pleistocenu služila tudi kot brlog jamskih hijen. Zaradi tega tam nakopičeno favnistično gradivo obsega tako kosti in zobe odraslih hijen in njihovih mladičev kot tudi ostanke plena oz. mrhovine.

V skladu s pričakovanji med slednjimi ne izstopa nobena vrsta. Hijeno namreč kot mrhovinarja pritegne meso katere koli poginule živali ne glede na razlog pogina (tj. plenilec, bolezen, izčrpanost ali preprosto visoka starost). Selektivnost je opazna zgolj v povezavi z razpoložljivostjo in velikostjo plena. Velik plen praviloma iščejo v tropih, pri čemer na samo mesto uplenitve navadno dospejo, potem ko ga je primarni plenilec že zapustil. V primeru Baranice je bilo ugotovljeno, da so hijene v jamo prinašale predvsem zelo velike, velike in srednje velike rastlinojede, ne pa tudi manjših živali (npr. bobrov, zajcev). Delež zastopanosti posameznih rastlinojedov domnevno odseva predvsem njihovo pogostnost v takratnem okolju. Tako gre iz razpoložljivega favnističnega gradiva sklepati, da je bil orjaški jelen v okolici Baranice pogostejši od navadnega, kabaloidni konj pogostejši od hidruntinusa in kozorog pogostejši od gamsa. Da so v gradivu iz Baranice tudi ostanki največjih živali (npr. mamuta, nosoroga), gre najbrž pripisati dejstvu, da jama leži v neposredni bližini vira pitne vode, tako da pot prenosa kadavra ni bila dolga.

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[2] Novejše raziskave jamskih sistemov Jordanije so pokazale, da so brlogi progastih hijen majhni in ozki, tako da je v njih prostora zgolj za mladiče. Čeprav je jamska hijena genetsko bolj sorodna lisasti, obstaja možnost, da so bile v etološkem smislu vendarle bliže progastim hijenam, saj obe združuje praksa prinašanja večjih kosti v jamo (Kempe *et al.* 2006).

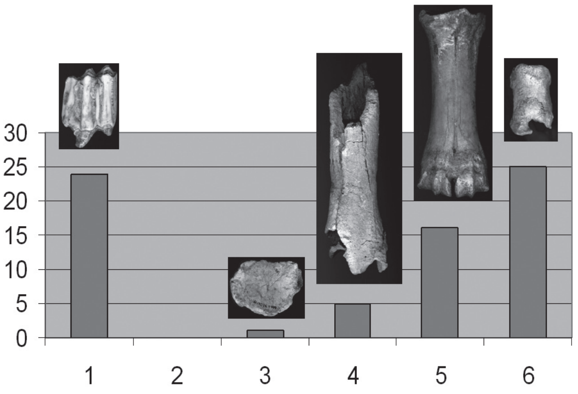

Fig.6: Baranica Cave, *Bison priscus* skeleton elements frequency: 1 – cranial; 2 – vertebra and ribs; 3 – girdles; 4 – long bones; 5 – metapodials; 6 – carpals, tarsals and phanages.
Sl. 6: Jama Baranica, zastopanost posameznih skeletnih elementov vrste *Bison priscus*: 1 – lobanja; 2 – vretenca in rebra; 3 – oplečje/okolčje; 4 – dolge kosti; 5 – metapodiji; 6 – zapestne in nartne kosti ter prstnice.

presented by very young or very old animal remains, while large (horse, bison, giant deer) to medium sized (ibex) herbivorous remains comprise also remains of young adults and adults. This is probably the consequence of altering strategies on hunting and scavenging, with the largest animals being exclusively scavenged, while juveniles and large to medium sized adults were casually hunted. On the other hand, the body part representation is similar for most of the herbivorous prey in those cases where the representation of these respective species suggests a pattern (horse, bison, giant deer and ibex). Cranial elements are well-represented, and among them by far the most numerous are teeth. Distal extremities are even more frequent, while upper extremities, girdles, vertebrae and ribs are rare or entirely missing (*Fig. 6*).

CONCLUSION: COMPETITION FOR THE LIVING SPACE IN BARANICA

Animal remains that were accumulated in Baranica Cave indicate prolonged use of various passages and chambers of the cave by hyaena. Several characteristics indicate that the Baranica II assemblage was almost exclusively, and Baranica I to a great extent, accumulated by hyaena: the taxonomic variability of the faunal composition, large number of carnivorous taxa present, abundant hyaena remains, the prevalence of very large and large-size when compared to middle and small size herbivores, and tooth marks and modifications on a large number of mammal bones. There is a single major difference in relation to most of the other described fossil hyaena den sites. It relates to the fact that only one coprolite has been found[3]. The presence of one would indicate that their preservation was possible, which in turn accentuates their absence. However, it is possible

Selektivnost pri izbiri plena je razvidna tudi v različni zastopanosti posameznih starostnih skupin uplenjenih živali. Od velikih živali (npr. mamuta, nosoroga) so v gradivu prisotni skoraj izključno ostanki zelo mladih ali zelo starih primerkov, medtem ko so veliki (konj, zober, orjaški jelen) in srednje veliki (kozorog) rastlinojedi zastopani tudi z najdbami mladih odraslih in odraslih živali. Ugotovitev je najbrž povezana z dejstvom, da sta se strategiji lova in mrhovinarstva razlikovali na način, da so bile največje živali hijenam dostopne zgolj kot mrhovina, medtem ko so mlade mamute ali nosoroge ter srednje velike rastlinojede vseh starosti občasno tudi plenile. Drugače kot ob vzporejanju starostnih struktur analiza zastopanosti posameznih skeletnih elementov ni pokazala na obstoj opaznejših medvrstnih razlik pri nobenem od zadovoljivo zastopanih rastlinojedov (konjev, zobrov, orjaških jelenov in kozorogov). Številni so ostanki kranialnih skeletnih elementov, predvsem zob. Še bolje zastopane so kosti distalnega dela okončin, medtem ko je ostankov proksimalnega dela okončin, oplečja oz. okolčja, vretenc in reber zgolj peščica oz. ti v celoti manjkajo (*sl. 6*).

SKLEP: TEKMOVANJE ZA ŽIVLJENJSKI PROSTOR V BARANICI

Živalski ostanki iz jame Baranica pričajo, da so hijene njene hodnike in dvorane uporabljale dalj časa. Vrstna pestrost vzorca (vključno z velikim številom zverskih vrst), številni ostanki hijene, boljša zastopanost zelo velikih in velikih rastlinojedov nasproti srednje velikim in majhnim ter številne obgrizene kosti so vse indici v prid tezi, da so v Baranico II zahajale skoraj izključno, v Baranico I pa predvsem hijene. V primerjavi z večino drugih objavljenih jamskih brlogov navedene vrste se tisti iz Baranice razlikuje predvsem po tem, da je bil ob kosteh najden zgolj en primerek koprolita.[3] Njegova prisotnost dokazuje, da so se koproliti v tamkajšnjem mikrookolju očitno lahko ohranili, kar le še poudarja pomen njihove siceršnje odsotnosti. Je pa seveda povsem mogoče tudi to, da niso enakomerno razporejeni po

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[3] This single coprolite is sampled for pollen analysis: 13 pollen grains were extracted, not enough for precise reconstruction, but still giving some information on the vegetation, indicating a very open landscape in the surroundings of Baranica, with the presence of steppe taxa related to rather harsh climatic conditions (Argant, Dimitrijević 2007).

[3] Palinološka analiza koprolita je zajela 13 pelodnih zrn. Žal skromnost vzorca onemogoča natančno rekonstrukcijo paleookolja, vseeno pa iz rezultatov analize izhaja, da je bila pokrajina v okolici Baranice zelo odprta. Najdeni so bili namreč ostanki stepskih vrst, vezanih na razmeroma ostre klimatske razmere.

that coprolites were not evenly distributed across the den site but concentrated in unexcavated areas.

In Baranica II, there is also a complete absence of traces of other inhabitants: there are no artifacts made by humans, no cubs’ remains of other carnivorous species, and no teeth traces on bones that would indicate larger or smaller species of carnivores than hyaena.

With Baranica I the circumstances are more complicated. The presence of humans is proven on the basis of lithic implements. However, humans probably only rarely visited Baranica, and did not spent too much time in it. The number of artifacts is low, they all belong to defined tool types and no flint chips have been found, even in wet-sieved samples, indicating that artifacts had not been made on-site, but brought from outside. There are also almost no traces of flint artifacts on animal bones to indicate their usage for processing animal carcasses.

It is more likely that various species of carnivores occasionally used this part of the cave than Baranica II – fox and wolf, for example. The pattern of bone fragmentation differs, and there are traces of gnawing that correspond to smaller teeth than hyaenas’. Three milk teeth of cave bear have been found. Although cave bear remains are not numerous, and probably bears did not shelter in the entrance part that was excavated, it is quite probable that they used some of the unexplored parts of the cave. It is already mentioned that Baranica is a complex cave system, of which Baranica II and I are only small parts.

Undoubtedly, competition for the living space in Baranica was fierce, but cave hyaena doiminated in these “battles”.

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površini jame, temveč večinoma ležijo na katerem od njenih neizkopanih delov.

V Baranici II poleg koprolitov v celoti manjkajo tudi sledi eventualnih drugih obiskovalcev jame: ni namreč človekovih artefaktov, ni ostankov mladičev drugih zverskih vrst in ni niti odtisov zob, ki bi jih lahko povezali s katero od večjih oz. manjših zveri, kot je hijena.

Okoliščine, povezane z Baranico I, so bolj zapletene. Najdbe kamnitih izdelkov dokazujejo prisotnost človeka, čeprav je jamo verjetno obiskoval bolj poredkoma. Število artefaktov je namreč pičlo, zastopani so zgolj končni izdelki, odsotnost odbitkov – tudi v sedimentu, ki je bil spran skozi sita – pa priča o tem, da orodij ni izdeloval v jami. Skoraj v celoti manjkajo tudi sledi urezov na kosteh, ki bi kazali na uporabo kamnitih orodij pri raztelešanju plena oz. mrhovine.

Podobno kot ljudje so tudi različne zveri (npr. lisica, volk) obiskovale predvsem Baranico I. Vzorec fragmentiranosti kostnih najdb s tega dela jame je namreč drugačen, na nekaterih obgrizenih kosteh so prisotni odtisi zob, ki so manjši od hijeninih. V navedenem gradivu so, kot že omenjeno, tudi trije mlečni zobje jamskega medveda. Nizko število ostankov gre vsaj do neke mere gotovo povezati z dejstvom, da so arheološka izkopavanja zajela zgolj vhodni del Baranice I, medtem ko so medvedi najbrž večinoma prezimovali v globljih delih jame. Ne gre namreč pozabiti, da je Baranica kompleksen jamski sistem, od katerega predstavljata Baranica I in II zgolj manjši del.

Tekmovanje za življenjski prostor v Baranici je bilo nedvomno ostro, a kot kaže, je bila zmagovalec v teh “bitkah” prav hijena.

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Prevod: Borut Toškan

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SEX AND SIZE OF THE KRAPINA CAVE BEARS

SPOL IN VELIKOST KRAPINSKIH JAMSKIH MEDVEDOV

Preston T. MIRACLE

Abstract

Krapina, world-famous for its large and variable Neandertal fossils, is also a key site for examining Neandertal lifeways and environments during the last interglacial period (MIS 5e, approximately 130,000 BP). The largest sample of vertebrates at Krapina comes from the cave bear (*Ursus spelaeus*). This study presents a detailed analysis of the sex structure of the Krapina cave bear assemblage and compares it to other sites in the region. The Krapina cave bear assemblage is overwhelmingly dominated by males (frequency of males from 63.6–100%, depending on the element analysed), and the male bias is found in the head, teeth, and major limb bones. Krapina was primarily used by prime-aged to old-adult male cave bears, once the rockshelter had mostly filled with sediment eroded from the shelter roof and wall (Miracle 2007). Contrasts in body size between Krapina and nearby sites, after sexual dimorphism is taken into account, are significant and striking. The Krapina male cave bears are smaller than male cave bears from Divje babe I facies A (MIS 3) and Divje babe I facies C (MIS 5a-d). The small size of the Krapina male cave bears is best understood as an adaptation to a full interglacial climate. These results suggest that Krapina's stratigraphy extended neither into later substages of the last interglacial (e.g. MIS 5a-d) nor into the last glacial (MIS 3–4). Temporal changes at Krapina in subsistence activities, stone tool production, and site use (Miracle 2007) occurred over a relatively short time period; Neandertals were behaviourally flexible and shifted their activities and strategies in response to local conditions and opportunities.

Keywords: Krapina, Divje babe, cave bear, Pleistocene, sexual dimorphism, body size, Croatia, Slovenia, palaeontology

Izvleček

Krapina, ki je svetovno slavo dosegla s svojim obsežnim in pestrim vzorcem neandertalskih fosilov, je tudi ključno najdišče za razumevanje načina življenja te izumrle vrste človečnjakov ter okolja v zadnji medledeni dobi (MIS 5e) pred približno 130.000 leti. Vendar pa predmet tega prispevka ni neandertalec, temveč jamski medved (*Ursus spelaeus*), najbolje zastopan vretenčar v najdišču. Rezultati detajlne analize spolne strukture krapinskih medvedov so pokazali na izrazito prevlado samcev (njihov delež niha med 63,3 in 100 %, odvisno od analiziranega skeletnega elementa), in to tako pri najdbah glave in zob kot tudi kosti okončin. Potem ko so spodmol v večjem delu zapolnili sedimenti, ki so nastali z erodiranjem stropa, so najdišče očitno povečini uporabljali mladi odrasli do odrasli medvedi (Miracle 2007). Analiza velikosti je pokazala na obstoj značilnih, od spolnega dimorfizma neodvisnih razlik v velikosti živali iz Krapine v primerjavi s tistimi iz sosednjih najdišč. Kot se je namreč izkazalo, so samci iz Krapine po svojih dimenzijah zaostajali tako za primerki istega spola iz Divjih bab I – facies A (MIS 3) kot tudi za tistimi iz faciesa C (MIS 5a–d). Majhnost krapinskih jamskih medvedov lahko najbolje razložimo kot prilagoditev na klimatske razmere visokega interglaciala. Iz navedenega gre torej sklepati, da v Krapini manjkajo tako sedimenti iz kasnejših faz zadnjega interglaciala (npr. MIS 5a–d) kot tudi tisti iz zadnjega glaciala (MIS 3–4). V primeru obravnavanega najdišča je do časovnih sprememb v njegovi uporabi, v aktivnostih, ki so zagotavljale obstanek, ter v izdelavi kamnitih orodij prišlo v razmeroma kratkem času; neandertalci so bili očitno vedenjsko prožni, tako da so lahko spreminjali svoje dejavnosti in strategije odvisno od vsakokratnih lokalnih razmer in možnosti.

Ključne besede Krapina, Divje babe I, jamski medved, pleistocen, spolni dimorfizem, velikost telesa

INTRODUCTION

Every since their discovery over a century ago, Krapina's world-famous Neandertals have commanded the palaeoanthropological spotlight. The almost 1000 Neandertal fossils have contributed immeasurably to our knowledge of Neandertal morphology and behaviour owing to their variability and diversity (Gorjanović-Kramberger 1906; Smith 1976; Radovčić *et al.* 1988; Frayer 2006). Recently the archaeological context of these remains has received greater attention through detailed studies of the Mousterian stone tools (Simek 1991; Simek, Smith 1997) and the palaeontology and zooarchaeology of the animal remains (Miracle 2007). The stone artefacts and animal remains are proving to be a rich and productive source of new information and insight about how Neandertals behaved as well as their subsistence practices, social organization, and interactions with their surroundings.

Without wishing to take anything away from the Krapina Neandertals, it is important to note that numerically the most important taxon in the Krapina collections is the cave bear (Miracle 2007, 10), even though many of the ribs, vertebrae, and limb extremities published in the first faunal list (Gorjanović-Kramberger 1901, 177 f) are now missing from the faunal collection. Because bears and hominins were sympatric species over hundreds of thousands of years in Europe, and owing to their shared (time-shared?) use of caves and rock overhangs for shelter and habitation, the ecology of one has important implications for the other (Gamble 1986; Miracle 1991; Stiner *et al.* 1998). The Krapina cave bear assemblage is thus interesting in its own right as well as for the information it provides about the context of Neandertal activities and occupations.

A basic morphological and metrical description of the cave bear remains from Krapina has been recently presented in the context of taphonomic and zooarchaeological analyses (Miracle 2007). The Krapina cave bear assemblage showed highly skewed sex and age profiles, and it was concluded that "the last major phase of occupation at Krapina (layer 9) [was not by Neandertals but by] ... prime-adult to old male cave bears" (Miracle 2007, 236). There is no evidence of hominin involvement in the accumulation or modification of cave bear remains. Thus "internecine killing may have been a common source of [cave bear] mortality; in such cases Krapina was heavily contested by bears as a den" (Miracle 2007, 236). It was also suggested that the changing composition and character of the cave bear-dominated assemblage in layer 9 at Krapina suggested that sedimentation continued beyond full interglacial conditions of Marine Isotope Substage (MIS) 5e into a stadial (MIS 5d) marked by a somewhat cooler and more arid climate (Miracle 2007, 216). Increased intraspecific competition among cave bears

UVOD

Vse od samega odkritja pred več kot stoletjem so svetovno znani krapinski neandertalci v središču paleoantropološkega zanimanja. Skoraj 1000 razpoložljivih fosilnih najdb je spričo svoje variabilnosti in raznolikosti ogromno prispevalo k našemu poznavanju morfologije in vedenja neandertalcev (Gorjanović-Kramberger 1906; Smith 1976; Radovčić *et al.* 1988; Frayer 2006). V zadnjem času se je več pozornosti namenjalo arheološkemu kontekstu navedenih najdb. Med drugim so bila npr. analizirana musterjenska kamnita orodja (Simek 1991; Simek, Smith 1997), opravljeni pa sta bili tudi paleontološka in arheozoološka študija favnističnega gradiva (Miracle 2007). Tako kamnita orodja kot tudi živalski ostanki so se pokazali kot bogat in ploden vir novih spoznanj o neandertalčevem vedenju, aktivnostih, ki so mu zagotavljale obstanek, socialni organiziranosti ter interakciji z okolico.

Ne da bi želeli v čemer koli zmanjšati pomen krapinskih neandertalcev, pa se zdi na tem mestu vendarle pomembno poudariti, da je kvantitativno najpomembnejši takson v gradivu iz obravnavanega najdišča vendarle jamski medved (Miracle 2007). In to navkljub temu, da so se številni ostanki reber, vretenc in kosti spodnjih delov okončin, ki so sicer navedeni na prvem seznamu favnističnih najdb (Gorjanović-Kramberger 1901, 177s), kasneje izgubili in danes niso več sestavni del obstoječe zbirke. Glede na to, da so bili evropski hominini in medvedi stotisočletja simpatrični, pri čemer so oboji (časovno deljeno?) uporabljali jame in spodmole za zavetišče in bivališče, je imela ekologija enih pomembne implikacije za druge (Gamble 1986; Miracle 1991; Stiner *et al.* 1998). Krapinski jamski medved je torej zanimiv že sam po sebi, ob tem pa seveda ponuja tudi spoznanja o kontekstu neandertalčevih aktivnosti in bivanja v jami.

Krajši morfološki in metrični opis ostankov jamskega medveda iz Krapine je bil predstavljen že v okviru nedavno objavljenih tafonomske in zooarheološke študije živalskega gradiva iz navedenega najdišča (Miracle 2007). Rezultati so pokazali na izrazito asimetrično porazdeljenost najdb med oba spola oz. med posamezne starostne razrede ter tako privedli do sklepa, da "so med zadnjo izrazitejšo poselitveno fazo v Krapini (plast 9) tam [namesto neandertalcev] ... prevladovali mladi odrasli do stari samci jamskega medveda" (Miracle 2007, 236). Ker na ostankih ni bilo opaziti nikakršnih indicev za domnevo o aktivni vlogi homininov pri njihovem kopičenju oz. procesiranju, je bila omenjena tudi možnost, da so "pomemben vir smrtnosti [pri jamskem medvedu] predstavljali medsebojni spopadi; to bi seveda pričalo o ogorčenem boju za prezimovanje v obravnavanem spodmolu" (Miracle 2007, 236). V isti publikaciji je tudi omenjeno, da bi spreminjajoča se sestava in značaj skupka favnističnih ostankov iz plasti 9 lahko kazali na nadaljevanje sedimentacije v Krapini tudi še po koncu at Krapina thus appears to have occurred in a context of deteriorating climatic conditions.

This ecological interpretation of the Krapina cave bears rests on somewhat shaky foundations. First of all, collection and curation biases have had a major impact on the Krapina cave bear assemblage. Although it has been argued that the presence of heavily worn and fragmentary teeth indicates that there was not a curatorial preference for the relatively larger remains of adult male cave bears, there is no corroborating evidence of a male-skewed sex ratio other than the relatively large number of cave bear baccula (Miracle 2007, 61 f).

The second wobbly support comes from the chronology. Electron spin resonance (ESR) dates on rhino teeth date the deposits to ca. 130,000 ± 10,000 B.P. (Rink *et al.* 1995), which falls within Marine Isotope Substage (MIS) 5e. Given that the MIS 5e/5d transition occurred about 115 ka (Lowe, Walker 1997, 327), the existing chronometric dates from Krapina can be used to support both a "short stratigraphy", in which deposition occurred only during MIS 5e, and a "long stratigraphy" in which deposition extended into MIS 5d. Large mammals have shown dramatic changes in body size that correlate with global changes in temperature; especially striking is the decrease in body size across the Pleistocene-Holocene transition (Kurtén 1965; Davis 1981). Kurtén (1968, 123) reported that Eemian forms of cave bear were "on average somewhat smaller than the full-fledged cave bears of the last glaciation." Hence one could use the size of the Krapina cave bears to address the issue of chronology. Cave bears that lived at a time of full interglacial conditions (e.g. MIS 5e) should be smaller than those that died under stadial (e.g. MIS 5d) or glacial (e.g. MIS 2–4) conditions.

Because cave bears were highly sexually dimorphic (Kurtén 1955), one needs to control for sex before one can compare body size. The degrees of sexual dimorphism and body size are population specific; they can change over space and time in response to various environmental factors. Furthermore, the quality of interpretations of sexual dimorphism and body size depends on assemblage homogeneity and size. The homogeneity of the Krapina cave bear assemblage is difficult to address; although the assemblage probably represents a single regional population, there is little control of the time span over which it could have been sampled. Although sedimentation at Krapina appears to have been episodic and most of the cave bear remains appear to have come from a single depositional layer (Miracle 2007, 5), the remains could have accumulated over decades, centuries, or even millennia. Thus the potential impact of assemblage homogeneity and heterogeneity must be acknowledged even if it cannot be evaluated.

The goals of this study are to analyse in detail the sex structure of the Krapina cave bear assemblages and to compare the Krapina bear assemblages to other sites

visokointerglacialnih razmer morske izotopske podstopnje (= MIS; *Marine Isotope Substage*) 5e v nekoliko hladnejši in bolj sušen stadial MIS 5d (Miracle 2007, 216). V skladu s tem bi lahko povečanje konkurence med jamskimi medvedi za prezimovanje (pri medvedih ne gre za pravo zimsko spanje/hibrnacijo, marveč prej za dremež) v krapinskem spodmolu umestili v kontekst poslabšanja klimatskih razmer.

Ekološka interpretacija krapinskih jamskih medvedov stoji na nekoliko majavih nogah. Kot prvi razlog za to velja navesti pristranskost pri pobiranju in konzerviranju najdb, kar je nedvomno imelo velik negativen vpliv na vsebino obstoječe zbirke kosti in zob. Čeprav naj bi prisotnost močno obrabljenih zob pričala o tem, da kustosi med urejanjem zbirke niso dajali prednosti dobro ohranjenim velikim ostankom odraslih samcev, pa z izjemo dokaj številnih ostankov penilnih kosti (*os penis*) drugih očitnih dokazov za razmerje, nagnjeno v izrazito prid samcem, med spoloma pravzaprav ni (Miracle 2007, 61 s).

Drugo težavo predstavlja kronologija. Datacije nosorogovih zob, pridobljene s tehniko elektronske spinske resonance (ESR; *Electron Spin Resonance*), so pokazale na starost pribl. 130.000 ± 10.000 BP (Rink *et al.* 1995), kar sovpada z MIS 5e. Ker naj bi do prehoda MIS 5e v 5d prišlo pred pribl. 115.000 leti (Lowe, Walker 1997, 327), lahko kronometrične datume iz Krapine razumemo kot argument v prid tako "kratki stratigrafiji", po kateri naj bi sedimentacija potekala zgolj v MIS 5e, kot tudi "dolgi stratigrafiji", v skladu s katero naj bi se sedimentacija nadaljevala še tudi v MIS 5d. Globalne spremembe v temperaturah so na nivoju velikih sesalcev odsevale v očitnih spremembah velikosti živali; še posebej izstopajoč v tem smislu je bil upad velikosti na prehodu iz pleistocena v holocen (Kurtén 1965; Davis 1981). Po poročanju Kurténa (1968, 123) naj bi bili jamski medvedi iz zadnjega interglaciala "v povprečju nekoliko manjši od povsem odraslih primerkov iz zadnjega glaciala". Glede na navedeno bi torej kronološko problematiko lahko pomagali pojasniti tudi podatki o velikosti krapinskih jamskih medvedov. Živali iz visokega interglaciala so namreč po velikosti domnevno zaostajale za tistimi, ki so živele v razmerah stadialne (npr. MIS 5d) ali glacialne (npr. MIS 2–4) klime.

Jamski medved izkazuje očiten spolni dimorfizem (Kurtén 1955), zato študije velikosti brez predhodne razvrstitve analiziranih ostankov med oba spola niso smiselne. Pri tem sta seveda tako izraženost spolnega dimorfizma kot tudi sama velikost živali populacijsko specifični; v prostoru in času sta spremenljivi, pač v odvisnosti od različnih okoljskih dejavnikov. Poleg tega je kvaliteta interpretacije podatkov o spolnem dimorfizmu in telesni velikosti odvisna tudi od obsega in homogenosti analiziranega gradiva, kar pa je v primeru Krapine težko oceniti. Čeprav obravnavani vzorec namreč najverjetneje vključuje ostanke zgolj ene regijske populacije, pa ni zanesljivih podatkov o tem, kako dolgo so se ti dejansko from the region. The focus is on the major limb bones to investigate the degree of sexual dimorphism in these populations and evidence of contrasts in body size between these sites after sexual dimorphism has been taken into account. These analyses are used to answer two main questions:

1. Do cave bear long-bones from Krapina show a male-skewed sex ratio similar to that observed in the canine teeth? What are the implications of these results for interpretations of cave bear ecology at Krapina?
2. How large were the Krapina cave bears compared to cave bears from nearby sites of known age? What are the implications of these results for interpretations of the chronology of Krapina?

KRAPINA STRATIGRAPHY AND CAVE BEARS

Krapina is a rockshelter located at 120 m a.s.l. in Miocene sandstone on the northeastern slope of Hušnjakovo hill about 25 m above the Krapinica River (*Fig. 1*). The site was excavated from 1899–1905 by Dragutin Gorjanović-Kramberger (Gorjanović-Kramberger 1906; Radovčić 1988). The rockshelter contained a sequence of over 9 metres of deposit. The lowermost metre consisted of mostly fluvial sediments, although there were some lenses bearing stone artefacts and animal remains; together they were labelled as "layer 1" . The overlying 8 metres of allocthonous cave sediments contained 8 visible cultural layers that in section appear as darker bands that were presumably rich in ash, charcoal, and archaeological remains. These layers were numbered layer 2 (lowest) to layer 9 (uppermost).

Gorjanović published brief observations about the Krapina bears, focussing on evidence of pathologies on the cave bear bones (Gorjanović-Kramberger 1902). Later he briefly considered the implications of the faunal remains for Neandertal subsistence (Gorjanović-Kramberger 1913, 36 f). He suggested that cave bears died at the site of their own accord, noting that many of the cave bear bones showed evidence of osteoarthritis and old age. Although only 12 of these remains were marked with stratigraphic information (layers 1, 5–6, 7, and 9), Gorjanović (Gorjanović-Kramberger 1913, 2) noted that remains of cave bears were dominant in the uppermost part of the sequence (layer 9), as he also indicated on stratigraphic sections (Gorjanović-Kramberger 1901, 173; Malez 1970a, Profile 4, Prilog 1–2).

The cave bear (*Ursus spelaeus*) is represented by a NISP of 365 and MNI[1] of 12 based on the upper C; a relatively large number of these remains are measurable (Miracle 2007, 30). The Krapina cave bear assemblage contains all parts of the skeleton, although the

kopičili v spodmolu. Res je, da je bila sedimentacija v Krapini najbrž epizodična in da večji del medvedjih ostankov izvira iz iste plasti (Miracle 2007, 5), a ti so se vendarle lahko kopičili desetletja, stoletja ali celo tisočletja trajajoče obdobje. Morebitnega vpliva homogenosti oz. heterogenosti analiziranega favnističnega skupka se je torej treba vsekakor zavedati, čeprav ga sicer ne moremo oceniti.

Namen prispevka je bil natančno preučiti spolno strukturo krapinskih jamskih medvedov in jo primerjati s spolnimi strukturami, ki se nanašajo na medvede iz drugih najdišč v regiji. Poudarek je bil na dolgih kosteh okončin, pri čemer so nas zanimale tudi stopnja izraženosti spolnega dimorfizma v obravnavanih populacijah ter morebitne razlike v telesni velikosti medvedov iz različnih najdišč (seveda ob upoštevanju spola). V tukaj predstavljeni študiji smo torej iskali odgovora na naslednji osrednji vprašanji:

1. Ali tudi med dolgimi kostmi iz Krapine prevladujejo primerki samcev, tako kot je bilo to že ugotovljeno pri podočnikih? Kakšne so implikacije teh rezultatov za interpretacijo ekologije krapinskih jamskih medvedov?
2. Kako veliki so bili krapinski jamski medvedi v primerjavi s tistimi znane starosti iz drugih najdišč v regiji? Kakšne so implikacije teh rezultatov za kronologijo Krapine?

STRATIGRAFIJA KRAPINE IN JAMSKI MEDVEDI

Krapina je spodmol, ki se je na nadmorski višini 120 m oblikoval v miocenskem peščenjaku severovzhodnega pobočja Hušnjakovega hriba, kakšnih 25 m nad strugo reke Krapinice (*sl. 1*). V letih 1899–1905 je na najdišču izkopaval Dragutin Gorjanović-Kramberger (Gorjanović-Kramberger 1906; Radovčić 1988). V spodmolu je bilo dokumentiranih več kot devet metrov odloženega materiala. Najgloblјo plast okvirne debeline enega metra sestavljajo večinoma fluvialni sedimenti, čeprav so bile vmes odkrite tudi posamezne leče s kamnitimi artefakti in živalskimi ostanki; oboje skupaj predstavlja "plast 1". Preostalih osem metrov sedimentnega zaporedja sestavljajo alohtoni jamski sedimenti. Prepoznati je bilo mogoče osem kulturnih plasti, ki so v profilu videti kot temnejše proge, domnevno bogate s pepelom, ogljem in arheološkimi najdbami. Te plasti so bile oštevilčene od 2 (najgloblja plast) do 9 (najvišja plast).

Gorjanović je svoje ugotovitve o krapinskih jamskih medvedih strnil v krajše poročilo, s poudarkom na patoloških primerkih kosti (Gorjanović-Kramberger 1902). Kasneje se je na kratko ustavil še pri implikacijah živalskih ostankov za strategijo preživetja neandertalcev (Gorjanović-Kramberger 1913, 36 s). Sklepal je, da za pogin jamskih medvedov niso bili odgovorni ljudje; med izkopanimi kostmi je bilo namreč veliko takih, ki so pripadale bolnim (osteoartritis) ali ostarelim živalim. Čeprav so bili za zgolj dvanajst od teh kosti znani

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[1] NISP – *Number of Identified Specimens*; MNI – *Minimum number of individuals*.

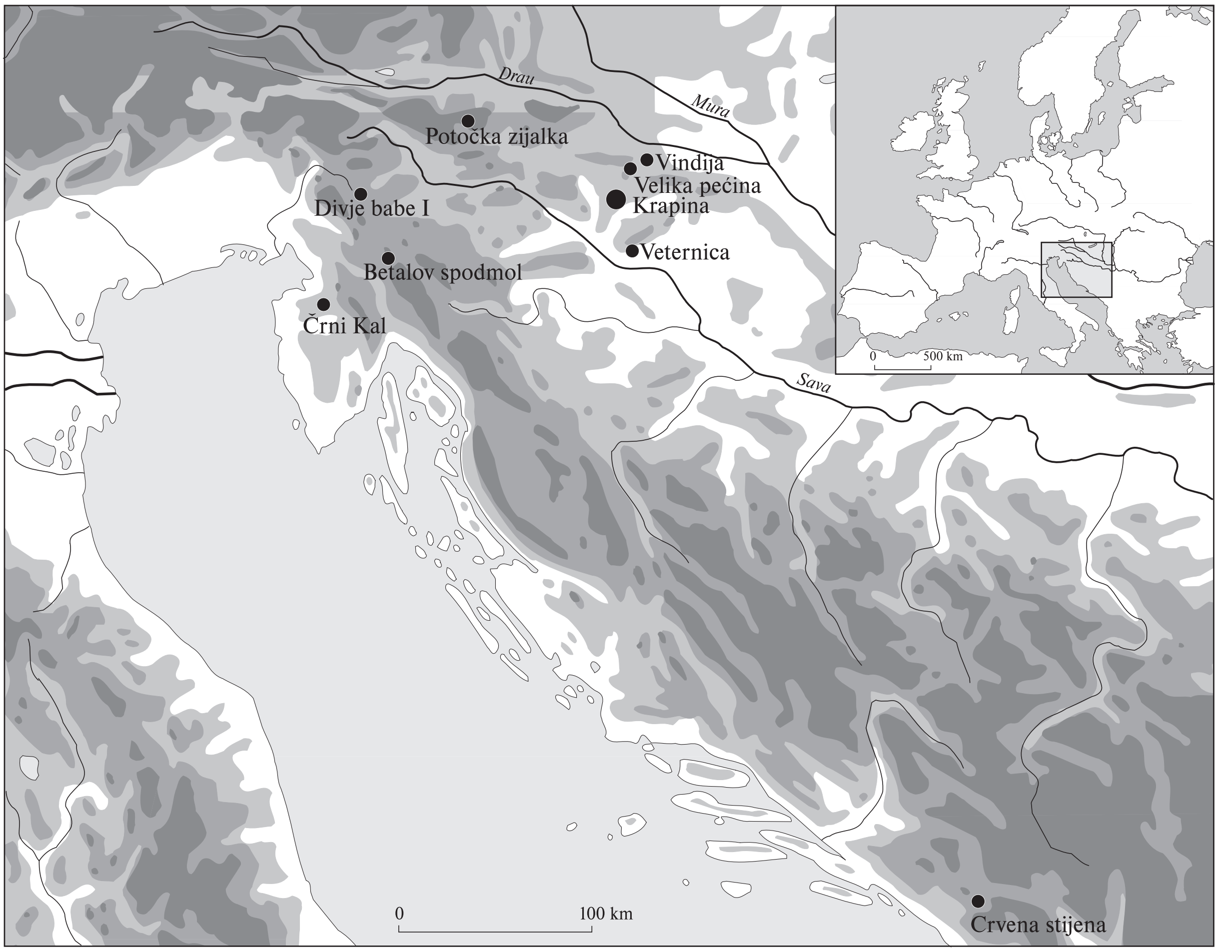

Fig. 1: Map of the region showing the location of Krapina, Divje babe I, and other important sites.
Sl. 1: Zemljevid območja s Krapino, Divjimi babami I ter drugimi pomembnejšimi najdišči.

axial skeleton, with the exception of the bacculum, is under-represented relative to the appendicular skeleton (Miracle 2007, 79). Some of this pattern is owing to a curatorial bias; many of the axial remains have disappeared from the collection since Gorjanović's original inventory in 1901 (Miracle 2007, 9). However, if one compares the frequency of major limbs to the boney parts of the head, one finds that upper and lower limbs are present in similar numbers to heads (Miracle 2007, 79 f). These data suggest that complete cave bear skeletons were deposited at Krapina. There is little evidence of modification of cave bear bones by either carnivores (1.1% of bone NISP gnawed) or hominins (2.2% of bone NISP with cut marks), and over 75% of the cave bear bones are whole (Miracle 2007, 80).

Owing to the rather modest size of the Krapina cave bear assemblage, the standard approach of searching for bimodal distributions of measurements, whether using univariate, bivariate, or multivariate techniques, has proven to be inapplicable. Therefore it has been necessary to compare the dimensions of the Krapina cave bear limb bones to much larger assemblages from

stratigrafski podatki (plasti 1, 5–6, 7 in 9), je Gorjanović (Gorjanović-Kramberger 1913, 2) prevlado ostankov jamskega medveda v zgornjem delu sedimentnega stolpca (plast 9) vseeno opazil in to tudi ustrezno označil na stratigrafskem profilu (Gorjanović-Kramberger 1901, 173; Malez 1970a, profil 4, prilogi 1–2).

Danes obsega zbirka ostankov jamskega medveda (*Ursus speleaus*) iz Krapine 365 najdb (NISP = 365), ki so – sodeč po podočnikih – pripadale najmanj dvanajstim živalim (MNI[1] = 12; Miracle 2007, 30). V gradivu so zastopani vsi skeletni elementi, so pa kosti osnega skeleta – z izjemo penilne – manj številne od tistih privesnega skeleta (Miracle 2007, 79). Delno so za navedeno neravnovesje odgovorni kustosi zbirke; mnogi ostanki osnega skeleta, ki jih je Gorjanović vključil v svoj popis najdb iz leta 1901, so namreč kasneje izginili (Miracle 2007, 9). Po drugi strani pa primerjava frekvence pojavljanja večjih kosti okončin in koščenih delov glave kaže, da je zastopanost ostankov prednjih in zadnjih

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[1] NISP – število določenih primerkov (*Number of Identified Specimens*); MNI – najmanjše število živali (*Minimum number of individuals*).

nearby sites in Slovenia (Pacher *et al.* 2004; Turk 2007), several caves in the Eastern Alps (Reisinger, Hohenegger 1998), as well as to a large sample of cave bears from Spain (Torres *et al.* 1991).

The site of Divje babe I provides a particularly important assemblage for comparisons. Recent, state-of-the-art research on Divje babe I has provided excellent and detailed information about cave bear and hominin activities at the site (Turk 2007). Divje babe I is relatively close to Krapina (150 km) and has a long sequence spanning from MIS 5a-d to MIS 3 (Blackwell *et al.* 2007). Furthermore, the cave bear assemblage from Divje babe I is large and has been published in detail (Jambrešić, Turk 2007; Toškan 2007a; 2007b). The Divje babe I cave bears are thus an ideal sample to compare to Krapina.

CAVE BEAR SEX RATIO

Cave bears were highly sexually dimorphic and this dimorphism is particularly apparent in the dimensions of the canines (Koby 1949; Kurtén 1955). Kurtén (1955; 1976) argued that lower canine breadths in cave bears at the Würm cave sites of Mixnitz and Odessa were bimodal with modes at 16–17 mm and 21–22 mm, and with a little overlap between these distributions in the range of 18–20 mm. One expects the exact position of these modes to vary with populations of smaller versus larger-sized bears, and the degree of sexual dimorphism may also vary among populations (Grandal-d'Anglade, López-González 2005). Even over a distance as short as 400 km in Hokkaido, Japan, there is a significant cline in recent brown bear skull sizes that may be related to climate, diet, and/or growth rates (Ohdachi *et al.* 1992). To interpret the Krapina data I have thus sought comparative data from relatively nearby sites. At Mokriška jama in Slovenia, there is a bimodal distribution of upper and lower canine breadths with very little overlap between the modes in the range of 17.5–19 mm, and on the basis of this distribution Debeljak (2007, 477) classified remains smaller than 18 mm as female and those larger than 18.5 mm as male. Similar means of canine breadths for females and males are also present at the nearby site of Potočka zijalka in Slovenia (Debeljak 2004, 178). The histogram of cave bear upper and lower canine breadths at Krapina may be bimodal with a main mode at 17.75–19.25 mm and a smaller second mode between 15.75–16.75 mm (*Fig. 2*). The primary mode at Krapina is exactly in between the modes identified at Mixnitz, Odessa, and Mokriška jama. Identification of a second mode in the histogram is made difficult by the small sample size. One explanation of the Krapina distribution is that the sample is composed of larger-than-average females and smaller-than-average males, which is to say that the population was not sexually dimorphic. This explanation seems unlikely given the clear evidence of

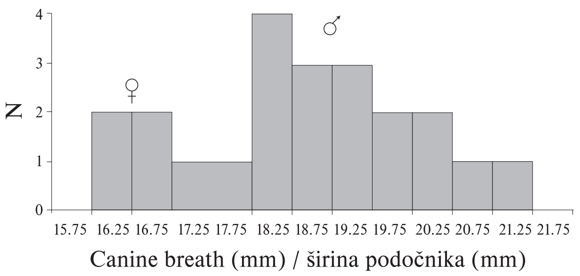

Fig. 2: Histogram of the upper and lower canine breadths of cave bears from Krapina. Canine breadth measured buccal-lingually at the base of the crown. Data from Miracle (2007, Tabs. 16 and 17).

Sl. 2: Histogram za širino zgornjih in spodnjih podočnikov krapinskih jamskih medvedov. Širina podočnikov je merjena bukalno-lingvalno na bazi krone. Vir podatkov: Miracle (2007, tab. 16–17).

nog – glede na glavo – primerljiva (Miracle 2007, 79 s). V Krapini so torej očitno ležali celi skeleti jamskih medvedov. Število kosti s sledmi delovanja zveri (obgrizenih je 1,1 % medvedjih ostankov) oz. homininov (urezi so prisotni na 2,2 % medvedjih najdb) je pičlo. Na drugi strani je delež nepoškodovanih, v celoti ohranjenih kosti kar 75-odstoten NISP (Miracle 2007, 80).

Standardne metode za preučevanje biomodalne porazdelitve metričnih podatkov – najsi bodo to univariatne, bivariatne ali pa multivariatne – so se v primeru Krapine izkazale za neuporabne, saj je bil vzorec za kaj takega preprosto preskromen. Namesto tega je bilo treba dimenzije kosti okončin krapinskih jamskih medvedov primerjati z obsežnejšimi vzorci iz bližnjih najdišč na Slovenskem (Pacher *et al.* 2004; Turk 2007), iz več vzhodnoalpskih jam (Reisinger, Hohenegger 1998) ter z bogatim gradivom iz Španije (Torres *et al.* 1991).

Divje babe I so v tem smislu še posebej pomembne, saj so sodobne raziskave zadnjih let omogočile odlično in detajlno sliko medvedjih in človekovih aktivnosti v jami (Turk 2007). Najdišče je razmeroma malo oddaljeno od Krapine (pribl. 150 km) in obsega najdbe iz relativno dolgega obdobja od MIS 5a–d do MIS 3 (Blackwell *et al.* 2007). Dodano vrednost pomeni tudi že večkrat podrobno objavljen bogat vzorec ostankov jamskega medveda (Jambrešić, Turk 2007; Toškan 2007a; 2007b). Navedeno gradivo predstavlja torej idealno primerjavo vzorcu iz Krapine.

RAZMERJE MED SPOLOMA PRI JAMSKEM MEDVEDU

Jamski medved je bil izrazito spolno dimorfna vrsta, kar je še posebej očitno v velikosti podočnikov (Koby 1949; Kurtén 1955). Kurtén (1955; 1976) je tako npr. pokazal, da je bila porazdelitev podatkov o širini

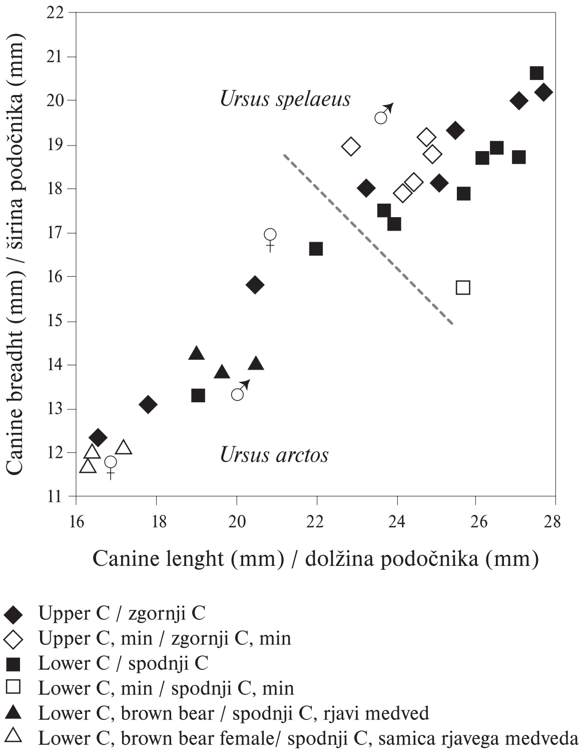

Fig. 3: Crossplot of upper and lower canine breadth on canine length (measured mesio-distally at the base of the crown) of cave bears from Krapina, brown bears from Krapina, and brown bears from other Pleistocene and Holocene sites in the Alps. Krapina data from Miracle (2007, Tabs. 16, 17, and 22). Alpine brown bear data from Döppes, Pacher (2005, Tab. 3).
Sl. 3: Grafični prikaz razmerja med širino in dolžino (merjeno mezialno-distalno na bazi krone) zgornjih in spodnjih podočnikov krapinskih jamskih in rjavih medvedov ter rjavih medvedov z drugih pleistocenskih in holocenskih najdišč v Alpah. Vira podatkov: za krapinske primerke – Miracle (2007, tab. 16–17 ter 22); za alpske rjave medvede – Döppes, Pacher (2005, tab. 3).

sexual dimorphism in other collections from Europe. A better explanation of this pattern is that the cave bears in the vicinity of Krapina during the last interglacial were sexually dimorphic and smaller in body size than cave bear populations from Würmian contexts in other parts of Europe.

A crossplot of canine breadth against canine length (*Fig. 3*), shows a break in the distribution of mesial-distal length at the base of the crown between 22–24 mm and a break in the buccal-lingual breadth at the base of the crown between 17–18 mm. Sexual dimorphism is the most likely explanation for these discontinuous distributions; canines with a breadth greater than 17 mm and a length greater than 23 mm are identified as male. Of 21 measurable canines from Krapina, 17 are sexed as male and 4 as female (*Tab. 1*).

spodnjih podočnikov medvedov iz würmskih plasti jam Mixnitz in Odessa bimodalna, z modusoma pri 16–17 mm in 21–22 mm ter minimalnim prekrivanjem obeh porazdelitev med vrednostima 18 in 20 mm. Pričakovati seveda je, da navedeni podatki niso stalni, temveč se nekoliko spreminjajo v odvisnosti od velikosti medvedov na posameznem najdišču, pozabiti pa ne gre niti na določene medpopulacijske razlike v izrazitosti spolnega dimorfizma (Grandal-d'Anglade, López-González 2005). Pri recentnih rjavih medvedih z japonskega otoka Hokaido je bil tako že na razmeroma kratki razdalji 400 km opazen očiten trend spreminjanja velikosti lobanje, kar odseva klimo, prehrano in/ali stopnjo rasti (Ohdachi *et al.* 1992). Spričo navedenega so bila kot vir komparativnega gradiva za analizo krapinskega upoštevana zgolj najdišča iz razmeroma bližnje okolice. V primeru Mokriške jame je bilo pri bimodalni porazdelitvi podatkov o širini zgornjih in spodnjih podočnikov prekrivanje obeh krivulj na območju med modusoma (tj. med 17,5 in 19 mm) zelo majhno. Na tej podlagi je Debeljakova (2007, 477) primerke ožje od 18 mm pripisala samicam, širše od 18,5 mm pa samcem. Podobna slika je bila ugotovljena tudi za nedaleč stran ležeče jamsko najdišče Potočka zijalka (Debeljak 2004, 178). Pri jamskih medvedih iz Krapine histogram za širino zgornjih in spodnjih podočnikov kaže na bimodalno porazdelitev metričnih podatkov z modusoma pri 15,75–16,75 mm ter 17,75–19,25 mm (*sl. 2*). Slednji je

Tab. 1: Sexual dimorphism in cave bear canine crown breadth. Data sources: Krapina (Miracle 2007, Tabs. 16 and 17); Divje babe I (Toškan 2007a, Tab. 15.1); Mokriška jama (Debeljak 2007, Fig. 2); Potočka zijalka (Debeljak 2004, 178).
Tab. 1: Spolni dimorfizem pri širini krone podočnikov jamskih medvedov. Viri podatkov: Krapina (Miracle 2007, tab. 16–17); Divje babe I (Toškan 2007a, tab. 15.1); Mokriška jama (Debeljak 2007, sl. 2); Potočka zijalka (Debeljak 2004, 178).

	Females / samice				**Males / samci**			
Site / najdišče	**Mean / povprečje**	**s.d.**	**Range / razpon**	**N**	**Mean / povprečje**	**s.d.**	**Range / razpon**	**N**
Krapina	16.3	0.44	15.8 – 16.7	4	19.0	1.05	17.2 – 20.9	17
Divje babe I	15.2		13.0 – 18.0		19.9		17.0 – 23.0	
Mokriška jama	15.9	0.86	13.5 – 18.0	148	21.3	1.41	18.5 – 25.5	204
Potočka zijalka	16.6		14.5 – 18.5	17	21.5		19.0 – 24.0	51

Is this highly skewed sex ratio in favour of males also found in other cave bear elements at Krapina? Of the 10 measurable crania and cranial fragments (Miracle 2007, Tab. 14), five can be sexed as male and one as female on the basis of the associated canines. Two more cranial fragments (#271, 272) can be sexed as male on the basis of greatest mastoid breadth (215 mm and 204 mm, respectively); greatest mastoid breadth is the most dimorphic parameter on cave bear skulls, and the Krapina dimensions are beyond the female range and within the range of males from other sites in Europe (Grandal-d'Anglade, López-González 2005, Fig. 4). The two remaining measured skull fragments (#267, 271.1) come from relatively large individuals and are probably from males, although they do not preserve portions that are known to be particularly diagnostic (Miracle 2007, Tab. 14).

Cave bears are also highly sexually dimorphic in limb bone length (Grandal-d'Anglade, López-González 2005, 326; Reisinger, Hohenegger 1998; Torres 1988a; 1988b). Dimensions of the Krapina cave bear limb bones (Miracle 2007, 67 ff, Tabs. 18–19) are compared directly to the much larger assemblage from the nearby site of Divje babe I, because of the close proximity of this assemblage as well as the detailed publication of measurements on individual specimens (Jambrešić, Turk 2007). Comparisons are also made to assemblages from several caves in the Eastern Alps (Reisinger, Hohenegger 1998), as well as to a large sample of cave bears from Spain (Torres *et al.* 1991).

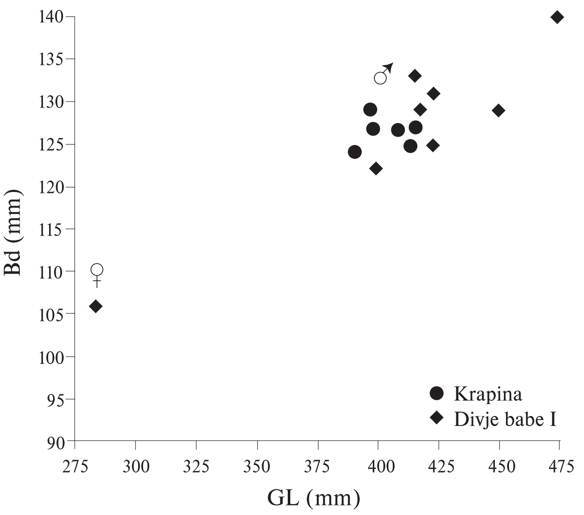

Fig. 4: Crossplot of greatest distal breadth (Bd) against greatest length (GL) in cave bear humeri from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 18). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2a).

Sl. 4: Grafični prikaz razmerja med največjo širino distalnega konca (Bd) in največjo dolžino (GL) nadlahtnic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 18); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2a).

nedvoumen in se umešča natanko med modalni vrednosti, ki sta bili ugotovljeni za gradivo iz najdišč Mixnitz, Odessa in Mokriška jama. V nasprotju s tem je modus pri 15,75–16,75 mm slabo prepoznaven, kar gre najbrž na račun preskromne velikosti vzorca. Ugotovljeno porazdelitev metričnih podatkov bi načeloma lahko razložili s tezo, da vzorec iz Krapine obsega ostanke nadpovprečno velikih samic in podpovprečno velikih samcev, oz. z drugimi besedami, tamkajšnja populacija jamskih medvedov pač ni bila spolno dimorfna. Ker pa bi to bil absolutno unikaten primer med evropskimi najdišči, se takšna razlaga ne zdi utemeljena. Veliko verjetneje namreč je, da so bili seveda tudi krapinski jamski medvedi iz zadnjega interglaciala spolno dimorfni, pri čemer pa so tako samci kot samice po velikosti zaostajali za konspecifičnimi primerki iz würmskih kontekstov z drugih najdišč po Evropi.

Grafični prikaz razmerja med širno in dolžino podočnikov (*sl. 3*) kaže prekinitev v zveznosti porazdelitve podatkov o mezialno-distalni dolžini baze krone med vrednostima 22 in 24 mm; v primeru podatkov za bukalno-lingvalno širino baze krone je bila podobna prekinitev prepoznana pri vrednostih med 17 in 18 mm. Najverjetnejša razlaga za opisano nezveznost obeh porazdelitev je seveda spolni dimorfizem, pri čemer gre primerke s širino nad 17 mm in dolžino nad 23 mm pripisati samcem. Od skupno 21 zadovoljivo ohranjenih in torej izmerljivih podočnikov iz Krapine jih je bilo takih kar 17, medtem ko so bile samice zastopane z zgolj štirimi primerki (*tab. 1*).

Je podobno izrazito asimetričnost v zastopanosti obeh spolov najti tudi pri drugih skeletnih elementih krapinskih jamskih medvedov? Od desetih izmerljivih primerkov lobanj oz. lobanjskih fragmentov (Miracle 2007, tab. 14) jih je bilo na podlagi dimenzij pripadajočih podočnikov samcem pripisanih pet, samicam pa ena. Nadaljnja dva fragmenta (#271, 272) sta bila kot ostanka samcev prepoznana na podlagi največje mastoidne širine

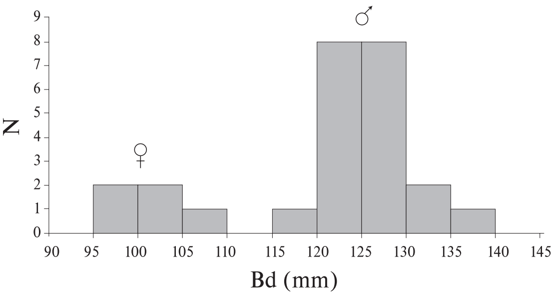

Fig. 5: Histogram of greatest distal breadth (Bd) of cave bear humeri from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 18). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2a).

Sl. 5: Histogram za največjo širino distalnega konca (Bd) nadlahtnic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 18); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2a).

For the humerus, a plot of greatest length (GL) versus greatest breadth (Bd) shows a well defined cluster of relatively large humeri and a much smaller outlier (*Fig.4*). These groups are interpreted as being from males and females, respectively. A histogram of greatest breadth shows a clear bimodal distribution (*Fig. 5*); humeri with Bd > 115 mm are identified as male and those with Bd < 110 mm as female. The distal breadth of cave bear humeri from Spain (N = 67) is also bimodally distributed; Bd > 118 mm are interpreted as male while Bd < 112 mm are interpreted as female (Torres *et al.* 1991, 22). The similarity of these distributions is quite remarkable. Nine of the 10 Krapina humeri are identified as male; the remaining humerus (#516) comes from a relatively large individual and is probably also from a male.

The histogram of ulna greatest length is roughly bimodal, with a smaller mode between 325–335 mm and a larger mode with multiple peaks between 355–400 mm that are interpreted as being from females and males, respectively (*Fig. 6*). Ulnae with greatest lengths between these distributions are classified as female? (335–340 mm), unknown (340–350 mm), and male? (350–355 mm). Torres *et al.* (1991, 22, Fig. 5.2 A1–B1) also found bimodality in greatest ulna length (GL) in Spanish cave bears (N = 44), with a smaller mode between 305–335 mm and a larger mode with a peak between 380–410 mm. They attributed ulnae with GL < 365 mm as female and those with GL > 365 mm as male. In three cave bear assemblages from the Eastern Alps, Reisinger and Hohenegger (1998, 105) found clear bimodality in ulna GL, with a break in the distribution at either 360 mm (Conturines cave, Gamssulzen cave) or 350 mm (Herdengel cave). The overall size of Divje babe I and Krapina cave bears appears to be somewhat smaller than those at other sites, with the exception of Herdengel cave. On this basis, seven of the Krapina ulnae are identified as male or male? and one is classified as

(tj. 215 mm in 204 mm), sicer najbolj dimorfnega parametra v okviru lobanje jamskega medveda. Pri tem se oba navedena primerka iz Krapine umeščata znotraj variacijske širine za samce iz drugih evropskih najdišč ter s tem očitno presegata vrednosti, ki so bile ugotovljene pri samicah (Grandal-d'Anglade, López-González 2005, sl. 4). Tudi preostala dva izmerljiva lobanjska odlomka (#267, 271.1) sta najverjetneje pripadala samcema; ne pri enem ne pri drugem sicer niso ohranjeni posebej diagnostični deli, sta pa oba razmeroma velika (Miracle 2007, tab. 14).

Znano je, da so pri jamskem medvedu izrazito spolno dimorfne tudi dolge kosti okončin (Grandal-d'Anglade, López-González 2005, 326; Reisinger, Hohenegger 1998; Torres 1988a; 1988b). Dimenzije teh skeletnih elementov pri krapinskih medvedih (Miracle 2007, 67 ss, tab. 18–19) so bile neposredno primerjane z veliko bogatejšim vzorcem iz Divjih bab I; korpus metričnih podatkov z navedenega najdišča je bil namreč detajlno objavljen (Jambrešić, Turk 2007), sama razdalja med obema jamama pa ne presega 150 km. V primerjavo je bilo vključenih tudi več vzhodnoalpskih najdišč (Reisinger, Hohenegger 1998) ter bogat vzorec iz Španije (Torres *et al.* 1991).

V primeru nadlahtnic je na grafičnem prikazu razmerja med največjo dolžino kosti (GL) in širino njenega distalnega konca (Bd) mogoče prepoznati oblak razmeroma velikih primerkov, od katerega odstopa veliko manjši osamelec (*sl. 4*). Navedeno dihotomijo gre interpretirati kot odsev spolnega dimorfizma, pri čemer predstavljajo večji primerki ostanek samcev, manjši izolirani osamelec pa samico. Histogram za parameter "največja širina distalnega konca" izkazuje očitno bimodalno porazdelitev (*sl. 5*); pri tem gre nadlahtnice z Bd nad 115 mm prišteti k medvedom, tiste z Bd pod 110 mm pa medvedkam. Bimodalna porazdelitev obravnavanega parametra je bila ugotovljena tudi v primeru nadlahtnic iz Španije (N = 67), kjer so

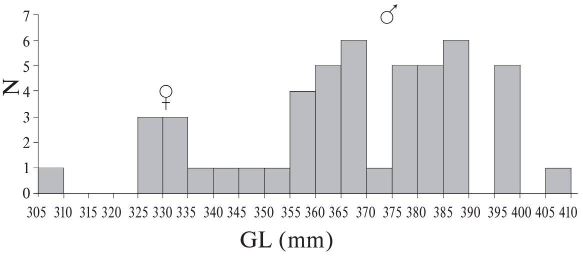

Fig. 6: Histogram of greatest length (GL) of cave bear ulnae from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 18). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2b).

Sl. 6: Histogram za največjo dolžino (GL) komolčnic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 18); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2b).

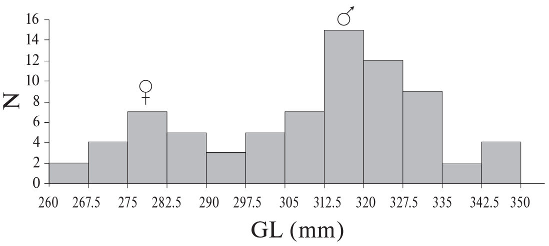

Fig. 7: Histogram of greatest length (GL) of cave bear radii from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 18). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2c).

Sl. 7: Histogram za največjo dolžino (GL) koželjnic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 18); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2c).

unknown. The remaining three damaged ulnae are not assigned a sex, although two relatively large specimens are probably from males.

The histogram of radius greatest length is also bimodal, with modes at 275–282.5 mm and 312.5–320 mm (*Fig. 7*). Radii with GL ≤ 290 mm are classified as female, while those with GL > 297.5 mm are classified as male. Torres *et al.* (1991, 23, Fig. 5.3) also found bimodality in greatest radius length (GL) in Spanish cave bears (N = 85), with a smaller mode between 275–290 mm and a larger mode with a peak between 305–320 mm. A similar pattern was found in the Eastern Alps, although the break in distributions was at 310 mm (Reisinger, Hohenegger 1998, 105). These distributions are very similar to those from Divje babe I and Krapina; all of them can be interpreted in terms of sexual dimorphism, although the Divje babe I and Krapina radii appear to be on average somewhat smaller than radii from the other sites. On this basis, seven of the Krapina radii are identified as male. Of the remaining four damaged radii, two large proximal ends are probably from males (Bp > 50 mm), one small proximal end (Bp = 44.6 mm) is probably from a female (*Fig. 8*), and a small distal end (Bd = 65.2 mm) is also probably from a female.

The femora likewise show a strongly bimodal distribution of greatest length, with a break in the distribution between 400–410 mm (*Fig. 9*). Femur GL in Iberian cave bears (N = 33) is also strongly bimodal, with breaks in the distribution between 420–440 mm, depending on the population (Torres *et al.* 1991, 28, Fig. 5.12). The Eastern Alpine cave bear assemblages show a break in the distribution of femur GL somewhere between 410–450 mm, depending on the population (Reisinger, Hohenegger 1998, 106). These distributions are again very similar to those from Divje babe I and Krapina; in all cases sexual dimorphism is the best explanation of this bimodality. Greatest proximal breadth (Bp) also has a bimodal distribution (*Fig. 10*), allowing the assignment of sex from fragmentary femora; those with a Bp < 110 mm were classified as female. All of the Krapina femora were classified as male on the basis of both greatest length and proximal breadth.

A histogram of tibia GL is strongly bimodal, and the distribution can be cut between 270 and 280 mm (*Fig. 11*). A bivariate plot of tibia proximal breath (Bp) against greatest length (GL) also reveals two distinct groups; one tibia with a GL of 272 mm (D.b. 880/27) is grouped with the smaller specimens owing to its small proximal breadth (*Fig. 12*). I interpret tibae with GL > 275 mm to be from males and those with GL ≤ 275 mm to be from females. Tibia distal breadth is also strongly bimodal in distribution, with a break between 67.5–70 mm (*Fig. 13*). A single tibia (D.b. 1178) with GL in the female range and Db in the male range has been left unsexed. Tibia GL is also bimodal in Iberian cave bears (Torres *et al.* 1991, 29), although the break in the distribution varies by assem-

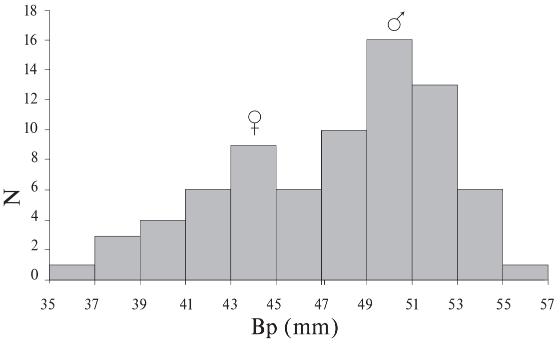

Fig. 8: Histogram of proximal breadth (Bp) of cave bear radii from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 18). Divje babe I data from Jambrešić,Turk (2007, Tab. 16.2c).

Sl. 8: Histogram za največjo širino proksimalnega konca (Bp) koželjnic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 18); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2c).

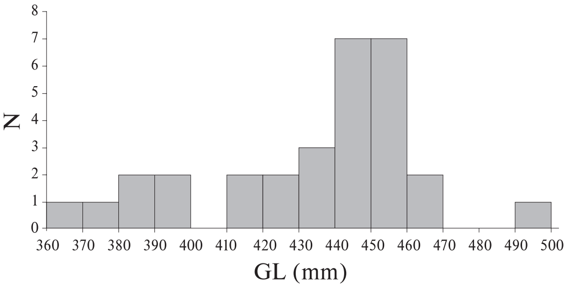

Fig. 9: Histogram of greatest length (GL) of cave bear femora from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 19). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2d).

Sl. 9: Histogram za največjo dolžino (Bd) stegnenic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 19); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2d).

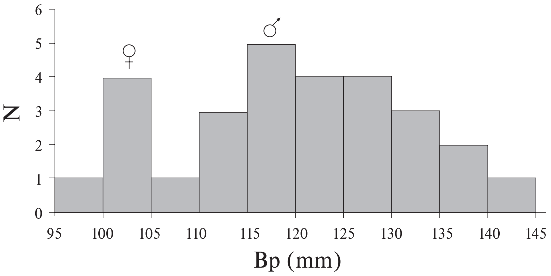

Fig. 10: Histogram of proximal breadth (Bp) of cave bear femora from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 19). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2d).

Sl. 10: Histogram za največjo širino proksimalnega konca (Bp) stegnenic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 19); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2d).

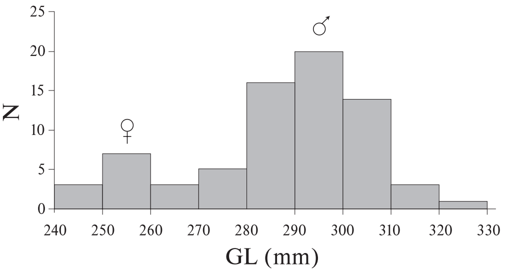

Fig. 11: Histogram of greatest length (GL) of cave bear tibiae from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 19), Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2e).
Sl. 11: Histogram za največjo dolžino (GL) golenic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 19); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2e).

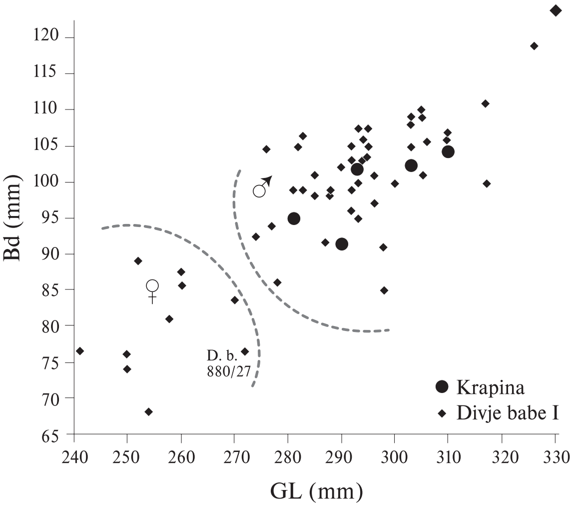

Fig. 12: Crossplot of greatest proximal breadth (Bp) against greatest length (GL) of cave bear tibiae from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 19). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2e).
Sl. 12: Grafični prikaz razmerja med največjo širino proksimalnega konca (Bp) in največjo dolžino (GL) golenic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 19); za Divje babe I – Jambrešić, Turk (2007, Tab. 16.2e).

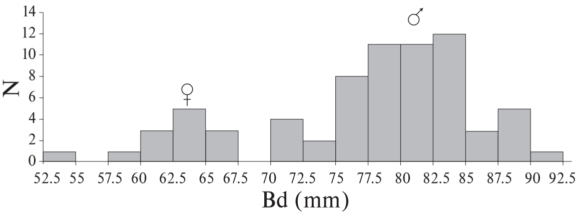

Fig. 13: Histogram of greatest distal breadth (Bd) of cave bear tibiae from Krapina and Divje babe I. Krapina data from Miracle (2007, Tab. 19). Divje babe I data from Jambrešić, Turk (2007, Tab. 16.2e).
Sl. 13: Histogram za največjo širino distalnega konca (Bd) golenic jamskih medvedov iz Krapine in Divjih bab I. Viri podatkov: za Krapino – Miracle (2007, tab. 19); za Divje babe I – Jambrešić, Turk (2007, tab. 16.2e).

bili kot ostanki samcev prepoznani primerki z Bd nad 118 mm, kot ostanki samic pa tisti z Bd pod 112 mm (Torres *et al.* 1991, 22). Podobnost obeh porazdelitev je vsekakor zanimiva. Sicer pa je bilo od skupno desetih nadlahtnic iz Krapine devet primerkov z gotovostjo pripisanih samcem, enako pa najbrž velja tudi za desetega (#516), ki je prav tako pripadal razmeroma veliki živali.

V grobem je bimodalna tudi porazdelitev izmerjenih vrednosti za največjo dolžino komolčnice, z manj izrazitim modusom med 325 in 335 mm ter tistim izrazitejšim z več vrhovi pri vrednostih med 355 in 400 mm (*sl. 6*). Podobno kot zgoraj je tudi tu bimodalnost interpretirana kot odraz razlik med spoloma. Pri tem so bile komolčnice, katerih največja dolžina se umešča med obe zgornji modalni vrednosti, vključene v eno od naslednjih kategorij: “samica?” (335–340 mm), “spol ni znan” (340–350 mm) ter “samec?” (350–355 mm). Bimodalno so bili porazdeljeni tudi podatki o največji dolžini (GL) komolčnic jamskih medvedov iz Španije (Torres *et al.* 1991, 22, sl. 5.2 A1–B1), z modusoma med 305 in 335 mm ter med 380 in 410 mm. Na podlagi navedenega so bili kot ostanki medvedov prepoznani primerki z GL nad 365 mm, ostanki medvedk pa tisti z GL pod 365 mm. Podobno sliko sta pri treh vzhodnoalpskih vzorcih odkrila tudi Reisinger in Hohenegger (1998, 105), s prekinitvijo zveznosti pri vrednostih 360 mm (jami Conturines in Gamssulzen) oz. 350 mm (jama Herdengel). Velikost jamskih medvedov iz Divjih bab I in Krapine je najbrž nekoliko zaostajala za velikostjo živali iz zgoraj navedenih najdišč, z izjemo jame Herdengel. Posledično je bilo sedem komolčnic iz Krapine vključenih v skupino “samec” oz. “samec?”, eden pa v skupino “spol ni znan”. Preostali trije primerki niso omogočali zanesljivega razlikovanja med spoloma, čeprav bi dva od njih spričo njune velikosti najbrž vendarle lahko pripisali samcem.

Bimodalno porazdelitev kaže tudi histogram za največjo dolžino koželjnic, z modusoma pri 275–282,5 mm ter 312,5–320 mm (*sl. 7*). Primerki daljši od 290 mm naj bi tako pripadali samicam, tisti daljši od 297,5 mm pa samcem. V prav tako bimodalno porazdeljenih metričnih podatkih za španske živali (N = 85; Torres *et al.* 1991, 23, sl. 5.3) sta bili modalni vrednosti prepoznani pri 275–290 mm oz. 305–320 mm. Podoben vzorec je bil ugotovljen tudi pri vzhodnoalpskih primerkih živali, le da je bila pri teh prekinitev v zveznosti opazna pri GL = 310 mm (Reisinger, Hohenegger 1998, 105). Kar zadeva porazdelitev podatkov o največji dolžini koželjnic jamskih medvedov iz Krapine oz. Divjih bab I, je ta prav tako bimodalna in torej – tako kot v zgornjih primerih – odseva spolni dimorfizem. Razlika med Krapino in Divjimi babami I na eni strani ter vzhodnoalpskim in španskim vzorcem na drugi je torej zgolj v tem, da so koželjnice iz prvih dveh najdišč nekoliko manjše. Tako naj bi sedem od skupno enajstih krapinskih primerkov koželjnice zagotovo pripadalo samcem, dva poškodovana z največjo širino proksimalnega konca nad 50 mm pa blage from as low as 260–270 mm (N = 18, Troskaeta) to 280–290 mm (N = 40, Iberian sample). The complete Krapina tibiae (N = 5) are clearly from males. The remaining three specimens have greatest proximal or distal breadths sufficiently large to also classify them as males.

CAVE BEAR SEX RATIO: DISCUSSION

While it is difficult to be certain of the sexing of a given specimen based on measurements alone, I think that these data give a fair representation of the overall composition of the cave bear sample from Krapina. The assemblage is overwhelmingly dominated by males; the frequency of long-bones sexed as male ranges from 63.6–100% (*Tab. 2*). The male bias is not limited to the canine teeth, and one cannot explain this sex ratio by a preferential collection/curation of larger (male) canine teeth (Miracle 2007, 61). Furthermore, although there was a curation bias for cave bear remains from Krapina, it would appear to have most severely affected axial elements and the limb extremities relative to other parts of the skeleton (Miracle 2007, 32).

How can one interpret the extremely skewed sex ratio at Krapina? The frequency of male cave bears at Krapina exceeds the maximum of 67% males based on canine breadth from 12 Pleistocene sites in Europe (Kurtén 1958, 45–46, Tab. 14) as well as the frequency of males inferred from long-bone dimensions from Herdengel cave and Divje babe I facies A (*Tab. 3*). Kurtén (1958, 5) suggested that two instances of highly skewed sex ratios (% Males of 90% and 22.7%) were explainable by curatorial decisions that led to a collection bias for larger (mostly male) specimens; in the former case the museum was able to retain the "finest specimens", while in the latter case the best, mostly male, pieces went to private collectors. The Krapina cave bear assemblage has been selectively culled since the time of excavation, and the strongly male-biased sex ratio seems easily explainable in terms of a collection bias for the "finest specimens" .

If one considers Krapina within the context of other assemblages from the region, however, it becomes apparent that a strongly male-biased sex ratio may reflect more than just a collection bias. I return to the analysis of the Divje babe I long-bones. The same graphs, distributions, and observations that were used to sex the Krapina remains can also be used to sex the Divje babe I cave bear long-bones. The results are presented in *table 4*. Jambrešić and Turk (2007, 383 f) concluded from their detailed metric analyses of the tibae from Divje babe I that "in both facies A and B, there are a higher number of longer and more robust specimens, which is interpreted as a predominance of males." In facies A the frequency of males ranges from 81.5% (tibia) to 100% (humerus); the overall frequency of males is 87.2% (*Tab. 5*). In

Tab. 2: Frequency of cave bear remains from Krapina sexed as female (F), male (M) or indeterminate (?). The "% Male" is calculated as M/(F+M+?)*100 %.
Tab. 2: Število ostankov krapinskih jamskih medvedov, ki so bili pripisani samicam (F), samcem (M) oz. jim spola ni bilo mogoče določiti (?). Podatek "% samcev" je bil izračunan kot M/(F+M+?)*100 %.

Element	**?**	**F**	**M**	**% Male / % samcev**
Crania	2	1	7	70.0
C^1		2	15	88.2
C_1	1	2	12	80.0
Humerus	1	0	9	90.0
Ulna	4	0	7	63.6
Radius		2	9	81.8
Femur		0	9	100.0
Tibia		0	8	100.0
Total / skupaj	8	7	76	83.5

Tab. 3: Frequency of male cave bears from sites in the eastern Alps based on long-bone dimensions (Conturines Cave, Gamssulzen Cave, Herdengel Cave, data from Reisinger and Hohenegger 1998, 107, 113) and metacarpal dimensions (Divje babe I, data from Toškan 2007b, Tab. 17.1).
Tab. 3: Število samcem pripisanih ostankov jamskih medvedov v gradivu iz vzhodnoalpskih najdišč (jame Conturines, Gamssulzen in Herdengel; vir podatkov: Reisinger, Hohenegger 1998, 107, 113) ter iz Divjih bab I (Toškan 2007b, tab. 17.1). V slednjem primeru je bil spol določen na osnovi dimenzij dlančnic, pri vzhodnoalpskih najdbah pa glede na velikost dolgih kosti.

Site (cave) / najdišče (jama)	**F**	**M**	**Total / skupaj**	**% Male / % samcev**
Conturines	71	21	92	22.8
Gamssulzen	33	14	47	29.8
Herdengel	34	65	99	65.7
Divje babe I, facies A	76	146	222	65.8
Divje babe I, facies C	95	76	171	44.4

pogojno; samice naj bi bile zastopane s po enim primerkom proksimalnega konca koželjnice (Bp = 44,6 mm) in enim distalnega (Bd = 65,2 mm; *sl. 8*).

Pri stegnenicah je bila prekinitev v zveznosti bimodalne porazdelitve podatkov o največji dolžini navedenega skeletnega elementa ugotovljena pri vrednostih med 400 in 410 mm (*sl. 9*). Podobno sliko kažejo tudi španski jamski medvedi, pri katerih pa prekinitev v zveznosti porazdelitve niha med vrednostma 420 in 440 mm, pač odvisno od populacije (Torres *et al.* 1991, 28, sl. 5.12). Pri gradivu z vzhodnoalpskih najdišč so bile medpopulacijske razlike v tem pogledu še za odtenek izrazitejše (prekinitev med 410–450 mm; Reisinger, Hohenegger 1998, 106), v vseh primerih pa gre facies B the results for the different long-bones are again consistent (% Male ranges from 67.6–84.6%) and the overall frequency of males is 73.1%. Finally, in facies C the reverse pattern is true – males make up only 34.6% of the assemblage. Analysis of sexual dimorphism in cave bear long-bones shows that the bias either for or against males is more pronounced than that observed in the metapodials, although the pattern of stratigraphic change is similar (Toškan 2007b). Separate taphonomic analyses of male and female cave bear remains from Divje babe I would be profitable. Toškan (2007b, 399 f) has

Tab. 4: Sex determination of cave bear long-bones from Divje babe I. Inventory numbers from Jambrešić and Turk (2007, Tabs. 16.2a–e). All specimens from Jambrešić and Turk (2007, Tabs. 16.2a–e) that are not listed here are "male" .
Tab. 4: Razvrstitev dolgih kosti jamskih medvedov iz Divjih bab I med oba spola. Inventurne številke so bile povzete po Jambrešić, Turk (2007, tab. 16.2a–e). Vsi primerki, ki jih navajata Jambrešić, Turk (2007, tab. 16.2a–e) in na tem mestu niso navedeni, so bili pripisani samcem.

Element	**Sex ? / spol ?**	**Female / samica**
Humerus		29, 2189, 2409, 2411, 2414
Ulna		343, 387, 1695, 2196, 2201, 2285, 2370, 2372
Radius	1362, 2293	161, 166, 201, 215, 391, 506, 533, 550, 551, 1625, 1804, 1806, 1952, 1953, 1954, 1956, 2292, 2294, 2394, 2396, 2405
Femur	2351, 2352	200, 381, 620, 2239, 2355, 2357, 2416
Tibia	1178, 2258	159, 382, 383, 880, 1179, 1284, 1626, 1645, 1694, 2253, 2260, 2384, 2385

bimodalnost razumeti kot odsev spolnega dimorfizma. Slednje seveda velja tudi za vzorca iz Krapine in Divjih bab I. Bimodalno porazdelitev kažejo tudi vrednosti največje širine proksimalnega konca (Bp; *sl. 10*), zaradi česar je prepoznavanje spola mogoče tudi pri odlomkih stegnenic (primerki z Bp nad 110 mm naj bi pripadali samcem). Na podlagi navedenih dveh kriterijev (tj. GL in Bp) so bile vse stegnenice krapinskih jamskih medvedov pripisane močnejšemu od obeh spolov.

Histogram za največjo dolžino golenice je močno bimodalen, s porazdelitvijo, ki se deli na dva dela pri vrednostih med 270 in 280 mm (*sl. 11*). Dve ločeni skupini sta prepoznavni tudi na grafičnem prikazu razmerja med širino proksimalnega konca (Bp) in največjo dolžino kosti (GL); primerek z GL = 272 (D.b. 880/27) se k manjšim golenicam umešča zaradi ozkega proksimalnega konca (*sl. 12*). Pri gradivu iz Krapine so bile k samcem pripisane golenice z GL nad 275 mm, k samicam pa tiste z GL 275 mm oz. manjšim od 275 mm. Izrazito bimodalna je tudi porazdelitev podatkov o globini distalnega konca, s prekinitvijo v zveznosti porazdelitve pri vrednostih med 67,5 in 70 mm (*sl. 13*). Primerek iz Divjih bab I (D.b. 1178), ki se je po največji dolžini umeščal k medvedkam, po globini distalnega konca pa k medvedom, ni bil dokončno pripisan k nobenemu od obeh spolov. Bimodalna porazdelitev podatkov o največji dolžini golenic je bila ugotovljena tudi pri španskih jamskih medvedih (Torres *et al.* 1991, 29), pri katerih prekinitev v zveznosti distribucije niha med 260–270 mm (N = 18; Troskaeta) in 280–290 mm (N = 40; iberski vzorec). Vseh pet v celoti ohranjenih golenic iz Krapine je bilo brez sence dvoma pripisanih samcem, na podlagi širine proksimalnih oz. distalnih koncev golenice pa najbrž enako lahko umestimo tudi vse tri zgolj delno ohranjene golenične primerke.

RAZMERJE MED SPOLOMA PRI JAMSKEM MEDVEDU: RAZPRAVA

Prepoznavanje spola pri vsaki posamezni kosti oz. zobu zgolj na podlagi metričnih podatkov je sicer težavno in pogosto ne povsem zanesljivo, v primeru zgoraj predstavljenih rezultatov analize krapinskih

Tab. 5: Sex ratio of cave bear long-bones from Divje babe I by facies. The "% Male" is calculated as M/(F+M+?)*100 %. Bones listed under notes are not included in facies totals.
Tab. 5: Razmerje med spoloma pri dolgih kosteh jamskih medvedov iz Divjih bab I po faciesih. Podatek "% samcev" je bil izračunan kot M/(F+M+?)*100 %. Kosti, ki so podane v opombah, niso bile vključene v izračun skupnega števila najdb za posamezno facies.

Element	**Facies A**				**Facies B**				**Facies C**				**Notes / opombe**
	Sex ? / spol ?	**F**	**M**	**% Male / % samcev**	**Sex ? / spol ?**	**F**	**M**	**% Male / % samcev**	**Sex ? / spol ?**	**F**	**M**	**% Male / % samcev**	
Humerus		0	6	100.0		3	7	70.0		1	1	50.0	1 F (B/C)
Ulna		1	20	95.2		4	12	75.0		1	1	50.0	2 F (B/C)
Radius	1	3	21	84.0	1	10	23	67.6		7	2	22.2	1 F, 1 M (B/C)
Femur		1	6	85.7		2	11	84.6	2	4	1	14.3	
Tibia	1	4	22	81.5	1	7	23	74.2		2	4	66.7	1 M (A/B), 4 M (B/C)
Total	2	9	75	87.2	2	26	76	73.1	2	15	9	34.6	

already commented on the “lack” of adult male cave bear canines relative to metapodials in the MIS 3 assemblages, suggesting that these canines were selectively taken away from the site by Palaeolithic people. Such an analysis is for another time and place. Here I simply note that the male cave bear bias is even stronger at Divje babe I facies A than at Krapina, and that this skewed sex ratio cannot be explained away as a collection bias at the time of excavation or curation.

The sex composition may also vary with the age at death of the cave bears. Males and females are roughly equally represented among older juvenile, sub-adult, and younger adult cave bears at Potočka zijalka; among older adults, males make up 83.3% of the age class (canines: N = 54; Debeljak 2004, 179). A similar pattern of changing sex composition by age is also present at Mokriška jama, although old adult males make up only 73% of the age class (canines: N = 293; Debeljak 2004, 178). This pattern is very similar to that found at Krapina. Remains of juvenile cave bears are rare at Krapina; the age structure shows a predominance of prime-aged adults (Miracle 2007, Fig. 304). Of the 36 canine teeth, 29 of them (80.6%) show moderate to heavy wear and only two of them (5.5%) are tooth buds. The adult and old-adult cohorts are dominated by males; there are too few juvenile and sub-adult remains to examine the sex structure in those cohorts.

Looking further afield, the frequency of males reaches as high as 88.6% for particular skeletal elements at Herdengel Cave (tibia: N = 35; Reisinger, Hohenegger 1998, 113), and at Grotta Lattaia the frequency of males is 87.5% for skull (N = 8) and 81.5% for skull and long-bones combined (N = 27, calculated using skull, humerus, ulna, radius, femur, and tibia from Argenti, Mazza 2006, Tab. 1). Although the sample from Grotta Lattaia is inadequate for a detailed analysis of cave bear sex ratios (Argenti, Mazza 2006, 1555), the strong male bias is striking, particularly on the large sample of skulls plus long-bones. I conclude from this brief survey of other cave bear assemblages that a strongly biased male sex ratio can be created by processes other than excavation/curation bias. Although much remains unknown and problematic about the excavation methods and curation history of Krapina, I think that the skewed cave bear sex ratio at Krapina reflects more than just a curatorial bias.

SIZE OF THE KRAPINA CAVE BEARS

As discussed above, dating of the Krapina assemblage is not straightforward. Although ESR dates and detailed revision of the fauna suggest that much of the assemblage was deposited under interglacial (MIS 5) or even full interglacial (MIS 5e) conditions (Rink *et al.* 1995; Miracle 2007), there has been debate over how late

jamskih medvedov pa se o njihovi zanesljivosti vendarle ne zdi potrebno dvomiti. Na očitno prevlado samcev v gradivu iz navedenega najdišča so namreč pokazale tako analize posameznih dolgih kosti okončin (delež samcev niha med 63,3 odstotka in 100 odstotki; *tab. 2*) kot tudi podočniki. Prav zaradi navedenega ugotovljene slike nikakor ne gre pripisati preferenci izkopavalcev in/ali kustosov do (večjih) podočnikov samcev (Miracle 2007, 61). Toliko bolj zato, ker naj bi selektivni pristop k oblikovanju in urejanju zbirke prizadel predvsem osni skelet in kosti okončin (Miracle 2007, 32).

Na točki, ko so rezultati analize spolne strukture krapinskih jamskih medvedov nedvoumno pokazali na očitno prevlado medvedov nad medvedkami, se velja v nadaljevanju posvetiti interpretaciji navedene slike. Dejstvo je, da relativna frekvenca pojavljanja samcev v Krapini presega najvišji, na podlagi širine podočnikov ugotovljeni delež živali navedenega spola med vzorci iz dvanajstih pleistocenskih najdišč v Evropi (Kurtén 1958, 45 s, tab. 14). Obenem podatek za Krapino presega tudi deleža, ki sta bila na podlagi dimenzij dolgih kosti ugotovljena ob analizi najdb z najdišč Herdengel in Divje babe I – facies A (*tab. 3*). Ko se je z vzorcema z izrazito visoko (tj. 90%; jama Hohlestein) oz. nizko (tj. 22,7%; jama Sibyllen) prevlado samcev srečal Kurtén (1958, 5), je nesimetrično zastopanost obeh spolov pripisal kustosovi preferenci do večjih primerkov (ki so torej povečini pripadali samcem); pri tem naj bi imel v primeru jame Hohlestein “najatraktivnejše” najdbe pravico zadržati muzej, pri najdišču Sibyllenhöhle pa so te pripadle zasebnim zbirateljem. Ker je bila selektivno oblikovana tudi zbirka ostankov jamskih medvedov iz Krapine, bi nemara podoben argument načeloma veljalo uporabiti tudi v tem primeru.

A pozor! Če na Krapino pogledamo v kontekstu drugih najdišč z ostanki jamskega medveda v regiji, se premočrtno povezovanje močno prevladujočega deleža samcev s pristranskostjo kustosa ne zdi več dovolj prepričljivo. Vrnimo se tako za hip k analizi dolgih kosti iz Divjih bab I. Enake grafične prikaze, porazdelitve in zapažanja, kot so bili uporabljeni pri spolnem razvrščanju v primeru Krapine, lahko uporabimo tudi za dolge kosti okončin iz Divjih bab I (*tab. 4*). Kot sta iz rezultatov detajlne metrične analize golenic iz navedenega najdišča sklepala Jambrešić in Turk (2007, 383 s), prevladujejo v faciesih A in B daljši in robustnejši primerki, ki so bili kot taki pripisani samcem. V okviru faciesa A je delež dolgih kosti močnejšega spola nihal med 81,5 odstotka (golenice) in 100 odstotki (nadlahtnica), s povprečno vrednostjo pri 87,2 odstotka (*tab. 5*). Medsebojno primerljivi so tudi podatki o relativni frekvenci pojavljanja vsakega od obeh spolov pri posameznih dolgih kosteh iz faciesa B, čeprav je tu premoč samcev za odtenek manj izrazita (delež slednjih niha med 67,6 in 84,6 %; povprečje: 73,1 %).

in time the Krapina sequence extends. Malez (1970b; Malez 1978; Malez, M. & V. 1989) suggested that the uppermost layers were deposited in the Würm II stadial (MIS 3), while Herak (1947) and Patou-Mathis (1997) suggested that these layers were deposited during the early Würm glacial (MIS 4). While the faunal assemblages indicate a shift from full interglacial to somewhat cooler conditions within the sequence, I have argued that the entire assemblage falls within MIS 5 (Miracle 2007, 216). The portion of the assemblage that is primarily in question is that from the top of the sequence, layer 9, from which the majority of the cave bear remains probably derive (Miracle 2007, 32, 211). The size of the cave bears from Krapina may thus also be indicative of the age of layer 9. If these remains were deposited during the early Würm glacial, then they should be as large as, or even larger than cave bears from the region that lived under glacial conditions (MIS 3–4). If they were deposited under interglacial conditions (MIS 5), then they should be smaller than those that lived under glacial conditions.

There are several sites with large vertebrate assemblages in the immediate region of the Croatian Zagorje that could provide suitable comparisons to interglacial and glacial cave bears (Malez 1963; 1986; Paunović 1988; Miracle 1991; Miracle *et al.* 2010). Unfortunately, none of the cave bear assemblages have been published in sufficient detail to infer sex ratios and compare body size. The closest assemblages with adequate cave bear assemblages that have been published in detail are Divje babe I (Turk 2007), Mokriška jama (Debeljak 2007), and Potočka zijalka (Pacher *et al.* 2004). I focus on Divje babe I owing to its long sequence and large cave bear assemblage.

The Divje babe I assemblage is an excellent comperandum to Krapina because it can be divided into discrete facies of different ages. At the bottom of the sequence are layers 13–23, facies C, that were deposited under relatively warmer conditions and date to ca. 116–80 ka (MIS 5a-d; Blackwell *et al.* 2007, 154). After an apparent gap in the sequence that corresponds to the full glacial conditions of MIS 4, there is a series of layers (2–12) grouped into facies A and B, that were deposited under relatively colder conditions from ca. 70–38 ka (MIS 3; Blackwell *et al.* 2007, 155). If the Krapina cave bear remains were deposited under full interglacial conditions (MIS 5e), then they should be smaller than the Divje babe I facies C assemblage deposited under cooler interglacial conditions (MIS 5a–d). On the other hand, if they were deposited during the cooler part of MIS 5a-d, then they should be the same size as Divje babe I facies C, although they might still be smaller than the glacial assemblages from Divje babe I facies A and B. Finally, if the Krapina cave bears lived under glacial conditions, then they should be similar in body size to the Divje babe I facies A and B cave bear assemblages. These hypotheses are predicated on the assumption that the

Povsem drugačno sliko pa kaže gradivo iz faciesa C, kjer s 65,4 odstotka prevladujejo ostanki medvedk. Razlika med deležema samcev in samic pri najdbah iz posameznega faciesa je sicer pri metapodjih nekoliko manj izrazita kot pri dolgih kosteh, sam vzorec spolne strukture z zgoraj omenjenim obratom na prehodu iz faciesa C v B pa ostaja podoben (Toškan 2007b). V zvezi s tem bi se zdelo koristno opraviti ločeni tafonomski analizi ostankov samcev in samic. Toškan (2007b, 399 s) je tako v okviru gradiva iz MIS 3 ugotovil primanjkljaj podočnikov odraslih samcev glede na stanje pri metapodijih ter to komentiral kot domnevno posledico njihovega selektivnega pobiranja s strani paleolitskih ljudi. Preslikava tovrstnih razmišljanj na primer Krapine je seveda v tem trenutku neumestna – ne nazadnje je tu govor o prostorsko in časovno povsem različnih kontekstih. Je pa na tem mestu vsekakor vredno omeniti, da je prevlada ostankov samcev v gradivu iz Krapine še očitnejša, kot je bilo to ugotovljeno pri obeh mlajših faciesih v Divjih babah I, ter da takšne slike preprosto ni mogoče zadovoljivo razložiti zgolj z argumentom o pristranskosti izkopavalcev oz. kustosov zbirke.

Spolna struktura se lahko spreminja tudi v odvisnosti od starosti ob poginu. Če namreč med starejšimi mladiči, subadultnimi živalmi in mladimi odraslimi medvedi iz Potočke zijalke opaznejših razlik v deležu zastopanosti obeh spolov ni bilo, pa predstavljajo v razredu starejših odraslih primerkov samci kar 83,3 odstotka vseh najdb (N = 54 podočnikov; Debeljak 2004, 179). Podoben vzorec spreminjanja spolne strukture populacije s starostjo je bil ugotovljen tudi v primeru Mokriške jame, čeprav tu delež samcev med starejšimi odraslimi medvedi ne presega 73 odstotkov (N = 293 podočnikov; Debeljak 2004, 178). V okviru krapinskega vzorca, ki v osnovi prav tako izkazuje podobno sliko, je ostankov mladih jamskih medvedov malo; rezultati analize starostne strukture so namreč izpostavili prevlado ostankov mladih odraslih živali (Miracle 2007, sl. 304). Od 36 podočnikov jih tako kar 29 (tj. 80,6 %) kaže zmerno do močno obrabo, medtem ko je bilo število najdenih zasnov zob zgolj dve (tj. 5,5 %). Če torej spolne strukture mladih in subadultnih živali ni mogoče oceniti, pa med odraslimi in starimi odraslimi tudi tu očitno prevladujejo prav samci.

Poglejmo sedaj še nekoliko dlje. V okviru gradiva iz jame Herdengel je bil delež samcev med ostanki golenic kar 88,6-odstoten (N = 35, Reisinger, Hohenegger 1998, 113), v primeru najdišča Grotta Lattaia je znašal podobno visokih 87,5 odstotka (ob upoštevanju zgolj lobanj; N = 8) oz. 81,5 odstotka (ob upoštevanju lobanj in dolgih kosti, tj. nadlahtnic, komolčnic, koželjnic, stegnenic in golenic; N = 27; Argenti, Mazza 2006, tab. 1). Čeprav drugi od obeh navedenih vzorcev sam po sebi ni primeren za detajlno analizo spolne strukture jamskih medvedov (Argenti, Mazza 2006; 1555), ostaja ugotovljena izrazita prevlada samcev vendarle pozornost body was primarily determined by ambient temperature and regional climatic conditions; one knows, of course, that body size is influenced by a wide range of factors in addition to ambient temperature (Damuth, MacFadden 1990). Pleistocene cave bear populations in the Croatian Zagorje might be larger or smaller than those in central Slovenia owing to other factors such as food availability, intra-specific competition, inter-specific competition, and so forth. Nonetheless, this simple comparison between Krapina and Divje babe I is a useful starting point for further analyses and research on this topic.

The Krapina male cave bears are much smaller in canine breadth than are the remains identified as male cave bears from Mokriška jama, Potočka zijalka, and Divje babe I (*Tab. 1*). Mokriška jama is dated on the basis of associated "Aurignacian" artefacts to the "middle Würmian period (OIS 3)", and the size difference in canine breadth is highly statistically significant (Mann-Whitney U = 286, Z = -5.72, $p < 0.001$).[2] There is not enough information about the distribution of the Divje babe I canines to compare them statistically to the Krapina remains. There is, however, more detailed information about the small sample of upper canines associated with male cave bear skulls from interpleniglacial (OIS 3) deposits from Divje babe I (Toškan 2007a, 358, Tab. 15.1). The mean breadth of these upper canines from Divje babe I is 22.3 mm (N = 6, s.d. = 2.68), while that for upper canines from Krapina is 19.0 mm (N= 6, s.d. = 0.82). A two-tailed Mann-Whitney test shows this difference to be significant at the 1% level (U = 2, 1% critical value = 2).

How does the size of cave bear long-bones from Krapina compare to assemblages from Divje babe I and other sites in the wider region? Given the strongly biased sex ratio from Krapina, it would be inappropriate to compare these assemblages without taking sexual dimorphism into account. Simple summary statistics show that long-bones sexed as "male" from Krapina are indeed larger than long-bones sexed as "female" from Divje babe I and from sites in the eastern Alps (*Tab. 6*). The lack of females cave bears at Krapina prevents a comparison of their long-bone lengths. Male cave bears from Krapina, however, have on average shorter long-bones than males from Divje babe I, with the exception of the tibia (*Tab. 6*). On the other hand, the Divje babe I male

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Tab. 6: Cave bear long-bone lengths from Krapina compared to Divje babe I (remains sexed in *Tab. 4,* calculated from data in Jambrešić, Turk 2007) and sites in the eastern Alps (data from Reisinger, Hohenegger 1998).
Tab. 6: Primerjava dolžine dolgih kosti jamskih medvedov iz Krapine s tistimi iz Divjih bab I (spol posameznih primerkov podan v *tab. 4*; izračunano na osnovi podatkov v Jambrešić, Turk 2007) oz. z vzhodnoalpskih najdišč (vir podatkov: Reisinger, Hohenegger 1998).

zbujajoča – sploh v primeru razmeroma velikega vzorca lobanj in dolgih kosti. Navedeno tako le še dodatno podkrepljuje tezo o tem, da do močno nesorazmerne zastopanosti obeh spolov v zbirkah ostankov jamskega medveda iz posameznih najdišč lahko pride tudi povsem neodvisno od morebitnih izkopavalčevih oz. kustosovih preferenc do določene skupine najdb.

VELIKOST KRAPINSKIH JAMSKIH MEDVEDOV

Časovna umestitev krapinskih jamskih medvedov je, kot je bilo zgoraj že omenjeno, do neke mere nejasna. Čeprav ESR-datacije in detajlna revizija vseh živalskih ostankov kažejo na to, da se je pretežni del tukaj obravnavanega gradiva odložil v interglacialnih (MIS 5) ali celo visokointerglacialnih (MIS 5e) razmerah (Rink *et al.* 1995; Miracle 2007), pa natančen časovni razpon vendarle še ni znan. Malez (1970b; 1978; Malez, M. in V. 1989) je tako predlagal, da so se najvišje plasti odložile v stadialu würm II (MIS 3), medtem ko naj bi po Heraku (1947) in Patou-Mathisovi (1997) te nastale nekoliko prej, tj. v zgodnjewürmskem glacialu (MIS 4). Čeprav favnistična sestava gradiva iz Krapine v okviru preučevanega profila sicer kaže na določen premik od visokointerglacialnih klimatskih razmer k nekoliko hladnejšim, sam celoten vzorec postavljam v MIS 5 (Miracle 2007, 216). Najbolj problematično je v tem smislu gradivo iz najvišje plasti (tj. plasti 9), od koder najbrž izvira tudi večina medvedjih najdb (Miracle 2007, 32, 211). Pri razjasnjevanju kronostratigrafskega vprašanja bi tako lahko bili koristni tudi podatki o velikosti krapinskh jamskih medvedov. Če je namreč čas nastanka plasti 9 dejansko mogoče postaviti v zgodnji würm, potem bi morali biti v njej zajeti medvedji ostanki po svoji velikosti najmanj primerljivi s tistimi iz glacialnih (MIS 3–4) kontekstov drugih najdišč v regiji. Če ni bilo tako in je torej plast 9 v resnici nastajala v interglacialnih razmerah (MIS 5), pa bi za krapinske jamske medvede pričakovali, da bodo po velikosti zaostajali za tistimi, ki so ta prostor naseljevali v kasnejšem glacialu.

Na območju Hrvaškega Zagorja leži kar nekaj najdišč z bogatim gradivom velikih sesalcev pleistocenske

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[2] The frequency of canines of different breadths from Mokriška jama was read off from the published histogram (Debeljak 2007, Fig. 2), and canines were identified as "male" or "female" using Debeljak's criteria. To calculate the U statistic, all canines from a single size division were assumed to have the size of the midpoint of the division – e.g. 6 canines from the size range "14.0–14.5" were all treated as having a breadth of 14.25 mm. While this procedure has slightly reduced the variance of the Mokriška jama sample, it does not affect the overall results.

	Krapina Male / samci					Divje babe I Male / samci					Divje babe I Female / samice					East Alpine Male V Alpe, samci			East Alpine Female V Alpe, samice		
Element: measure Element: meritev	**Mean / povprečje**	**s.d.**	**Min**	**Max**	**N**	**Mean / povprečje**	**s.d.**	**Min**	**Max**	**N**	**Mean / povprečje**	**s.d.**	**Min**	**Max**	**N**	**Mean / povprečje**	**s.d.**	**N**	**Mean / povprečje**	**s.d.**	**N**
Humerus: GL	403.5	9.97	390	415	6	425.3	25.23	390	473	9	284.0				1	424.6	14.63	26	367.9	8.3	24
Radius: GL	305.3	7.25	298	317	7	324.1	11.16	304	350	47	280.9	8.80	267	296	20	330.2	8.89	20	286.4	10.41	38
Ulna: GL	364.3	4.64	354	368	7	379.8	14.35	350	406	30	329.3	8.78	310	340	8	372.9	17.47	24	325.6	12.09	44
Femur: GL	442.0	14.03	417	464	8	451.8	18.52	420	500	16	383.7	11.93	365	395	6	462.1	18.74	30	390.2	12.53	32
Tibia: GL	295.4	11.33	281	310	5	295.3	11.32	274	326	53	257.5	8.54	241	272	13	302.6	7.46	37	265.8	10.4	38

starosti, ki bi lahko predstavljali ustrezen korpus primerjalnih podatkov za interglacialne in glacialne medvede (Malez 1963; 1986; Paunović 1988; Miracle 1991; Miracle *et al.* 2010). Žal nobeden od teh vzorcev ni bil dovolj detajlno objavljen, da bi omogočal razvrščanje posameznih najdb med oba spola ter v nadaljevanju izvedbo korektne analize velikosti obravnavanih medvedov. Najbližja najdišča, ki so zadostila temu pogoju, so tako Divje babe I (Turk 2007), Mokriška jama (Debeljak 2007) in Potočka zijalka (Pacher *et al.* 2004). V okviru tukaj predstavljene analize je bil izmed naštetih treh poudarek na Divjih babah I, saj to najdišče izstopa po dolgem geološkem zapisu in bogatem vzorcu.

Dodatna prednost navedenega gradiva je tudi, da je najdbe iz posameznih faz würma mogoče obravnavati ločeno. Najgloblje raziskane plasti 13–23, ki so nastajale v zmernih klimatskih razmerah v obdobju med pribl. 116.000 in 80.000 leti (MIS 5a–d; Blackwell *et al.* 2007, 154), tako sestavljajo t. i. facies C. Domnevni prekinitvi v sedimentaciji za časa trajanja glacialnega sunka MIS 4 je sledilo odlaganje plasti 2–12, ki jih je mogoče grupirati v faciesa A in B in ki so nastajale v klimatsko zaostrenih razmerah pred pribl. 70.000–38.000 leti (MIS 3; Blackwell *et al.* 2007, 155). Če so krapinski jamski medvedi živeli v obdobju visokega interglaciala (MIS 5e), potem bi morali biti manjši od primerkov iz faciesa C Divjih bab I, ki jih gre očitno povezati z nekoliko hladnejšo fazo zadnjega interglaciala (tj. MIS 5a–d). V kolikor gre tukaj obravnavane medvede umestiti v klimatsko manj ugoden del MIS 5a–d, bi ti morali velikostno v grobem sovpadati s tistimi iz Divjih bab I – facies C, še vedno pa bi lahko nekoliko zaostajali za primerki iz "glacialnih" faciesov A in B. In še zadnja od možnosti: če so krapinski jamski medvedi živeli v glacialnih razmerah, potem bi morala biti njihova velikost primerljiva prav z velikostjo živali iz faciesov A in B. Navedene hipoteze temeljijo na predpostavki, da so telesno velikost v odločilni meri določale lokalna temperatura in regionalne klimatske razmere, čeprav je sicer znano, da je bila v resnici odvisna od veliko širšega spektra različnih dejavnikov (Damuth, MacFadden 1990). Pleistocenski jamski medvedi iz Hrvaškega Zagorja so tako lahko bili večji oz. manjši od tistih iz osrednje Slovenije tudi zaradi razlik v npr. dostopnosti hrane, ostrine znotraj- ter medvrstnega tekmovanja idr. Ne glede na to je tukajšnja primerjava med Krapino in Divjimi babami I koristno izhodišče za nadaljnje analize in raziskovanje navedene teme.

Samcem pripisani podočniki jamskega medveda iz Krapine so očitno ožji od primerkov istega spola iz Mokriške jame, Potočke zijalke in Divjih bab I (*tab. 1*). Primerki iz Mokriške jame, ki so na podlagi tamkajšnjih "orinasjenskih" artefaktov datirani v srednji würm (MIS 3), so se v primerjavi s tistimi iz Krapine pokazali kot visoko statistično značilno širši (Mann-Whitneyev

Tab. 7: Male cave bear long-bone dimensions from Krapina compared to Divje babe I facies A.
Tab. 7: Primerjava dolžine dolgih kosti samcev iz Krapine in faciesa A Divjih bab I.

	Krapina Males / samci					**Divje babe I facies A Males / samci**					**Mann-Whitney Test / Mann-Whitneyev test**	
Element: measure / Element: meritev	**Mean / povprečje**	**s.d.**	**Min**	**Max**	**N**	**Mean / povprečje**	**s.d.**	**Min**	**Max**	**N**	**U**	**Signif. (2-tailed) / znač. (dvostranski)**
Humerus: GL	403.5	10.0	390	415	6	448.7	25.0	423	473	3	0	5%
Humerus: Bp	90.0	5.1	81	95	6	89.2	1.9	87	90.5	3	6.5	n.s. / n. z.
Humerus: Bd	125.6	2.2	122.3	129.1	8	129.2	5.7	125	140	6	13	n.s. / n. z.
Radius: GL	305.3	7.3	298	317	7	325.4	10.5	304	343	21	8	1%
Radius: Bp	49.6	2.2	46.4	52.2	9	50.1	3.3	42	55	21	81.5	n.s. / n. z.
Radius: Bd	74.4	3.6	69.8	80.1	7	76.9	5.1	68	84	21	50	n.s. / n. z.
Ulna: GL	364.3	4.6	354	368	7	385.0	13.5	359	406	20	17	1%
Femur: GL	442.0	14.0	417	464	8	450.7	16.5	420	465	6	13.5	n.s. / n. z.
Femur: Bp	120.7	5.9	112	129	9	135.2	5.9	130	143	5	0	1%
Femur: DC	57.0	3.0	51.5	61.2	9	59.5	3.1	56	65	6	15.5	n.s. / n. z.
Femur: Bd	98.2	6.0	87.2	105	8	107.7	4.2	104	115	6	3	1%
Tibia: GL	295.4	11.3	281	310	5	298.8	10.7	277	317	23	45	n.s. / n. z.
Tibia: Bp	100.6	5.5	91.6	107.4	7	102.9	4.6	94	111	20	57	n.s. / n. z.
Tibia: Bd	78.1	4.9	70.7	81.6	5	82.7	3.0	76	89	23	23	5%

and female cave bear assemblages are roughly similar in size to the assemblages from the eastern Alps. Are these size differences statistically significant, and are there differences between Krapina and the different depositional facies at Divje babe I? These questions have been addressed by using non-parametric significance tests (two-tailed Mann-Whitney tests) to compare Krapina to Divje babe I facies A and C.

The Divje babe I male cave bear humeri from facies A are significantly larger (two-tailed Mann-Whitney test) than male cave bear humeri from Krapina in greatest length (*Tab. 7*). The Divje babe I male cave bear ulnae and radii from facies A are also significantly longer (GL) than male cave bear ulnae and radii from Krapina. Looking at the femur and tibia, the Divje babe I male specimens from facies A are not significantly longer than those from Krapina, although they are significantly broader at the proximal (femur) and distal ends (*Tab. 7*). This size difference suggests that the Divje babe I facies A and Krapina male cave bears lived under contrasting conditions. Given other evidence of age differences between these assemblages, I suggest that this size difference is best explained by the formation of the Krapina assemblage during interglacial (MIS 5) conditions. These results are further evidence against extending the Krapina sequence into MIS 3 or MIS 4; Krapina layer 9 dates to MIS 5.

Comparison of the Krapina cave bear assemblages to those from Divje babe I facies C is of particular interest given the secure dating of the latter assemblage to MIS 5a-d. Nonetheless, such comparisons are impeded by the relatively small sample of male cave bear remains from facies C. For many of the long-bones, only a single

test: U = 286; Z = -5,72; p < 0,001).[2] Vzorec iz Divjih bab I takšne primerjave ni omogočal, saj so podatki o porazdelitvi metričnih podatkov tamkajšnjih podočnikov preskopi. Podrobneje so predstavljeni zgolj podatki o majhnem vzorcu podočnikov, ki so bili še vraščeni v zgornje čeljustnice samcev iz interpleniglacialnih plasti (tj. OIS 3) navedenega najdišča (Toškan 2007a, 358, tab. 15.1). Povprečna širina navedenih primerkov znaša 22,3 mm (N = 6; s.d. = 2,68), medtem ko je ta pri krapinskih medvedih zgolj 19 mm (N = 6; s.d. = 0,82). Obojestranski Mann-Whitneyjev test je navedeno razliko prepoznal kot statistično značilno pri enoodstotni stopnji tveganja (U = 2, 1 % kritične vrednosti = 2).

V nadaljevanju se posvečamo primerjavi velikosti dolgih kosti jamskega medveda iz Krapine s tistimi iz Divjih bab I in drugih najdišč v širši regiji. Spričo močno asimetrične spolne strukture krapinskega vzorca bi bila takšna primerjava brez upoštevanja spolnega dimorfizma seveda nesmiselna. Že preprosta opisna statistika namreč nedvoumno pokaže, da velikost samcem pripisanih dolgih kosti iz Krapine presega velikost tistih iz Divjih bab I oz. iz vzhodnoalpskih najdišč, ki so bile uvrščene k samicam (*tab. 6*). Žal skorajšnja odsotnost dolgih ko-

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[2] Podatek o številu podočnikov na posamezen velikostni razred (velikost je opredeljena kot širina zoba) v gradivu iz Mokriške jame je bil razbran iz objavljenega histograma (Debeljak 2007, sl. 2); pri tem so bile pri razvrščanju podočnikov med oba spola upoštevane avtoričine smernice. Izračun *U*-statistike je temeljil na predpostavki, da širina vseh primerkov v posameznem velikostnem razredu ustreza sredinski točki – npr. vsem šestim podočnikom iz velikostnega razreda “14,0–14,5” so bile pripisane širine 14,25 mm. Čeprav je takšen pristop malenkostno omejil varianco vzorca iz Mokriške jame, to na končni rezultat ni vplivalo.

male specimen is present. Although there is a suggestive pattern of bones from Divje babe I facies C being relatively large compared to corresponding bones from Krapina, it is impossible to meaningfully compare these assemblages on a bone-by-bone basis.

In a detailed multivariate metric study of cave bear metapodial bones from Divje babe I (N = 1598), Toškan (2007b) demonstrated not only significant sexual dimorphism, but also an increase in size from facies C (MIS 5) to facies A (MIS 3). Toškan used the measurements on bones from facies B to create standards for the different parameters of the 10 different metapodial bones. Measurements on individual bones from facies A and C were then standardized using the mean and standard deviation of corresponding metapodials from facies B. These standardized measurements could then be compared across different dimensions among the metapodials. This procedure considerably increased the sample size available for analysis.

Therefore, to increase the available sample size I have standardized the greatest length of the major long-bones (humerus, radius, ulna, femur, tibia) sexed as male from Krapina, Divje babe I facies C, and Divje babe I facies A relative to measurements of similarly sexed bones from Divje babe I facies B.[3] A histogram

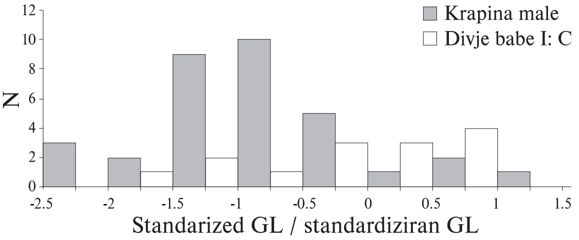

Fig. 14: Histogram of standardized scores of greatest length (GL) of cave bear long-bones from Krapina and Divje babe I, facies C.
Sl. 14: Histogram za standardizirane vrednosti največje dolžine (GL) dolgih kosti jamskih medvedov iz Krapine in Divjih bab I – facies C.

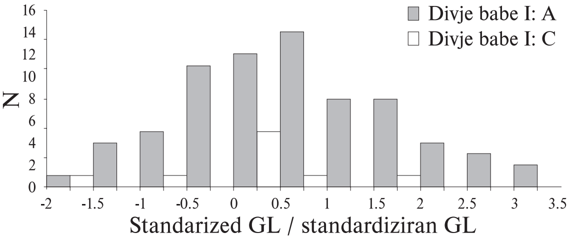

Fig. 15: Histogram of standardized scores of greatest length (GL) of cave bear long-bones from Divje babe I, facies A and C.
Sl. 15: Histogram za standardizirane vrednosti največje dolžine (GL) dolgih kosti jamskih medvedov iz Divjih bab I – faciesa A in C.

sti samic v gradivu iz Krapine onemogoča neposredno primerjanje velikosti medvedk iz navedenih najdišč. Je pa zato takšna primerjava možna pri samcih, pri čemer primerki iz Krapine v največji dolžini posamezne dolge kosti – z edino izjemo golenice – vedno zaostajajo za tistimi iz Divjih bab I (*tab. 6*). Po drugi strani opaznejših razlik med najdbami iz Divjih bab I in tistimi iz vzhodnoalpskih najdišč ni opaziti pri nobenem od obeh spolov. So zgoraj predstavljene razlike statistično značilne? Gre razlike pričakovati tudi med gradivom iz Krapine in tistim iz posameznih faciesov Divjih bab I? Pri iskanju odgovorov na navedeni vprašanji sem uporabil neparametrični obojestranski Mann-Whitneyjev test, s katerim sem primerjal vzorec iz Krapine s tistima iz faciesov A in C Divjih bab I.

Samcem pripisani primerki nadlahtnic iz Divjih bab I – facies A so se izkazali za statistično značilno daljši od tistih iz Krapine (*tab. 7*). Isto je bilo ugotovljeno tudi v primeru komolčnic in koželjnic, ne pa stegnenic in golenic, čeprav so tudi pri slednjih dveh značilne razlike pri nekaterih drugih dimenzijah, tj. pri širini proksimalnega (stegnenica) oz. distalnega (golenica) konca (*tab. 7*). Iz navedenih rezultatov izhaja, da so bile razmere, v katerih so živeli samci iz Divjih bab I za časa nastajanja faciesa A, precej drugačne od tistih, ki so bile lastne samcem krapinske populacije. Glede na jasno razliko v geološki starosti obeh vzorcev se zdi ugotovljene velikostne razlike najučinkoviteje razložiti s tezo, da so se ostanki krapinskih jamskih medvedov pač nakopičili v interglacialnih razmerah (MIS 5). Navedene rezultate je tako mogoče razumeti tudi kot dodaten argument proti podaljševanju obdobja nastajanja krapinskih sedimentov še v MIS 3 ali MIS 4; tamkajšnja plast 9 očitno datira v MIS 5.

Vzporejanje ostankov jamskega medveda iz Krapine s tistimi iz faciesa C Divjih bab I se zdi še posebej zanimivo, saj je umestitev slednje v MIS 5a–d zanesljiva. Žal pa takšne primerjave v praksi ni mogoče opraviti, saj gradivo iz faciesa C Divjih bab I izstopa po majhnem številu ostankov samcev, tisti iz Krapine pa samic. V splošnem se sicer dozdeva, da bi najdbe iz krapinskega vzorca dejansko lahko bile nekoliko manjše, vendar pa gre pri tem zgolj za vtis in ne za zanesljivo ugotovitev.

Detajlna metrična študija metapodijev jamskega medveda iz Divjih bab I (N = 1598) ni pokazala le na obstoj značilnih razlik med spoloma, marveč tudi na porast velikosti navedenih skeletnih elementov od tistih iz faciesa C (MIS 5) do onih iz faciesa A (MIS 3; Toškan 2007b). Pri tem so bili metapodiji iz faciesa B uporabljeni kot referenčni vzorec za standardiziranje vrednosti posameznih parametrov pri desetih različnih metapodialnih kosteh. V nadaljevanju so bile nato te standardizirane vrednosti primerjane ob sočasnem upoštevanju vseh parametrov posameznih metapodijev.

Z namenom povečati velikost razpoložljivega vzorca so bili na podoben način standardizirani tudi podatki o največji dolžini dolgih kosti (tj. nadlahtnice, koželjnice,

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[3] Bones from Divje babe I facies A/B and B/C were excluded from all analyses.

of standardized GL shows that male cave bear bones from Divje babe I facies C tend to be longer than those from Krapina (*Fig. 14*). A two-tailed Mann-Whitney test shows that this difference is significant at the 1% level ($U = 68$, $N_{(\text{Divje babe I facies C})} = 9$, $N_{(\text{Krapina})} = 33$, $z = 2.468$). A similar analysis of distal breadth did not reveal a significant difference between these assemblages (not illustrated). Thus, the male cave bears at Krapina were significantly shorter, although not necessarily lighter, than male cave bears at Divje babe I facies C.

Using a similar approach to standardization, it is also possible to compare facies C to facies A within Divje babe I. The shape of the facies A distribution is close to normal; the facies C distribution is similar to that of facies A (*Fig. 15*). There is not a statistically significant difference between these assemblages in standardized GL. While this result is rather different from that obtained by Toškan (2007b) in his analysis of the metapodial bones, this could be the result of the much smaller sample size of cave bear long-bones compared to metapodials as well as to contrasts in the analytical techniques employed.

CAVE BEAR SIZE: DISCUSSION

This study of male cave bear long-bone lengths shows that the Krapina specimens are significantly smaller than bones from Divje babe I facies C (MIS 5a-d) and Divje babe I facies A (MIS 3). This size difference holds for the canine teeth as well as the major limb bones. There could have been many potential causes for this size difference, ranging from genetic differences between distinct populations, contrasts in the quality or amount of food, or adaptations to differences in temperature/climate. Of these possible explanations, the latter corresponds well with the chronological/climatic contrasts between the Divje babe I assemblage that was mostly deposited during MIS 3, and the Krapina assemblage deposited during MIS 5. The Divje babe I facies C assemblage long-bone dimensions are in most cases larger than those from Krapina, and when dimensions are standardized to allow the aggregation of a large comparative sample, GL is significantly larger at Divje babe I facies C than at Krapina. Although other factors may have caused this size difference, this result is consistent with a chronological and climatic interpretation; the Krapina male cave bears are smaller than those from Divje babe I (facies C) because the former were adapted to the relatively warmer conditions of the full interglacial (MIS 5e), while the latter were adapted to somewhat cooler conditions later in the last interglacial (MIS 5a-d).

Accepting this interpretation of the age difference between these assemblages, these comparisons show that glacial-age male cave bears were larger than their interglacial predecessors. These size changes, however,

komolčnice, stegnenice, golenice) samcev iz Krapine ter Divjih bab I – faciesov A in C, medtem ko so dolge kosti samcev iz faciesa B služile kot referenčni vzorec.[3] Iz histograma tako standardiziranih vrednosti največje dolžine dolgih kosti izhaja, da so bile te pri samcih iz faciesa C Divjih bab I daljše od tistih iz Krapine (*sl. 14*). Kot je pokazal dvostranski Mann-Whitneyjev test, so navedene razlike pri enoodstotni stopnji tveganja celo statistično značilne ($U = 68$; $N_{(\text{Divje babe – facies C})} = 9$; $N_{(\text{Krapina})} = 33$; $z = 2{,}468$). Podobno zastavljena primerjava širine distalnega konca dolgih kosti ni izpostavila statistično značilnih razlik med navedenimi vzorci (ni prikazano). Sklepamo torej lahko, da so bili samci krapinskih jamskih medvedov v primerjavi s tistimi iz faciesa C Divjih bab I zagotovo značilno nižje rasti, ne pa tudi nujno lažji.

Z uporabo enakega postopka standardiziranja je mogoče na podoben način kot zgoraj med seboj primerjati tudi gradivo iz faciesov C in A Divjih bab I. Kot je razvidno iz *slike 15,* se porazdelitev standardiziranih podatkov o največji dolžini (GL) izbranih dolgih kosti v primeru obeh obravnavanih vzorcev približuje normalni. Zanimivo je, da primerjava ni pokazala statistično značilnih razlik med vzorcema. Toškan (2007b) je namreč v svoji študiji metapodijev prišel do drugačnih rezultatov, kar pa bi lahko bila posledica bistveno bogatejšega vzorca dlančnic oz. stopalnic glede na dolge kosti ter tudi nekoliko drugačnih analitičnih pristopov.

VELIKOST JAMSKIH MEDVEDOV: RAZPRAVA

Študija dolžine dolgih kosti samcev jamskih medvedov je pokazala, da so bili primerki iz Krapine v tem pogledu značilno manjši od tistih iz faciesa C (MIS 5a–d) oz. faciesa A (MIS 3) Divjih bab I. Navedene razlike v velikosti so bile ugotovljene tako pri podočnikih kot pri osrednjih dolgih kosteh okončin in bi lahko bile odsev več različnih dejavnikov: od medpopulacijskih razlik v genotipu in razlike v kakovosti ter količini hrane pa do prilagoditve na različne temperature/podnebje. Posebej zanimiva je prav slednja razlaga, saj ta lepo sovpada s kronološkim/klimatskim neskladjem med gradivom iz Divjih bab I, ki se je večinoma odlagalo v MIS 3, ter tistim iz Krapine, ki je datirano v MIS 5. Dimenzije dolgih kosti iz Divjih bab I – facies C v večini primerov presegajo tiste iz Krapine, primerjava standardiziranih vrednosti parametra "največja dolžina" pa je med obema navedenima vzorcema pokazala celo na statistično značilne razlike (primerki iz Divjih bab I so večji). Čeprav potencialnega vpliva drugih dejavnikov na ugotovljene razlike v velikosti ni mogoče izključiti, je zgornja razlaga povsem skladna s kronološko in klimatsko interpretacijo. Samci krapinskih jamskih medvedov naj bi tako bili od tistih iz Divjih bab I (facies C) manjši predvsem

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[3] Kosti iz Divjih bab I – faciesov A/B in B/C so bile izključene iz vseh analiz.

were not uniform across the male cave bear skeleton. The forelimbs increased significantly in length, but not breadth, while the hind limbs did not increase in length, although they did in breadth. Hence body shape changed along with size. Although the forelimb lengthened in glacial bears, there is no evidence that bears were carrying more weight or mass on their forelimbs. The hind limbs show the opposite pattern – increase in weight bearing but not overall length in glacial compared to interglacial male bears. It is interesting to note that sexual dimorphism in long-bone lengths (Reisinger, Hohenegger 1998) and overall metapodial size (Toškan 2007b) is more clearly expressed in the forelimb as opposed to the hind limb.

Such a contrast in limb proportions is probably related to the locomotor adaptation. One might hypothesise that there were differences between Krapina and Divje babe I in terms of roughness of terrain and distribution/availability of food that favoured particular body shapes and the amount and manner in which bears ambled across the landscape. If confirmed, it would be interesting to compare these changes in limb proportions to other hypotheses about progressively increasing plantigrady within the cave bear lineage (Toškan 2007b, 402, and references therein) and the adaptive significance of relatively wide long-bone shafts in cave bears (Viranta 1994). At present there is not sufficient material, there are too many temporal gaps between assemblages, and there is too little control over chronology and palaeoecology to identify evolutionary trends as opposed to local adaptations. The explanation of these patterns requires further work, including detailed morphological comparisons between these assemblages.

CONCLUSION

Returning to the questions posed at the beginning of this study, one can emphatically affirm that cave bear long-bones from Krapina show a male-skewed sex ratio similar to that previously documented for the canine teeth. While this pattern has probably been influenced by recovery biases and curatorial decisions, there are good reasons to believe that it is "real" ; in fact, heavily male-biased cave bear assemblages are relatively common in the wider region in contexts where recovery and curation biases were not significant factors.

These results have interesting implications for our understanding of cave bear life history and ecology. One explanation of Krapina's skewed cave bear sex ratio is the ecology of den choice. Kurtén (1955; 1958) and others (e.g. Andrews, Turner 1992) have suggested that adult females, particularly those pregnant or with cubs, would have avoided adult males during hibernation. Brown bears provide a useful analogue; hibernating bears are usually either solitary, or else are females with dependent

zato, ker so bili prvi prilagojeni na razmeroma tople razmere visokega interglaciala (MIS 5e), drugi pa na do neke mere hladnejše podnebje zaključnega dela zadnjega interglaciala (MIS 5a–d).

Ko torej enkrat sprejmemo interpretacijo o različni geološki starosti gradiv iz navedenih dveh najdišč, lahko rezultate brez težav sprejmemo kot dokaz povečanja velikosti medvedov iz zadnjega glaciala glede na tiste iz predhodnega interglaciala. Pri tem je zanimivo, da je navedeno povečanje različne dele skeleta zajelo različno intenzivno. Tako so se kosti prednjih okončin značilno podaljšale, ni pa se povečala tudi njihova širina, medtem ko je pri kosteh zadnjih okončin slika obratna. To pa torej obenem pomeni, da se je vzporedno z velikostjo telesa spreminjala tudi njegova oblika. Čeprav so bile dolge kosti prednjih okončin pri medvedih iz zadnjega glaciala daljše od tistih pri njihovih interglacialnih predhodnikih, pa dokazov o hkratnem povečanju obremenitve prednjega para nog ni. Obratno sliko kažejo kosti zadnjih nog, kjer naj bi z nastopom glaciala prišlo do povečanja njihove obremenitve, medtem ko samo podaljšanje posameznih skeletnih elementov ni bilo ugotovljeno. K temu je zanimivo dodati, da spolni dimorfizem izraziteje odseva v dolžini dolgih kosti in skupni velikosti metapodijev prednjega para okončin kot v primeru zadnjega (Reisinger, Hohenegger 1998; Toškan 2007b).

Ugotovljene razlike v proporcih okončin med medvedi iz Krapine in Divjih bab I so najbrž povezane s prilagoditvami gibanja ene in druge populacije. Domnevamo namreč lahko, da so bile med pokrajinama v okolici obeh navedenih najdišč določene razlike v razgibanosti terena ter v porazdelitvi/dostopnosti hrane, ki so favorizirale določen obseg in način hoje ter obliko telesa. V kolikor bi bilo navedeno domnevo mogoče potrditi, bi bilo zgoraj predstavljene razlike v proporcih dolgih kosti zanimivo primerjati s tezami o postopoma vse bolj izraženi plantigradnosti pri ledenodobnih medvedih (Toškan 2007b, 402 ter tam citirani viri) ter o prilagoditvenem pomenu relativno širokih diafiz dolgih kosti jamskih medvedov (Viranta 1994). Žal dandanes prepoznavanje vloge evolucijskih trendov nasproti lokalnim prilagoditvam še ni izvedljivo zaradi preskromnega gradiva, preštevilnih časovnih vrzeli med posameznimi vzorci ter preslabega poznavanja kronologije in paleoekologije. Do bolj poglobljenega poznavanja navedene problematike bo torej lahko pripeljalo zgolj nadaljevanje raziskav, vključno s primerjanjem morfologije jamskih medvedov s posameznih najdišč.

SKLEP

Vrnimo se za hip k uvodoma postavljenemu vprašanju o tem, ali se na dolgih kosteh okončin temelječa spolna struktura krapinskih jamskih medvedov ujema young. Kurtén (1958, 46 f) suggested that these features of bear behaviour might have had a spatial expression, with females and young choosing smaller caves that were hidden and more easily defended, while "the enormous Drachenhöhle at Mixnitz, which probably served as winter quarters for several individuals, would be generally avoided by more experienced female bears in gestation." The relatively large size and openness of the bedrock shelter at Krapina may have made it a much more appealing hibernation spot for cave bear males than females.

As discussed briefly above, the strongly male-biased sex structure complements the mortality structure dominated by prime adults followed by old animals. Although a few foetal and neonatal remains attest to the occasional use of Krapina by pregnant female cave bears, the rockshelter only rarely served as a nursery den. Krapina was primarily used by prime-aged to old-adult male cave bears once the rockshelter had mostly filled with sediment eroded from the shelter roof and wall (Miracle 2007).

A second and related factor is the altitude of the cave. Reisinger and Hohenegger (1998, 113) suggest that the predominance of female cave bears at higher altitude sites, like Conturines (2775 m a.s.l.) and Gamssulzen Caves (1300 m a.s.l.) compared to lower altitude sites like Herdengel Cave (780 m a.s.l.), lies in the preference of females for "ecologically extreme regions" for hiding cubs from males. The presence of male-dominated assemblages, especially in the old-age cohort, at sites like Mokriška jama (1500 m a.s.l.) and Potočka zijalka (1700 m a.s.l.) suggests that altitude *per se* is not the relevant factor (Debeljak 2004, 179). Although Krapina lies at a relatively low altitude (120 m a.s.l.), I think that the mophology of the shelter had a stronger influence on the male-biased sex structure than the low-altitude setting.

Toškan (2007b, 403) interpreted the shift in sex ratio at Divje babe I – from female dominated during the more temperate conditions of facies C, to male dominated during the cooler and more extreme climatic conditions of facies A in terms of cave bear life history. In modern black and brown bears, pregnant females are the first to occupy a lair in good climatic conditions, followed by subadults and finally adult males. Furthermore, postponement or even absence of hibernation in males can be caused by abundant food in the autumn. Hence, under good climatic conditions one expects more females relative to males to be hibernating, which should skew sex ratios from lair sites in favour of females (Toškan 2007b, 403). In contrast, under more severe climatic conditions the males enter hibernation at the same time as pregnant females and subadults, increasing intersexual competition for appropriate lairs. Since pregnant females and those with young avoid solitary males, the onset of severe climatic conditions will favour males in lairs. Thus, the shift in sex ratio at Divje babe I

s tisto, ki izhaja iz podočnikov? Kot so pokazali tukaj predstavljeni rezultati, je odgovor nedvoumno pozitiven: v obeh primerih je bila namreč ugotovljena očitna prevlada samcev. K takšni sliki sta v manjši meri zagotovo prispevali pristranskost izkopavalcev in selektivna politika kustosov, v splošnem pa naj bi vendarle odsevala "resnično" stanje. Ne nazadnje so vzorci z izrazito večinsko zastopanostjo samcev v širši regiji razmeroma pogosti tudi v kontekstih, kjer nepristanskost izkopavalcev in kustosov ni igrala omembe vredne vloge.

Rezultati tukajšnje študije imajo zanimive implikacije za naše razumevanje življenja, zgodovine in ekologije jamskega medveda. Ena od možnih razlag večinske zastopanosti samcev v Krapini je vezana na izbiro brloga. Po mnenju Kurténa (1955; 1958) in še nekaterih drugih avtorjev (npr. Andrews, Turner 1992) naj bi se odrasle samice – še posebej breje oz. tiste z mladiči – med obdobjem prezimovanja izogibale odraslih samcev. Koristno analogijo ponujajo rjavi medvedi, pri katerih so hibernirajoče živali navadno bodisi solitarne bodisi gre za samice z mladiči, še odvisnimi od nje. Pri tem Kurtén (1958, 46 s) dodaja, da bi takšno vedenje lahko imelo tudi "prostorsko komponento": samice in mladiči naj bi tako izbirali predvsem manjše, skrite, lažje ubranljive jame, medtem ko naj bi se "gromozanski jami Drachenhöhle v bližini Mixnitza, ki je najbrž služila kot zimski brlog večjemu številu živali, bolj izkušene breje samice v splošnem izogibale". V skladu z napisanim je tako spodmol v Krapini s svojim razmeroma obsežnim vhodom kot zimski brlog bolj privlačil samce od samic.

Kot je bilo zgoraj že podrobneje obravnavano, se v korist samcev močno asimetrična spolna struktura dopolnjuje s starostno, ki kaže prevlado mladih odraslih ter – v drugi vrsti – starih živali. Čeprav posamezne najdbe kosti zarodkov oz. komaj skotenih mladičev sicer pričajo o občasni uporabi Krapine tudi brejih samic, se to ni dogajalo pogosto. Ko so spodmol v večjem delu zapolnili sedimenti, ki so nastali z erodiranjem stropa, so najdišče pač povečini uporabljali mladi odrasli do odrasli samci (Miracle 2007).

Drugi – s prvim sicer nedvomno povezan – dejavnik vpliva na spolno strukturo tafocenoze je nadmorska višina jame. V zvezi s tem sta Reisinger in Hohenegger (1998, 113) predlagala, da bi lahko večinsko zastopanost samic v visokoležečih najdiščih, kot sta jami Conturines (2775 m n. m.) in Gamssulzen (1300 m n. m.), v primerjavi s stanjem v nižjeležečih (npr. jama Herdengel: 780 m n. m.) razlagali kot njihovo preferenco do "ekološko ekstremnih okolij" pri izbiri skrivališč za mladiče pred samci. Po drugi strani pa prevlada samcev – sploh med ostanki starih živali – v gradivu iz Mokriške jame (1500 m n. m.) in Potočke zijalke (1700 m n. m.) nakazuje, da nadmorska višina kot taka vendarle ne bi smela imeti odločujočujočega vpliva (Debeljak 2004, 179). Čeprav Krapina leži na razmeroma nizki nadmorski višini (120 m), se zdi, da je is explained in terms of a deterioration in climatic conditions from MIS 5a-d to MIS 3.

Toškan's interpretation of Divje babe I makes good sense for that site. The situation at Krapina appears to have been quite different. The rockshelter at Krapina was never a very appealing lair for pregnant females. Local conditions, in this case the morphology of the shelter, but perhaps also other factors of forage availability and terrain, had a much greater influence on lair choice at Krapina than did regional climates and general conditions.

This detailed analysis of the sex structure of the Krapina cave bears suggests that the last major phase of occupation at Krapina (layer 9) was by prime-adult to old male cave bears. These animals probably came to the shelter to use it as a hibernation den. On rare occasions, perhaps after a longer period of abandonment, female bears also used the site to hibernate and give birth. While internecine killing may have been a common source of mortality, the infrequent evidence of gnawing on the cave bear bones suggests that most carcasses were not cannibalized. The relatively low incidence of modification of cave bear bones suggests a relatively rapid burial. A rapid sedimentation of layer 9 raises the possibility that Krapina was used as a bear den for a relatively short period of time. Further progress on – if not resolution of – the issue of the chronostratigraphic extent of the Krapina sequence can be made through a consideration of the body size of the Krapina cave bears.

Thus, returning to the second question – the size of Krapina cave bears compared to animals from nearby sites of known age – it becomes apparent that male cave bears at Krapina were quite diminutive in stature compared to somewhat younger samples from Divje babe I, Mokriška jama, and Potočka zijalka. Comparisons to different facies at Divje babe I suggests that the Krapina cave bears were deposited under full interglacial conditions (MIS 5e) and that the stratigraphic sequence at the site does not extend beyond MIS 5e.

At the scale of comparing interglacial to glacial, or even at the finer scale of comparing full interglacial to other interglacial assemblages, there is justification for treating Krapina as a single unit. The Krapina assemblages have greater temporal homogeneity and integrity than previously thought. Restriction of the Krapina sequence to MIS 5e thus heightens its importance and significance as a reference point for the last interglacial in Central and Southeastern Europe.

This analysis of cave bear size at Krapina suggests that deposition occurred over an interval of thousands of years rather than tens of thousands of years. Possible temporal changes and trends in the assemblages, whether faunal (Miracle 2007), hominin (e.g. Smith 1976; Wolpoff 1980), and/or artefact (e.g. Simek and Smith 1997, 573), must be explained by short-term processes that operated within a time frame of at most

prevlada samcev med krapinskimi medvedi prej odsev morfologije samega spodmola kot pa njegove nizke lege.

Toškan (2007b) je v okviru študije metapodijev jamskih medvedov iz Divjih bab I ugotovil, da so v obdobju razmeroma zmerne klime (facies C) jamo obiskovale večinoma samice, v bolj hladnih in vlažnih fazah zadnjega glaciala (facies A) pa je bila večinoma domena samcev. Navedeni obrat je poskušal razložiti z upoštevanjem biologije navedene vrste (Toškan 2007b, 403). Znano je, da pri recentnih rjavih in črnih medvedih v obdobju ugodnih klimatskih razmer potencialne jamske brloge prve zasedejo breje samice, ki jim nato sledijo subadultne živali in na koncu še odrasli samci. Pri tem lahko obilne količine hrane v jesenskem času pri slednjih sprožijo zamik v začetku hiberniranja ali celo njegov izostanek. Iz tega bi lahko sklepali, da je tudi v klimatsko razmeroma ugodnih fazah pleistocena prezimovalo več samic od samcev, kar je seveda botrovalo prevladi ostankov medvedk med gradivom iz posameznih jamskih brlogov (Toškan 2007b, 403). V nasprotju s tem naj bi z nastopom ostrejše klime samci začenjali hibernirati približno sočasno kot breje samice in subadultne živali, kar je seveda zaostrilo medspolno tekmovanje za primerne brloge. Ker se breje samice in mladi medvedi praviloma izogibajo samotarskih samcev, bi ob vsakršni zaostritvi podnebnih razmer samci imeli prednost pri zasedbi jamskih brlogov. Skratka: razlike v spolni strukturi med vzorcema iz faciesa C in faciesa A Divjih bab I avtor razlaga z zaostritvijo klime s prehodom iz MIS 5a–d v MIS 3.

Toškanova interpretacija stanja v Divjih babah I se dejansko zdi utemeljena za dano najdišče, v primeru Krapine pa so se stvari domnevno odvijale nekoliko drugače. Tamkajšnji spodmol za breje medvedke namreč nikoli ni bil posebej zanimiv kot brlog. Lokalne razmere – v tem smislu predvsem morfologija samega spodmola, morda pa tudi npr. dostopnost hrane ali razgibanost terena – so morale imeti namreč v primeru Krapine veliko večji vpliv na spolno strukturo hibernirajočih medvedov od regionalnega podnebja in splošnih razmer.

Podrobna analiza razmerja med spoloma v gradivu krapinskih jamskih medvedov je pokazala, da so med zadnjo izrazitejšo poselitveno fazo (plast 9) spodmol obiskovali predvsem mlajši odrasli do stari samci. Ti so tja najbrž zahajali predvsem zato, ker jim je spodmol služil kot zimski brlog. Ob redkih priložnostih – morda potem ko je bila lokacija za neko daljše časovno obdobje zapuščena – so v jami prezimovale in v njej kotile tudi breje samice. Čeprav bi bilo lahko medsebojno ubijanje pri jamskem medvedu načeloma pomemben vzrok pogina, pa maloštevilnost obgrizenih medvedjih kosti takšni tezi v primeru Krapine nasprotuje. Redke so tudi druge vrste modifikacij na kosteh, kar kaže na to, da je moral sediment razmeroma hitro prekriti kosti. Eventualna hitra sedimentacija plasti 9 seveda sproža nove domneve, med drugim tudi o tem, da naj bi Krapina kot jamski brlog služila zgolj v razmeroma kratkem časovnem obdobju.

a dozen or so millennia. The temporal changes in subsistence activities, raw material choice for making stone tools, and site use (Miracle 2007) at Krapina occurred over a relatively short time period and suggest that Neandertals were behaviourally flexible, shifting their activities and strategies in response to local conditions and opportunities.

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Vzporejanje velikosti krapinskih jamskih medvedov z velikostjo tistih iz bližnjih dobro datiranih najdišč je pokazalo, da so bili samci iz Krapine nižje rasti od geološko sicer nekoliko mlajših primerkov iz Divjih bab I, Mokriške jame in Potočke zijalke. Iz primerjave z najdbami iz posameznih faciesov Divjih bab I med drugim tudi izhaja, da so krapinski jamski medvedi živeli v visokointerglacialnih razmerah (MIS 5e) in da se sedimentacija v spodmolu ni nadaljevala v obdobja po MIS 5e.

Primerjavi jamskih medvedov interglacialne in glacialne starosti kot tudi živali iz visokega interglaciala s tisimi iz drugih faz riss-würma podkrepljujeta odločitev o obravnavi krapinskega gradiva kot enotnega vzorca. Gre namreč za gradivo, ki ga označujeta večja časovna homogenost in celovitost kot je bilo predhodno domnevano. Omejitev geološkega zapisa Krapine na MIS 5e torej povečuje pomen najdišča kot referenčne točke za zadnji interglacial srednje in jugovzhodne Evrope.

Predstavljena študija krapinskih jamskih medvedov nakazuje, da so plasti nastajale v obdobju nekaj tisoč in ne nekaj desettisoč let. Eventualne časovne spremembe v gradivu – bodisi favnističnem (Miracle 2007), hominskem (npr. Smith 1976; Wolpoff 1980) ali na nivoju artefaktov (npr. Simek, Smith 1997, 573) – je torej treba razložiti s pomočjo kratkotrajnih procesov, ki niso delovali dlje kot ducat tisočletij. Prav dejstvo, da so bile časovne spremembe v aktivnostih, ki omogočajo preživetje, v izbiri surovin za izdelavo kamnitih orodij ter v načinu uporabe spodmola (Miracle 2007) v Krapini razmeroma hitre, pa kaže na to, da so bili neandertalci vedenjsko prožni in da so kot taki ustrezno prilagajali svoje aktivnosti in strategijo vsakokratnim lokalnim razmeram in priložnostim.

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Prevod: Borut Toškan

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DIET, PHYSIOLOGY AND ENVIRONMENT OF THE CAVE BEAR: A BIOGEOCHEMICAL STUDY

PREHRANA, FIZIOLOGIJA IN OKOLJE JAMSKEGA MEDVEDA: BIOGEOKEMIČNA RAZISKAVA

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Abstract

In the last years, biogeochemical studies based on stable isotope analysis on fossil remains of cave bears were conducted by different research groups in order to elucidate some of the still open questions of the palaeobiology of this extinct species. In particular, questions about the diet of the cave bears were intensively addressed. Published results, however, give an unclear view if isotopic analysis are not considered in connection with the insights from other fields of research.

However, the isotopic signatures cannot be interpreted straightforward and alone. It is necessary to take into account other data such as the phylogeny, the morphology, and the particular physiology, in a well-known chronological framework, to get a clear picture of the palaeobiology of an extinct species.

In this work we review the available isotopic data coming only from well-contextualized cave bear sites, and explore how the climate can influence the physiology of the cave bears through their hibernation length and, in turn, the isotopic signatures registered in their bones.

Keywords: *Ursus spelaeus*, stable isotopes, diet, hibernation, palaeoenvironment

INTRODUCTION

The cave bear (*Ursus speleaus* Rosenmüller) is an extinct ursid that lived in a large part of Europe during the Pleistocene. Separated from the evolution line of the brown bear from 2.4 to 3.1 million years ago (Krause *et al.* 2008) or minimum 1My ago (Loreille *et al.* 2001), it developed clear morphological adaptations towards a preferably herbivorous type of diet clearly visible in its

Izvleček

V zadnjih letih so različne raziskovalne skupine opravile številne biogeokemične raziskave, ki so temeljile na analizi stabilnih izotopov fosilnih ostankov jamskih medvedov, da bi preučili nekatera odprta vprašanja o paleobiologiji te izumrle vrste. Še zlasti intenzivno so se ukvarjali z raziskovalnimi vprašanji, ki se nanašajo na prehrano jamskih medvedov, vendar pa bi rezultati analize stabilnih izotopov brez sodelovanja drugih raziskovalnih področij ostali nejasni.

Izotopskega zapisa namreč ni moč interpretirati poenostavljeno in izolirano. Pri interpretaciji je treba upoštevati tudi druge podatke, kot so filogenetski, morfološki in še zlasti fiziološki, skupaj z jasnim kronološkim okvirom, kar nam pomaga razjasniti paleobiologijo izumrlih vrst.

V tem prispevku podajamo pregled obstoječih podatkov o izotopski sestavi, ki izvirajo iz nahajališč jamskih medvedov z jasnim najdiščnim kontekstom, ter raziskujemo vpliv klime na fiziologijo (dolžino hibernacije) in posledično izotopsko sestavo kosti.

Ključne besede: *Ursus spelaeus*, stabilni izotopi, prehrana, hibernacija, paleookolje

UVOD

Jamski medved (*Ursus speleaus* Rosenmüller) je izumrla vrsta iz rodu medvedov, ki je v pleistocenu živela v večjem delu Evrope. Od evolucijske linije rjavega medveda se je ločil pred najmanj milijonom let (Loreille *et al.* 2001), morda pa celo že pred 2,4 do 3,1 milijona let (Krause *et al.* 2008). Razvoj zobovja in žvekalnih mišic jamskega medveda kaže očitne prilagoditve na pretežno dentition and masticatory musculature (Kurtén 1976; Mazza *et al.* 1995; Rabeder 1999; Grandal-d'Anglade, López-González 2005; Grandal-d'Anglade 2010).

The trophic level of an extinct animal may be also studied through stable isotopes of carbon (C) and especially of nitrogen (N). The stable isotopes data have confirmed a mainly herbivorous diet for this species in sites throughout Europe (Bocherens *et al.* 1994; 2006; Fernández-Mosquera *et al.* 2001; Nelson *et al.* 1998) though in some specific cases (Richards *et al.* 2008) this indicator may suggest a less herbivorous contribution to the whole diet.

The impossibility of knowing environmental parameters that may condition the isotopic signatures, such as the starting values of vegetation and soil, obliges one to act cautiously when comparing the absolute values of this signature among individuals, even of the same species.

In this work we review the available isotopic data coming only from well-contextualized sites in order to establish the physiological and environmental information obtained with this technique and to evaluate its possibilities and limitations in the field of the questions that are still pending on the palaeobiology of the cave bear.

BIOLOGY AND ISOTOPIC SIGNATURE OF *Ursus spelaeus*

The isotopic values of the bone collagen show the diet of an animal but also depend on their metabolic processes, and both diet and metabolism act according to their environmental variations (Hedges *et al.* 2004). In the case of bears, apart from their mainly herbivorous alimentation, their special metabolism during hibernation (whose duration depends on the climate) may decisively influence the isotopic signature.

The $\delta^{13}C$ values of the bone collagen are determined first by the type of material that forms the diet; in all cases it may be supposed to be a diet mainly based on C3 plants (herbaceous and bushy of temperate climate). Apart from the wide range of $\delta^{13}C$ values in this type of plants, there is the physiological effect of hibernation, as during it bears nourish almost exclusively on their fatty reserves. As the fats are impoverished in the heavy isotope (DeNiro, Epstein 1978; Tieszen, Bouton 1989), the resulting values will be more negative than the ones of other non-hibernating herbivores (Bocherens *et al.* 1997).

The $\delta^{15}N$ values of the collagen clearly indicate a trophic level of the herbivore. In some case, as the Liñares site, the $\delta^{15}N$ values are surprisingly lower than the values of coeval herbivores (*Cervus elaphus*). Though low $\delta^{15}N$ values have been frequently described in the literature for the cave bear, the only hypothesis that has been posed to explain them up to now is that the diet could be rich in N-fixing plants, like the leguminous

rastlinsko prehrano (Kurtén 1976; Mazza *et al.* 1995; Rabeder 1999; Grandal-d'Anglade, López-González 2005; Grandal-d'Anglade 2010).

Trofični nivo te danes izumrle živali lahko preučujemo tudi z analizo stabilnih izotopov ogljika (C) in še zlasti dušika (N). Podatki o meritvah stabilnih izotopov iz različnih delov Evrope so potrdili pretežno rastlinsko prehrano jamskega medveda (Bocherens *et al.* 1994; 2006; Fernández-Mosquera *et al.* 2001; Nelson *et al.* 1998), čeprav je bil delež rastlinske hrane v nekaterih primerih morda vendarle manj izrazit (Richards *et al.* 2008).

Nepoznavanje nekdanjih okoljskih razmer, ki so vplivale na izotopski zapis, ter samih izotopskih vrednosti vegetacije in tal narekuje previdnost pri primerjavi absolutnih vrednosti posameznih živali, pa čeprav gre za isto vrsto.

V tem prispevku podajamo pregled obstoječih podatkov o izotopski sestavi, ki izvirajo iz nahajališč z jasnim najdiščnim kontekstom in tako osvetljujejo problematiko fiziologije in nekdanjega okolja jamskih medvedov; namen predstavitve je torej ovrednotiti možnosti in omejitve raziskovalne metode pri iskanju odgovorov na nerešena vprašanja v zvezi s paleobiologijo jamskega medveda.

BIOLOGIJA IN IZOTOPSKI ZAPIS VRSTE *Ursus spelaeus*

Izotopske vrednosti kostnega kolagena odsevajo prehrano živali in njihovo presnovo, preko navedenih dveh dejavnikov pa nanje vplivajo tudi spremembe okolja (Hedges *et al.* 2004). Izotopski zapis pri medvedih tako ne odseva zgolj njihove pretežno rastlinske prehrane, marveč v veliki meri tudi posebno vrsto presnove med hibernacijo (katere dolžina je odvisna od klime).

Vrednosti $\delta^{13}C$ kostnega kolagena so v prvi vrsti odvisne od prehrane, pri čemer lahko domnevamo, da je ta vedno temeljila na rastlinah tipa C3 (tj. na zeliščih in grmih, ki uspevajo v zmerno topli klimi). Poleg širokega spektra vrednosti $\delta^{13}C$ pri tem tipu rastlin moramo upoštevati tudi fiziološki vpliv hibernacije, med katero se medvedi prehranjujejo skoraj izključno z lastnimi maščobnimi rezervami. Ker maščobe vsebujejo manj težjega izotopa (DeNiro, Epstein 1978; Tieszen, Bouton 1989), so končne izotopske vrednosti bolj negativne kot pri ostalih rastlinojedih, ki hibernacije ne poznajo (Bocherens *et al.* 1997).

Iz vrednosti $\delta^{15}N$ kolagena jasno izhaja herbivornost jamskega medveda. V nekaterih primerih, kot na najdišču Liñares, so vrednosti $\delta^{15}N$ presenetljivo nižje od vrednosti drugih rastlinojedih sesalcev (npr. jelen oz. *Cervus elaphus*) iz istega časovnega obdobja. Čeprav je objavljenih podatkov o nizki vrednosti $\delta^{15}N$ pri jamskem medvedu veliko, edini poskus njihove interpretacije ostaja tisti, po katerem naj bi bila prehrana jamskih medvedov pač bogata z rastlinami, ki kopičijo ones (Vila Taboada *et al.* 2001), which are rich in proteins and also a common component of the present bears' diet, at least in certain periods of the year (Mowat, Heard 2006; Rodríguez *et al.* 2007).

Hibernation also influences the isotopic values of the nitrogen. It is a period with a variable duration during which the bear takes neither water nor food, also neither urinates nor defecates. However, its metabolism does not slow down (Hissa 1997). The energy is obtained from the accumulated fats, and the muscular mass is not lost but renewed (Lohuis *et al.* 2007). The products of the catabolism, like urea, are not excreted but recycled (Nelson *et al.* 1975; Floyd *et al.* 1990; Barboza *et al.* 1997) and the bone tissue does not suffer losses but is actively remodelled (Donahue *et al.* 2006; Lennox *et al.* 2008; McGee *et al.* 2008). During dormancy the protein synthesis is carried out from the nitrogenised compounds produced thanks to the reuse of the reabsorbed urea. Therefore, the collagen extracted from the bone remains will be able to record the physiological changes that occurred during hibernation.

Some authors do not share this interpretation. According to Lennox *et al.* 2008, hibernating polar bears accumulate new bone prior to hibernation (as an anticipation of bone loss during hibernation) while American black bears would synthesize new bone just after hibernation to compensate for bone loss during hibernation (McGee *et al.* 2008).

However, it was observed that American black bears (Nelson, Beck 1984) stop feeding up to three or four weeks before entering the den. This behaviour, known as "pre hibernation lethargy" was also described for Brown bears (Craighead, F.C. & J.J. 1972; Manchi, Swenson 2005 and references therein). The pre-denning fast was interpreted as a mechanism to trigger the hibernation metabolism, as suggested by the recorded ratio urea/creatinine in serum: this ratio reaches the same values in pre-denning black bears than in hibernating black bears and differs significantly from the ratio observed during midsummer (Nelson *et al*. 1984).

Female polar bears start fasting up to 2 or three months before entering in the den (Atkinson 1996). Thus, serum markers of bone turnover can be detected before the bears enter in their den (Lennox *et al.* 2008), but this pre-denning bone turnover presumably does not differ from the bone turnover experienced during hibernation, since in both cases the bears are not eating.

According to our model, the $\delta^{15}N$ values of animals that hibernated for longer periods (i.e. in cold phases), will be greater that those who lived during temperate periods (Fernández-Mosquera *et al.* 2001; Grandal-d'Anglade, Fernández Mosquera 2008), though the values do not reach those of a carnivorous animal.

For the moment, this effect could not be quantified in the bone collagen, but certainly in present brown

dušik (npr. stročnice; Vila Taboada *et al.* 2001). Te namreč vsebujejo veliko beljakovin in so vsaj v nekaterih letnih časih pomemben sestavni del prehrane recentnih medvedov (Mowat, Heard 2006; Rodríguez *et al.* 2007).

Na izotopske vrednosti dušika vpliva tudi hibernacija. To obdobje, ko medved ne uživa vode ali hrane, niti ne urinira ali iztreblja, traja različno dolgo, njegov metabolizem pa se kljub temu ne upočasni (Hissa 1997). Medved dobiva energijo iz nakopičenih maščob, vendar mišične mase ne izgublja, ampak jo celo obnavlja (Lohuis *et al.* 2007). Razpadni produkti, kot je na primer sečnina, niso izločeni, marveč se reciklirajo (Nelson *et al.* 1975; Floyd *et al.* 1990; Barboza *et al.* 1997), prav tako pa se ne zmanjšuje niti količina kostnega tkiva, ki se – nasprotno – aktivno preoblikuje (Donahue *et al.* 2006; Lennox *et al.* 2008; McGee *et al.* 2008). Med dormanco sinteza proteinov poteka iz sestavin, obogatenih z dušikom, ki nastajajo med ponovno uporabo reabsorbirane sečnine. Zato kolagen, ki ga izločimo iz kostnih ostankov, beleži fiziološke spremembe med hibernacijo.

Nekateri avtorji se z zgornjo interpretacijo ne strinjajo. Po mnenju Lennoxa *et al.* (2008) severni medvedi kopičijo novo kostno tkivo že pred hibernacijo (kot nadomestilo za izgubo kostnega tkiva med samim prezimovanjem), medtem ko ameriški črni medvedi izgubo kostnega tkiva med hibernacijo nadomestijo takoj, ko se ta konča (McGee *et al.* 2008).

Vendar pa je v zvezi s tem treba omeniti opažanja, po katerih se ameriški črni medvedi (Nelson, Beck 1984) do tri ali štiri tedne pred vstopom v brlog ne prehranjujejo. To obnašanje, znano kot "letargija pred začetkom hibernacije", je bilo opisano tudi pri rjavem medvedu (Craighead, F.C. in J.J. 1972; Manchi, Swenson 2005 in tam navedeni viri). Stradanje pred vstopom v prezimovališče so raziskovalci interpretirali kot mehanizem, ki sproži hibernacijski metabolizem, kar se kaže v izmerjenem razmerju med sečnino in kreatininom v serumu: to razmerje je pri črnih medvedih pred hibernacijo in med njo enako, pri čemer pa bistveno odstopa od vrednosti sredi poletja (Nelson *et al*. 1984).

Samice severnega medveda začnejo stradati do dva ali tri mesece pred vstopom v brlog (Atkinson, 1996). Serumske markerje za preoblikovanje kosti lahko zato pri teh medvedih najdemo že tudi pri živalih, ki so še zunaj brloga (Lennox *et al.* 2008). Pri tem se preoblikovanje kosti pred hibernacijo domnevno ne razlikuje od tistega med njo, saj živali v obeh primerih stradajo.

Glede na naš model bi morale vrednosti $\delta^{15}N$ pri živalih, ki so zaradi hladnega podnebja hibernirale dlje, presegati tiste pri medvedih v obdobju zmerno toplega podnebja (Fernández-Mosquera *et al.* 2001; Grandal-d'Anglade, Fernández-Mosquera 2008), čeprav tudi te še vedno ne dosegajo vrednosti pri karnivorih.

Dasiravno vpliva dolžine hibernacije v kostnem kolagenu za zdaj še ne moremo točno kvantificirati, so raziskovalci pri recentnem rjavem medvedu med

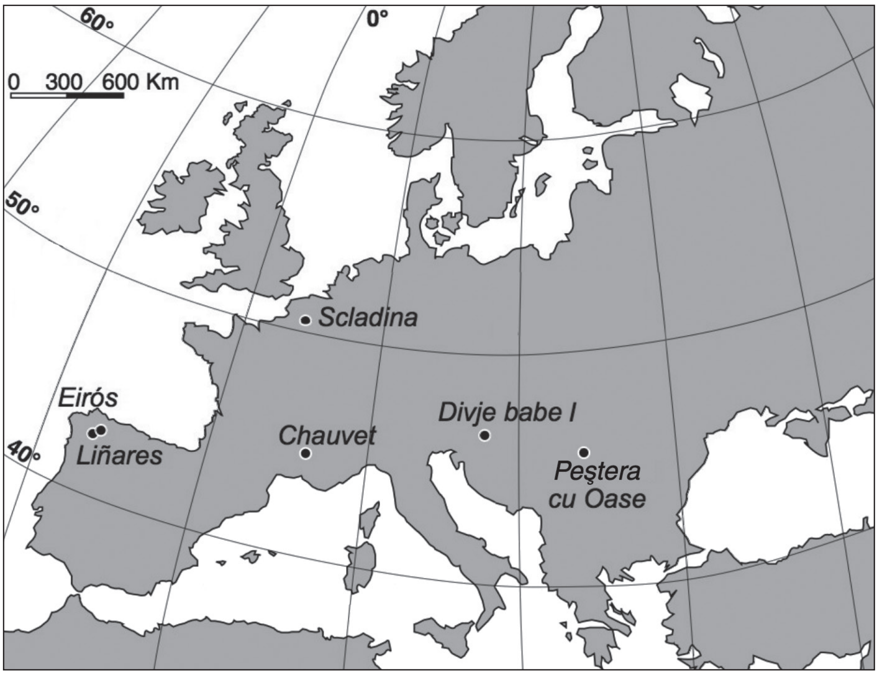


Fig. 1: Map of the sites included in this revision.
Sl. 1: Zemljevid z najdišči, omenjenimi v prispevku.

bears it has been noted that the δ^{15}N of the blood serum is about 2 ‰ higher during hibernation (Jenkins *et al.* 2004), as well as an increase of about 1 ‰ in the muscular δ^{15}N after 3 months of hibernation (Lohuis *et al.* 2007). The latter authors interpret their data as a consequence of the quality of food intake just before hibernation, not from changes occurring during hibernation, but, as already commented, the bears experience a metabolic hibernation several weeks before denning. Thus, the increase in muscular δ^{15}N can be also linked to the reuse of nitrogen compounds before denning. However both tissues (muscle and bone) do not necessarily show the same renewal rate. More interestingly, amino acid synthesis pathways differ notably (Wolf *et al.* 2009) and differences in δ^{15}N enrichment should be expected for different tissues, according to their amino acid composition.

Several studies demonstrate that bone properties (porosity, bone geometry, strength or mineralization) are maintained during bear hibernation (see McGee-Lawrence *et al.* 2009, for a recent review) due to a decreased bone turnover followed by the normal feeding period during which a more active bone remodelling takes place (McGee *et al.* 2008). This effect would erase, fully or in part, the isotopic signature achieved by the bone collagen during the hibernation. The clue of our hypothesis is that longer hibernations are linked to shorter periods of normal feeding. Bears that lived during cold periods would accumulate bone collagen enriched in the heavy isotope.

hibernacijo ugotovili za približno 2 ‰ višje vrednosti δ^{15}N v krvnem serumu (Jenkins *et al.* 2004) ter 1 ‰ povišanje vrednosti δ^{15}N v mišicah po treh mesecih prezimovanja (Lohuis *et al.* 2007). Lohuis *et al.* (2007) rezultate svoje raziskave razlagajo s tem, da je na izotopsko sestavo vplivala kakovost hrane v času tik pred nastopom hibernacije, ne pa spremembe, do katerih je prišlo med njo. Vendar pa, kot smo že omenili, do metabolizma, značilnega za hibernacijo, pri medvedih dejansko pride že več tednov pred njihovim vstopom v brlog, zato bi porast mišičnih vrednosti δ^{15}N lahko povezali tudi s ponovno uporabo dušikovih sestavin pred samim začetkom prezimovanja. Hitrost obnove pri obeh tkivih (mišicah in kosteh) je lahko različna, še pomembneje pa je, da se tudi načini sinteze aminokislin zelo razlikujejo (Wolf *et al.* 2009), zato v različnih tkivih lahko pričakujemo različno obogatitev vrednosti δ^{15}N, pač odvisno od njihove aminokislinske sestave.

Več študij je pokazalo, da se lastnosti kosti (poroznost, trdnost, mineralizacija) zaradi upočasnjenega ritma obnove med hibernacijo ohranjajo (glej McGee-Lawrence *et al.* 2009 za najnovejši pregled), temu pa v času normalnega prehranjevanja sledi aktivnejše obnavljanje kosti (McGee *et al.* 2008). Pri tem bi aktivnejše obnavljanje kosti lahko v celoti ali deloma izbrisalo izotopski zapis, ki je nastal v kolagenu med hibernacijo. Ključna za našo hipotezo je zato domneva, da je podaljšanje obdobja hibernacije povezano s skrajšanjem obdobja normalnega prehranjevanja. Medvedi iz hladnejših klimatskih obdobjih naj bi tako v svojih kosteh kopičili kolagen, ki je obogaten s težjimi izotopi.

Tab. 1: Sites included in this revision and some relevant data. Chronology is based on direct radiocarbon datings or stratigraphic information. Dates were calibrated (Weniger *et al.* 2009) for comparative purposes. References are: 1 – Bocherens *et al.* 2006; 2 – Nelson *et al.* 1998; 3 – Nelson, Ku 1997; 4 – Grandal-d'Anglade, Vidal Romaní 1997; 5 – Fernández-Mosquera 1999; 6 – this study; 7 – López González *et al.* 1997; 8 – Vila Taboada *et al.* 1999; 9 – Bocherens *et al.* 1997.
Tab. 1: Seznam v prispevku omenjenih najdišč z nekaterimi dodatnimi podatki. Kronologija temelji na radiokarbonskem datiranju ali stratigrafskih podatkih. Datumi so kalibrirani (Weniger *et al.* 2009), kar omogoča primerjavo med najdišči. Viri: 1 – Bocherens *et al.* 2006; 2 – Nelson *et al.* 1998; 3 – Nelson, Ku 1997; 4 – Grandal-d'Anglade, Vidal Romaní 1997; 5 – Fernández-Mosquera 1999; 6 – ta raziskava; 7 – López González *et al.* 1997; 8 – Vila Taboada *et al.* 1999; 9 – Bocherens *et al.* 1997.

Site / najdišče	**Country / država**	**Chronology / časovni razpon**	**References / viri**
Chauvet	France / Francija	20-29 Ky BP / 20.000–29.000 pred sedanjostjo	1
Divje babe I	Slovenia / Slovenija	45-49 Ky BP / 45.000–49.000 pred sedanjostjo	2, 3
Eirós	Spain / Španija	24-30 Ky BP / 24.000–30.000 pred sedanjostjo	4, 5, 6
Liñares	Spain / Španija	35 Ky BP / 35.000 pred sedanjostjo	7, 8
Scladina	Belgium / Belgija	40 Ky BP / 40.000 pred sedanjostjo	9,10

SITES INCLUDED

For this study, chronologically and isotopically well-contextualized cave bear sites have been seleted, with a representative number of samples. Data have been taken from the literature.

The selected sites are shown in *figure 1* and the most relevant data in *table 1*. The Peştera cu Oase site (Romania), the isotopic values of which will be discussed further on, is also included in the map.

DIFFERENCES IN THE ISOTOPIC SIGNATURE RELATED TO THE CHRONOLOGY

In general, the studied populations show homogeneous isotopic values, except for some isolated specimens that are outside the range of their population, which will then be discussed. The average values for each site are shown in *table 2* and range between 0.6 ‰ and 6.1 ‰ for $\delta^{15}N$ and between -19.0 ‰ and 22.5 ‰ for $\delta^{13}C$. These values first indicate that the trophic chain is based on C3 plants (herbaceous and bushy of temperate climate).

In *figure 2*, there are represented the isotopic values of the bears and also the ranges of coeval herbivores (cervids, equids, bovids) of those sites where they have been recovered and studied. The $\delta^{15}N$ values of the bears, in spite of their wide range, do not exceed those of their coeval herbivores.

With these data we could affirm that cave bears would have an alimentation preferably herbivorous, but what is the reason for the observed inter-sites differences; differences which in most of the cases are statistically significant (*Tab. 3*).

OBRAVNAVANA NAJDIŠČA

Študija zajema samo najdišča z jasno kronologijo in kontekstom ter reprezentativnim številom najdenih kosti jamskega medveda. Podatke smo vzeli iz literature.

Izbrana najdišča so prikazana na *sliki 1*, najpomembnejši podatki pa v *tabeli 1*. Prikazana je tudi lega jame Peştera cu Oase (Romunija), o kateri bomo podrobneje razpravljali v nadaljevanju.

RAZLIKE V IZOTOPSKEM ZAPISU, KI SO POVEZANE S KRONOLOGIJO

Izotopske vrednosti obravnavanih populacij so večinoma homogene. Izjemo predstavljajo nekateri ločeni primerki, ki se precej razlikujejo od razpona, značilnega za njihovo populacijo, in jih bomo obravnavali posebej. Povprečne vrednosti za posamezna najdišča so prikazane v *tabeli 2*; v primeru vrednosti $\delta^{15}N$ se te gibljejo med 0,6 ‰ in 6,1 ‰, kar zadeva $\delta^{13}C$ pa med –19,0 ‰ in –22,5 ‰. Ti podatki nakazujejo, da je prehranska veriga temeljila na rastlinah tipa C3 (tj. zeliščih in grmih zmerno tople klime).

Na *sliki 2* so prikazani podatki za medvede in sočasne kopitarje (jelenjad, konji, govedo) s posameznih najdišč. Vrednosti $\delta^{15}N$ za medvede kljub njihovemu sicer širokem razponu ne presegajo izmerjenih vrednosti pri drugih sočasnih herbivorih.

Ti podatki torej potrjujejo, da so medvedi pretežno uživali rastlinsko hrano, ne razložijo pa povečini statistično značilnih razlik med posameznimi najdišči (*tab. 3*).

Variabilnost živalskega zapisa $\delta^{13}C$ bi lahko bila posledica variabilnosti $\delta^{13}C$ pri različnih rastlinah tipa

Tab. 2: Mean values, standard deviations, number of samples and extreme values of the stable isotopic signatures in cave bear bone collagen from the included sites.
Tab. 2: Povprečje, standardna deviacija, število vzorcev in skrajne vrednosti stabilnih izotopov v kolagenu kosti jamskega medveda z obravnavnih najdišč.

δ 13C	**Mean / povprečje**	**Std. Dev.**	**n**	**Min.**	**Max.**
Chauvet	-20.5	0.291	16	-21.2	-20.1
Divje babe I	-20.4	0.568	11	-21.0	-19.0
Eirós	-21.0	0.489	34	-22.2	-20.0
Liñares	-21.1	0.268	20	-21.7	-20.6
Scladina	-22.1	0.248	7	-22.5	-21.8
Total	-21.0	0.585	88	-22.5	-19.0

δ 15N	**Mean / povprečje**	**Std. Dev.**	**n**	**Min.**	**Max.**
Chauvet	3.8	0.882	16	0.9	4.8
Divje babe I	1.9	0.703	11	0.6	3.3
Eirós	4.6	0.708	34	2.7	5.7
Liñares	1.8	0.450	20	0.9	2.4
Scladina	4.9	1.182	7	3.0	6.1
Total	3.5	1.467	88	0.6	6.1

The variations observed in δ^{13}C may be due to the wide range of values that C3 plants present (between -22 ‰ and -33 ‰; Bender 1971), and also to other environmental factors. For example, an environment densely tree-covered would produce more negative δ^{13}C values in the vegetation than would occur in open environments (Bocherens *et al.* 1994), which is known as the "canopy effect"; the latter, however, seems not to be responsible for the more negative values observed in some of these sites (e.g. Scladina). Nevertheless, it is noteworthy that – as shown by pollinic and sedimentological studies – the surroundings of Scladina are described as an open steppe environment in the bears' occupation period of 1-A level considered here (Cordy, Bastin 1992).

The variation range of the δ^{15}N values is greater (5.5 ‰) and its interpretation is especially interesting for the implication that may have as to the position of the cave bear in the trophic chain. However, in any of the considered sites there have been described morphological or metrical features, or taphonomic signs in accompanying species that allow for supposing that some of the studied populations of cave bears had a different alimentation behaviour.

Considering that the remains included in this study correspond to different chronologies within the final Pleistocene, and that during this period the climatic fluctuations were extreme (Petit *et al.* 1999), it seems to be necessary to see the isotopic data in relation with their chronology and the climate of the moment.

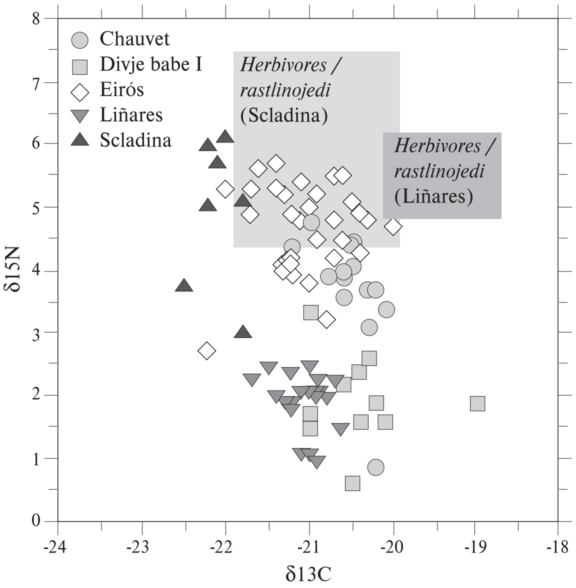


Fig. 2: Bivariate diagram of the isotopic signatures (δ^{13}C and δ^{15}N) of cave bears – and coeval herbivores when available – of the included sites. Data taken from the references listed in *table 1*.
Sl. 2: Diagram izotopskih vrednosti (δ^{13}C in δ^{15}N) za jamske medvede in druge sočasne herbivore (če so bili ti podatki pridobljeni). Viri so navedeni v *tabeli 1*.

C3 (razpon: –22 ‰ do –33 ‰; Bender 1971) in drugih okoljskih dejavnikov. Tako so npr. v okolju, ki je na gosto poraslo z drevjem, vrednosti δ^{13}C nižje kot v bolj odprti krajini (Bocherens *et al.* 1994), kar poznamo kot t. i. "efekt krošenj". To pa seveda ne more biti razlog za nižje vrednosti na nekaterih najdiščih, kot je na primer Scladina, kjer palinološke in sedimentološke raziskave kažejo, da je v času bivanja jamskega medveda med nastajanjem plasti 1-A najdišče obdajala odprta stepa (Cordy, Bastin 1992).

Variabilnost δ^{15}N je večja (5,5 ‰), kar ima pomembne implikacije za razumevanje položaja jamskega medveda v prehranjevalni verigi, vendar pa na vsakem od opisanih najdišč najdemo bodisi morfološke ali metrične značilnosti bodisi tafonomske značilnosti spremljajočih vrst, ki kažejo na nekoliko drugačne prehranjevalne navade jamskih medvedov iz nekaterih preučevanih populacij.

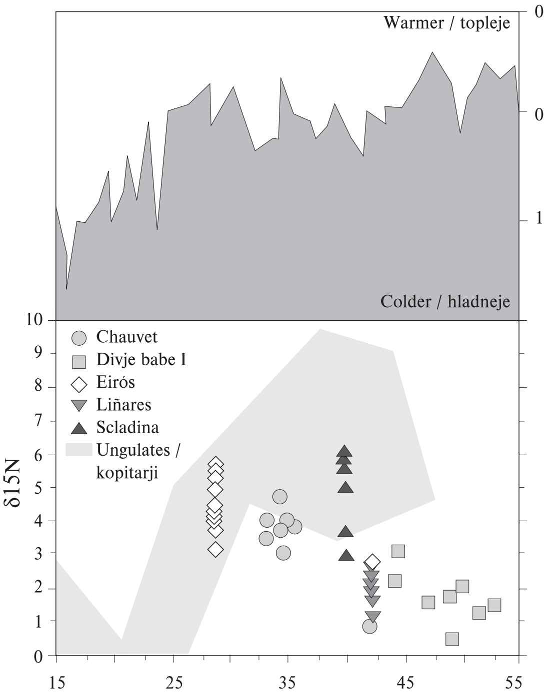
Če upoštevamo dejstvo, da ostanki jamskih medvedov, ki so bili zajeti v to raziskavo, pripadajo različnim časovnim obdobjem v mlajšem pleistocenu, ko so bila klimatska nihanja zelo izrazita (Petit *et al.* 1999), potem je izotopske podatke treba obravnavati v povezavi s kronološko opredelitvijo in klimo vsakega posameznega obdobja.

Na *sliki 3* vrednosti δ^{15}N tukaj obravnavanih jamskih medvedov primerjamo s podatki za kopitarje z različnih evropskih najdišč (Richards, Hedges 2003) ter opazujemo njihovo variabilnost skozi čas v primerjavi z globalno klimatološko krivuljo.

Tab. 3: Differences of mean values for $\delta^{13}C$ and $\delta^{15}N$ from the included sites. Outlier individuals from Eirós and Chauvet caves were not included in this statistic analysis. The observed differences are: (***) – highly statistically significant, $p < 0.0001$; (**) – statistically significant, $p < 0.001$; (*) – slightly statistically significant, $p < 0.1$; (•) – not significant.
Tab. 3: Razlike med povprečnimi vrednostmi $\delta^{13}C$ in $\delta^{15}N$ na obravnavanih najdiščih. Izstopajoči posamezni primerki iz jam Eirós in Chauvet v analizo niso bili zajeti. Razlike so lahko: (***) – visoko statistično značilne, $p < 0,0001$; (**) – značilne, $p < 0,001$; (*) – slabo značilne, $p < 0,1$; (•) – statistično niso značilne.

		δ 13C				
		Chauvet	Divje babe I	Eirós	Liñares	Scladina
δ 15N	Chauvet		•	**	***	***
	Divje babe I	***		**	***	***
	Eirós	**	***		•	***
	Liñares	***	•	***		***
	Scladina	*	***	•	***	

Fig. 3: Nitrogen isotopic values of cave bears from the sites here included, and ungulates from different sites in Europe (from Richards, Hedges 2002) compared to the climate curve for the last 55 to 15 Ky, obtained from oxygen stable isotopes in the Vostok ice core (from Petit *et al.* 1999)
Sl. 3: Dušikove izotopske vrednosti za jamske medvede z najdišč, ki jih obravnavamo v tem prispevku, in kopitarje z različnih evropskih najdišč (*cf.* Richards, Hedges 2002) v primerjavi s klimatsko krivuljo kisikovih izotopov v letih 55.000 in 15.000, ledena vrtina Vostok (*cf.* Petit *et al.* 1999)



In *figure 3*, there are the observed isotopic $\delta^{15}N$ values of the considered sites compared to the ones of the ungulates of different European sites (Richards, Hedges 2003), and their variation along the time, apart from the global climate curve for the same period.

Both the cave bears and the ungulates responded to climate change, though not in the same way. In ungulates, the $\delta^{15}N$ values go down with the climatic cooling, which is attributed to changes in the activity of nitrogen cycling processes associated with cold climates and permafrost development (Drucker *et al.* 2003; Stevens *et al.* 2008). In fact, in present ecosystems there has been checked a decrease in the $\delta^{15}N$ of soils and plants related to the decrease of temperature and increase of precipitation (Amundson *et al.* 2003). In cave bears, on the contrary, the trend in the $\delta^{15}N$ values is to increase in the coolest periods.

So, the bears of the Eirós and Chauvet sites, whose chronology locates them in cold moments, present higher isotopic values relative to those from Liñares or Divje Babe I, which lived in a more temperate climate. In *figure 3*, it may be also observed how isolated remains, which show isotopic values very far from the range of their corresponding site, are of different chronology, if dated (Eirós and Chauvet).

Finally, the Scladina 1-A site seems to deviate from the described trend. However, in this site, located at greater altitude than the rest, there have been described cold climates and an open steppe environment during the bears' occupation (Cordy, Bastin 1992).

Tako jamski medvedi kot kopitarji se odzivajo na klimatska nihanja, ampak njihovi odzivi so nasprotni. Pri kopitarjih vrednosti $\delta^{15}N$ upadajo hkrati s klimatskim ohlajanjem, kar lahko pripišemo spremembam v kroženju dušika v povezavi s hladno klimo in pojavom permafrosta (Drucker *et al.* 2003; Stevens *et al.* 2008). V današnjih ekosistemih je upad $\delta^{15}N$ v tleh in rastlinah dejansko povezan z upadom temperature in porastom količine padavin (Amundson *et al.* 2003). Pri jamskih medvedih pa v nasprotju s kopitarji vrednosti $\delta^{15}N$ narastejo prav v najhladnejših obdobjih.

Zato imajo ostanki jamskih medvedov z najdišč Eirós in Chauvet, ki so datirani v najhladnejša obdobja, višje izotopske vrednosti od medvedov iz Liñaresa ali Divjih bab I, ki so živeli v zmernejši klimi. Na *sliki 3* lahko tudi opazimo, da se posamične izotopske vredno-

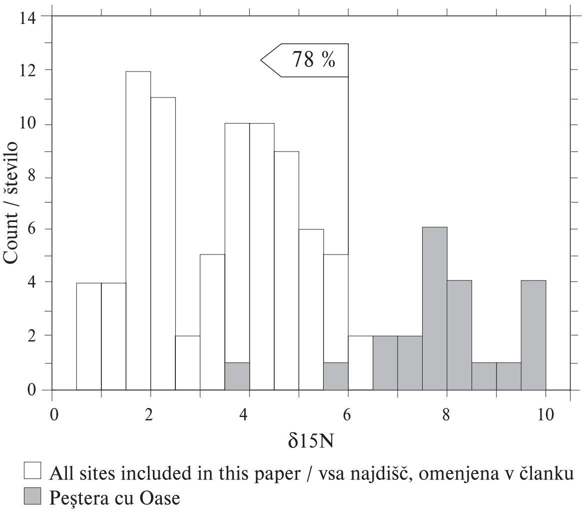


Fig. 4: Frequency distribution of the δ15N values of all the cave bear sites included and those from Peştera cu Oase (Romania)
Sl. 4: Porazdelitev posameznih vrednosti δ^{15}N za vsa najdišča, ki so obravnavana v tem prispevku, vključno s kostmi jamskega medveda iz jame Peştera cu Oase (Romunija).

SITES WITH ANOMALOUS ISOTOPIC VALUES

The studies of stable isotopes in the present trophic chains establish that the difference between the chain links in δ^{15}N is 3 ‰ (De Niro, Epstein 1981), or 3 to 5 ‰, according to more up-to-date studies (Bocherens, Drucker 2003). But there also exist studies on how the environmental conditions influence the isotopic signature accumulated in the bone collagen. It is a fundamental mistake to ignore these studies to infer diets, and, therefore, behaviours from the collagen isotopic signature.

Likewise, the collagen isotopic signature has to be evaluated with all the non environmental uncertainties that take part in its definition: the starting isotopic value of the ingested matter, the metabolic routes that take part in the bone remodelling, to cite the most important ones. It seems to be clear that only the comparison of values of morphologically and environmentally well characterised sites may help to clarify these aspects.

Recently, a study of a cave bear site has been published (Peştera cu Oase, Romania), with isotopic data very different from the ones obtained up to now (Richards *et al.* 2008; *Fig. 4*). It can be clearly seen how most of the δ^{15}N values of the Peştera bears rise well over all other data from the comparative sites – and for most of the values published so far (Richards *et al.* 2008).

The difference between the δ^{15}N values obtained in Peştera cu Oase (average 7.8 ±1.4 ‰, n = 22) and the most frequent ones in the rest of the sites is practically equivalent to two trophic levels. Coeval herbivores of

sti, ki ležijo precej zunaj običajnega razpona vrednosti za posamično najdišče, nanašajo na vzorce iz drugih obdobij (Eirós in Chauvet).

Zdi se, da najdišče Scladina 1-A odstopa od zgoraj opisanega trenda. Vendar pa velja ob tem poudariti, da je v času, ko so se tam zadrževali jamski medvedi, v okolici prevladovala odprta stepska vegetacija kot odsev hladne klime (Cordy, Bastin 1992). Scladina leži namreč na večji nadmorski višini kot ostala obravnavana najdišča.

NAJDIŠČA Z IZSTOPAJOČIMI IZOTOPSKIMI VREDNOSTMI

Raziskave stabilnih izotopov v današnjih prehrambenih verigah dokazujejo, da znaša razlika v vrednostih δ^{15}N med posameznimi členi v prehranjevalni verigi 3 ‰ (De Niro, Epstein 1981), oz. glede na novejše študije (Bocherens, Drucker 2003) med 3 in 5 ‰. Obstajajo pa tudi raziskave vpliva okoljskih razmer na nastajanje izotopskega zapisa v kostnem kolagenu. Izsledki teh študij so bistvenega pomena za pravilno rekonstrukcijo prehrane in vedenja živali, temelječo na izotopski sestavi kolagena.

Zato je nujno potrebno, da pri ovrednotenju izotopskega zapisa v kolagenu upoštevamo tudi vse od okoljskih sprememb neodvisne dejavnike: npr. začetno izotopsko vrednost zaužite hrane in procese presnove, ki potekajo pri preoblikovanju kosti, če omenimo samo najpomembnejša. Jasno je, da nam pri tem lahko pomaga le primerjava podatkov, ki izvirajo z najdišč z zanesljivimi morfološkimi in okoljskimi podatki.

Pred nedavnim objavljeni rezultati raziskave na najdišču jamskega medveda Peştera cu Oase (Romunija) so pokazali na izotopske vrednosti, ki močno odstopajo od dosedanjih rezultatov (Richards *et al.* 2008). Kot je lepo vidno na *sliki 4*, večina vrednosti δ^{15}N iz Peştere močno presega tiste iz drugih primerjanih najdišč – in vseh doslej objavljenih podatkov (Richards *et al.* 2008).

Razlika med vrednostmi δ^{15}N iz jame Peştera cu Oase (povprečje: 7,8 ± 1,4 ‰, n = 22) in najpogostejšimi vrednostmi na ostalih najdiščih je skoraj razreda velikosti dveh trofičnih nivojev. Ostali herbivori, ki so v tistem obdobju prav tako naseljevali okolico jame, imajo nižje vrednosti (*Cervus elaphus*: povprečje δ^{15}N = 5,4 ‰, n = 3), medtem ko so te pri sočasnih karnivorih višje (*Canis lupus*: povprečje δ^{15}N = 9,7 ‰, n = 5). Navedeni rezultati naj bi odsevali drugačen jedilnik jamskih medvedov iz tega romunskega najdišča v primerjavi s primerki iste vrste iz drugih delov Evrope. To pa ima seveda implikacije za razumevanje prehranskih navad vrste kot celote.

the same cave show lower values (*Cervus elaphus*: average δ^{15}N = 5.4 ‰, n = 3), while coeval true carnivores show higher values (*Canis lupus*: average δ^{15}N= 9.7 ‰, n = 5). These values allow the authors to suggest a different alimentation behaviour for the cave bear of this site – and in general for the whole species.

IS IT POSSIBLE TO ADMIT CARNIVORISM AS AN ALTERNATIVE EXPLANATION?

Though it seems to be risky to extend to a whole species the interpretation of the higher δ^{15}N values in only one site, it could certainly occur that specific populations had had a more specialized alimentary behaviour.

In the case of the Peştera cu Oase site, with δ^{15}N values above the normal range in the species, a type of alimentation mainly based on items of animal origin has been proposed (Richards *et al.* 2008). The study cannot, however, indentify the possible alimentation sources of these bears: the herbivores of the same site present C isotopic signatures not compatible with the possibility of having been used as food for the bears, because in the trophic chains based on C3 plants a moderate trophic effect in the carbon is produced (van der Merwe 1985). Bocherens and Drucker (2003) found an increase between prey and predator collagen ranging from 0.8 to 1.3 ‰. Thus, the δ^{13}C values of the carnivores should be slightly less negative than those of their preys but in Peştera the average δ^{13}C for bears is -21.5 ± 0.4 ‰ while δ^{13}C for red deer is -19.9 ‰ and for coeval wolves -19.2 ‰.

Some taphonomic studies of cave bear sites suggest the possibility that the bears developed an intraspecific scavenging behaviour on the corpses of the individuals that died during hibernation (Pinto, Andrews 2004).

Also, the taphonomy study of Peştera cu Oase (Quilès *et al.* 2005) suggests the possibility of intraspecific scavenging. The scavenging could explain a high δ^{15}N value if it were a normal and repeated behaviour, not occasional. However, other sites where the proportion of scavenged animals remains is several times higher, like Eirós (Pinto, Andrews 2004), show average δ^{15}N values (5.1 ‰) considerably lower than Peştera cu Oase. Also, again the C values of the Peştera bears do not coincide with those of a diet based on the scavenging. For example, the isotopic analysis of bone remains of the cave hyena *Crocuta crocuta* of the Scladina site gave δ^{15}N values = 9.3‰ ± 0.6 and δ^{13}C =-19.7 ± 0.3, n = 6 (Bocherens *et al.* 1997), much more consistent with their scavenging habits than the value of the Peştera bears.

Previously, an omnivorous or even carnivorous diet has been proposed for the cave bear. Hilderbrand *et al.* (1996) study bears coming from museum collections, without stating their original locality or chronology, for which they obtain very high δ^{15}N values (average: 8.4 ‰,

ALI JE MOŽNO KOT ALTERNATIVNO RAZLAGO SPREJETI PREHRANJEVANJE Z MESOM?

Čeprav je višje vrednosti δ^{15}N na samo enem najdišču neustrezno preslikati na celotno vrsto, je prav gotovo možno, da so določene populacije dejansko imele bolj specializirane prehranske navade.

Jamskim medvedom iz jame Peştera cu Oase, katerih vrednosti δ^{15}N očitno presegajo njihov razpon pri drugih populacijah iste vrste, so raziskovalci pripisali jedilnik s hrano pretežno živalskega izvora (Richards *et al.* 2008). Pri tem pa raziskava ni mogla določiti virov hrane za te medvede: herbivori z istega najdišča glede na njihov izotopski zapis ogljika to ne bi mogli biti; v prehrambenih verigah, ki temeljijo na rastlinah tipa C3, prihaja namreč pri ogljiku do zgolj zmernega trofičnega učinka (van der Merwe 1985). Po poročanju Bocherensa in Druckerjeve (2003) znaša tako povišanje vrednosti navedenega izotopa v kolagenu med plenom in plenilcem le med 0,8 in 1,3 ‰. Zaradi navedenega so vrednosti δ^{13}C pri karnivorih le malenkost manj negativne od vrednosti pri njihovem plenu. Na drugi strani znaša povprečna vrednost medvedov na najdišču Peştera –21.5 ± 0.4 ‰, medtem ko so vrednosti za jelene in volkove iz istega obdobja –9,9 ‰ oz. –19,2 ‰.

Nekatere tafonomske študije jamskih medvedov nakazujejo možnost, da bi medvedi razvili mrhovinarstvo znotraj iste vrste in se hranili s trupli živali, ki so poginile med hibernacijo (Pinto, Andrews 2004).

Na to možnost kažejo tudi tafonomske študije na najdišču Peştera cu Oase (Quilès *et al.* 2005). S tem bi lahko razložili visoke vrednosti δ^{15}N, vendar le v primeru, če je šlo za običajen, ponavljajoč se pojav, ne pa za občasen. Vendar pa imajo nekatera druga najdišča, ki jih označuje precej večji delež ostankov mrhovine (npr. Eirós; Pinto, Andrews 2004), opazno nižje povprečne vrednosti δ^{15}N (tj. 5,1 ‰) od tistih iz Peştere cu Oase. Tudi vrednosti za ogljikove izotope pri medvedih iz navedenega najdišča odstopajo od vrednosti, ki so značilne za mrhovinarje. Izotopska analiza kostnih ostankov jamske hijene (*Crocuta crocuta*) iz najdišča Scladina je dala naslednje vrednosti δ^{15}N oz. δ^{13}C: 9,3 ‰ ± 0,6 oz. –19,7 ± 0,3 (n = 6; Bocherens *et al.* 1997); te so veliko bolj v skladu s pomenom mrhovine v njihovi prehrani, kot pa to velja za vrednosti medvedov iz Peştere.

V preteklosti so nekateri raziskovalci že predlagali, da so bili jamski medvedi v resnici omnivori ali karnivori. Hilderbrand *et al.* (1996) so preučevali medvede iz muzejskih zbirk (brez navajanja najdiščnih podatkov ali kronologije), za katere so dobili zelo visoke vrednosti δ^{15}N (povprečje: 8,4 ‰, n = 10). Na podlagi navedenih podatkov so nato sklepali, da je prehrana vsebovala veliko beljakovin živalskega izvora.

Isti avtorji tudi domnevajo, da na tak način prehrane kaže tudi izstopajoča velikost analiziranih primerkov, n = 10), which for the authors is a hint of a high proportion of animal-origin protein in their diet.

According to these authors, this type of alimentation is also justified by the large size of the studied specimens, though they do not give metric data (Hilderbrand *et al.* 1999). However, all the studies carried out up to now on bears of different sites in which no outstanding morphometric differences have been described, being all bears of the same big size that characterizes this species, gave δ^{15}N values very inferior to those obtained by Hilderbrand *et al.* (1996), except for the bears of Peştera cu Oase. In studies that include cave bear's sexed remains no differences are also observed in the isotopic signatures of males and females (Grandal-d'Anglade, López González 2004; Pérez-Rama *et al.* 2011).

Leaving apart the remains studied by Hilderbrand *et al.* (1996), as their exact geographic origin, morphology and size are unknown, it is underlined that the bears from Peştera cu Oase also present no differences, neither in size or morphology nor in their genetics, with respect to the bears of the rest of studied sites (Quilès *et al.* 2006; Richards *et al.* 2008).

The high δ^{15}N values in the bears from Peştera exceed those of any other site, even in those that are chronologically placed in a cold period. But there are other possible causes for the high δ^{15}N values. Numerous studies on different mammals and birds have shown that the enrichment in δ^{15}N with respect to the diet is greater if it is poor in proteins (Robbins *et al.* 2005 and references therein), due to a recycling of nitrogenised compounds (Gannes *et al.* 1997). Therefore, it is possible that long hibernations or a diet poor in protein, or both, are responsible for the high δ^{15}N values of this population, with no need to mention a more carnivorous alimentation.

Anyway, it seems evident that it is risky to extend the specific results obtained in only one site to infer the alimentary behaviour of a species so broadly distributed and isotopically well-characterised as the cave bear, especially when these precise values differ so largely from all the known ones. It is necessary to remember the studies of cranial and dental morphology that undoubtedly evidence the adaptation towards a preferably herbivorous alimentation (Kurtén 1976; Rabeder 1999; Grandal-d'Anglade, López González 2004; 2005; Grandal-d'Anglade 2010).

THE CAVE BEARS FROM DIVJE BABE I

The Divje babe I site may be an example of the differences in the isotopic signatures that depend on the climate of the moment. The samples of this cave are not contemporaneous and come, in fact, from different stratigraphic levels (Nelson, Ku 1997). The sedimentological studies and the datings by ESR carried out in the different levels (Turk 2003; Turk *et al.* 2006) show us a

čeprav konkretnih metričnih podatkov sicer ne podajajo (Hilderbrand *et al.* 1999). Vendar pa so vse dosedanje raziskave gradiva iz različnih evropskih najdišč, ki so zajele medvede brez izrazitih morfometričnih posebnosti (živali so bile pač za to vrsto značilno velike), pokazale nižje vrednosti δ^{15}N od tistih, ki jih navajajo Hilderbrand in sodelavci (1996). Izjema je le najdišče Peştera cu Oase. V študijah, kjer so določali tudi spol živali, niso opazili nobenih razlik med izotopskim zapisom samcev in samic (Grandal-d'Anglade, López González 2004; Pérez-Rama *et al.* 2011).

Tudi če zaradi nejasnega geografskega porekla, morfologije in velikosti zanemarimo študijo Hilderbranda *et al.* (1996), je treba poudariti, da se medvedi z najdišča Peştera cu Oase po velikosti, morfologiji ali genetskem zapisu ne razlikujejo od tistih iz drugih najdišč (Quilès *et al.* 2006; Richards *et al.* 2008).

Visoke vrednosti δ^{15}N medvedov z najdišča Peştera so višje od vrednosti s katerega koli drugega najdišča, tudi od tistih, ki kronološko sodijo v hladna obdobja. Vendar pa bi lahko bili za visoke vrednosti δ^{15}N še drugi razlogi. Številne študije različnih sesalcev in ptic so pokazale, da je obogatitev z δ^{15}N večja, kadar je prehrana revna z beljakovinami (Robbins *et al.* 2005 in tam navedeni viri), saj v takih primerih prihaja do ponovne uporabe dušikovih sestavin (Gannes *et al.* 1997). Zato obstaja možnost, da sta višjim vrednostim δ^{15}N pri tej populaciji jamskih medvedov – popolnoma neodvisno od eventualnega prehranjevanja z mrhovino – botrovali dolga hibernacija ali/in prehrana, revna z beljakovinami.

Kakor koli že, očitno je na podlagi natančnih rezultatov iz samo enega najdišča tvegano sklepati o prehrambenih navadah vrste, ki je tako zelo široko razširjena in izotopsko karakteristična, kot je jamski medved. Še zlasti zato, ker se te vrednosti tako močno razlikujejo od vseh ostalih. Navsezadnje se je treba zavedati, da raziskave morfologije lobanje in zobovja nedvomno kažejo prilagoditev na pretežno rastlinsko hrano (Kurtén 1976; Rabeder 1999; Grandal-d'Anglade, López González 2004; 2005; Grandal-d'Anglade 2010).

JAMSKI MEDVEDI IZ DIVJIH BAB I

Najdišče Divje babe I je vzorčen primer raznolikosti izotopskega zapisa, ki je bil odvisen od vsakokratnih klimatskih razmer. Vzorci iz te jame ne sodijo vsi v isto časovno obdobje in izvirajo iz različnih stratigrafskih plasti (Nelson, Ku 1997). Sedimentološke raziskave in ESR-datiranje (Turk 2003; Turk *et al.* 2006) so pokazali, da so bile klimatske razmere med nastajanjem plasti 8–12 hladne in vlažne, medtem ko je bila klima za časa odlaganja plasti 13–21 zmernejša in bolj suha. Izotopske vrednosti teh maloštevilnih vzorcev, ki pa imajo jasen stratigrafski kontekst, kažejo očitno razliko. Če namreč znaša povprečna vrednost δ^{15}N za vzorce iz plasti 8 in colder and more humid environment for layers 8 to 12, while from layer 13 forward the climate would be more temperate and dry. The isotopic values of those few samples, for which the level of origin could be established, show the following difference: the samples of layers 8 and 10 give average $\delta^{15}N$ values of 2.4 ‰ (n = 3), while the average value of the ones corresponding to more temperate and dry levels is of 1.5 ‰ (n = 6).

Morphometric and demographic studies on bear's bone remains coming from different levels of this site show differences both in shape and size as well as in demographical composition of the population when comparing levels corresponding to climatically different phases (Toškan 2007). A larger isotopic study of these bone remains could provide interesting results that contribute to clarifying the role of the climate in the isotopic signature of cave bears and the possible use of these isotopic values as climatic proxies in the European sites.

FINAL REMARKS

The isotopic data ($\delta^{13}C$ and $\delta^{15}N$) obtained in the considered populations show a type of herbivorous alimentation for the cave bear.

However, the nitrogen isotopic values do not directly show the diet of an animal, as the metabolism also plays an important role. Particularly, the bears' special metabolism during hibernation may cause differences in the nitrogen isotopic signatures in the bone collagen, though the range of these signatures remains within the normal values in herbivores.

Both diet and physiology depend very directly on the environmental conditions in which the organisms lived, conditions that have varied considerably along the Pleistocene; from that derives the main interest of the chronological and taphonomic characterization of the studied site. When the isotopic values are studied in well-characterised populations, it is observed that the individuals with anomalous isotopic values correspond to chronologies different from the rest of individuals.

The most useful isotopic values are those obtained from a wide number of bone remains of stratigraphically and chronologically well-characterised sites, as the interpretation of this type of data requires a well-defined palaeoenvironmental setting.

Anomalous isotopic values recorded in an isolated population of cave bear should not be used to infer the alimentary behaviour of the whole species. In any case, one should explore which the cause of the anomaly may be, taking into account chronological, environmental, morphometric, and physiologic data.

In a species like the cave bear, which in the last 1 to 3 million years achieved some marked adaptations towards a more herbivorous diet than its sister species, the brown bear, one stands on thin ice when consider-

10 2,4 ‰ (n = 3), znaša za vzorce iz plasti 13–21, ki so nastale v okoliščinah bolj suhe klime, zgolj 1,5 ‰ (n = 6).

Analiza morfometrije medvedjih kosti in demografskih trendov iz različnih plasti jame kaže na razlike v obliki in velikosti kosti in v demografski sestavi populacij, ki so živele v različnih klimatskih obdobjih (Toškan 2007). Obsežnejša analiza teh vzorcev bi lahko dala zanimive podatke o vlogi klime pri nastajanju izotopskega zapisa v kosteh jamskih medvedov in bi bila pomembna za morebitno uporabo stabilnih izotopov kot indikatorja nekdanje klime v Evropi.

SKLEP

Izotopski podatki ($\delta^{13}C$ in $\delta^{15}N$) analiziranih populacij kažejo na rastlinsko prehrano jamskega medveda.

Vendar pa vrednosti stabilnih izotopov dušika odslikavajo prehrano te živali le posredno; pomemben je bil tudi metabolizem. Zlasti specifičen metabolizem jamskega medveda med hibernacijo bi lahko povzročil razlike v izotopskem zapisu dušika v kostnem kolagenu, čeprav vrednosti ostajajo v razponu, značilnem za herbivore.

Prehrana in fiziologija sta zelo neposredno povezani z okoljskimi razmerami organizmov, te pa so se v pleistocenu stalno spreminjale, zato sta kronološka in tafonomska opredelitev najdišč tako pomembni. Kadar izotopske vrednosti preučujemo pri podrobno preučevanih populacijah, se praviloma izkaže, da posamezni izstopajoči primerki preprosto izvirajo iz drugega časovnega obdobja.

Najbolj izpovedne so tiste izotopske vrednosti, ki so bile izmerjene na velikem številu kostnih ostankov iz stratigrafsko in kronološko dobro opredeljenih najdišč. Za interpretacijo izotopskega zapisa so podatki o okoljskih razmerah namreč bistvenega pomena.

Na podlagi izstopajočih vrednosti stabilnih izotopov pri medvedih iz neke izolirane populacije ne bi smeli sklepati na prehrano vrste kot celote. Zato bi bilo vedno treba raziskati, kateri so vzroki za te izstopajoče vrednosti, in pri tem upoštevati tudi kronološke, okoljske, morfometrične in fiziološke podatke.

V zvezi z vrsto, kot je jamski medved, ki se je z nekaj očitnimi adaptacijam v zadnjem milijonu do treh milijonov let bolj prilagodil rastlinski hrani kot njegova sorodna vrsta rjavi medved, je težko govoriti o razvoju nespecializiranih prehranjevalnih navad (vključno s prehodom od pretežno rastlinske k povečini mesni prehrani), ki bi jih pripisali okoljskim spremembam v pleistocenu in odstopanjem med različnimi deli Evrope.

Po eni strani iz tega zornega kota ne moremo razložiti, kako bi se jamski medved sploh lahko prilagodil na izključno rastlinsko hrano in preživel, še zlasti zato, ker se je področje njegove geografske razširjenosti prekrivalo z vsejedim rjavim medvedom.

ing that the response to the environmental changes that occurred along the Pleistocene or across Europe was to develop an unspecialized alimentary behaviour, including a shift from a purely herbivorous diet to a diet totally based on items of animal origin.

On the one hand, from that perspective it cannot be explained how the adaptations towards herbivorism that this species presents would have appeared and continued, even more taking into account that along its geographic range it coexisted with the preferably omnivorous brown bear.

On the other hand, and as we stated before, the isotopic values cannot be directly interpreted as indicators of the alimentation type, as the physiology of each species modulates the starting signature of its diet. In the case of bears, their peculiar physiology during hibernation, the duration of which depends in turn on the climate, cannot be omitted when we interpret the isotopic values of their fossil remains.

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Vendar pa, kot smo poudarili že prej, stabilni izotopi ne morejo biti neposreden indikator za vrsto prehrane; na začetni izotopski zapis hrane namreč kasneje vplivajo še fiziološki procesi. Pri medvedih pa je v okviru interpretacije izotopskih vrednosti v fosilnem kostnem materialu treba upoštevati tudi posebne fiziološke procese med hibernacijo, dolžina katere je odvisna od klime.

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STATISTICAL ANALYSIS ON METAPODIAL BONES OF LIVING BROWN BEARS REGARDING GENDER DIFFERENCES IN MALES AND FEMALES

STATISTIČNA ANALIZA METAPODIJEV RECENTNIH RJAVIH MEDVEDOV S POUDARKOM NA RAZLIKAH MED SPOLOMA

Kerstin ATHEN

Abstract

The results presented here are part of a 'Synthesys' Project, in which the metrical data of *Ursus arctos* metapodial bones of the Naturhistoriska riksmuseet in Stockholm were collected. The data were statistically analysed using univariate as well as discriminant methods in order to find distinguishing features linked to sexual dimorphism. The results showed that this material, of which the gender was known *a priori*, could successfully be separated into the two gender groups. In the two-sample tests, 89 % of the examined parameters showed significant differences between males and females, verifying sexual dimorphism. Two to three variables each were extracted in eight out of ten skeletal elements using discriminant analysis, which showed a significant distinction between the gender groups.

Keywords: *Ursus arctos*, statistics, discriminant analysis, gender classification

INTRODUCTION

The results presented here are part of the project SE-TAF-4683 at the Naturhistoriska riksmuseet (Swedish Museum of Natural History) in Stockholm. SE-TAF-4683 received support from Synthesys (http://www.synthesys.info/) which is financed by the European Community – Research Infrastructure Action under the FP6 "Structuring the European Research Area" Programme; project title: Statistical analysis of metapodial bones on brown bears in order to find answers to bear phylogeny and to further classify existing data on

Izvleček

Predstavljena raziskava je del programa EU Synthesys, v okviru katerega so bili pridobljeni podatki o dimenzijah metapodijev vrste *Ursus arctos*, ki jih hrani stockholmski Naturhistoriska riksmuseet. Podatki so bili statistično obdelani z uporabo metod univariatnih in diskriminantnih analiz z namenom prepoznati spolnospecifične lastnosti. Kot so pokazali rezultati, je bilo mogoče obdelane metapodije medvedov, katerih spol je bil znan vnaprej, dejansko uspešno razvrstiti med samce in samice. Kar 89 odstotkov analiziranih parametrov je namreč pokazalo na obstoj značilnih razlik med samci in samicami, kar kaže na izrazit spolni dimorfizem. S pomočjo diskriminantne analize so bile pri kar osmih od skupno desetih preučevanih skeletnih elementov izločene po dve do tri spremenljivke, ki so izkazovale obstoj značilnih razlik med obema spoloma.

Ključne besede: *Ursus arctos*, statistika, diskriminantna analiza, razvrščanje po spolu

UVOD

Predstavljeni rezultati so del projekta SE-TAF-4683 pri stockholmskem Naturhistoriska riksmuseet (švedskem Prirodoslovnem muzeju). SE-TAF-4683 je podprl Synthesys (http://www.synthesys.info/), ki ga financira Raziskovalna infrastrukturna dejavnost pri EU v okviru programa FP6 ("Strukturiranje evropskega raziskovalnega prostora") z naslovom 'Statistična analiza metapodijev rjavega medveda z namenom raziskovanja problematike filogenije medvedov ter nadaljnje obdelave že obstoječih podatkov o izumrlem jamskem medveextinct cave bears regarding gender and differences in the mobility of males and females. In this investigation the author analysed whether single metapodial bone parameters or a combination of those parameters allow for classification of an individual as male or female. In case this method is successful, individuals with an unknown gender may also be classified. In addition, other gender specific analyses, e.g. on fossils, would be possible.

This project was developed from previous research on samples from *Ursus spelaeus* and *U. deningeri* described in the author's dissertation (Athen 2007) with focus on species classification. The fossil material examined in the Ph.D. project could not be separated into gender groups because of incomplete data sets, low sample sizes and the high number of fossil sites. Although this was not a central issue in the dissertation, the parameters collected from *U. arctos* skeletons were potentially interesting for comparisons between extinct and related living species. For the investigation presented here, the material of the *U. arctos* collection of the Naturhistoriska riksmuseet was chosen because of its outstanding sample size (ca. 400 individuals with ca. 250 skulls, plus ca. 150 skeletons and partial skeletons) and the excellent condition and detailed information of available *U. arctos* individuals. Based on the analysis of data of living *U. arctos* specimens, a more extensive analysis of fossil *U. spelaeus* data is possible.

The aim of this project was to determine gender specific parameters of metapodial bones of *U. arctos*, which will allow for a simple and reliable gender separation for further statistical analyses. Analysing the two gender groups separately in following studies will mean less scattered data and better distinction of interspecific and intraspecific morphological variability.

MATERIAL AND METHODS

For this statistical investigation, specimens were chosen from the extensive collection of *U. arctos* material of the Naturhistoriska riksmuseet collection in Stockholm according to the following criteria:

1. adult individuals
2. completely macerated skeletons in perfect condition; skeletal elements loose instead of assembled
3. skeletons of which not only the metapodial bones exist, but also other parts of the skeleton (especially long bones), preferably complete skeletons
4. specimens with known gender as identified in writing upon delivery
5. individuals who had lived in the wild
6. geographical origin limited to Sweden.

The examined Swedish *arctos* individuals were delivered to the museum from 1940 to 2006. These individuals had been shot, were traffic casualties or chance

du, povezanih s spolom in medspolnimi razlikami v mobilnosti'. V predstavljeni študiji namerava avtorica ugotoviti, ali je iz dimenzij posameznega metapodija oz. njihove kombinacije mogoče sklepati na spol živali. V kolikor bi se metodologija izkazala za uspešno, bi se tako enemu od obeh spolov dalo pripisati tudi tiste primerke, za katere ta podatek ne bi bil vnaprej znan. Poleg tega bi takšen izid omogočil izvedbo tudi cele vrste drugih spolnospecifičnih analiz, vključno s takimi, ki bi zajele fosilno gradivo.

Projekt je nadaljevanje predhodnih raziskav ostankov vrst *Ursus spelaeus* in *U. deningeri*, ki so bile osredinjene na taksonomske klasifikacije posameznih primerkov. Rezultati so bili predstavljeni v okviru avtoričine doktorske disertacije (Athen 2007), pri čemer pa prepoznavanje spola spričo pomanjkljivih podatkovnih nizov, skromnih vzorcev ter številnih analiziranih najdišč žal ni bilo mogoče. Navedena problematika sicer ni bila osrednja tema disertacije, je pa pridobljeni korpus metričnih podatkov vseeno potencialno zanimiv za primerjanje izumrlih in njim sorodnih recentnih medvedjih vrst. Tukaj predstavljena študija temelji na analizi obsežnega osteološkega vzorca rjavega medveda, ki ga hrani švedski Prirodoslovni muzej (tj. pribl. 400 osebkov z okoli 250 lobanjami ter dodatnih pribl. 150 okostij oz. delov okostij). Zbirko odlikujeta odlična stopnja ohranjenosti gradiva ter bogata vzporedna dokumentacija. Rezultati analize podatkov o recentni vrsti *U. arctos* bi v nadaljevanju lahko predstavljali koristno izhodišče za izvedbo sorodne študije tudi pri že izumrlem jamskem medvedu (*U. spelaeus*).

Namen na tem mestu predstavljene raziskave je bil določiti spolnospecifične parametre pri metapodijih vrste *U. arctos*, ki bi omogočali hitro in zanesljivo razlikovanje med spoloma kot uvod v nadaljnje statistične analize. Ločena obravnava vsakega od obeh spolov bi zmanjšala razpršenost podatkov in tako olajšala študije znotraj- in medvrstne morfološke variabilnosti.

GRADIVO IN METODE

V okviru predstavljene študije je bilo obdelano bogato osteološko gradivo vrste *U. arctos*, ki ga hrani švedski Prirodoslovni muzej iz Stockholma. Pri tem so bile v analizo vključene zgolj kosti živali, ki so ustrezale naslednjim kriterijem:

1. Odrasla žival.
2. V celoti zmaceriran kadaver z okostjem v odličnem stanju ohranjenosti, pri čemer posamezni skeletni elementi niso smeli biti sestavljeni v skelet.
3. Ohranjen večji del (po možnosti kar celoten) skeleta, ne zgolj metapodiji.
4. Znan spol.
5. V naravi živeča žival.
6. Geografsko poreklo, omejeno na Švedsko.

finds (partly highly skeletonised so that the cause of death could not be determined). At the museum the finds had been macerated, well cleansed, degreased and inventoried.

On the basis of these criteria 58 individuals (29 males plus 29 females) were chosen for statistical analysis. Data were collected and analysed alternately from the right or the left body side. To reach a balanced number of males and females some subadult individuals had to be included. Keeping further investigations in mind, metapodial bones had been chosen for this project.

The examined *U. arctos*-individuals have the following inventory numbers: A580011, A580040, A580046, A580049, A587706, A587707, A700051, A740035, A775051, A805097, A825068, A835024, A835160, A845073, A855134, A865113, A865150, A865174, A875239, A885129, A885244, A885265, A895054, A895139, A895151, A905022, A905082, A915126, A945254, A945255, A955023, A955024, A965019, A965066, A975167, A975216, A985015, A985698, A985752, A995013, A995160, A995233, A20005188, A20005331, A20005332, A20018275, A20018276, A20018327, A20018366, A20018367, A20025014, A20025058, A20025059, A20025072, A20035117, A20045313, A20055140, A20065415.

The collection of data was conducted with the digital sliding calliper TCM 227 579 for 0-150 mm with an accuracy of +/- 0.03 mm. The choice of parameters (variables, features) measured in the metapodial bones was based on the nomenclatures of Duerst (1926), von den Driesch (1976) and Grandal D`Anglade (1993). The

Muzej je analizirane primerke pridobil med letoma 1940 in 2006. Pretežni del živali je bil bodisi ustreljen bodisi povožen. Naključnih najdb, pri katerih vzroka pogina ni bilo mogoče ugotoviti, je zgolj peščica. V muzeju so bila trupla zmacerirana, dobro očiščena, razmaščena in inventarizirana.

Končni izbor živali, opravljen na podlagi zgornjih kriterijev, je vključeval 29 samcev in 29 samic (skupno torej 58 živali), katerih podatki so bili v nadaljevanju predmet statistične analize. Pri zajemanju podatkov so bili izmenično merjeni skeletni elementi iz levega in desnega para okončin. Z namenom izenačitve števila samcev in samic je bilo v vzorec zajetih tudi nekaj subadultnih živali. V tem prispevku so predstavljeni rezultati, ki se nanašajo zgolj na metapodialne kosti.

Inventarne številke analiziranih primerkov: A580011, A580040, A580046, A580049, A587706, A587707, A700051, A740035, A775051, A805097, A825068, A835024, A835160, A845073, A855134, A865113, A865150, A865174, A875239, A885129, A885244, A885265, A895054, A895139, A895151, A905022, A905082, A915126, A945254, A945255, A955023, A955024, A965019, A965066, A975167, A975216, A985015, A985698, A985752, A995013, A995160, A995233, A20005188, A20005331, A20005332, A20018275, A20018276, A20018327, A20018366, A20018367, A20025014, A20025058, A20025059, A20025072, A20035117, A20045313, A20055140, A20065415.

Tab. 1: Explanation of abbreviations used.
Tab. 1: Obrazložitev v besedilu uporabljenih okrajšav.

Abb. **Okrajšave**	**Explanation** **Obrazložitev**	**Source** **Vir**
Mc I-V	Metacarpals I-V Dlančnice I–V	–
Mt I-V	Metatarsals I-V Stopalnice I–V	–
L	Anatomical length, parallel to the main axis of the diaphysis Anatomska dolžina, vzporedna z osnovno osjo diafize	Duerst (1926) von den Driesch (1976)
GL	Greatest length Največja dolžina	von den Driesch (1976)
B/SB	Width of the diaphysis/smallest width of the diaphysis Širina diafize/najmanjša širina diafize	Duerst (1926) von den Driesch (1976)
D/SD	Depth of the diaphysis/smallest thickness of the diaphysis Globina diafize/najmanjša debelina diafize	von den Driesch (1976)
GBp/Bp	Greatest width proximal/proximal width Največja širina proksimalnega dela	Duerst (1926) von den Driesch (1976)
SBp	Smallest proximal width Najmanjša širina proksimalnega dela	Duerst (1926)
BJp	Greatest width of the proximal joint Največja širina proksimalnega sklepa	Duerst (1926)
DJp	Greatest thickness of the proximal joint Največja debelina proksimalnega sklepa	Athen (2007)

Abb. **Okrajšave**	**Explanation** **Obrazložitev**	**Source** **Vir**
Dp	Proximal depth, i.e. thickness of the epiphysis Globina proksimalnega dela, tj. debelina epifize	von den Driesch (1976) Grandal-d'Anglade (1993)
SBdE	Smallest width of the distal epicondyle Najmanjša širina distalnega nadčvrša oz. epikondila	Duerst (1926)
BdE	Greatest width of the distal epicondyle Največja širina distalnega nadčvrša oz. epikondila	Grandal-d'Anglade (1993)
Bd	Greatest distal width Največja širina distalnega dela	Duerst (1926) von den Driesch (1976)
Dd	Greatest distal depth, i.e. thickness of the distal epiphysis Največja globina distalnega dela, tj. debelina distalne epifize	Duerst (1926) von den Driesch (1976)
Hd	Dist. height middle of the epiphyse - highest point of the crista Višina dist. dela med sredino epifize in najvišjo točko grebena	Duerst (1926)
PCm	Dorsal view, position of the crista on the distal caput, distance to the median margin Dorzalni pogled, lega grebena na distalni glavi, razdalja do medialnega roba	Duerst (1926)
PCl	Dorsal view, position of the crista on the distal caput, distance to the lateral margin Dorzalni pogled, lega grebena na distalni glavi, razdalja do lateralnega roba	Duerst (1926)

abbreviations used in the text are explained in *table 1*. 154 defined parameters were measured in 10 metapodial bones; i.e. 15 to 17 measurements in each specimen. Altogether 575 objects (285 metacarpalia + 290 metatarsalia) were analysed. Data acquisition of both body sides would have caused statistical error, so that the data of only one body side were randomly measured and analysed using Excel 2003. Statistical calculations were conducted with the software packages SPSS[1] and SAS[2].

In the preliminary analysis the data were tested for its approximately Gaussian distribution (Shapiro-Wilk [Graf *et al.* 1998]; the probability of error[3] was 10 %) and for its homogeneity of variance (Levene-test; Brosius 2002). Depending on the preliminary results, the variables were then allocated to suitable univariate parametrical or non-parametrical main test procedures: *t*-test (comparison of means), Welch's *t*-test or *U*-test (comparison of median values after Mann and Whitney). First these calculations were carried out in SPSS, then exact *p*-values with the *alpha*-adjustment after Bonferroni and Holm (Sachs 2002) were completed in SAS, which produces figures with more than three places after the decimal point and is much more precise. The *alpha*-adjustment was used to adjust the probability of error because the two-sample test checks the null hypothesis 154 times (null hypothesis: there is no difference between the means, respectively the medians of males and females). Given a probability of error of 5 %, this means that the exact *p*-value has to be smaller than 0.000016233 [0.05 / (10*154*2); in words: *p*-value

Metrični podatki so bili pridobljeni s pomočjo digitalnega kljunastega merila TCM 227 579, s skalo od 0 do 150 mm in natančnostjo +/–0,03 mm. Izbor merjenih parametrov (spremenljivk, dimenzij) temelji na nomenklaturi in smernicah, ki jih podajajo Duerst (1926), von den Driesch (1976) in Grandal D'Anglade (1993); v besedilu uporabljene okrajšave so predstavljene v *tabeli 1*. Skupno je bilo na desetih metapodijih (tj. mc I–V ter mt I–V) merjenih 154 parametrov oz. 15 do 17 na posamezen metapodij. Pri tem je analiza zajela 575 kosti (285 dlančnic in 290 stopalnic). Statistična obdelava je bila opravljena s pomočjo programskih paketov SPSS[1] in SAS[2].

Kot uvod v statistično analizo sta bila ugotavljana skladnost razporeditve metričnih podatkov z normalno porazdelitvijo (Shapiro-Wilkov test [Graf *et al.* 1998]; verjetnost[3] napake: 10 %) ter opravljen test homogenosti variance (Levenov test; Brosius 2002). Glede na dobljene rezultate so bile nato posamezne spremenljivke vpeljane v ustrezni parametrični ali neparametrični univariatni test, tj. bodisi v *t*-test (primerjava povprečij) bodisi v Welchev *t*-test (primerjava median po Mann-Whitneyju). Osnovno testiranje je bilo opravljeno s pomočjo programskega paketa SPSS, temu je nato sledil še izračun natančnih *p*-vrednosti ob upoštevanju *alpha*-popravka po Bonferroniju in Holmu (Sachs 2002). Pri slednjem je bil uporabljen program SAS, saj ta omogoča prikaz števil z več kot tremi decimalnimi mesti, kar zagotavlja veliko večjo natančnost. Upoštevanje *alpha*-popravka izhaja iz potrebe po popravku izračunane vrednosti za

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[1] SPSS Inc., *SPSS für Windows 11.0.1. Software* (Chicago 2005).

[2] SAS Institute Inc., *The SAS for Windows 8.02 8e 4.10.2222* (Cary, North Carolina 2001).

[3] SAS Institute Inc., *SAS Qc Software: Usage and Reference* (Cary, North Carolina 1995).

[1] SPSS Inc., *SPSS für Windows 11.0.1. Software* (Chicago 2005).

[2] SAS Institute Inc., *The SAS for Windows 8.02 8e 4.10.2222* (Cary, North Carolina 2001).

[3] SAS Institute Inc., *SAS Qc Software: Usage and Reference* (Cary, North Carolina 1995).

divided by the sum of 10 metapodials multiplied by 154 measurements multiplied by the two-sided tests]. This procedure clearly identified the variables that did not confirm the null hypothesis and which significantly verify gender differences. The *alpha*-adjustment is a strict criterion for selection. This univariate testing revealed significant differences between the two gender groups.

In addition, multivariate tests traced the differences other than sexual dimorphism. The multivariate partial correlation analysis was applied to the logarithmised data. In this procedure, influence factors (the so-called control variables) were taken into consideration, and pairs of test variables and control variables were grouped. In the present case the influence factor was gender affiliation. The issued correlation coefficient provided information about the strength of the detected coherence. The algebraic sign indicated whether coherence was positive or negative. A diagnosed significantly positive coherence means that the value of a variable increases while the value of the positively correlated variable also increases. An issued significantly negative coherence means that the value of a variable increases while the value of the negatively correlated variable decreases. The partial correlation analysis identified the strong as well as the minor correlated variables. This provided important background information for the choice of variables in the subsequently applied discriminant analysis and for the adjacent interpretation of the results. The combination of parameters (the predetermined measurements, also using the logarithmised data) optimised the separation of males and females. As mentioned above, exclusively modern collection samples had been chosen, of which the gender had been clearly identified and documented beforehand. In the discriminant analysis, *a priori* classifications were compared with the newly calculated gender classification. The program output also showed the quality criteria eigenvalue, Wilk's lambda and *p*-value. In *table 2*, only the significant results of high quality with a classification probability of over 90 % are listed. This procedure detected gender differences in the multivariate context which had not been discovered by univariate methods.

RESULTS

The univariate main test procedures identified 137 out of 154 parameters that could be used to distinguish male and female brown bears. From these 137 highly significant variables, 66 were identified by the *t*-test, 58 by the Welch`s *t*-test, and 13 by the *U*-test after Mann and Whitney after the verification by the *alpha*-adjustment. These measurements showed significant gender differences.

In the multivariate partial correlation analysis, the coherence of two parameters on one skeletal element

verjetnost napake, do katere pride zaradi 154-kratnega testiranja ničelne hipoteze med izvajanjem dvovzorčnega testa (ničelna hipoteza: med povprečji oz. medianami samcev in samic ni nikakršne razlike). Ob določitvi verjetnosti za napako na ravni petih odstotkov to torej pomeni, da mora biti točna *p*-vrednost manjša od 0,000016233 (izpeljano iz: 0,05/[10*154*2]; obrazložitev: *p*-vrednost = 0,05; št. metapodijev: 10; št. parametrov/dimenzij: 154; metoda: dvostranski dvovzorčni test). Takšen pristop je omogočil prepoznavo spremenljivk, ki ne ustrezajo ničelni hipotezi in ki torej omogočajo razlikovanje med metapodiji samcev in samic.

V nadaljevanju so bile s pomočjo multivariatnih testov preučevane tudi razlike, ki niso neposredno povezane s spolom. Enega takšnih poskusov predstavlja multivariatna delna korelacijska analiza, v katero so bili vpeljani logaritmirani podatki. Namen analize je bil grupirati pare testnih spremenljivk ob hkratnem upoštevanju kontrolne spremenljivke (t. i. dejavnika vpliva; v tokratnem primeru je bil to spol), kjer bi se nato iz izračunanega korelacijskega koeficienta dalo sklepati na moč ugotovljene soodvisnosti. Pri tem sama smer korelacije izhaja iz koeficientovega predznaka. Tako statistično značilna pozitivna korelacija priča o tem, da vrednost dane spremenljivke narašča vzporedno z naraščanjem pozitivno korelirane spremenljivke in obratno. S pomočjo delne korelacijske analize je bilo mogoče prepoznati tako močno kot tudi šibko soodvisne parametre. Med drugim so bili navedeni podatki v pomoč pri izboru spremenljivk za kasnejšo diskriminantno analizo, olajšali pa so tudi interpretacijo njenih rezultatov. S kombiniranjem parametrov (vnaprej določene meritve, uporabljajoč tudi logaritmirane podatke) je bila uspešnost pri razvrščanju posameznih živalskih primerkov po spolu še večja. Kot je že bilo navedeno, so bili v analizo vključeni zgolj metapodiji tistih medvedov, katerih spol je bil znan in dokumentiran. V okviru diskriminantne analize so bili podatki o dejanski spolni pripadnosti primerjani s tistimi, ki izhajajo iz rezultatov statistične analize. Ti so poleg drugega vključevali tudi podatek o lastni vrednosti, Wilkovi lambdi in *p*-vrednosti. Visoko statistično značilni rezultati z verjetnostjo razvrstitve nad 90 odstotkov so podani v *tabeli 2*. Iz njih nedvoumno izhaja, da je z opisanim pristopom vsekakor mogoče prepoznati medspolne razlike v multivariatnem kontekstu, česar z univariatno metodo ni bilo mogoče.

REZULTATI

Uporabljeni univariatni testi so izmed 154 parametrov izločili 137 takih, ki omogočajo uspešno razlikovanje med samci in samicami rjavega medveda. Izmed navedenih 137 visoko značilnih spremenljivk jih je bilo 66 prepoznanih s pomočjo *t*-testa, 58 jih je izpostavil Welchev *t*-test, preostalih 13 pa Mann-Whitneyjev *U*-test was calculated while taking the potential influence factor "gender affiliation" into account. The results were revealed by the correlation coefficient and the *p*-value. In most cases the results showed a significantly positive pairwise coherence – a quasi linear growth. Merely some of the variables of the metatarsalia II (mt II) and the metatarsalia V (mt V) correlated negatively when influenced by the factor "gender affiliation": the mt II large values for GL correlating with small SBp, large SBp correlating with small BJp and BdE. Also, for the mt V, large values of SB, Bp, SBp, SBdE, Hd and PCm correlated with small DJp. The information from the correlation analysis was taken into account for the choice of variables for the discriminant analysis.

All logarithmised data of the 154 variables were analysed in the discrimant analysis, because neither normal distribution nor homogeneity of variance were requirements for the application of this method. With this procedure the discriminatory power of the gender features was tested, which had been revealed by the *t*-test, Welch`s *t*-test and *U*-test. *Table 2* shows a list of the most significant results ($p < 5$ %) with the greatest possible probability of correct classification. The result of mc I, listed in the first row, is briefly exemplified in the following. Out of 58 *a priori* classified individuals, 28 males and 28 females with complete data sets were analysed in the procedure. Out of these 56 cases 98.2 % were correctly classified, thus only one single individual was erroneously classified in this particular combination of parameters (LN_Dp, LN_Dd). The high eigenvalue, the low Wilk's lambda as well as the *p*-value of <0.0001 (< 5 %) speak for the reliability of these results. *Table 2* also shows that in the discriminant analysis of metacarpalia I-V, metatarsalia I, III and IV led to good results. Only the analysis of metatarsalia II and metatarsalia V were inferior (< 90 %); for this reason these were not listed in *table 2* (see also the results of the correlation analysis). The combinations of parameters, which are listed in *table 2*, resulted in probabilities of correct classification of > 90 % combined with a high quality of the results in the examined data pool. They provide a clear distinction of the two genders. In the present dataset a 100 % accuracy was achieved in only one gender group (either *arctos* males or females), not in both groups at the same time.

Frequently, only a few features were suitable indicators for gender affiliation. The logarithmised variables mc I / Dp, mc II / Dp, mc IV / GL, BdE, Dp and Bd, mc V / Dd, mt III / Dp and Bd, extracted in the discriminant analysis, had been identified as highly significant in the *t*-test before. The logarithmised variables mc I / Dd, mc II / Hd and PCl, mc III / Dp and Bd, mc V / Bd, mt I / Dd and BdE, mt III / GBp, mt IV / Bd and PCl had been identified as significantly separative between the gender groups in the Welch`s *t*-test before. The logarithmised variable mc IV / SBdE, extracted in the discriminant analysis, had resulted from the *U*-test before. The loga-

po upoštevanju *alpha*-popravka. Navedene meritve so, kot omenjeno, izkazovale značilne medspolne razlike.

Multivariatna delna korelacijska analiza je omogočila izračun narave in obsega soodvisnosti med pari parametrov na posamezen skeletni element, pri čemer je bil kot potencialni dejavnik vpliva uporabljen podatek o spolu posamezne živali; rezultat je predstavljal korelacijski koeficient s pripadajočo *p*-vrednostjo. V večini primerov je bila soodvisnost med pari spremenljivk značilna in pozitivna in je skoraj ustrezala linearni rasti. V tem smislu predstavljajo izjemo zgolj posamezni parametri na stopalnici II (mt II) in stopalnici V (mt V), ki so – ko je bil kot dejavnik vpliva upoštevana spolna pripadnost – izkazovali negativno korelacijo. Pri mt II so tako visoke vrednosti za GL korelirale z nizkimi za SBp, visoke za SBp pa z nizkimi za BJp in BdE, v okviru mt V pa so nizke vrednosti za parametre SB, Bp, SBp, SBdE, Hd in PCm sovpadale z visokimi za DJp. Rezultati korelacijske analize so bili opora pri izbiri vstopnih spremenljivk za diskriminantno analizo.

V okviru diskriminantne analize je bilo upoštevanih vseh 154 (logaritmiranih) spremenljivk, saj ta ne predpostavlja niti normalne porazdelitve vstopnih podatkov niti homogenosti variance. Namen analize je bil testirati diskriminantno moč spolnospecifičnih parametrov, ki so jih izpostavili rezultati *t*-testa, Welchevega *t*-testa oz. *U*-testa. Statistično značilni rezultati (tj. $p < 0,05$) z največjo možno verjetnostjo pravilne razvrstitve so prikazani v *tabeli 2*. V nadaljevanju so na kratko povzeti rezultati za mc I, ki so sicer navedeni v prvi vrsti tabele. Analiza je zajela prve dlančnice 56 od skupno 58 rjavih medvedov z vnaprej znano spolno pripadnostjo (tj. po 28 samcev in samic). Izmed teh je bilo z diskriminantno analizo mogoče med oba spola pravilno razvrstiti 55 (oz. 98,2 odstotka) primerkov. Drugače povedano: ob upoštevanju optimalne kombinacije parametrov (tj. LN_Dp, LN_Dd) je bil spol napačno ocenjen zgolj v primeru ene same dlančnice I. Visoka lastna vrednost, nizka Wilkova lambda ter *p*-vrednost pod 0,0001 (< 0,05) kažejo na verodostojnost predstavljenih rezultatov. Podobno velja tudi za preostale štiri dlančnice in za stopalnice I, III in IV (*tab. 2*); več kot deset odstotkov zgrešenih razvrstitev med oba spola je bilo ugotovljenih zgolj v primeru stopalnic II in V. Ne glede na v splošnem zadovoljivo razlikovanje med metapodiji samcev in samic pa je bila popolnoma točna razvrstitev v primeru tukaj obravnavanega vzorca ugotovljena le za enega od obeh spolov naenkrat (bodisi *arctos* samci bodisi samice), nikoli za oba.

Prepoznavanje spola pri posameznih metapodijih je bilo mnogokrat uspešno že ob upoštevanju zgolj peščice parametrov. Logaritmirane spremenljivke mc I / Dp, mc II / Dp, mc IV / GL, BdE, Dp in Bd, mc V 7 Dd ter mt III / Dp in Bd, ki so bile izločene z diskriminantno analizo, so bile kot visoko statistično značilne prepoznane že na podlagi rezultatov *t*-testa. V istem smislu je že rithmised variables mc III / SB and mt I / SD, which also resulted from the discriminant analysis, did not prove significantly separative in the two-sample tests. Moreover, an unerring gender classification was easier with the metacarpalia rather than with the metatarsalia. Achieving a 100 % probability of correct classification was possible for the females in the combination with the logarithmised variables SB, Dp and Bd of the mc III. A 100 % probability of correct classification was possible for the males with the combination of the logarithmised variables Dp, Dd of the mc I, with Dp, Hd, PCl on the mc II, with GL, SBdE, BdE on the mc IV as well as with SD, Dd, BdE on the mt I.

In the group of error classifications, the ratio of males to females was 6 : 7 (males, who had been classified as females in the analysis, and the other way round) and therefore was not specific for either gender. The female brown bears with the numbers A985752, A20035117, A905082, and A965019 had erroneously been classified as males in several of their metapodial bones. This was also the case for three males (A20065415, A875239, A580040) who had been classified as females. The females A580011, A955024, and A995233 as well as the males A965066, A587707, and A775051 were incorrectly classified in only one of the ten metapodial bones.

DISCUSSION

In this study, data of living *Ursus arctos* were collected. For this purpose the collection of the Naturhistoriska riksmuseet in Stockholm was studied and analysed. The gender of each analysed individual was identified according to inventory documents. The aim was to find simple criteria in order to identify the gender of bone specimens.

Alltogether, 137 out of 154 variables (88.96 %), which had been extracted as gender specific differences in the univariate two-sample tests, clearly verified sexual dimorphism. It is generally known that ursids show sexual dimorphism, which might be more or less pronounced, depending on geographical location, landscape and diet. The results showed that the mean values, respectively the middle ranks of the *arctos* males, were always bigger than those of the females. In this study the comparison of the mean values showed that the Swedish *U. arctos* female metapodial bones were 11.4 % smaller in size (length, width, thickness of the skeletal elements) than male metapodial bones. That males are bigger than females was not surprising, but it was remarkable that the size difference was more evident in mc IV and mc V as well as in mt I and mt V than in the other metapodial bones.

In most cases, correlation analysis revealed positive significant pairwise coherences. Merely some parameters from the skeletal elements mt II and mt V

Welchev *t*-test prepoznal diskriminatorne potenciale logaritmiranih spremenljivk mc I / Dd, mc II / Hd in PCl, mc III / Dp in Bd, mc V / Bd in BdE, mt III / GBp ter mt IV / Bd in PCl. *U*-test je pokazal na primernost parametra mc IV / SBdE. V nasprotju z navedenimi spremenljivkami pa parametra mc II / SB in mt I / SD, ki ju je prav tako izločila diskriminantna analiza, kot diskriminatorne ni izpostavil nobeden od treh navedenih dvovzorčnih testov. Rezultati so nadalje pokazali, da je prepoznavanje spola v primeru dlančnic uspešnejše kot pri stopalnicah. Popolnoma točna razvrstitev je bila tako dosežena v primeru mc III samic (uporabljena kombinacija logaritmiranih parametrov SB, Dp in Bd) ter mc I (kombinacija logaritmiranih parametrov Dp in Dd), mc II (kombinacija logaritmiranih parametrov Dp, Hd, PCl), mc IV (kombinacija logaritmiranih parametrov GL, SBdE in BdE) ter mt I (kombinacija logaritmiranih parametrov SD, Dd in BdE) samcev.

Razmerje med samci in samicami med napačno razvrščenimi metapodiji znaša 6 : 7 (tj. število samcev, ki je bilo zmotno uvrščeno k samicam in obratno), tako da tovrstne napake očitno niso spolnospecifične. Samice z inventarnimi števili A985752, A 20035117, A 905082 in A965019 so bile zmotno razvrščene med samce na podlagi dimenzij več od skupno desetih analiziranih metapodijev (tj. mc I–V ter mt I–V). Podobno velja za tri samce (A20065415, A875239, A580040), ki so bili zmotno pripisani samicam. Medvedke A580011, A955024 in A995233 ter medvedi A965066, A587707 in A775051 so bili napačno razvrščeni zgolj v primeru enega metapodija.

RAZPRAVA

Članek obravnava podatke o recentnih medvedih vrste *Ursus arctos*, ki jih hrani stockholmski Prorodoslovni muzej (Naturhistoriska riksmuseet). Za vsako od analiziranih živali je bilo mogoče iz priložene dokumentacije ugotoviti spol. Namen raziskave je bil odkriti preproste kriterije, ki bi dovoljevali razvrstitev metapodijev med oba spola.

Rezultati so pokazali, da kar 137 izmed 154 (tj. 88,96 %) spremenljivk, ki so jih kot spolnospecifične izpostavili univariatni dvovzorčni testi, zadovoljivo odseva spolni dimorfizem. Ta je pri medvedih praviloma dobro izražen (samci so v povprečju večji), spreminja pa se v odvisnosti od geografske lege, pokrajine in prehrane. Primerki, zajeti v predstavljeno študijo, so pokazali, da so metapodiji samic s Švedskega v povprečju 11,4 odstotka manjši (dolžina, širina, debelina kosti) od dlančnic/stopalnic samcev. Zaostajanje samic za samci je samo po sebi pričakovano, preseneča pa ugotovitev, da je razlika med spoloma v primeru mc IV in V ter mt I in V večja kot v primeru drugih metapodijev.

Korelacijska analiza je v večini primerov pokazala na obstoj statistično značilne pozitivne korelacije znocorrelated negatively under the influence of the factor "gender affiliation", e.g. in mt V the value for DJp was smaller in one of the two gender groups, while Bp, SBp and SBdE increased. This can possibly be linked to the results of the discriminant analysis, in which mt II and mt V did not show highly significant positive results.

In the discriminant analysis very good classification results were achieved with the 154 parameters. For gender separation, especially the thickness of the proximal epiphysis (Dp on mc I, II, III, IV and mt III), the distal width (Bd on mc III, IV, V and on mt III, mt IV) and the distal depth (Dd on mc I, V and mt I) were useful. The parameters on the proximal and distal joint surfaces (BJp, DJp, PCm, PCl; for abbreviations see above) which had been successful in the species classification (Athen 2007), did not appear to be crucial for gender classification. Mt II and mt V were not suitable for gender distinction in contrast to the other eight metapodial bones, possibly because of negatively correlated variables; this probably made a correct classification impossible. The differences revealed in the univariate tests may be connected to a discrepancy in the proportions of the skeletal elements mt II and mt V.

The results of the discriminant analysis showed that in most cases, combinations of only two to three variables (i.e. measurements) were needed as characteristic features with a probability of correct classification of at least 92.9 %. The highly significant results of the discriminant analysis and the univariate two-sample tests are concurrent. Also, the discriminant analysis showed that correct gender classification was more likely with metacarpal bones than metatarsals.

When one single large collection of individuals is available, the potential error of including several populations in a data pool should be avoided. The individuals in this project originated from Torne Lappmark and Norrbotten in the far north of Sweden, from Norrland and Jämtland (central Sweden) down to Dalarna, which is the most southern distribution area. The publications of Taberlet *et al.* (1995) and Waits *et al.* (2002) state that there are apparently four subpopulations (one western and one eastern genotype) within *U. arctos* specimens. The analysis of nuclear DNA showed that the northern individuals belong to the eastern genotype – 33 individuals in this study. The southern individuals (17 from Dalarna) belong to the western genotype. In eight cases it is not possible to identify the corresponding Swedish province. According to the research of Taberlet and Waits, the two genotypes differ significantly. In this study, however, the data pool was not separated into genotypes because the number of cases would have been reduced. The results of low sample sizes are difficult to interpret. A geographical (and therefore a genetic) differentiation into western and eastern subspecies is presumed for *Ursus arctos* (Kurtén 1959; Hofreiter *et al.* 2002). Possibly, the existence of two to

traj izbranih parov spremenljivk. Zgolj v primeru mt II in mt V so posamezni parametri izkazovali negativno soodvisnost, ko je bil kot vplivni dejavnik izbran spol. Pri mt V je bilo npr. tako v primeru spremenljivke DJp, katere vrednosti so pri enem od obeh spolov padale vzporedno z naraščanjem vrednosti Bp, SBp in SBdE. To gre morda povezati z rezultati diskriminantne analize, kjer pri mt II in V statistično značilnih razlik med spoloma ni bilo mogoče dokazati.

Diskriminantna analiza je omogočila zelo dobro razlikovanje med spoloma pri vseh 154 parametrih. Po primernosti izstopajo predvsem debelina proksimalne epifize (Dp; izpovedna pri mc I, II, III, IV in mt III), širina distalnega dela (Bd; izpovedna pri mc III, IV, V ter mt III in IV) ter globina distalnega dela (Dd; izpovedna pri mc I, V in mt I). Dimenzije sklepnih površin, ki omogočajo taksonomsko determinacijo (tj. Bjp, DJp, PCm, PCl; glej zgoraj za obrazložitev okrajšav; Athen 2007), se za potrebe razlikovanja med spoloma niso izkazale za posebej izpovedne. Stopalnici II in V – za razliko od ostalih osmih metapodijev – razlikovanja med samci in samicami ne omogočajo, kar gre najbrž pripisati negativno koreliranim spremenljivkam. Razlike, ki so jih razkrili univariatni testi, bi lahko bile povezane z razliko v proporcih skeletnih elementov mt II in mt V. Rezultati diskriminantne analize so pokazali, da zelo uspešno (tj. > 92,9 % pravilnih razvrstitev) razlikovanje med spoloma pogosto omogočajo že kombinacije zgolj dveh ali treh parametrov. Pri tem visoko statistično značilni rezultati diskriminantne analize sovpadajo s tistimi, ki izhajajo iz univariatnih dvovzorčnih testov. Diskriminantna analiza je med drugim pokazala tudi to, da je razvrščanje med spoloma na podlagi dlančnic uspešnejše, kot to velja za stopalnice.

Pri študijah, kjer vsi analizirani primerki živali izvirajo iz iste muzejske zbirke, se je treba ogniti potencialni nevarnosti zajemanja podatkov iz več različnih populacij. V naši raziskavi obravnavani švedski medvedi so izvirali iz daljnega severa države (Torne Lappmark in Norrbotten), njenega osrednjega dela (Norrland in Jämtland) in iz Dalarne na jugu, najjužnejše točke območja razširjenosti obravnavane vrste v Skandinaviji. V okviru vrste *U. arctos* so bili prepoznani štiri subpopulacije in dva različna genotipa – en vzhodni in en zahodni (Taberelt *et al.* 1995; Waits *et al.* 2002). Analiza jedrne DNK je pokazala, da živali s severa Švedske pripadajo skupini z vzhodnim genotipom (v tukaj predstavljeni študiji je takih primerkov 33). Pri živalih iz južnega dela areala (17 primerkov iz Dalarne) je bil ugotovljen zahodni genotip; v primeru preostalih osmih tukaj analiziranih medvedov območja izvora ni bilo mogoče ugotoviti. Čeprav so raziskave Taberleta in Waitsa pokazale na obstoj značilnih razlik med obema genotipoma, pa živali, ki so bile zajete v tukaj predstavljeni študiji, nismo nadalje delili na ustrezne podvzorce; ti bi namreč obsegali preskromno število primerkov, kar bi otežilo interpretacijo rezultatov. Vrsta *U. arctos* naj bi sicer obsegala dve podvrsti: zaho-

Tab. 2: Significant results of high quality in the discriminant analysis.
Tab. 2: Visoko statistično značilni rezultati diskriminantne analize.

Gender **Spol**	N	**Skeletal element** variables logarithmised **Skeletni element /** logaritmirane spremenljivke	**% correct classi-fication / pravilne razvrstitve**	**Predicted gender affiliation in % Napovedan % samcev, samic**		**Quality criteria** **Kriterij kvalitete**		
				♀	♂	**Eigen-value** **Lastna vrednost**	**Wilk's Λ** **Wilkova Λ**	***p*-value** ***p*-vrednost**
♀	28	Metacarpalia I / LN_Dp, LN_Dd	98.2	96.4	3.6	2.450	0.290	<0.000016233
♂	28			0.0	100.0			
♀	29	Metacarpalia II / LN_Dp, LN_Hd, LN_PCl	96.5	93.1	6.9	3.018	0.249	<0.000016233
♂	28			0.0	100			
♀	29	Metacarpalia III / LN_SB, LN_Dp, LN_Bd	98.2	100	0.0	3.443	0.225	<0.000016233
♂	27			3.7	96.3			
♀	29	Metacarpalia IV / LN_GL, LN_SBdE, LN_BdE	98.2	96.6	3.4	3.257	0.235	<0.000016233
♂	27			0.0	100			
♀	29	Metacarpalia IV / LN_Dp, LN_Bd, LN_SBdE	96.4	96.6	3.4	3.646	0.215	<0.000016233
♂	26			3.8	96.2			
♀	28	Metacarpalia V / LN_Bd, LN_Dd	92.9	89.3	10.7	2.097	0.323	<0.000016233
♂	28			3.6	96.4			
♀	29	Metatarsalia I / LN_SD, LN_Dd, LN_BdE	94.8	89.7	10.3	2.177	0.315	<0.000016233
♂	29			0.0	100			
♀	29	Metatarsalia III / LN_GBp, LN_Dp, LN_Bd	93.1	93.1	6.9	2.053	0.327	<0.000016233
♂	29			6.9	93.1			
♀	29	Metatarsalia IV / LN_Bd, LN_PCl	94.8	93.1	6.9	2.884	0.257	<0.000016233
♂	29			3.4	96.6			

Explanation of abbreviations / razlaga okrajšav:

Abbreviation **Okrajšava**	**Explanation** **Obrazložitev**
Gender Spol	Definite gender affiliation; *a priorily* known gender Dejanski spol; *a priori* znan spol
♀	Female *U. arctos* Samica *U. arctos*
♂	Male *U. arctos* Samec *U. arctos*
N	Number of cases included in the analysis Število primerkov, vključenih v analizo
% correct classification % pravilne razvrstitve	Amount of new classifications (calculated gender affiliation) using the extracted combinations of variables in comparison to the *a priori*-classification (column 1 "gender") Število pravilno razvrščenih primerkov, izračunan na snovi izločenih kombinacij parametrov, v primerjavi z *a priori* znanim podatkom o spolu (glej prvi stolpec: "Spol").
Predicted gender affiliation in % Napovedan % samcev, samic	Part of the classification per gender Napovedan delež vsakega od obeh spolov
Eigenvalue Lastna vrednsot	Explains the portion of the variance, i.e. the ratio of the dispersion between gender groups (QSZ) to the dispersion within gender groups (QSI); comparable to the *F*-value in the analysis of variance Razloži delež variance, tj. količnik med razpršenostjo med spoloma (QSZ) in razpršenostjo znotraj skupine samcev in samic QSI); podatek je primerljiv s *F*-vrednostjo pri enosmerni analizi variance

Abbreviation **Okrajšava**	**Explanation** **Obrazložitev**
Wilk's lambda (Λ) Wilkova lambda (Λ)	Indicates dispersion within gender groups (QSI) to entire dispersion (QSZ+QSI); quotient of the sum of squares within gender groups (QSI) and the entire sum of square (QSZ+QSI) Kaže na razpršenost znotraj skupine samcev oz. samic (QSI) napram skupni razpršenosti (QZ + QSI); količnik vsote kvadratov znotraj skupine samcev/samic (QSI) in skupne vsote kvadratov (QSZ + QSI)
p-value *p*-vrednost	Probability of error; significant are *p*-values < 0.05 (< 5%) Verjetnost napake; statistično značilne so *p*-vrednosti pod 0,05 (< 5 %)

four subpopulations explains why a 100 % probability of correct classification was achieved in only one of the two gender groups. On the other hand, this reflects the different gender-specific features of males and females (see *Tab. 2*).

The 13 individuals, which had been classified erroneously by one or the other combination of parameters (A985752, A20035117, A905082, A965019, A20065415, A875239, A580040, A580011, A955024, A995233, A965066, A587707, A775051), exhibit no anomalies, neither in their body size nor in any other features which could possibly explain these errors sufficiently. The finding sites of the bear carcasses were scattered from Lappmark over Härjedalen to Dalarna or, very seldomly, unknown.

A few of these individuals were not fully grown, as identified by the closure level of the scapulae and ilii sutures. However, the author regards this as an unlikely explanation for errors, because the other parts of the skeletons seemed fully developed and mature.

The data acquisition in such a biostatistical analysis is unfortunately very time-consuming. Nevertheless, a growing data pool offers the possibility of extensive comparisons and cannot be appreciated highly enough. The separation of data into two groups (males, females) could be used in other continuing statistical analyses. This should help interpret the results gained from fossil material and in the comparison of statistical methods to genetic investigations. However, the results presented here need to be verified in more *U. arctos* material, before the method can be tested on fossil data from *U. spelaeus* and *U. deningeri*. The results of this study will be used in the author's continued investigation of fossil metapodial bones, described in her dissertation. The results of this Synthesys Project on *U. arctos* should help separate fossil material into gender groups. The findings of these separate investigations on fossil gender groups should help understand genetic changes over a certain geological period of time.

dno in vzhodno (Kurtén 1959; Hofreiter *et al.* 2002). V luči zgoraj navedenega bi bilo tako načeloma možno, da gre izostanek popolnoma točne razvrstitve analiziranih metapodijev med samce in samice pri obeh spolih hkrati pripisati prav heterogenosti vzorca, ki je vključeval primerke iz dveh do štirih različnih subpopulacij. Po drugi strani pa seveda ne gre pozabiti niti na spolnospecifične značilnosti samcev in samic (*cf. tab. 2*).

Izmed 13 medvedov, katerih spol je bil na podlagi katere od kombinacij parametrov napačno ugotovljen (A985752, A20035117, A905082, A965019, A20065415, A875239, A580040, A580011, A955024, A995233, A965066, A587707, A775051), nobeden ne kaže kakršne koli anomalije – niti v telesni velikosti niti v kateri od drugih lastnosti, ki bi lahko zadovoljivo razložile navedene napačne klasifikacije. Analizirani medvedi sicer izvirajo s številnih lokacij, razpršenih od Lappmarka prek Härjedalna do Dalarne, in so zgolj v posameznih primerih neznane. Dejstvo je, da med zgoraj navedenimi 13 živalmi niso bile vse odrasle; to dokazujejo posamezni primeri še ne v celoti osificiranih lopatic in medenic. Vendar pa to po avtoričinem mnenju ne more biti razlog za napako pri ugotavljanju spola, saj so bile pri vseh ostalih skeletnih elementih epi- in diafize že popolnoma zraščene.

Zajemanje podatkov za tovrstne biostatistične analize je časovno zelo potratno. To pa nikakor ne pomeni, da je tudi nesmiselno, saj zgolj bogate podatkovne baze omogočajo izvedbo obsežnih primerjalnih analiz. Uspešno grupiranje podatkov v dve skupini (samci, samice) lahko seveda med drugim služi kot izhodišče za izvedbo še drugih statističnih analiz na danem vzorcu. Ob tem gre seveda tudi pričakovati, da bodo tukaj predstavljena dognanja olajšala interpretacijo rezultatov raziskav fosilnega gradiva ter omogočila neposrednejšo primerjavo izsledkov morfometričnih in genetskih študij.

Naj ob koncu vendarle poudarim, da je treba verodostojnost tukaj predstavljenih rezultatov seveda najprej preveriti z analizo dodatnih vzorcev rjavega medveda in jo šele zatem prenesti tudi na izumrli vrsti *U. spelaeus* in *U. denningeri*. To je tudi avtoričin namen, zapisan že v doktorski disertaciji. Rezultati pričujočega programa Synthesys, vezanega na rjavega medveda, naj bi tako postopoma pripomogli tudi k uspešnemu prepoznavanju spola pri fosilnih vrstah ter s tem olajšali razumevanje ugotovljenih diahronih genetskih sprememb.

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RECENT BROWN BEAR BIOLOGY AS A TOOL TO STUDY THE CAVE BEAR

BIOLOGIJA DANAŠNJEGA RJAVEGA MEDVEDA KOT PRIPOMOČEK ZA PREUČEVANJE JAMSKEGA MEDVEDA

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Abstract

The study presents some basic data on the biology of recent brown bears (*Ursus arctos*) that may help towards understanding some elements of cave bear (*Ursus spelaeus*) life. Both species belong to the same genus and were sympatric in large parts of today's Croatia and Slovenia at one period of their evolutionary history. The long term study (since 1981) of brown bears in Croatia provided certain amount of scientific data. The fields of research that may be relevant for comparison with cave bears are reviewed here: 1. denning ecology, 2. reproduction and growth, 3. movements 4. habitat requirements, 5. activity patterns, and 6. feeding habits.

Keywords: cave bear, *Ursus spelaeus*, brown bear, *Ursus arctos*, Croatia, Slovenia, biology, ecology

INTRODUCTION

Organisms belonging to the same genus are the most closely related groups of species. Although reproductively isolated and morphologically different to various degrees, they usually share many biological and ecological features. When dealing with the living species, sometimes the threatened status or remoteness of one species justifies using the most closely related species in order to study the other one, especially when some kinds of invasive experiments are involved. One special example is the use of primates in testing human medical remedies. When one species is extinct, the insight into the recent living one may be quite a useful approach to understanding certain

Izvleček

Razprava predstavlja nekaj temeljnih podatkov o biologiji današnjih rjavih medvedov (*Ursus arctos*), ki nam lahko pomagajo pri razumevanju nekaterih dejstev o življenju jamskega medveda (*Ursus spelaeus*). Obe vrsti pripadata istemu rodu in sta bili v nekem obdobju svoje evolucijske zgodovine simpatrični v večjem delu sedanje Hrvaške in Slovenije. Dolgoročno preučevanje rjavih medvedov, ki na Hrvaškem poteka od leta 1981, je dalo določeno količino znanstvenih podatkov. Obravnavala sva naslednja raziskovalna področja, ki so lahko pomembna za primerjavo z jamskimi medvedi: 1. ekologijo brlogov, 2. razmnoževanje in rast, 3. gibanje, 4. zahteve v povezavi z življenjskim prostorom, 5. vedenjske vzorce in 6. prehranjevalne navade.

Ključne besede: jamski medved (*Ursus spelaeus*), rjavi medved (*Ursus arctos*), Hrvaška, Slovenija, biologija, ekologija

UVOD

Organizmi, ki pripadajo istemu rodu, so najtesneje povezane skupine vrst. Čeprav se med sabo ne morejo razmnoževati in se morfološko bolj ali manj razlikujejo, jih običajno povezujejo mnoge biološke in ekološke značilnosti. Ko se ukvarjamo z ogroženimi ali težko dostopnimi še živečimi vrstami, je včasih upravičeno določene raziskave – sploh tiste invazivne – namesto na njih samih izvesti na vrstah, ki so z njimi najtesneje povezane. Poseben primer je uporaba primatov pri preizkušanju človeških zdravil. Preučevanje še živečih sorodnih vrst pa ima prav poseben pomen pri raziskavah že izumrlih, saj pomembno prispeva k razumevanju do-

Fig. 1: Find of a cave bear scull in the Pod zubom Buljme cave, Croatia.
Sl. 1: Najdba lobanje jamskega medveda v jami Pod zubom Buljme na Hrvaškem.

aspects of ancient life. Of course, a careful evaluation of each finding has to be done. Conversely, the differences determined may help understand the evolutionary pathways and even part of the reason for extinction. As the two species cohabited in part of their history, the mutual influence may be speculated as well.

In most of the upper Pleistocene localities of Europe, including all of today's Croatia and Slovenia, the skeletal remains of cave bear (*Ursus spelaeus* Rosenmüller; *Fig. 1*) and brown bear (*Ursus arctos* Linné) have been found. Usually findings of the cave bear were considerably more numerous than findings of the brown bear. In the so called "bear caves", remains of the cave bear make up to (occasionaly even more than; *cf.* Toškan 2007, 223) even 95 % of all findings (Gužvica 1996). However, the remains of the brown bear, although not numerous, appear occasionally at the Pleistocene localities.

The recent brown bear lives in the parts of the Dinaric Mountain range that is shared by Croatia and Slovenia and covers substantial parts of both countries. The Croatian long term study of brown bears has covered many aspects of their biology and ecology and may be used to compare with cave bear life history (Huber, Roth 1993; 1997).

The morphological differences between the two species have been studied and published to a certain

ločenih vidikov starodavnega življenja. Seveda je pri tem treba pazljivo ovrednotiti vsako ugotovitev. Obratno pa ugotovljene razlike lahko pomagajo razumeti razvojne poti in celo del vzrokov za izumrtje. Če sta dve vrsti živeli v delu svoje zgodovine skupaj, lahko računamo tudi na obojestransko vplivanje.

Ostanki jamskega medveda (*Ursus spelaeus* Rosenmüller; *sl. 1*) oz. rjavega medveda (*Ursus arctos* Linné) so bili najdeni v večini mlajšepleistocenskih najdišč v Evropi, vključno s tistimi v sedanji Hrvaški in Sloveniji. Običajno so bile najdbe jamskega medveda občutno številnejše, saj lahko njihov delež v t. i. "medvedjih jamah" dosega do 95 odstotkov vseh živalskih ostankov (Gužvica 1996), izjemoma celo več (Toškan 2007, 223). Najdbe rjavega medveda v pleistocenskih najdiščih pa so zgolj občasne in bistveno manj številne.

Današnji rjavi medved živi v delih Dinarskega gorstva, ki se razprostira na Hrvaškem in v Sloveniji ter pokriva znatne dele ozemlja obeh držav. Dolgoročno preučevanje teh zveri na Hrvaškem je zajelo mnoge vidike njihove biologije in ekologije. Dobljene podatke lahko med drugim uporabimo tudi za primerjavo z jamskim medvedom (Huber, Roth 1993; 1997).

Morfološke razlike med obema navedenima medvedjima vrstama so bile preučevane in v določeni meri tudi predstavljene v številnih publikacijah. Torres (1988) extent. Torres (1988) analyzed the majority of skeletal elements. The methods of numerical taxonomy on the basis of metrical data on the metapodia of the brown and cave bears were used by e.g. Krklec (1995). Gužvica *et al.* (1996) defined a simple and reliable method for differentiation of the brown and cave bear skulls by use of indices of linear measurements, and Gužvica *et al.* (1995) analyzed and compared the appearance of the supratrochlear opening on cave and recent brown bear humerals. In the past two decades, several paleobiological and biochronological data on cave bears were published, including those by the junior author of this paper (Gužvica 1991; 1992-1993; Gužvica *et al* 1995; 1996; 2000; Gužvica, Radanović-Gužvica 2000; 2002). However, published studies comparing biological aspects of the cave and brown bears species are absent.

The objective of this study is to give a brief overview of the recent brown bear life histories in the Northern Dinaric range and to compare some of them with the known cave bear features.

MATERIAL AND METHODS

Croatia holds a population of 600-1000 brown bears (Huber *et al.* 2008), 200-220 gray wolves (*Canis lupus*; Štrbenac *et al.* 2005) and 40-60 Eurasian lynx (*Lynx lynx*; Firšt *et al.* 2005). Bears are game animals, while wolves and lynx are strictly protected. All populations belong to the Dinaric mountain range and are shared with neighboring Slovenia and Bosnia and Herzegovina. Careful management based on detailed management plans is keeping the bear population increasing, wolf population stable, while lynx is still slightly decreasing and requires most attention (Štrbenac *et al.* 2005).

The Large Carnivore Study Team of the Zagreb Faculty of Veterinary Medicine has been studying the biology and health status of brown bears in Croatia since 1981. The approach included live capturing of wild animals and collection of dead specimens. So far we have captured and handled 58 wild brown bears (37 radio-tracked). In addition we performed 112 handlings of captive bears. Bodies of retrieved dead large carnivores included 120 bears and have undergone various degrees of investigation depending on the state and completeness of the remains. Human caused mortality dominated among all three investigated species. That included legal and illegal shooting and traffic kills. The pathology determined at post mortems was rarely the cause of death. The health status has been additionally monitored through serum antibodies and biochemistry of living animals. In more recent years the genetic diagnostic approach has been used for parasitological investigations. Genetic studies of large carnivores themselves are used for insight into genetic diversity and population sizes. The results are yielded in over 120

je npr. analiziral večino kostnih elementov, medtem ko se je Krklecova (1995) posvetila metodam numerične taksonomije na podlagi merskih podatkov dlančnic in stopalnic rjavega in jamskega medveda. Gužvica *et al.* (1996) so določili preprost in zanesljiv način za razlikovanje med lobanjami rjavega in jamskega medveda z uporabo indeksov linearnih meritev ter (Gužvica *et al.* 1995) analizirali in primerjali odprtino nad sklepnim valjem nadlahtnice (*foramen supratrochleare*) jamskega in današnjega rjavega medveda. V zadnjih dveh desetletjih je bilo objavljenih tudi več paleobioloških in biokronoloških podatkov o jamskem medvedu, tudi tistih, ki jih je pridobil soavtor tega prispevka (Gužvica 1991; 1992–1993; Gužvica *et al.* 1995; 1996; 2000; Gužvica, Radanović-Gužvica 2000; 2002). Na drugi strani pa še vedno v celoti manjkajo objave razprav, ki bi primerjale biološke vidike obeh omenjenih medvedjih vrst.

Namen te razprave je podati kratek pregled biologije današnjega rjavega medveda na območju severnega Dinarskega gorstva in jo delno primerjati z znanimi značilnostmi jamskega medveda.

GRADIVO IN METODE

Na Hrvaškem živi od 600 do 1.000 rjavih medvedov (Huber *et al.* 2008), od 200 do 220 sivih volkov (*Canis lupus*; Štrbenac *et al.* 2005) in od 40 do 60 evrazijskih risov (*Lynx lynx*; Firšt *et al.* 2005). Medvedi sodijo med lovno divjad, volkovi in risi pa so strogo zaščiteni. Vse populacije živijo na območju Dinarskega gorstva in prehajajo tudi v sosednji državi Slovenijo in Bosno in Hercegovino. Zaradi skrbnega gospodarjenja, ki temelji na podrobnih gospodarskih načrtih, populacija medvedov narašča, populacija volkov je stabilna, medtem ko se populacija risov še vedno rahlo zmanjšuje in ji je zato treba nameniti več pozornosti (Štrbenac *et al.* 2005).

Skupina za raziskovanje velikih zveri na zagrebški Veterinarski fakulteti preučuje biologijo in zdravstveno stanje rjavih medvedov na Hrvaškem od leta 1981. Projekt obsega tako ulov divje živečih živali kot zbiranje poginulih. Doslej smo ujeli in obravnavali 58 divjih rjavih medvedov (37 radijsko sledenih). Poleg tega smo obravnavali še 112 medvedov v ujetništvu. Med pridobljenimi trupli velikih zveri je bilo 120 medvedjih, ki so bila – odvisno od stanja in ohranjenosti ostankov – deležna različno obsežnih raziskav. Pri vseh treh raziskovanih vrstah velikih zveri je bil prevladujoč dejavnik pogina človek, najsi je šlo za zakonit lov, krivolov ali pogin v prometu. Pri obdukcijah ugotovljene bolezni so bile le redko povzročiteljice pogina. Zdravstveno stanje živih živali se je preverjalo z dodatnim opazovanjem in s pomočjo serumskih protiteles in biokemijskih raziskav. V zadnjih letih se je za parazitološke raziskave uporabljala genetska diagnostika. Genetska preučevanja velikih zveri dajejo vpogled v genetsko raznolikost in velikost popupublications, which can be roughly grouped as follows: health status and pathology (including parasitology, genetics and immobilization) 43, biology and ecology 21, status, management and human attitudes 57 papers (see Huber's publications). Most of the results were applied in conservation and management.

For this study we analyzed the most relevant data from Dinaric brown bear studies on: 1. denning ecology (Huber, Roth 1997), 2. reproduction and growth (Frkovic *et al.* 2001; Swenson *et al.* 2007), 3. movements (Huber, Roth 1993; Ordiz *et al.* 2007), 4. habitat requirements (Kusak, Huber 1998), 5. activity patterns (Roth, Huber 1986; Kaczensky *et al.* 2005), and 6. feeding habits (Cicnjak *et al.* 1987; Huber *et al.* 1993).

RESULTS AND DISCUSSION

As listed in the Material and methods chapter, here we present the overview of relevant data on recent brown bears in Croatia.

DENNING

Twenty-eight dens of 15 different European brown bears were located, monitored and measured during 1981-92 (Huber, Roth 1997; *Fig. 2*) and fifteen more dens were measured after that (Huber, unpublished data). However, only the measurement data of the 28 are used here. Ten of them were used by females with cubs, nine by single females, five by males and four by bears of unknown category. Occasionally bears used more than one den in the same winter (four bears

lacij. Izsledki so bili predstavljeni v več kot 120 objavah, ki jih lahko grobo razvrstimo takole: zdravstveno stanje in bolezenska slika (vključno s parazitologijo, genetiko in imobilizacijo) 43 člankov, biologija in ekologija 21 člankov, stanje, gospodarjenje in odnos ljudi do preučevanih živali 57 člankov (glej Huberjeve objave). Večina izsledkov je bila upoštevana pri varstveni strategiji in gospodarjenju.

Za to razpravo smo analizirali najpomembnejše podatke iz razprav o dinarskem rjavem medvedu z naslednjih področij: 1. ekologija izbire brlogov (Huber, Roth 1997), 2. razmnoževanje in rast (Frković *et al.* 2001; Swenson *et al.* 2007), 3. gibanje (Huber, Roth 1993; Ordiz *et al.* 2007), 4. zahteve v povezavi z življenjskim prostorom (Kusak, Huber 1998), 5. vedenjski vzorci (Roth, Huber 1986; Kaczensky *et al.* 2005) in 6. prehranjevalne navade (Cicnjak *et al.* 1987; Huber *et al.* 1993).

REZULTATI IN RAZPRAVA

Kot sva navedla v poglavju o gradivu in metodah, podajava v nadaljevanju pregled pomembnih podatkov o današnjem rjavem medvedu na Hrvaškem.

BRLOGI

Med letoma 1981 in 1992 je bilo najdenih, opazovanih in izmerjenih 28 brlogov 15 različnih evropskih rjavih medvedov (Huber, Roth 1997; *sl. 2*); po koncu tega obdobja jih je bilo izmerjenih še 15 (Huber, neobjavljeni podatki), vendar ti v tem članku niso upoštevani. Od navedenih 28 brlogov so jih deset uporabljale samice z

Fig. 2: Taking measurements of a maternal den (female with two yearling cubs) in the Plitvice Lakes National Park, Croatia.
Sl. 2: Merjenje brloga samice z dvema leto dni starima mladičema v Narodnem parku Plitviška jezera na Hrvaškem.

used 2-4 dens, mean = 3). Most of the dens (22) were constructed in natural rock cavities, which could be attributed to the local abundance of such karst features. We did not record the den re-use of any radio-marked bears, but 2 of their dens have remains of old nests below the new material. Nine dens were checked for a total of 19 den years, and only one was used again, five years later by an unknown bear. Den entrances opened to all exposures with no significant preference: north 6, east 9, south 5, and west 8. Dens in the rock cavities were on the mean slope of 53°; 15 of 22 (68 %) were associated with a vertical cliff wall, built on the bottom (*n* = 10) or in a fracture (*n* = 5) of a solid rock. Cavities represented ancient water sink or source holes (*n* = 19) or spaces among large boulders (*n* = 3). Modifications made by bears were restricted to the dirt on the bottom of the cavity: nest depression, tunnel and or entrance width. Only two dens were among the roots of standing trees and those were the only ones totally dug by bears. The remaining four dens were simple nests on open ground under the branches of conifer trees.

mladiči, devet samotarske samice in pet samci; pri štirih živalih ta podatek ni znan. Občasno so medvedi v isti zimi uporabili več kot en brlog (štirje so uporabili 2 do 4 brloge, povprečje = 3). Večina brlogov (22) je bila v naravnih skalnih votlinah, ki jih je na obravnavanem območju veliko. Pri radijsko sledenih medvedih nismo zabeležili nobene ponovne uporabe brloga, smo pa v dveh primerih pod novim gnezdom opazili ostanke starega. Devet brlogov je bilo nadziranih skupno 19 let, a je samo enega izmed njih pet let po prvi zabeleženi uporabi ponovno zasedel neznani medved. Vhodi v brloge so bili usmerjeni na vse strani neba brez značilnega odstopanja katere od njih (tj. na sever: 6; na vzhod: 9; na jug: 5; na zahod: 8). Brlogi v skalnih votlinah so bili na pobočjih s povprečnim naklonom 53°; 15 od 22 (68 %) jih je bilo v navpični skalni steni. Urejeni so bili na dnu (*n* = 10) ali v prelomu masivne skale (*n* = 5). Votline so predstavljale bodisi nekdanje vodne ponore oz. izvire (n = 19) bodisi prostore med velikimi skalami (*n* = 3). Spremembe, ki so jih povzročili medvedi, so bile omejene na sediment na tleh votline: poglobitev

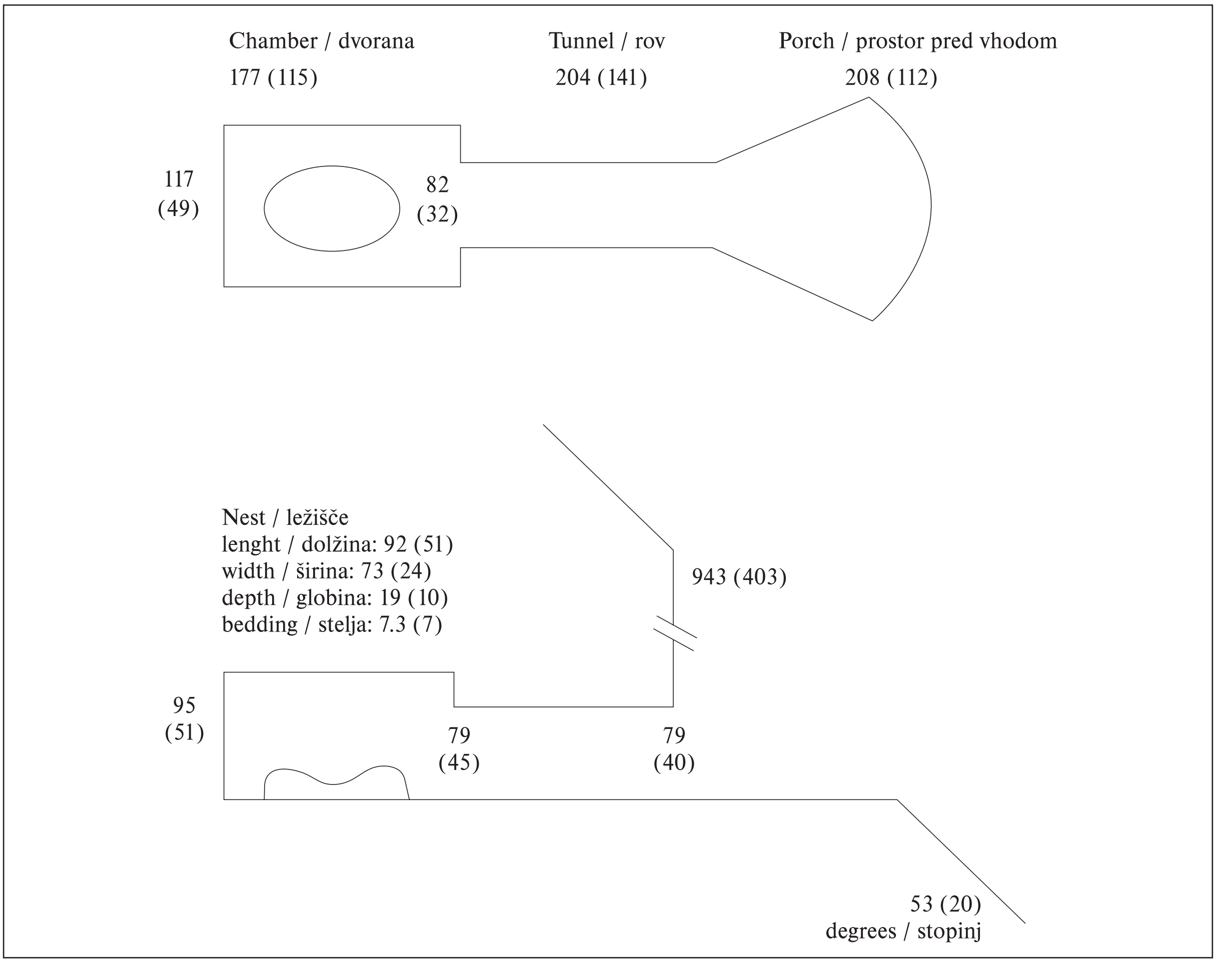

Fig. 3: Top view and profile of the hypothetical European brown bear den in Croatia based on mean values of 22 dens in rock cavities. Shown are means and SD in cm (Huber, Roth 1997).
Sl. 3: Tloris in presek hipotetičnega brloga evropskega rjavega medveda na Hrvaškem na temelju povprečnih vrednosti 22 brlogov v skalnih votlinah. Prikazana so povprečja in standardna deviacija (SD) v cm (Huber, Roth 1997).

Mean measurements of den entrance, tunnel, chamber, porch, slope angle, elevation and the distance to the nearest road or house were calculated for dens in rock cavities and root excavations. From these data a hypothetical rock cavity den was drawn (*Fig. 3*). There was no significant difference in any den dimension due to bear reproductive status or size class; i.e. maternal vs. non-maternal (also male vs. female), over or below 100 kg mass. Only nest sizes were significantly larger (79 x 98 cm) for mothers with cubs and for bears over 100 kg, compared to single females and smaller bears (57 x 60 cm) ($p < 0.05$). No den related mortality was revealed in our study.

Cave bears bear their very name due to the fact that the majority of their remains were found in caves of various sizes and shapes. The prevalence of cave bear remains in Pleistocene cave sediments is not necessarily explained by greater use of them over earthen dens in the past. Limestone caves provide a better preservation environment for the bones of deceased bears (Stiner 1999). The fact that cave bear dental adaptations testify to a great dependence on seasonal plant food makes a strong case for cave bears as hibernators. Basic similarities in the hibernation behaviour of distinct bear species permit a few generalizations about the relations between bear diet and hibernation behaviour, hibernation-related mortality, and criteria governing den site choice. The location of a den is secret, because sleeping bears are vulnerable to attack by wolves, humans, and other bears. Hibernation dens are places where bears occasionally die, but hibernating bears may perish from violent or non-violent causes inside dens. Differences in mortality patterns can be used to test the cave bears' connection to prehistoric human activities in the same shelter (Stiner 1999).

REPRODUCTION AND GROWTH

Mean litter sizes and maximum survival of cubs of brown bears in Croatia (*Fig. 4*) were calculated based on 116 observations of 106 brown bear family groups. The mean litter size was 2.39 ($n = 56$; range 1-4) for cubs of the year (COY) and 1.96 ($n = 50$; range 1-4) for yearlings. The difference of 0.43 (18 %) was statistically significant. No significant difference in COY or yearling litter sizes was found between spring and fall of the same year. Significantly larger litters of all ages were observed with mothers away from feeding stations ($\overline{X} = 2.36$; $n = 47$), than at feeding stations ($\overline{X} = 2.05$; $n = 59$). This suggests that the feeding of bears in Croatia for management purposes has not influenced bear reproduction (Frković *et al.* 2001). We recorded one female reproducing on her third birthday and another on her fourth, which falls within the group of youngest reproductive ages documented in the literature (Zedrosser *et al.* 2004). Most

gnezda, rova in/ali širine vhoda. Samo dva brloga sta bila med koreninami rastočih dreves. Ta sta bila tudi edina, ki so ju v celoti izkopali medvedi. Preostali štirje so bili preprosta gnezda na prostem pod vejami iglavcev.

Za brloge v skalnih votlinah in med koreninami smo izračunali povprečne mere vhoda, rova, dvorane, preddverja, naklona pobočja, nadmorske višine in oddaljenosti do najbližje ceste ali hiše. Na podlagi teh podatkov smo narisali hipotetičen brlog v skalni votlini (*sl. 3*). Razlike v merah brlogov med medvedi, ki se razlikujejo po razmnoževalnem statusu (tj. materinski proti nematerinski stan; tudi samčev proti samičin) oz. velikosti (masa nad ali pod 100 kg), praviloma niso dosegale meje statistične značilnosti. Pri samicah z mladiči in pri medvedih z maso nad 100 kg je bila v primerjavi s samicami brez mladičev in manjšimi medvedi statistično značilno večja zgolj velikost gnezda (tj. 79 x 98 cm nasproti 57 x 60 cm; $p < 0,05$). Pri najini raziskavi nisva zasledila nobenega pogina medveda v brlogu.

Jamski medvedi imajo tako ime zato, ker je bila večina njihovih ostankov najdena v jamah različnih velikosti in oblik. Prevlada ostankov jamskega medveda v pleistocenskih jamskih sedimentih ni nujno posledica pogostejše uporabe tovrstnih brlogov v primerjavi s površinskimi. Takšno stanje bi namreč lahko bilo tudi posledica različno intenzivnega propadanja kosti v različnih okoljih, saj so tafonomske izgube v jamah praviloma manjše (Stiner 1999).

Zobovje jamskega medveda kaže očitne prilagoditve na prehranjevanje s sezonsko razpoložljivo hrano rastlinskega izvora. Slednje velja za močan argument v prid tezi, da so jamski medvedi zimo prespali. Temeljne podobnosti s hibernacijo povezanih vedenjskih vzorcev pri različnih vrstah medvedov dovoljujejo nekaj posplošitev o odnosih med medvedjo prehrano na eni strani ter vedenjem med "zimskim spanjem" (v bistvu gre bolj za dremež), umrljivostjo v tem obdobju in pa merili za izbiro brloga na drugi. Kraj brloga je skriven, ker so speči medvedi ranljivi za napad volkov, ljudi in drugih medvedov. V zimskih brlogih medvedi občasno tudi poginejo, vzroki za to pa so lahko nasilni ali nenasilni. Razlike v vzorcih umrljivosti lahko služijo za preizkus povezave med jamskimi medvedi in dejavnostjo prazgodovinskega človeka v istem zatočišču (Stiner 1999).

RAZMNOŽEVANJE IN RAST

Povprečne velikosti legla in največje preživetje mladičev rjavih medvedov na Hrvaškem (*sl. 4*) so bili izračunani na podlagi 116 opazovanj 106 družinskih skupin rjavega medveda. Povprečna velikost legla je bila 2,39 ($n = 56$; razpon 1–4) za mladiče tekočega leta (MTL) in 1,96 ($n = 50$; razpon 1–4) za enoletne mladiče. Razlika 0,43 (oz. 18 %) je bila statistično značilna. Med velikostmi legla MTL ali enoletnih mladičev v

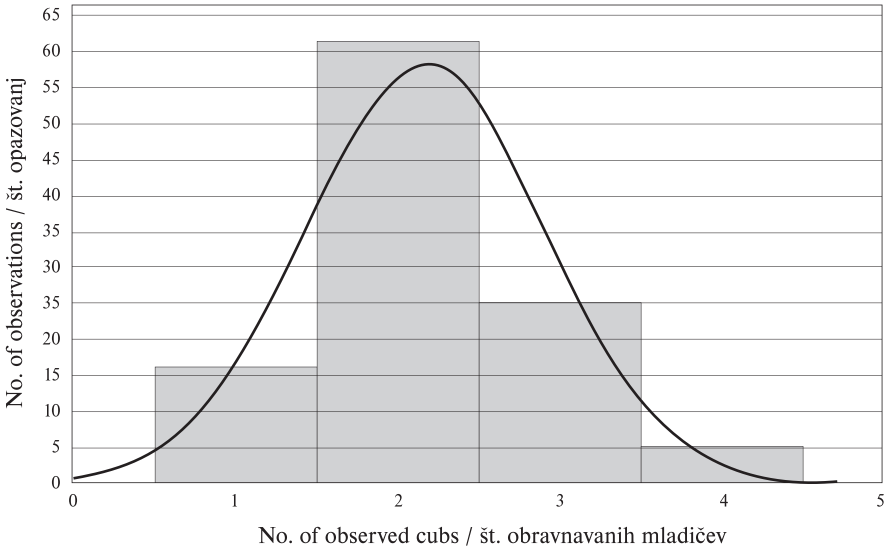

Fig. 4: Distribution of data for European brown bear litter sizes in Croatia (*n* = 106 family groups; Frković *et al.* 2001).
Sl. 4: Porazdelitev velikosti legel evropskega rjavega medveda na Hrvaškem (*n* = 106 družinskih skupin; Frković *et al.* 2001).

adult females reproduce once in two years and remain reproductive most of their life. The average population age was 4.7 years (SD = 3.1; Huber, Roth 1993).

Brown bears are usually born in January during the denning period, and have a mass of roughly 1/3 kg. They feed on mother's milk of 24 % fat and 12 % proteins. Up to the age of four months they double their body mass every 32 days (Huber *et al.* 1993).

We tested six hypotheses to explain the expected geographical differences in body masses of 1,771 brown bears from northern and southern Europe (Sweden and Norway compared with Slovenia and Croatia): Bergmann's rule, the fasting endurance hypothesis, and the dietary meat hypothesis, which predicted larger bears in the north; and hypotheses stressing the role of high primary productivity, high population density, low seasonality, and length of the growing season, which predicted larger bears in the south. Although brown bear populations in North America vary greatly in body mass, we found no significant difference in body mass between the two European populations using a new analytical approach incorporating modelled age-standardized body masses in linear models, when correcting for sex and season. The greater variation in North America may be due primarily to the presence of large bears that feed on salmon (*Oncorhynchus* spp.), which does not occur in Europe. Asymptotic body masses were 115 ± 9 (SE) kg in spring and 141 ± 9 kg in autumn for southern females, 248 ± 25 and 243 ± 24 kg for southern males vs. 96 ± 2 and 158 ± 4 kg for northern females, and 201 ± 4 and 273 ± 6 kg for northern males, respectively. Northern bears gained more body mass before hibernation and lost more during hibernation than southern bears, prob-

pomladi in jeseni istega leta značilne razlike niso bile ugotovljene.

Pri samicah, ki so bile oddaljene od krmišč, so bila opažena značilno večja legla ($\overline{X}$ = 2,36; *n* = 47) kot pri tistih blizu krmišč ($\overline{X}$ = 2,05; *n* = 59). Iz navedenega izhaja, da na Hrvaškem krmljenje medvedov iz gospodarskih razlogov ni vplivalo na razmnoževanje (Frković *et al.* 2001). Zabeležili smo eno samico, ki je imela mladiče pri treh letih, in eno, ki jih je imela pri štirih; njuna starost ob nastopu spolne zrelosti sodi med najnižje vrednosti, navedene v literaturi (Zedrosser *et al.* 2004). Večina odraslih samic ima mladiče enkrat na vsaki dve leti in ostane plodna večino svojega življenja. Povprečna starost med preučevano populacijo je bila 4,7 leta (SD = 3,1; Huber, Roth 1993).

Mladiči rjavega medveda se običajno skotijo januarja v brlogu, njihova telesna masa znaša približno tretjino kilograma. Hranijo se z materinim mlekom, ki vsebuje 24 odstotkov maščob in 12 odstotkov beljakovin. Do starosti štirih mesecev vsakih 32 dni podvojijo svojo telesno maso (Huber *et al.* 1993).

Da bi razložili pričakovane (ocenjene) zemljepisne razlike v telesnih masah 1.771 rjavih medvedov iz severne in južne Evrope (tj. Švedske in Norveške v primerjavi s Slovenijo in Hrvaško), smo preverili šest hipotez: Bergmannovo pravilo, hipotezo o postni vzdržljivosti in hipotezo o mesni prehrani, ki napovedujejo večje medvede na severu, ter na drugi strani hipoteze s poudarkom na vlogi visoke primarne produkcije, visoke gostote populacije, neizrazitosti sezonske razpoložljivosti hrane in dolžine obdobja rasti, ki vse napovedujejo večje medvede na jugu. Čeprav se populacije rjavega medveda v Severni Ameriki močno razlikujejo po telesni masi, pa v tem pogledu zna-

Tab. 1: Minimal, maximal and mean extrapolated values of cave bear body mass from Vindija, Velika pećina and Veternica caves in Croatia (Gužvica 1996).
Tab. 1: Najmanjše, največje in povprečne ekstrapolirane telesne mase jamskega medveda iz Vindije, Velike pećine in Veternice na Hrvaškem (Gužvica 1996).

Pleistocene site / pleistocensko najdišče	**n**	**Estimated body mass / ocenjena telesna masa (kg)**		
		Min.	**Max.**	**Mean / povprečje**
Vindija	309	327	1160	667
Velika pećina	162	291	1083	691
Veternica	142	376	1075	682

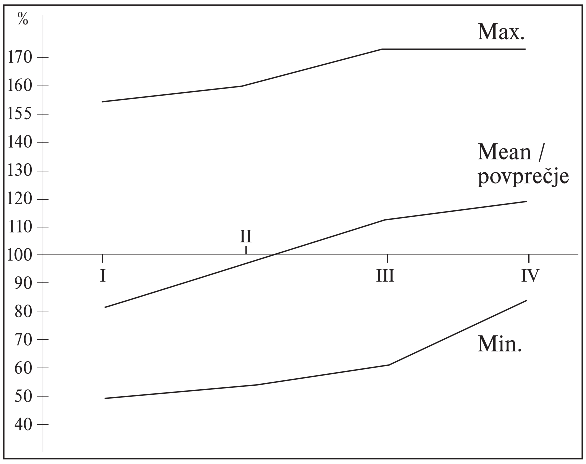

Fig. 5: Tendency of minimal, maximal and mean values of cave bear body mass in relation to the stratigraphic position in Vindija cave (Gužvica 1996)
Sl. 5: Trend najmanjših, največjih in povprečnih vrednosti telesne mase jamskega medveda glede na stratigrafsko lego v Vindiji (Gužvica 1996).

ably because hibernation was twice as long in the north. Moreover, northern bears gained and southern bears lost mass during the spring, perhaps due to the greater availability and use of protein-rich food in spring in the north. As reproductive success in bears is correlated with adult female body mass in interpopulation comparisons, brown bears may have relatively similar reproductive rates throughout Europe (Swenson *et al.* 2007).

The estimation of **cave bear** body mass according to the Legendre-Roth method (Legendre, Roth 1988) was performed on the Croatian Pleistocene sites of Vindija, Velika pećina and Veternica caves (*Tab. 1*). The lowest value of cave bear body mass (291 kg) was estimated in Velika pećina cave, and the highest (1160 kg) in Vindija cave (Gužvica 1996) (*Fig. 5*).

HABITAT REQUIREMENTS

A habitat suitability index (HSI) model was developed to assess the habitat quality of European brown bear in Gorski kotar, Croatia (Kusak, Huber 1998). We identified the natural components of bear

čilnih odstopanj med obema primerjanima evropskima populacijama nismo ugotovili. Pri tem sva za potrebe tukaj predstavljene raziskave uporabila nov analitičen pristop, ki zajema modelirane starostno standardizirane telesne mase v linearnih modelih, ob upoštevanju spola in letnega časa. Večja različnost v telesni masi v Severni Ameriki je morda zlasti posledica prisotnosti velikih medvedov, ki se hranijo z lososi (*Oncorhynchus* spp.); slednjih namreč v Evropi ni. Povprečna vrednost in standardna napaka (SE) za asimptotično telesno maso sta pri samicah iz južnejše populacije znašali 115 ± 9 (SE) kg spomladi in 141 ± 9 kg jeseni, pri samcih iz iste populacije pa 248 ± 25 kg spomladi in 243 ± 24 kg jeseni. Vrednosti za na severu živeče medvede so bile: 96 ± 2 in 158 ± 4 kg pri samicah ter 201 ± 4 in 273 ± 6 kg pri samcih. Iz navedenih podatkov izhaja, da so medvedi s severa Evrope v obdobju pred začetkom "zimskega spanja" očitneje pridobivali telesno maso v primerjavi s tistimi iz Slovenije in Hrvaške, so jo pa med samo hibernacijo tudi bolj pospešeno izgubljali. Ugotovitev gre najbrž pripisati dejstvu, da je bilo obdobje hibernacije na severu dvakrat daljše. Nadalje je bilo ugotovljeno, da so spomladi norveški in švedski medvedi pridobili telesno maso, slovenski in hrvaški pa jo izgubili, čemur najbrž botrujejo večje pomladanske količine beljakovinsko bogate hrane na severu. Ker je uspešno razmnoževanje pri medvedih odvisno od telesne mase odraslih samic, imajo lahko rjavi medvedi iz različnih evropskih populacij precej podobno raven razmnoževanja (Swenson *et al.* 2007).

Ocena telesne mase **jamskega medveda** po Legendre-Rothovi metodi (Legendre, Roth 1988) je bila narejena na gradivu s hrvaških pleistocenskih jamskih najdišč Vindija, Velika pećina in Veternica (*tab. 1*). Najnižja vrednost se je nanašala na primerek iz Velike pećine (tj. 291 kg), najvišja pa na primerek iz Vindije (1.160 kg; Gužvica 1996) (*sl. 5*).

ZAHTEVE V POVEZAVI Z ŽIVLJENJSKIM PROSTOROM

Za določanje kakovosti življenjskega prostora evropskega rjavega medveda v Gorskem kotarju na Hrvaškem je bil izdelan model indeksa ustreznosti življenjskega prostora (IUŽP; Kusak, Huber 1998).

Fig. 6: Rescuing a brown bear cub (age: one month) from the den abandoned by the mother after the forestry work disturbance.
Sl. 6: Reševanje enomesečnega mladiča rjavega medveda iz brloga, ki ga je mati zapustila zaradi motečih gozdarskih del.

habitat, most of which had been deteriorated by human activities. Food sources were available year-round. Human influence was manifested through a relatively high density of roads (1.91 km/km^2), including forest roads. Habitat fragmentation did not occur within the study area, but a highway construction was a possible threat. Habitat in Gorski kotar can be improved with changes in management practice. Changes that could have an immediate effect include closing forest roads, seasonal avoidance of logging in denning areas (*Fig. 6*), and changing laws that prevent small-scale bear management. Proposed measures with long-term effects include modifying forest management to improve natural forest cover and educating residents about garbage management. The conclusion was that all the natural components of brown bear in Croatia are fully satisfactory, but the influence of man can change the situation in various ways.

Bears need large unfragmented areas with good vegetation cover, enough diversity and low disturbance (Huber, Roth 1993). Depending on geographical latitude and general habitat quality, an individual bear may roam over some 100 km^2 up to 30,000 km^2. A bear walks in search for food, daily and winter shelter, sexual partners and to avoid other bears of the same sex. The estimation of home ranges of **cave bears** can only be based on the brown bear data.

Prepoznali smo naravne sestavne dele življenjskega prostora medvedov, od katerih se jih je večina poslabšala zaradi človeških dejavnosti. Viri hrane so bili na voljo vse leto. Človeški vpliv se je kazal skozi razmeroma visoko gostoto cest (1,91 km/km^2), vključno z gozdnimi. Drobljenja življenjskega prostora na preučevanem območju sicer ni bilo, a izgradnja avtoceste je nedvomno pomenila mogočo grožnjo. Življenjski prostor v Gorskem kotarju je mogoče izboljšati s spremembami v načinu gospodarjenja. Spremembe, ki bi lahko imele takojšen učinek, so zapiranje gozdnih cest, sezonsko preprečevanje sečnje lesa na območjih z brlogi (*sl. 6*) in sprememba zakonov, ki preprečujejo gospodarjenje z medvedi v majhnem obsegu. Predlagani ukrepi z dolgoročnimi učinki vključujejo spremembo gospodarjenja z gozdom, da bi izboljšali naravni gozdni pokrov, ter vzgojo prebivalcev pri ravnanju z odpadki. Ugotovili smo, da so vsi naravni sestavni deli življenjskega prostora rjavega medveda na Hrvaškem popolnoma zadovoljivi, vendar jih človeški vpliv lahko spremeni na različne načine.

Medvedi potrebujejo velika celovita območja z gostim rastlinskim pokrovom, dovolj biotske pestrosti in čim manj motenj (Huber, Roth 1993). Odvisno od zemljepisne širine in splošne kakovosti življenjskega prostora se posamezen medved lahko giblje na območju, velikem od 100 do 30.000 km^2. Mobilnost medvedov osmišlja iskanje hrane, dnevnih in zimskih zatočišč, spolnega partnerja in izogibanje drugim medvedom istega spola. Ocena obsega življenjskih območij **jamskih medvedov** lahko temelji zgolj na ustreznih podatkih za rjave medvede.

FOOD FINDING STRATEGY

When other carnivores kill a sizeable prey they often can stay at the spot and eat for up to a week. Unlike other carnivores, bears typically have to move their whole body for almost each tiny bite. Food for bears may be hidden almost everywhere: bears will turn-over many rocks, pluck rotten logs, dig at promising spots to find tubers, invertebrates and their larvae or eggs, food cashes of other animals, to catch a mouse or other small mammal. All this requires: 1. regarding their habitat, a vast and diverse area; 2. regarding the bears themselves, much intelligence, curiosity, determination, skills, memory, and endurance (Morić, Huber 1989; Roth, Huber 1986).

COVER VEGETATION FOR REST AND DENNING

Vegetation and topography in the bear habitat must provide hiding cover which the bear needs daily to prepare a day-bed, a resting place for most of the daytime (Kusak, Huber 1998). Day beds are on spots where the horizontal visibility is lower than at other, average parts of the habitat. Specially demanding is the site for a winter den. The winter den is always on a spot difficult to access. Preferable are rocky areas with natural spaces where the den can be dug out and/or arranged (Huber, Roth 1997; *Fig. 7*). The potential spots for digging are between the roots of large trees or at places with special structures like anthills in some areas. The den itself must fulfil several requirements: it should be big enough to accommodate a bear and eventually a litter, it should be small enough to maintain the bear's body heat together with favorable air temperature, it should be strong enough to be safe and not to collapse while the bear is in the den, and it should be waterproof. Above all it is important that the bear will not be found and disturbed during hibernation. Therefore a bear must have an extremely large and diverse habitat that holds appropriate spots for dens. A bear must know its habitat very well to be able to find a good spot for a den. A bear must know how and be skilful enough to dig the den, collect the nesting material and to make a nest where it can safely spend the winter (Huber 2010).

SOCIAL AND REPRODUCTIVE REQUIREMENTS

Bears live alone but maintain complex communication with other bears. Marks on trees and various scent marks make the presence of one bear known to the others. The success in the game of finding and avoiding other bears determines wether a bear can stay

STRATEGIJA ISKANJA HRANE

Ob uplenitvi večjega plena se lahko zver z njim prehranjuje tudi do tedna dni, zato se ji v tem času ni treba bistveneje oddaljevati od mesta uplenitve. Nasprotno pa se morajo medvedi običajno premakniti za praktično vsak grižljaj. Njihova hrana je lahko skrita skoraj povsod: medvedi bodo obrnili mnogo kamnov, vlekli trhla debla, kopali na obetavnih mestih, iščoč gomolje, nevretenčarje in njihove ličinke ali jajca, zaloge hrane drugih živali ali da bi ujeli miš oz. kakega drugega majhnega sesalca. Za vse to pa mora biti, prvič, njihov življenjski prostor prostran in raznolik, in drugič, biti morajo dovolj bistroumni, radovedni, vztrajni, vzdržljivi in imeti zadovoljivo raven znanja (izkušenj) ter dovolj dober spomin (Morić, Huber 1989; Roth, Huber 1986).

POMEN PREKRIVNE VEGETACIJE ZA POČITEK IN "ZIMSKO SPANJE"

Rastlinstvo in oblikovanost tal v življenjskem okolju medveda morata zagotoviti kritje, ki ga potrebuje za ureditev dnevnega ležišča, na katerem preživi večji del dneva (Kusak, Huber 1998). Takšna ležišča so na krajih, kjer je horizontalna vidljivost manjša od povprečja na ravni celotnega življenjskega prostora. Iskanje prostora za zimski brlog je še težavnejše. Ta je vedno na težko dostopnem kraju, pri čemer kot bolj zaželena izstopajo skalna območja z naravnimi votlinami, primernimi za izkopavanje/ureditev brloga (Huber, Roth 1997; *sl. 7*). Mogoča mesta za kopanje so med koreninami velikih dreves ali na krajih s posebnimi objekti, kot so lahko na nekaterih območjih mravljišča. Sam brlog mora izpolnjevati več pogojev: biti mora dovolj velik za nastanitev medveda (vključno z morebitnim leglom), a obenem dovolj majhen in z ugodno mikroklimo, da lahko medved v njem ohranja želeno telesno temperaturo, biti mora dovolj trden in varen, da se med prezimovanjem medveda ne poruši, in biti mora suh. Predvsem je pomembno, da medved med "zimskim spanjem" ni odkrit in moten. Zato mora imeti izredno velik in raznolik življenjski prostor, ki vključuje primerne kraje za ureditev brloga. Ključno pri tem je, da posamezne živali dobro poznajo svoj življenjski prostor, da lahko tak kraj sploh najdejo. Poleg tega mora medved znati in biti dovolj vešč, da na izbrani ustrezni mikrolokaciji, kjer bo lahko varno prebil zimo, izkoplje brlog in zbere gnezditveni material zanj (Huber 2010).

DRUŽBENE IN RAZMNOŽEVALNE ZAHTEVE

Medvedi živijo sami, vendar vzdržujejo večplasten odnos z drugimi živalmi svoje vrste. Praske na drevesih in različna vonjalna sporočila omogočajo, da medvedi prepoznajo prisotnost drug drugega. Uspeh pri odkri-

Fig. 7: Young female brown bear in front of the den.
Sl. 7: Mlada samica rjavega medveda pred brlogom.

in one area or not. An error might result in the death of the weaker one. Finding a sexual partner during the mating season is specially demanding. Males roam over vast areas trying to fertilize as many females as possible. They must be capable of detecting the olfactory signals sent by females in heat and, at the same time have control over other males in orther to be able accurately to decide where to fight and where to retreat. A female with cubs forms the only bond within the species that lasts for at least a year and half (Frković *et al.* 2001). During that time a female has to skilfully avoid large males that may try to kill her cubs in order to mate with that particular female and to spread their own genes. Hence, social and reproductive requirements in bears also call for a large habitat, excellent knowledge of this habitat, and skilful behavior (Huber 2010).

PROCESS OF LEARNING

In bears, the share of learned skills compared to the inherited ones is much larger than in other carnivores, not to speak of other nonprimate mammals, and other nonmammal vertebrates or invertebrates. Most of the skills required for survival under the conditions of continuous search for what is needed and in avoidance of trouble, are learnt during the first two years of their life in nature while accompanied by their mother. Each bear develops its own behavioral strategy, exhibiting individualism rarely seen in the animal kingdom (Huber *et al.* 1994). The only common component may be the opportunistic behavior; a bear quickly learns to go for the easier way whenever possible. In a natural situ-

vanju in izogibanju drugim medvedom odloča, ali bo lahko posamezen medved ostal na določenem območju ali ne. Posledica napake je namreč lahko tudi smrt šibkejše od obeh spopadlih se živali. Izsleditev medvedke v obdobju parjenja je še posebej zahtevno. Samci se gibljejo po prostranih območjih z namenom oploditi čim večje število samic. Pri tem morajo biti zmožni zaznati vonjalna sporočila, ki jih pošiljajo pareče se samice, in hkrati nadzirati druge samce, da bi se lahko pravilno odločili med spopadom in umikom. Vez med samico in mladiči je edina pri obravnavani vrsti, ki traja vsaj poldrugo leto (Frković *et al.* 2001). V tem času se mora samica spretno izogibati velikim samcem, ki bi lahko poskusili ubiti njene mladiče, da bi se sami sparili z njo in na ta način razširili svoje lastne gene. Tudi zaradi navedenega družbene in razmnoževalne zahteve pri medvedih terjajo velik življenjski prostor, njegovo odlično poznavanje in spretno vedenje (Huber 2010).

POSTOPEK UČENJA

Delež naučenih veščin v primerjavi s podedovanimi je pri medvedih veliko večji kot pri drugih zvereh – da ne govorimo o drugih sesalcih z izjemo primatov – in pri drugih vretenčarjih in nevretenčarjih nasploh. Večino preživetvenih veščin v pogojih stalnega iskanja vsega, kar v danem trenutku pač potrebujejo, in hkratnega izogibanja nevšečnostim se mladiči naučijo v prvih dveh letih življenja še v spremstvu matere. Vsak medved razvije lastno vedenjsko strategijo, ki kaže individualizem, kakršnega vidimo v živalskem kraljestvu le redko (Huber *et al.* 1994). Edina skupna lastnost na ation, it optimizes the use of the potential benefits of each situation. When this concerns the relation to man, the opportunistic behavior is typically not a safe way of life. It is for instance much easier for a bear to eat large quantities of food at a garbage dump than to search for the same amount over many kilometres.

Through the mechanisms of natural selection, however, many mothers fail to successfully raise their offspring: cubs may be killed by an adult male, may die in an accident or simply starve. There are also cases in which the mother dies while nursing. Chances for survival of orphaned cubs are directly proportional to the length of time they spent with the mother. The ones that become orphaned while still in the den, i.e. during the first three months of their life, will surely die (Huber *et al.* 1993). If orphaned later in spring, summer or fall, cubs are faced with the cruel game of survival. They may survive only with enough luck not to be killed by other bears or other predators and to find sufficient food if the seasonal crop was good and the cub finds it. Due to opportunistic behavior, orphaned cubs occasionally survive by searching for food from human sources. They become habituated to people and, as nuisance, individuals never last long; either they have to be killed else they die in traffic or other human related accidents.

Cave bears lived in Pleistocene habitats that most of the time differed from the ones in the same areas today. However, some brown bear populations live in the Northern taiga and even in tundra biomes that resemble the Pleistocene glacial situation to some degree. Brown bears do exhibit extensive movements that are up to ten times larger in Northern climates, hence one can expect that the home ranges of cave bears might also have been large, which would make the gene flow quite fluent as well. Comparison of fossil remains of cave bears makes it possible to delineate populations. It is hard to speculate about the comparison of social and intellectual abilities, but the degree of differences among today's bear species may indicate some similarities.

ACTIVITY PATTERNS

We analysed the activity pattern of 16 individual bears (*Fig. 8*) monitored for 3,372 hours between May and October 1982-1998 in the Dinaric Mountains of Slovenia and Croatia (Kaczensky *et al.* 2005; Roth, Huber 1986). The data were collected via time sampling and basically analysed with two approaches: a general linear model (GLM) with seasonal component to delineate the most important variables influencing the activity pattern, and level and cluster analysis to group bears according to their 24-hour activity pattern. Time of the day and age were the most important variables predicting activity. Although individual variation in

ravni vrste bi bilo tako lahko oportunistično vedenje; medved se namreč hitro nauči izbrati lažjo pot, kadar koli je to mogoče. Zanj je tako npr. veliko lažje zaužiti velike količine hrane na smetišču kot pa jo iskati na več kilometrov dolgih razdaljah. V naravi takšen pristop omogoča optimalno izkoriščanje razpoložljivih danosti v nekem okolju, v odnosu do človeka pa pomeni takšno oportunistično vedenje vir nevarnosti.

Zaradi naravnega izbora mnogim samicam ne uspe vzgojiti svojih mladičev, saj te lahko ubije odrasel samec, lahko poginejo v nesreči ali pa preprosto podležejo lakoti. Znani so tudi primeri, ko mati pogine v obdobju dojenja; v takih primerih so možnosti za preživetje osirotelih mladičev premo sorazmerne z dolžino časa, ki so ga preživeli z materjo.

Tisti, ki so osiroteli že med bivanjem v brlogu, to je v prvih treh mesecih življenja, bodo zanesljivo poginili (Huber *et al.* 1993). Ob poginu matere v pozni pomladi, poletju ali jeseni pa se mladiči soočijo s kruto igro preživetja. Pri tem jim uspe samo, če imajo dovolj sreče pri izogibanju drugim medvedom ali drugim plenilcem in če najdejo dovolj hrane; slednje je seveda v pretežni meri odvisno od njene siceršnje sezonske razpoložljivosti. Zaradi oportunističnega načina življenja mladičem preživetje občasno omogoča uživanje hrane iz človeških virov. Pri tem se navadijo na sobivanje z ljudmi, ker pa jih slednji prepoznavajo kot nadležne, takšno stanje nikdar ne traja dolgo. Navedene živali se namreč bodisi znajdejo na seznamu za odstrel bodisi poginejo v prometnih oz. kakih drugih s človekom povezanih nesrečah.

Jamski medvedi so živeli v pleistocenskih življenjskih okoljih, ki so se večino časa razlikovala od današnjega stanja na istih območjih. Vendar pa najdemo posamezne populacije rjavega medveda tudi v biomih severne tajge in celo tundre, ki do določene mere spominjajo na pleistocenske okoliščine. Rjavi medvedi se gibljejo na velikih razdaljah, pri čemer te v severnih delih kontinenta do desetkrat presegajo tiste pri južnejših populacijah. Glede na navedeno lahko pričakujemo, da je bil velik tudi življenjski prostor jamskih medvedov, kar je omogočilo razmeroma tekoč pretok genov. Primerjava fosilnih ostankov jamskih medvedov nam omogoča razmejiti populacije, težje pa je razglabljati o družbenih in razumskih zmožnostih te izumrle zveri. Sama stopnja razlik med sedanjimi vrstami medvedov pa – tako se zdi – nakazuje nekaj podobnosti.

VEDENJSKI VZORCI

Analizirali smo vedenjske vzorce 16 posameznih medvedov (*sl. 8*), ki so bili opazovani 3.372 ur med majem in oktobrom v letih od 1982 do 1998 na območju Dinarskega gorstva Slovenije in Hrvaške (Kaczensky *et al.* 2005; Roth, Huber 1986). Podatke smo zbrali s časovnim vzorčenjem in pri njihovi analizi uporabili dva pristopa:

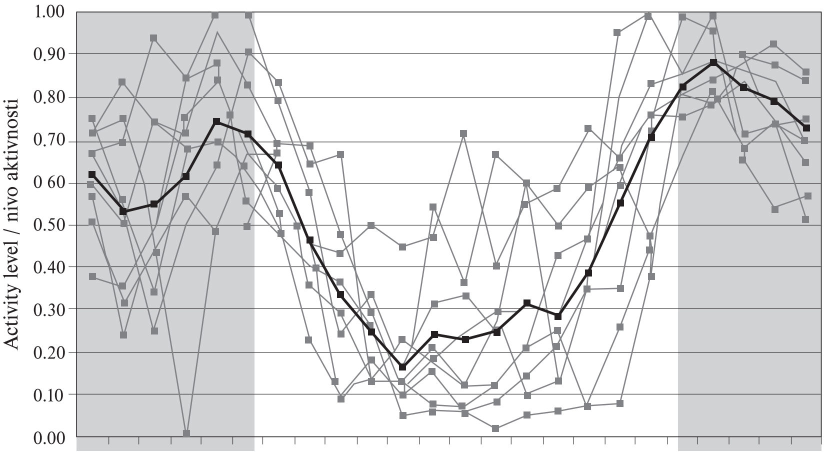

Fig. 8: Activity pattern of mostly adult European brown bears (*n* = 8) in Slovenia and Croatia. Shaded areas indicate night-time (Kaczensky *et al.* 2005).
Sl. 8: Vzorec dejavnosti večinoma odraslih evropskih rjavih medvedov (*n* = 8) v Sloveniji in na Hrvaškem. Osenčena območja označujejo noč (Kaczensky *et al.* 2005).

the activity pattern was high among individual bears, in general, yearlings were more diurnal and had a less distinct difference between day- and night-time activity levels than adult bears. Subadults were somewhat intermediate to adults and yearlings. We believe that nocturnal behaviour is most likely driven through negative experiences with humans, giving space for much individual variation. More research is needed to prove the causal relationship of nocturnal behaviour and the degree of disturbance to which an individual bear is exposed.

In most of Europe, true wilderness areas today do not exist and brown bears generally have to cope with human disturbance and infrastructure. The few studies in Europe that investigated brown bear activity have demonstrated a predominantly nocturnal and "shy" behaviour in bears. There is still quite a debate about whether the shy, nocturnal bears of Europe are the result of centuries of persecution by humans (genetically fixed trait) or wethere hunting and the high disturbance potential in the multi-use landscapes are the driving force (individual learnt trait).

Cave bears had some complex relations with humans of that time but it is hard to estimate the possible degree of how the human presence might have influenced their behaviour. Many behavioural features exhibited by recent brown bears are certainly the consequence of cohabitation with humans.

FEEDING HABITS

Brown bear food habits in Croatia were determined by analyzing 95 scats and feeding sites (Cicnjak *et al.* 1987). Only plant material was found in 76 % of samples, whereas 24 % contained both plant and animal mate-

splošni linearni model (SLM) s sezonsko sestavino, da bi začrtali najpomembnejše dejavnike vpliva na preučevan vedenjski vzorec, ter klastrsko analizo, da bi medvede razvrstili glede na njihov 24-urni vedenjski vzorec. Dnevni čas in starost živali sta bila najpomembnejši spremenljivki za napoved vedenja. Čeprav so bile med posameznimi medvedi iste starosti ugotovljene očitne razlike v vedenjskih vzorcih, so bili enoletni mladiči podnevi na splošno opazno bolj dejavni od odraslih medvedov, izstopali pa so tudi po manj izraženi razliki med dnevno in nočno ravnijo aktivnosti. Subadultne živali so v tem smislu zasedale vmesno lego. Avtorja verjameva, da na nočno vedenje najverjetneje vplivajo slabe izkušnje z ljudmi, kar odpira prostor precejšnji individualni variabilnosti. Vzročno povezavo med nočnim vedenjem in izpostavljenostjo nadlegovanju bo tako mogoče dokazati zgolj na podlagi rezultatov nadaljnjih raziskav.

V večini Evrope zdaj ni več pravih divjin, zato morajo rjavi medvedi na splošno sobivati z motečimi vplivi človeka oz. z njegovo infrastrukturo. Maloštevilne raziskave, ki so preučevale dejavnost rjavega medveda v Evropi, so dokazale zanj pretežno nočno in "plašno" vedenje. Pri tem je vprašanje, ali so ti plašni, ponoči dejavni medvedi posledica človekovega preganjanja skozi stoletja (genetsko določena značilnost) ali pa predvsem lova in izpostavljenosti številnim motnjam v pokrajinah, obremenjenih z različnimi uporabniki (individualna naučena značilnost), še vedno predmet živahne diskusije.

Jamski medvedi so imeli zagotovo večplastne odnose z ljudmi svojega časa, vendar pa je obseg vpliva človeške prisotnosti na njihovo vedenje težko oceniti. Mnoge vedenjske značilnosti današnjih rjavih medvedov so gotovo posledica sobivanja z ljudmi.

rial. At least 28 different plant and animal food items were identified. Plant material composition varied with phenology. Important food types by season were: spring – graminoids, forbs and ferns; summer – oats, insects, fruits and forbs; autumn – tree fruits, nuts and insects; and winter – nuts, fruits and mammals.

Vegetation in the bear habitat must comprise various plant species that provide food in different seasons. With the typical carnivore digestive system, bears are poor at decomposing plant cells and absorbing nutrients. This means that they have to find the optimal plant species and the edible parts of those plants at the right time and at the right spot. They also have to eat large quantities of those plants, while such food sources are rarely found in sufficient quantities at one spot. Bears need up to 10 % of proteins in their diet, most of which they can satisfy by insects and other invertebrates and possibly carrion (Cicnjak *et al.* 1987).

Cave bears had been predominantly herbivores as well, as could be demonstrated by teeth shape and wear, some stomach, intestine and faecal remains, and by stable isotope analyses. The cave bear presents a specific tooth morphology with wide grinding surfaces, and muscular insertions in the skull and the jaw, showing a great biting power, which is the reason why it is thought to follow a basically herbivorous diet (Kurtén 1976). The results of analysis of ^{13}C and ^{15}N in bone collagen point out the possibility of *Ursus spelaeus* feeding basically on nitrogen fixing plants, because of its low δ^{15}N signature, the lowest one among the published data from other Pleistocene herbivores (Vila Taboada *et al.* 2001). Also, it was concluded, from evidence on skull anatomy and bone collagen, that these extinct mammals were predominantly vegetarian, eating a specialised diet of high-quality plants. Compared with other megafaunal species that would also become extinct, the cave bear had a relatively restricted geographical range, being confined to Europe, which may offer an explanation as to why it died out so much earlier than the rest. Its highly specialised mode of life, especially a diet of high-quality plants, and its restricted distribution left it vulnerable to extinction as the climate cooled and its food source diminished (Pacher, Stuart 2008).

The brown bear, with which *Ursus spelaeus* shares a common ancestor, was spread throughout Europe and much of northern Asia and has survived to the present day. A fundamental question is: why did the brown bear survive to the present day, while the cave bear did not? Answers to this question may involve different dietary preferences, hibernation strategies, geographical ranges, habitat preferences and perhaps predation by humans.

PREHRANJEVALNE NAVADE

Prehranjevalne navade rjavega medveda na Hrvaškem so bile ugotavljane z analizo 95 iztrebkov in krmišč (Cicnjak *et al.* 1987). Pri tem so bili v 76 odstotkih vzorcev najdeni samo rastlinski ostanki, medtem ko jih je 24 odstotkov vsebovalo tako rastlinske kot živalske ostanke. Skupno je bilo v analiziranih vzorcih zastopanih vsaj 28 različnih vrst živali in rastlin. Sestava rastlinskih ostankov se je razlikovala glede na fenologijo. Pomembne vrste hrane v določenem letnem času so bile: spomladi trave, zeli in praprotnice, poleti oves, žuželke, sadeži in zeli, jeseni drevesni sadeži, oreščki in žuželke ter pozimi oreščki, sadeži in sesalci.

Rastlinstvo v medvedovem življenjskem prostoru mora biti vrstno pestro na način, da je hrana načeloma razpoložljiva v vseh letnih časih. Medvedi s svojim za mesojede značilnim prebavnim sistemom neučinkovito razgrajujejo rastlinske celice in slabo vsrkavajo hranila. To pomeni, da morajo vsakič sproti poiskati za dano obdobje najustreznejše rastlinske vrste, od katerih nato pojedo zgolj zanje najprimernejše dele. Ker pa so potrebe po količini zaužite hrane razmeroma velike, te v naravi praviloma ni najti na enem kraju. Medvedi potrebujejo v svoji prehrani do 10 odstotkov beljakovin; večino teh potreb potešijo z žuželkami in drugimi nevretenčarji ter občasno z mrhovino (Cicnjak *et al.* 1987).

Tudi **jamski medvedi** so bili pretežno rastlinojedi. To so pokazali oblika in obraba zob, posamezni vzorci želodčne in črevesne vsebine ter iztrebkov pa tudi stabilni izotopi. Za jamskega medveda je značilna posebna morfologija zobovja s širokimi žvekalnimi ploskvami ter mišičnimi nastavki na lobanji in čeljusti, ki kažejo na silovito moč ugriza. Iz tega izhaja, da je bila njegova prehrana v svojem bistvu rastlinskega izvora (Kurtén 1976). Sodeč po rezultatih analize izotopov ^{13}C in ^{15}N v kostnem kolagenu so bile osrednji vir hrane pri jamskem medvedu rastline, ki vežejo dušik; vrsta namreč izkazuje nizke vrednosti δ^{15}N, celo najnižje med vsemi objavljenimi podatki za pleistocenske rastlinojede (Vila Taboada *et al.* 2001). Da so bili ti izumrli sesalci v bistvu vegetarijanci, ki so jedli posebno hrano iz visoko kakovostnih rastlin, kažejo tudi anatomija lobanje in lastnosti kostnega kolagena. V primerjavi z drugo ravno tako izumrlo megafavno je imel jamski medved razmeroma omejeno območje razširjenosti, saj je živel samo v Evropi. Morda bi nam prav to lahko pojasnilo, zakaj je izumrl toliko prej kot druge orjaške vrste sesalcev. Njegov visoko specializirani način življenja, zlasti v smislu prehranjevanja z visoko kakovostnimi rastlinami, in njegova omejena razširjenost sta ob nastopu ostrejšega podnebja in vzporednem zmanjšanju virov hrane pomenila povečano tveganje za izumrtje (Pacher, Stuart 2008).

Rjavi medved, s katerim si vrsta *Ursus spelaeus* deli skupnega prednika, je bil razširjen po vsej Evropi in velikem delu severne Azije in se mu je uspelo obdržati do danes. Temeljno vprašanje je: zakaj se je rjavi medved izognil izumrtju, jamski pa ne? Odgovori na to vprašanje lahko zadevajo različnost prehranske izbire, strategije “zimskega spanja”, zemljepisne razširjenosti, izbire življenjskega prostora in morda tudi človekov lov.

Prevod: Dragan Božič

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VELIKE PODNEBNE SPREMEMBE RAZKRITE NA PODLAGI MALIH FOSILOV. NEKDANJE OKOLJE NA MEJI MED ZGODNJIM IN SREDNJIM WÜRMOM V OKOLICI DIVJIH BAB I (Z SLOVENIJA)

BIG CLIMATIC CHANGES REVEALED BY TINY FOSSILS. PALAEOENVIRONMENT AT THE BOUNDARY BETWEEN THE EARLY AND MIDDLE WÜRM IN THE SURROUNDINGS OF DIVJE BABE I (W SLOVENIA)

Borut TOŠKAN, Janez DIRJEC

> *"Raziskovanje paleolitskih najdišč ima mnogo ciljev, med katerimi sta temeljna za razumevanje vseh procesov v določenem prostoru kronologija in paleookolje."*
> I. Turk [ur.] 2007 (str. 479)

> *"The investigation of Palaeolithic sites has many objectives, of which the most fundamental to an understanding of all processes in a certain area are the chronology and palaeoenvironment."*
> I. Turk [Ed.] 2007 (p. 479)

Izvleček

V mlajšepleistocenskih (OIS 3 in OIS 5a) plasteh paleolitskega jamskega najdišča Divje babe I so bili med manjšimi zaščitnimi izkopavanji v letu 2006 najdeni ostanki najmanj 113 primerkov malih sesalcev, pripadajočih vsaj 15 različnim vrstam: *Sorex alpinus*, *S. araneus*, *S. minutus*, *Talpa europaea*, *Chionomys nivalis*, *Arvicola* ex gr. *amphibious - schermann*, *Myodes glareolus*, *Microtus agrestis*, *M. arvalis*, *M. liechtensteini*, *M. subterraneus*, *Apodemus sylvaticus*, *A. flavicollis*, *Glis glis*, in najmanj ena vrsta netopirjev. Na podlagi tedanjih združb malih sesalcev izhaja, da je povišana vlažnost v zaključnih fazah kronocone OIS 5a botrovala začetku širjenja gozdov na račun dotlej prevladujočih odprtih habitatov. Navedeni proces se je nadaljeval tudi v kronoconi OIS 3, ko je življenski prostor v okolici Divjih bab I predstavljal mozaičen preplet pretežno iglastih gozdov, travnatih površin in skalnatih predelov. Skladno z zaostritvijo klimatskih razmer je prišlo tudi do sprememb v spolni strukturi v jami prezimovajočih jamskih medvedov v korist samcev. Pridobljeni rezultati pomenijo neodvisno potrditev že objavljenih paleookoljskih rekonstrukcij za območje v okolici Divjih bab I na prehodu iz zgodnjega würma v srednji.

Ključne besede: Divje babe I, Slovenija, mlajši pleistocen, mikrofavna, jamski medved, paleoklima

Abstract

Small-scale rescue excavations of the Late Pleistocene layers of the Palaeolithic cave site of Divje babe I, performed in 2006, yielded the remains of at least 113 specimens of small mammals. They belong to at least 15 different species: *Sorex alpinus*, *S. araneus*, *S. minutus*, *Talpa europaea*, *Chionomys nivalis*, *Arvicola* ex gr. *amphibious - schermann*, *Myodes glareolus*, *Microtus agrestis*, *M. arvalis*, *M. liechtensteini*, *M. subterraneus*, *Apodemus sylvaticus*, *A. flavicollis*, *Glis glis* and at least one bat species. It can be inferred on the basis of the small mammal assemblages that an increase of humidity in the final stages of OIS 5a led to the progressive extension of forests on an expanse of up to then dominating open habitats. The process continued also in OIS 3, when a mosaic of predominantly coniferous forest with meadows and accumulations of rocky boulders is supposed to have existed in the area of Divje babe I. Parallel to the worsening of the climate, a change in the sex structure of cave bears hibernating in the cave has been observed, with an increased share of males. The presented results are to be seen as an independent confirmation of the already published palaeoenvironmental interpretations for the area of Divje babe I at the boundary of the Early and Middle Würm.

Keywords: Divje babe I, Slovenia, Late Pleistocene, small mammal fauna, cave bear, palaeoclimate

Sl. 1: Pobočje nad dolino Idrijce. Označen je vhod v jamo Divje babe I.
Fig. 1: The slope above the river Idrijca. Marked is the entrance of Divje babe I.

UVOD

Mali sesalci so veliko zanesljivejši kazalnik nekdanjih habitatov, kot to velja za velike. Pravzaprav je fosilizirana mikrofavna eno izmed osrednjih orodij za interpretacijo ekologije ali habitatov v času, ko se je ta kopičila. Tega se je dobro zavedal tudi Ivan Turk – eden vodilnih raziskovalcev paleolitskega obdobja v Sloveniji – in zato mokro presejanje sedimentov uveljavil kot standardni del arheoloških izkopavanj v tem delu Evrope. Na ta način je – med drugim – končno izpolnil predpogoj za izvedbo poglobljenih študij lokalne mlajšekvartarne mikrofavne (npr. Kryštufek 1997; Toškan, Kryštufek 2004; 2007; Toškan 2009).

Obsežna arheološka izkopavanja paleolitskega jamskega najdišča Divje babe I (*sl. 1*), ki jih je v večjem delu vodil prav I. Turk, so navrgla bogat vzorec ostankov malih sesalcev (N = 2.877). Pridobitev tako obsežnega gradiva je bila izvrstna priložnost za dokumentiranje würmske mikrofavne z južnega roba alpske poledenitve ter izvedbo poglobljene študije takratnega okolja. Sodeč po razlikah med skupkoma malih sesalcev iz dveh različnih faz zadnje poledenitve (tj. OIS 5a in OIS 3) naj bi

INTRODUCTION

Small mammal faunas are known to be better proxies for the past environment than are the larger mammals. As a matter of fact, micromammals in the fossil record provide one of the principal methods of interpreting the ecology or habitat existing at the time the fossils were preserved. Being well aware of this fact, Ivan Turk – one of the leading scientists for the Palaeolithic in Slovenia – established wet sieving of sediments as a standard part of archaeological excavations in the region, finally allowing for thorough studies of local Late Quaternary small mammal faunas (e.g. Kryštufek 1997; Toškan, Kryštufek 2004; 2007; Toškan 2009).

Extensive archaeological excavations at the Palaeolithic cave-site of Divje babe I (*Fig. 1*), in the most significant part directed by Turk himself, revealed a large sample of micromammal remains (N = 2,877). This material provided a good opportunity to document the Würmian small mammal faunas from the southern border of the Alpine glacier and to obtain deeper insights into the then environment. On the basis of the established differences between the micromammal assemblages dated to chrono-v tistem času dokaj odprto travniško krajino postopoma nadomestilo pretežno gozdnato okolje s prevladujočo vlogo iglavcev ter posameznimi travniki in skalnatimi površinami (Kryštufek 1997; Toškan, Kryštufek 2007). Izrazito multidisciplinarni pristop k obravnavi posameznih najdišč, ki ga je Ivan Turk vseskozi vneto spodbujal, je zagotovil izhodišče za preverbo zanesljivosti takšne paleookoljske interpretacije. Njena primerjava z izsledki sedimentoloških (Turk, Bastiani 2000; Turk *et al.* 2001; 2005; 2007a) in paleobotaničnih (Šercelj, Culiberg 1991; Culiberg 2007) raziskav ter raziskav sesalske makrofavne (Toškan 2007a) je pokazala na zadovoljivo stopnjo ujemanja med posameznimi kazalniki nekdanjega okolja in podnebnih razmer (Turk 2007a). Ne glede na to so dvomi nekaterih avtorjev o predstavljeni klimatološko-kronološki interpretaciji ostali (npr. Rabeder *et al.* 2008, tab. 1; Brodar 2009, 197 ss). Tudi zaradi tega sva po manjših zaščitnih izkopavanjih v letu 2006 izkoristila priložnost in dodatno preverila zanesljivost zgornjih rezultatov. Pri tem sva se osredinila na vzorec malih sesalcev, upoštevala pa sva tudi nekatere druge potencialne kazalnike nekdanjega podnebja (npr. Toškan 2006; 2007a, 239 ss). Rezultati raziskave so predstavljeni v tem prispevku.

NAJDIŠČE IN METODE

Divje babe I so 45 m dolga in do 15 m široka vodoravna jama, ki leži 230 m nad strugo reke Idrijce pri Cerknem (450 m n. m.). Debelina pleistocenskih klastičnih sedimentov v jami presega 13 m. Večinoma jih sestavljajo avtohtoni dolomitski bloki, grušč, pesek in melj (Turk *et al.* 2007). Med izkopavanji je bilo prepoznanih 26 plasti (časovni razpon: pribl. 115.000–35.000/40.000 let pred sedanjostjo), ki pa jih je bilo makroskopsko težko razlikovati. I. Turk (2003) je zato *ad hoc* določene geološke plasti nadomestil z novimi temeljnimi stratigrafskimi enotami, t. i. faciesi A do C. Zamenjava je bila opravljena na podlagi rezultatov analize vertikalne porazdelitve strukturnih agregatov (0,5–3 mm) in kostnih najdb (> 3 mm) vzdolž več profilov in znotraj dveh blokov sedimentov. Na podlagi več kot 90 razpoložljivih ^{14}C- (AMS) in ESR[1]-datumov sta bila faciesa A in B datirana v kisikovo izotopsko stopnjo 3 (= OIS 3; *Oxygen Isotopic Stage 3*), facies C pa v OIS 5a–d. Pridobljene so bile tudi štiri datacije U-niza (^{230}U/^{234}Th), ki pa se v primeru Divjih bab I niso izkazale za zanesljive (Turk *et al.* 2003). Kronocona OIS 4 v jami skoraj ni zastopana, saj je takrat prišlo do daljšega zastoja v sedimentaciji. Prehod med faciesoma A in B sovpada z nekdanjo plastjo 7 (tj. pribl. 50.000 let pred sedanjostjo = p. s.) tisti med faciesoma B in C pa z nekdanjo plastjo 11/12 (tj. pribl. 74.000 let p. s.). Slednji se tako

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[1] ESR – elektronska spinska rezonanca (*Electronic Spin Resonance*).

zones OIS 5a and OIS 3, a shift from a rather open habitat to a mosaic of mixed, predominantly coniferous forest, with meadows and rocky boulders has been proposed (Kryštufek 1997; Toškan, Kryštufek 2007). The all-round manner to dealing with the site, tirelessly encouraged by Turk, provided the opportunity to verify the reliability of such a palaeoenvironmental interpretation by comparing it to the results of sedimentological (Turk, Bastiani 2000; Turk *et al.* 2001; 2005; 2007a) and palaeobotanical (Šercelj, Culiberg 1991; Culiberg 2007) analyses, as well as to those that emerged from the study of large mammal remains (Toškan 2007a). While the conclusions generally coincided (Turk 2007a), not all doubts in the reliability of the existing climate-chronological interpretation have been removed (e.g. Rabeder *et al.* 2008, Tab. 1; Brodar 2009, 229 ff). Consequently, additional testing has been carried out by studying the small mammal remains obtained during a very limited rescue excavation in 2006. Other newly acquired data that can presumably be used to reconstruct past climates (e.g. Toškan 2006; 2007a, 260 ff) have also been taken into account. The results are presented in this paper.

SITE AND METHODS

Divje babe I is a 45-m-long and up to 15-m-wide horizontal cave, lying 230 m above the bed of the Idrijca River near Cerkno (450 m a.s.l.). The thickness of the Pleistocene clastic sediments in the cave exceeds 13 m. They are composed mostly of autochthonous dolomite blocks, rubble, sand and silt (Turk *et al.* 2007). Excavation established 26 layers (time span: approx. 115,000-35,000/40,000 years B.C.), which were mostly difficult to set apart macroscopically. Turk (2003) therefore substituted the *ad hoc* delineated geological layers with facies A to C, which were based on the analysis of the vertical distribution of structural aggregates (0.5–3 mm) and bone remains (> 3 mm) along several profiles and two blocks of sediments. More than 90 (Nelson, Ku 1997; Lau *et al.* 1997; Turk *et al.* 2001; 2006; Blackwell *et al.* 2007) available ^{14}C (AMS) and ESR[1] dates have shown that facies A and B formed in the Oxygen Isotopic Stage 3 (= OIS 3) and facies C in OIS 5a-d. Four U/Th dates are also available (Nelson, Ku 1997), but since extended gaps in sedimentation greatly influenced mobilisation and absorption of U, thus leading to its remobilisation, the determination of age by the U series method proved inaccurate in this case (Turk *et al.* 2003). OIS 4 is almost not represented in the cave, since a pause in sedimentation occurred at that time. The transition between facies A and B corresponds with the former layer 7 (i.e. approx. 50,000 years B.C.) and the transition between facies B and C with the former layer 11/12 (i.e. approx. 74,000 B.C.), thereby corresponding to the radiometri-

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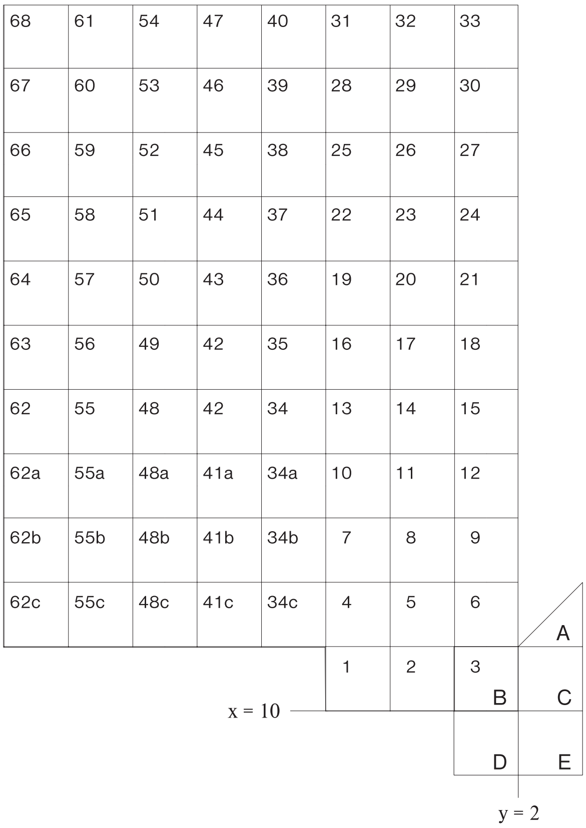
[1] ESR – Electronic Spin Resonance.



68	61	54	47	40	31	32	33	
67	60	53	46	39	28	29	30	
66	59	52	45	38	25	26	27	
65	58	51	44	37	22	23	24	
64	57	50	43	36	19	20	21	
63	56	49	42	35	16	17	18	
62	55	48	42	34	13	14	15	
62a	55a	48a	41a	34a	10	11	12	
62b	55b	48b	41b	34b	7	8	9	
62c	55c	48c	41c	34c	4	5	6	A
					1	2	3 B	C
							D	E

Sl. 2: Izkopno polje v jami Divje babe I od leta 1989 dalje (modificirano po Turk 1997, sl. 1.3). Prikazane so oznake kvadratov, ki so bili raziskani med zaščitnimi izkopavanji v letu 2006 (tj. kvadrati A–E), ter tistih, ki so bili izkopani v letih 1989–1999 (i.e. 1–68). Opomba: kv. B = kv. 3.

Fig. 2: The excavation field in the cave Divje babe I from 1989 onwards (modified from Turk 1997, Fig. 1.3). Also shown are the marks of quadrants excavated during the campaign of 2006 (i.e. quadrants A–E) as well as of quadrants excavated in the years 1989–1999 (i.e. 1–68). Note: sq. B = sq. 3.

ujema z radiometrično določeno kronološko mejo med OIS 5 in OIS 4 (Turk *et al.* 2001; Blackwell *et al.* 2007).

Metodologija terenskega raziskovanja med zaščitnimi izkopavanji iz leta 2006, ki so dala tukaj obravnavane živalske ostanke, je v celoti sledila tisti iz 90. let prejšnjega stoletja (Turk 2007c). Standardno vzorčno enoto je tako še naprej predstavljal kvader površine 1 x 1 m in debeline 12 cm (*sl. 2*). Sediment je bil v celoti spran skozi sita z velikostjo luknjic 10 mm, 3 mm in 0,5 mm. Vzorci posameznih frakcij so bili v nadaljevanju pregledani pod stereomikroskopom, pri čemer so bili pobrani ostanki malih sesalcev. Nabrano gradivo je obsegalo zobe, spodnje in zgornje čeljustnice ter postkranialne skeletne elemente, pri čemer pa slednjih v nadaljnjo analizo nisva vključila. Vsi vzorci so označeni s številko kvadrata in izkopa[2] na način kvadrat/izkop; izkopi so označeni od površja navzdol (za globine izkopov oz. režnjev glej Turk 2007c, opomba 1).

Kvantitativne primerjave med favnami temeljijo na številu določenih primerkov (*Number of Identified Specimens*, NISP) in najmanjšem številu živali (*Minimum Number of Individuals*, MNI). Statistična obdelava je bila izvedena s programskim paketom StatSoft 2001, STATISTICA za Windows, verzija 6.0. Nomenklatura meljakov voluharic je povzeta po van der Meulenu (1973).

Živalske ostanke iz Divjih bab I, ki so bili pridobljeni med izkopavanji leta 2006, hrani Narodni muzej Slovenije v Ljubljani.

OSTANKI MALIH SESALCEV

Skupno je bilo med izkopavanji v letu 2006 pridobljenih 892 predmeljakov in meljakov malih sesalcev, od česar jih je bilo 424 mogoče določiti vsaj do nivoja rodu. Gre za ostanke najmanj 113 živali, ki sva jih pripisala vsaj 15 vrstam iz šestih družin. Delež glodalcev presega 96 odstotkov določljivih primerkov, medtem ko je red netopirjev zastopan z zgolj štirimi najdbami. Vse v vzorcu zastopane vrste so na območju Slovenije prisotne še danes.

cally determined chronological border between OIS 5 and OIS 4 (Turk *et al.* 2001; Blackwell *et al.* 2007).

The fieldwork methodology of the rescue excavations in 2006, which yielded small mammal remains reported in this contribution, conformed to the practice established during the campaigns in the 1990's (Turk 2007c). The basic sample during excavations thus continued to be a 1 x 1 m square with a depth of 12 cm (*Fig. 2*). The sediment was sieved (mesh sizes of 10 mm, 3 mm, and 0.5 mm, respectively) and small mammal remnants were extracted under the dissecting microscope. The material consisted of isolated teeth, maxillae, mandibles, and postcranial fragments, with the latter not being considered in this paper. All samples are labeled with the number of their square and spit[2] expressed as square/spit. The spits are labeled from the surface downwards (for spit depths see Turk 2007c, footnote 5).

Quantitative comparisons among taxa are based on the *Number of Identified Specimens* (NISP) and on the *Minimum Number of Individuals* (MNI). Statistical analyses were performed using program package STATISTICA for Windows, version 6.0 (StatSoft Inc. 2001). Nomenclature of arvicoline molars follows van der Meulen (1973).

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[2] Posamezen sedimentacijski nivo je sestavljen iz vodoravno kopanih enot (režnjev) na način, da je upoštevan vpad (nagib) plasti. Sedimentacijski nivoji torej predstavljajo relativni čas (Turk 2003, 10).

[2] Each sedimentation level is composed of horizontal dug units (spits) in such a way that it takes into account the angle of incidence (dip) of the layer and thus represents relative time (Turk 2003, 24 f).

Taksonomski in nomenklatorni vir sta Wilson in Reeder (2005).

Red: Rovke in krti (Soricomorpha)
Družina: Rovke (Soricidae)

Sorex minutus Linnaeus, 1766

Gradivo: plast 12: vzorec E/36 (spodnja čeljustnica).

Mala rovka je zastopana s primerkom spodnje čeljustnice z vraščenima prvima dvema meljakoma. Taksonomska določitev temelji na velikosti najdbe.

Sorex araneus Linnaeus, 1758

Gradivo: plast 8/10: vzorec C/30 (zob).

Gozdni rovki je bil pripisan izoliran desni prvi zgornji meljak z obarvanim hipokonom; navedena značilnost je namreč vrstno specifična in tako omogoča zanesljivo razlikovanje med vrstama *S. araneus* in *S. alpinus* (Kryštufek 1991, 38).

Sorex alpinus Schinz, 1837

Gradivo: plast 8/10: vzorec C/30 (rostrum); plast 10: vzorec C/32 (zob); plast 11: vzorec B/34 (rostrum), vzorec C/34 (rostrum); plast 13: vzorec E/38 (rostrum).

Štirje rostrumi (vsi s še vedno prisotnim M^1) ter izoliran prvi zgornji meljak pripadajo gorski rovki; nobeden od petih M^1 nima obarvanega hipokona.

Sorex alpinus/*araneus*

Gradivo: plast 8/10: vzorec C/30 (2 zoba); plast 10: vzorec C/31 (spodnja čeljustnica, 3 zobje), vzorec C/32 (3 spodnje čeljustnice, zob); plast 11: vzorec A/34 (zob), vzorec C/33 (rostrum), vzorec E/34 (rostrum), vzorec E/35 (zob); plast 12/13: vzorec A/36 (zob), vzorec B/36 (spodnja čeljustnica).

Večine (N = 16) ostankov rovk iz rodu *Sorex* ni bilo mogoče določiti do nivoja vrste. Sodeč po velikosti najdb te pripadajo bodisi gozdni bodisi gorski rovki.

Družina: krti (Talpidae)

Talpa cf. *europaea* Linnaeus, 1758

Gradivo: plast 11: vzorec C/34 (zob), vzorec E/35 (zob).

Navadnemu krtu sta bila pripisana dva izolirana meljaka. Dasiravno razlikovanje med obema recentnima

The faunistic material from Divje babe I, gathered during the campaign of 2006, is deposited in the National Museum of Slovenia (Ljubljana).

SMALL MAMMAL REMAINS

In total, 892 small mammal cheek-teeth were obtained by excavations in 2006; 424 of these molars allowed identification to the generic level at least. The material belonged to no less than 113 specimens representing at least 15 species from six families. The share of rodents among identifiable items exceeds 96 %, while bats, on the other hand, are represented by no more than four specimens. All the species in the sample still occur in Slovenia.

Taxonomy and nomenclature follow Wilson, Reeder (2005).

Order: Shrews and moles (Soricomorpha)
Family: Shrews (Soricidae)

Sorex minutus Linnaeus, 1766

Material: Layer 12: sample E/36 (mandible).

The pigmy shrew is represented by a single fragment of mandible with the 1st and 2nd molar still nested in the bone. The identification to the specific level was based on small size.

Sorex araneus Linnaeus, 1758

Material: Layer 8/10: sample C/30 (tooth).

A single right 1st upper molar is referable to the common shrew. The determination depends on the pigmented hypocone, which allows reliable separation of *S. araneus* from *S. alpinus* (*cf.* Kryštufek 1991, 38).

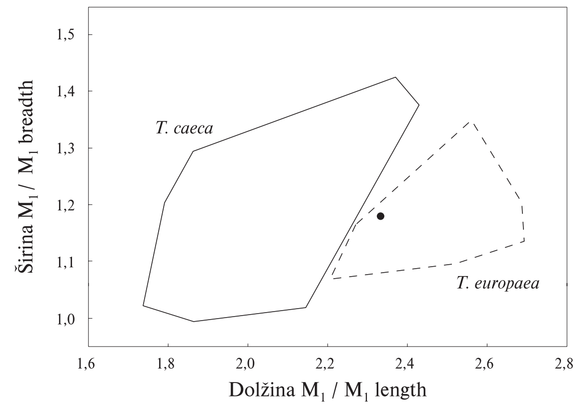
Sorex alpinus Schinz, 1837

Material: Layer 8/10: sample C/30 (rostrum); Layer 10: sample C/32 (tooth); Layer 11: sample B/34 (rostrum), sample C/34 (rostrum); Layer 13: sample E/38 (rostrum).

Four rostral fragments (all of them with M^1 still nested in the bone) and an isolated 1st upper molar belong to the Alpine shrew. The identification of the finds is based on the non-pigmented hypocones of 1st upper molars (*cf.* Kryštufek 1991, 38).

Sorex alpinus / *araneus*

Material: Layer 8/10: sample C/30 (2 teeth); Layer 10: sample C/31 (mandible, 3 teeth), sample C/32



Sl. 3: Odnos med širino in dolžino prvega spodnjega meljaka pri krtih (v mm). Poligona obkrožata vrednosti za 29 recentnih *T. europaea* iz zahodne Slovenije (prekinjena črta) in 30 recentnih *T. caeca* iz Bosne in Hercegovine, Črne gore ter Kosova (sklenjena črta). Pika predstavlja primerek iz Divjih bab I: izkopavanja iz leta 2006 (plast 11: vzorec E/34).
Fig. 3: Scatter plot of breadth of the first lower molar against its length in moles (in mm). Polygons enclose scores for 29 recent *T. europaea* from western Slovenia (dashed line) and 30 recent *T. caeca* from Bosnia and Herzegovina, Montenegro and Kosovo (full line). The dot indicates the speciemen from Divje babe I: 2006 excavation (layer 11: sample E/34).

vrstama rodu *Talpa* (tj. *T. europaea* in *T. caeca* Savii, 1822) zgolj na podlagi morfologije zob ni mogoče (Toškan 2002, 27 s), je takšna odločitev v skladu z odsotnostjo ostankov sredozemskega krta v mlajšem pleistocenu na območju Slovenije. V nasprotju s tem je bil navadni krt zastopan v številnih najdiščih (Rakovec 1973; Pohar 1976; Rabeder 2004), vključno z Divjimi babami I (Kryštufek 1997, 88).

Prvi spodnji meljak iz vzorca E/35 se po svoji velikosti umešča v variacijsko širino za recentne primerke navadnega krta iz zahodne Slovenije (ter tako presega največje vrednosti za sredozemskega krta iz Bosne in Hercegovine, Črne gore in Kosova; *sl. 3*). Prvi zgornji meljak iz vzorca C/34 je poškodovan in ga zato ni bilo mogoče izmeriti.

Red: Netopirji (Chiroptera)
Družina: Gladkonosi netopirji (Vespertilionidae)

Gradivo: plast 8/10: vzorec C/30 (zob); plast 10: vzorec C/32 (2 zoba); plast 13: vzorec D/38 (zob).

Štirje izolirani zobje so pripadali netopirjem. Gradivo žal zanesljive določitve do nivoja rodu/vrste ni dopuščalo.

Red: Glodalci (Rodentia)
Družina: Hrčki (Cricetidae)
Poddružina: Voluharice (Arvicolinae)

Myodes glareolus (Schreber, 1780)

Gradivo: plast 8/10: vzorec A/30 (5 zob), vzorec C/30 (16 zob); plast 10: vzorec A/31 (4 zobje), vzorec A/32 (3 zobje), vzorec C/31 (12 zob), vzorec C/32 (16 zob), vzorec E/33 (spodnja čeljustnica, 22 zob); plast 11: vzorec A/33 (4 zobje), vzorec A/34 (4 zobje), vzorec B/34 (2 zoba), vzorec C/33 (5 zob), vzorec C/34 (8 zob), vzorec E/34 (11 zob), vzorec E/35 (21 zob); plast 12: vzorec A/35 (4 zobje), vzorec B/35 (6 zob), vzorec D/36 (zob), vzorec E/36 (28 zob); plast 12/13: vzorec B/36 (2 zoba); plast 13: vzorec

(3 mandibles, tooth); Layer 11: sample A/34 (tooth), sample C/33 (rostrum), sample E/34 (rostrum), sample E/35 (tooth); Layer 12/13: sample A/36 (tooth), sample B/36 (mandible).

Most (N = 16) of the remains of *Sorex* shrews did not allow identification to the species level. On the basis of their size they might belong to either the common shrew or the Alpine shrew.

Family: Moles (Talpidae)

Talpa cf. *europaea* Linnaeus, 1758

Material: Layer 11: sample C/34 (tooth), sample E/35 (tooth).

Two isolated molars have been ascribed to the European mole. In spite of the fact that the two recent mole species of genus *Talpa* (i.e. *T. europaea* and *T. caeca* Savii, 1822) cannot be reliably identified on the basis of molars alone (Toškan 2002, 27 f), such a conclusion seems to be in line with the absence of the remains of the blind mole from the Late Pleistocene of Slovenia. Contrary to this, the European mole is known from several sites (Rakovec 1973; Pohar 1976; Rabeder 2004), including Divje babe I (Kryštufek 1997, 89).

Dimensions of the 1st lower molar from sample E/35 are within the range for the recent European mole from western Slovenia (and therefore exceed the maximal values for blind moles from Bosnia and Herzegovina, Montenegro and Kosovo; *Fig. 3*). The 1st upper molar from sample C/34 is fragmented and thus could not be measured.

Order: Bats (Chiroptera)
Family: Vespertilionids (Vespertilionidae)

Material: Layer 8/10: sample C/30 (tooth); Layer 10: sample C/32 (2 teeth); Layer 13: sample D/38 (tooth).

Tab. 1: Frekvence zastopanosti posameznih morfotipov tretjega zgornjega meljaka pri štirih vzorcih gozdnih voluharic (*Myodes glareolus*). Vzorci: 1 – recentni *M. glareolus* iz Slovenije; 2 – subfosilni primerki iz Viktorjevega spodmola (zgodnji in srednji holocen); 3 – subfosilni primerki iz Male Triglavce (zgodnji holocen); 4 – fosilni primerki iz Divjih bab I: izkopavanja iz let 1990–1999 (faciesi A do C; OIS 3 in OIS 5a); 5 – fosilni primerki iz Divjih bab I: izkopavanja iz leta 2006 (facies B; OIS 3); 6 – fosilni primerki iz Divjih bab I: izkopavanja iz leta 2006 (facies C; OIS 5a). Podatke za vzorec 2 podajata Toškan in Kryštufek (2004, tab. 15.6), za vzorec 3 Toškan (2009, 124), za vzorec 4 pa Toškan in Kryštufek (2007, tab. 10.8).
Tab. 1: Frequencies of morphotypes of 3rd upper molar in four bank vole (*Myodes glareolus*) samples. Samples: 1 – recent *M. glareolus* from Slovenia; 2 – subfossil specimens from Viktorjev spodmol (Early and Middle Holocene); 3 – subfossil specimens from Mala Triglavca (Early Holocene); 4 – fossil material from Divje babe I: excavation campaigns 1990–1999 (facies A to C; OIS 3 and OIS 5a); 5 – fossil material from Divje babe I: excavation campaign 2006 (facies B; OIS 3); 6 – fossil material from Divje babe I: excavation campaign 2006 (facies C; OIS 5a). Sample 2 is from Toškan & Kryštufek (2004, Tab. 15.6), sample 3 is from Toškan (2009, 124) and sample 4 from Toškan & Kryštufek (2007, Tab. 10.8).

Morfotip Morphotype	**Vzorec / Sample**					
	1	2	3	4	5	6
Simplex	5	26	3	11	6	0
Complex	7	10	1	1	2	1
Complex-typica	10	55	3	36	10	7
Complex-duplicata	8	12	2	18	4	2

C/36 (2 zoba), vzorec D/37 (2 zoba), vzorec D/38 (5 zob), vzorec E/37 (13 zob), vzorec E/38 (8 zob).

Gozdna (rdeča) voluharica je najbolje zastopan takson v vzorcu malih sesalcev, pridobljenih med izkopavanji leta 2006; enako velja tudi za predhodno izkopano gradivo (Kryštufek 1997, tab. 7.9; Toškan, Kryštufek 2007, tab. 10.12). Takšna percepcija je sicer nekoliko pristranska, saj značilna morfologija meljakov navedene vrste s prisotnostjo korenin in zaobljeno obliko skleninskih grebenov omogoča preprosto določitev vseh meljakov, medtem ko je bilo voluharice iz rodov *Microtus* in *Chionomys* mogoče zanesljivo identificarati le na podlagi M_1.

Rezultati metrične analize so potrdili predhodna opažanja Toškana in Kryštufka (2007, 213) o tem, da spremembe velikosti zob med klimatskimi oscilacijami niso vselej v skladu s pričakovanim pozitivnim Bergmannovim odzivom. Razlike v dolžini M_1 med primerki iz OIS 5a in tistimi iz veliko hladnejšega OIS 3 namreč ne dosegajo meje statistične značilnosti (Mann-Whitneyjev U-test: p = 0,626). Analiza morfotipov M^3 je pokazala na prevlado tipa *complex* (predvsem podtipa *typica*), kar je bilo sicer ugotovljeno tudi pri recentnih in subfosilnih gozdnih voluharicah iz Slovenije ter pri tistih fosilnih primerkih iz Divjih bab I, ki so bili pridobljeni med prejšnjimi izkopavanji (*tab. 1*).

Four isolated teeth were those of bats. The material did not allow genus/species level identification.

Order: Rodents (Rodentia)
Family: Hamsters, voles and lemmings (Cricetidae)
Subfamily: Voles and lemmings (Arvicolinae)

Myodes glareolus (Schreber, 1780)

Material: Layer 8/10: sample A/30 (5 teeth), sample C/30 (16 teeth); Layer 10: sample A/31 (4 teeth), sample A/32 (3 teeth), sample C/31 (12 teeth), sample C/32 (16 teeth), sample E/33 (mandible, 22 teeth); Layer 11: sample A/33 (4 teeth), sample A/34 (4 teeth), sample B/34 (2 teeth), sample C/33 (5 teeth), sample C/34 (8 teeth), sample E/34 (11 teeth), sample E/35 (21 teeth); Layer 12: sample A/35 (4 teeth), sample B/35 (6 teeth), sample D/36 (tooth), sample E/36 (28 teeth); Layer 12/13: sample B/36 (2 teeth); Layer 13: sample C/36 (2 teeth), sample D/37 (2 teeth), sample D/38 (5 teeth), sample E/37 (13 teeth), sample E/38 (8 teeth).

The bank vole is the most abundant small mammal taxon in the material of the 2006 campaign as well as in the assemblage revealed by previous excavations (Kryštufek 1997, Tab. 7.9; Toškan, Kryštufek 2007, Tab. 10.12). Such a perception is biased to some degree because its rooted molars with rounded salient angles allowed secure identification of all *M. glareolus* molars, contrary to *Microtus* and *Chionomys* voles, which were safely ascribed to genus/species only in the case of M_1 specimens.

Metric analysis confirmed the observations previously reported by Toškan, Kryštufek (2007, 213) that the size changes during climatic oscillations did not follow Bergmann response, as the difference in the length of M_1 between the material from OIS 5a and the much colder OIS 3 does not reach the level of statistical significance (Mann-Whitney U test: p = 0.626). The predominating M^3 morphotype was *complex* (particularly its *typical* expression). Such a situation accords with what has been observed in recent and sub-fossil bank voles from Slovenia as well as in fossil material of earlier campaigns undertaken in Divje babe I (*Tab. 1*).

Arvicola ex gr. *amphibious* - *schermann*

Material: Layer 10: sample C/32 (2 teeth), sample E/33 (tooth); Layer 11: sample E/35 (tooth); Layer 12: sample E/36 (2 teeth); Layer 13: sample E/37 (tooth).

As currently accepted (Wilson, Reeder 2005), the two long-known ecological morphotypes of the all-embracing *A. terrestris* correspond to two biological species: the amphibious *A. amphibious* (Linnaeus, *Arvicola* ex gr. *amphibious - schermann*

Gradivo: plast 10: vzorec C/32 (2 zoba), vzorec E/33 (zob); plast 11: vzorec E/35 (zob); plast 12: vzorec E/36 (2 zoba); plast 13: vzorec E/37 (zob).

Po sedanjem razumevanju (*cf.* Wilson, Reeder 2005) gre dva dolgo znana ekološka morfotipa vseobsegajoče vrste *A. terrestris* obravnavati kot dve biološki vrsti: dvoživno *A. amphibious* (Linaeus, 1758) ter manjšo, na življenje pod zemljo prilagojeno *A. schermann* (Shaw, 1801). Zaradi navedenega zanesljiva taksonomska določitev tukaj predstavljenih najdb iz rodu *Arvicola* do nivoja vrste ni možna.

Vzorec ostankov sesalske mikrofavne iz leta 2006 vključuje sedem izoliranih meljakov (najmanj ene od) zgoraj navedenih vrst. Primerjava dimenzij fosilnega, subfosilnega in recentnega gradiva z različnih lokacij v širši regiji je pokazala na obstoj določenih diahronih nihanj v velikosti (Mauch Lenardić 2005, 81 ss; Toškan, Kryštufek 2007, tab. 10.5; Toškan 2009, 120 s). Ugotovitev bi načeloma lahko razumeli kot indic za izmenjevanje obeh vrst,[3] čeprav seveda gre vzeti v obzir tudi bolj tradicionalne razlage, povezane z znotrajvrstnimi trendi. Dolžina edinega v celoti ohranjenega M^3 v gradivu iz leta 2006 znaša 2,58 mm in je potemtakem v okviru povprečja za fosilne voluharje iz Divjih bab I, izračunanem na podlagi najdb z izkopavanj v 90. letih prejšnjega stoletja (povprečje: 2,55 mm; razpon vrednosti: 2,20–2,70 mm; N = 10; Toškan, Kryštufek 2007, tab. 10.5).

Chionomys nivalis (Martins, 1842)

Gradivo: plast 8/10: vzorec C/30 (3 zobje); plast 10: vzorec C/31 (zob), vzorec E/33 (2 zoba); plast 11: vzorec A/33 (zob), vzorec C/33 (2 zoba), vzorec C/34 (6 zob), vzorec E/34 (2 zoba), vzorec E/35 (3 zobje); plast 12: vzorec E/36 (zob); plast 12/13: vzorec A/36 (zob); plast 13: vzorec D/38 (2 zoba), vzorec E/37 (zob), vzorec E/38 (2 zoba).

Snežna voluharica je zastopana s 27 izoliranimi prvimi spodnjimi meljaki. Njihova največja dolžina (mediana: 2,90 mm; razpon vrednosti: 2,83–3,00 mm; N = 6) sovpada z vrednostmi pri sočasno živečih[4] snežnih voluharicah, ki so jih dala predhodna izkopavanja (povprečje: 2,90 mm; razpon vrednosti: 2,55–3,15; N = 98; Toškan, Kryštufek 2007, tab. 10.3).

Izmed petih morfotipov M_1, ki jih navaja Nadachowski (1984a), sta v vzorcu iz leta 2006 zastopana dva: *nivalid* in *nivalid-ratticepid*. Pri tem ne preseneča, da ista

Tab. 2: Frekvence zastopanosti posameznih morfotipov prvega spodnjega meljaka pri fosilnih snežnih voluharicah (*Chionomys nivalis*) iz Divjih bab I. Vzorci: 1 – izkopavanja iz let 1990–1999: facies B (OIS 3); 2 – izkopavanja iz let 1990–1999: facies C (OIS 5a); 3 – izkopavanja iz leta 2006: facies B (OIS 3); 4 – izkopavanja iz leta 2006: facies C (OIS 5a). Podatke za vzorca 1 in 2 podajata Toškan in Kryštufek (2007, tab. 10.4).
Tab. 2: Frequencies of morphotypes of 1st lower molar in snow voles (*Chionomys nivalis*) from Divje babe I. Samples: 1 – excavation campaigns 1990–1999: facies B (OIS 3); 2 – excavation campaigns 1990–1999: facies C (OIS 5a); 3 – excavation campaign 2006: facies B (OIS 3); 4 – excavation campaign 2006: facies C (OIS 5a). Samples 1 and 2 are from Toškan & Kryštufek (2007, Tab. 10.4).

Morfotip Morphotype	**Vzorec / Sample**			
	1	2	3	4
Ratticepid	-	1	-	-
Advanced nivalid	-	1	-	-
Nivalid–ratticepid	8	15	3	3
Nivalid	29	65	17	3
Gud	-	-	-	-
SKUPAJ/TOTAL	37	82	20	6

1758) and the fossorial *A. schermann* (Shaw, 1801). This renders a reliable determination of the here-presented material to the specific level impossible.

In the small mammal assemblage obtained during the campaign of 2006, seven isolated molars of Eurasian and/or montane water vole were found. Diachronic variations in teeth size shown by the fossil, subfossil and recent material from several localities in the region (Mauch Lenardić 2005, 81 ff; Toškan, Kryštufek 2007, Tab. 10.5; Toškan 2009, 120 f) might indicate the alternation of the two species,[3] although a more traditional interpretation related to intraspecific trends cannot be ruled out. The length of the only preserved M^3 in the here presented small mammal assemblage equals 2.58 mm, which coincides with the average seen in previously excavated fossil water voles from Divje babe I (average: 2.55 mm; range: 2.20–2.70 mm; N = 10; Toškan, Kryštufek 2007, Tab. 10.5).

Chionomys nivalis (Martins, 1842)

Material: Layer 8/10: sample C/30 (3 teeth); Layer 10: sample C/31 (tooth), sample E/33 (2 teeth); Layer 11: sample A/33 (tooth), sample C/33 (2 teeth), sample C/34 (6 teeth), sample E/34 (2 teeth), sample E/35 (3 teeth); Layer 12: sample E/36 (tooth); Layer 12/13: sample A/36 (tooth); Layer 13: sample D/38 (2 teeth), sample E/37 (tooth), sample E/38 (2 teeth).

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[3] Vodni voluhar (*A. amphibious*) in podzemni voluhar (*A. schermann*) se razlikujeta v telesni masi, pri čemer je slednji manjši.

[4] Zobje izvirajo iz faciesov B in C in so tako datirani v OIS 5a ter v začetek OIS 3.

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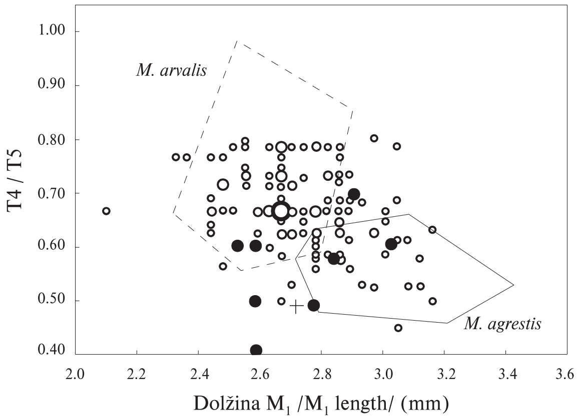
[3] The Eurasian water vole (*A. amphibius*) and the montane water vole (*A. schermann*) contrast in body mass, with the former being larger.



Sl. 4: Odnos med količnikom trikotnikov T4 in T5 kot imenovalcem (T4/T5) in dolžino prvega spodnjega meljaka pri *Microtus* ex. gr. *agrestis-arvalis* iz Divjih bab I (izkopavanja iz leta 2006, v mm). Poligona obkrožata vrednosti za 45 recentnih primerkov *M. agrestis* (sklenjena črta) in 45 recentnih primerkov *M. arvalis* (prekinjena črta) iz osrednje Slovenije. Pike (•) označujejo primerke iz faciesa B (tj. OIS 3), križec (+) pa edini nefragmentiran M_1 iz faciesa C (tj. OIS 5a). Za primerjavo so ponazorjeni tudi primerki iz faciesa C (tj. OIS 5a), ki so bili pridobljeni med izkopavanji v letih 1990–1999 (označeno z ○; velikost znakov ponazarja število primerkov; povzeto po Toškan, Kryštufek 2007, sl. 10.2). Nepoškodovanih primerkov iz faciesa B omenjena izkopavanja niso dala.

Fig. 4: Bivariate plot of quotient between enamel triangles T4 and T5 (T4/T5) against length of 1st lower molar in *Microtus* ex. gr. *agrestis-arvalis* from Divje babe I (excavation campaign 2006, in mm). Polygons enclose extremes for 45 recent *M. agrestis* (full line) and 45 recent *M. arvalis* (dashed line), respectively, from central Slovenia. Dots (•) indicate specimens from facies B (i.e. OIS 3), the cross (+) is the only non fragmented M_1 from facies C (i.e. OIS 5a). Comparative data for specimens dated to OIS 3 revealed by earlier excavations are also shown (○; the size of points indicates the number of specimens; taken from Toškan, Kryštufek 2007, Fig. 10.2). The latter excavation did not yield any unfragmented specimen originating from facies B.

morfotipa močno prevladujeta tudi v okviru bistveno bogatejšega vzorca, ki so ga navrgla izkopavanja konec prejšnjega stoletja (*tab. 2*).

Microtus ex gr. *agrestis - arvalis*

Gradivo: plast 8/10: vzorec C/30 (zob); plast 10: vzorec A/31 (3 zobje), vzorec A/32 (zob), vzorec C/31 (zob), vzorec C/32 (6 zob), vzorec E/33 (7 zob); plast 11: vzorec A/33 (3 zobje), vzorec A/44 (zob), vzorec C/34 (2 zoba), vzorec E/34 (5 zob), vzorec E/35 (5 zob); plast 12: vzorec E/36 (5 zob); plast 13: vzorec C/37 (zob), vzorec D/38 (3 zobje), vzorec E/37 (2 zoba), vzorec E/38 (zob).

Na podlagi oblike anterokonidnega kompleksa z ločenima dentinskima poljema T4 in T5 je bilo mogoče 30 arvikolinskih prvih spodnjih meljakov pripisati bodisi poljski voluharici *Microtus arvalis* (Pallas, 1779) bodisi travniški voluharici *Microtus agrestis* (Linnaeus, 1761). Razlikovanje med navedenima vrstama temelji na dejstvu, da sta trikotnika T4 in T5 pri prvi približno enake velikosti, pri drugi pa je T5 značilno večji (Nadachowski 1984b). Iz grafičnega prikaza razmerja med količnikom dolžine obeh trikotnikov (T4/T5) glede na največjo dolžino M_1 je bilo tako v vzorcu mogoče potrditi prisotnost obeh vrst (*sl. 4*). Podatek o zastopanosti travniške voluharice podkrepljujejo najdbe 17 M^2 z dodatnim posterolingvalnim trikotnikom (T5), čeprav je tudi ta znak sicer podvržen določeni časovni in geografski variabilnosti (npr. Kryštufek 1986, 38).

Prvi spodnji meljaki poljske oz. travniške voluharice, ki so bili pridobljeni med izkopavanji leta 2006, po svoji največji dolžini v ničemer ne odstopajo od sočasno živečih primerkov istih vrst, izkopanih v 90. letih prejšnjega stoletja (Toškan, Kryštufek 2007; Mann-Whitneyjev U-test: p = 0,783).

Microtus ex gr. *liechtensteini – subterraneus*

Gradivo: plast 8/10: vzorec C/30 (2 zoba); plast 10: vzorec C/31 (3 zobje), vzorec C/32 (4 zobje), vzorec

The snow vole is represented by 27 isolated 1st lower molars. Their greatest length (median: 2.90 mm; range: 2.83–3.00 mm; N = 6) conforms to what has been observed in snow voles of the same geological age[4] originating from other parts of the cave (average: 2.90 mm; range: 2.55–3.15 mm; N = 98; Toškan, Kryštufek 2007, Tab. 10.3).

Of the five morphotypes of M_1 listed by Nadachowski (1984a), the only two involved in the material obtained in 2006 are *nivalid* and *nivalid-ratticepid*. Not surprisingly, the same two morphotypes strongly predominated also in a much larger sample revealed by extensive excavations in the years 1990–1999 (*Tab. 2*).

Microtus ex gr. *agrestis – arvalis*

Material: Layer 8/10: sample C/30 (tooth); Layer 10: sample A/31 (3 teeth), sample A/32 (tooth), sample C/31 (tooth), sample C/32 (6 teeth), sample E/33 (7 teeth); Layer 11: sample A/33 (3 teeth), sample A/44 (tooth), sample C/34 (2 teeth), sample E/34 (5 teeth), sample E/35 (5 teeth); Layer 12: sample E/36 (5 teeth); Layer 13: sample C/37 (tooth), sample D/38 (3 teeth), sample E/37 (2 teeth), sample E/38 (tooth).

The shape of the anteroconid complex of M_1 with separate dentine fields of triangles T4 and T5 allocated 30 arvicoline first lower molars either to a field vole *Microtus arvalis* (Pallas, 1779) or to a common vole *M. agrestis* (Linnaeus, 1761). Species identification of first lower molars is

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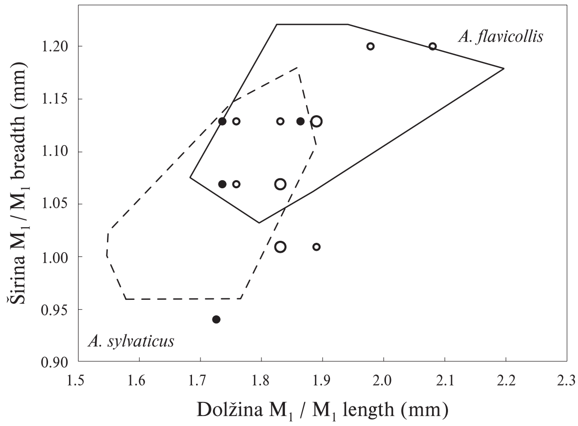
[4] The teeth originate from facies B and C and are thus dated to OIS 5a and the first part of OIS 3.



Sl. 5: Odnos med dolžino prvega spodnjega meljaka in njegovo širino pri *Apodemus* ex gr. *flavicollis - sylvaticus* iz Divjih bab I (izkopavanja iz leta 2006, v mm). Poligona obkrožata vrednosti za 35 recentnih primerkov *A. flavicollis* (sklenjena črta) in 35 recentnih primerkov *A. sylvaticus* (prekinjena črta) iz osrednje Slovenije. Pike (•) predstavljajo primerke iz faciesa C (tj. OIS 5a), krogi (○) pa tiste iz faciesa B (tj. OIS 3). Velikost znakov ponazarja število primerkov (N = 1 oz. N = 2).
Fig. 5: Bivariate plot of breadth of 1st lower molar against its length in *Apodemus* ex gr. *flavicollis-sylvaticus* from Divje babe I (excavation campaign 2006, in mm). Polygons enclose extremes for 35 recent *A. flavicollis* (full line) and 35 recent *A. sylvaticus* (dashed line), respectively, from central Slovenia. Dots (•) indicate specimens from facies C (i.e. OIS 5a), open circles (○) those originating from facies B (i.e. OIS 3). The size of points indicates the number of specimens (N = 1 or N = 2)

E/33 (7 zob); plast 11: vzorec A/34 (zob), vzorec C/34 (3 zobje), vzorec E/34 (2 zoba), vzorec E/35 (4 zobje); plast 12: vzorec E/36 (5 zob); plast 13: vzorec D/38 (zob), vzorec E/37 (5 zob).

Pitimoidne prve spodnje meljake (N = 37) lahko vse pripišemo vrtni voluharici *Microtus subterraneus* (de Salys-Longchamps, 1836) ali ilirski voluharici *M. liechtensteini* (Wettstein, 1927). Vrsti se razlikujeta po kromosomskem številu, morfološko pa sta si zelo podobni. *Microtus liechtensteini* je sicer večji, vendar se vrednosti dolžine njihovih izoliranih zob na veliko prekrivajo (Kryštufek 1997). Podatki o največji dolžini tukaj obravnavanih prvih spodnjih meljakov vrtne oz. ilirske voluharice se po svoji največji dolžini ujemajo s spodnjimi meljaki sočasno živečih primerkov istih vrst, izkopanih v 90. letih prejšnjega stoletja (Mann-Whitney-jev U test: p = 0,455).

Družina: Miši (Muridae)

Apodemus ex gr. *flavicollis - sylvaticus*

Gradivo: plast 8/10: vzorec A/30 (zob), vzorec C/30 (5 zob); plast 10: vzorec A/31 (2 zoba), vzorec A/32 (3 zobje), vzorec C/31 (8 zob), vzorec C/32 (16 zob), vzorec E/33 (2 zoba); plast 11: vzorec A/33 (zob), vzorec A/34 (3 zobje), vzorec B/34 (zob), vzorec C/33 (2 zoba), vzorec C/34 (zob), vzorec E/34 (6 zob), vzorec E/35 (4 zobje); plast 12: vzorec D/36 (zob), vzorec E/36 (3 zobje); plast 12/13: vzorec A/36 (zob); plast 13: vzorec D/37 (3 zobje), vzorec D/38 (3 zobje), vzorec E/37 (2 zoba), vzorec E/38 (3 zobje).

Rod *Apodemus* je zastopan s 65 izoliranimi zobmi, ki sva jih na podlagi velikosti in morfologije pripisala dvema recentnima vrstama (*sl. 5* in *6*): rumenogrli miši *A. flavicollis* (Melchior, 1834) in navadni belonogi miši *A. sylvaticus* (Linnaeus, 1758). Dimasta miš *A. agrarius*

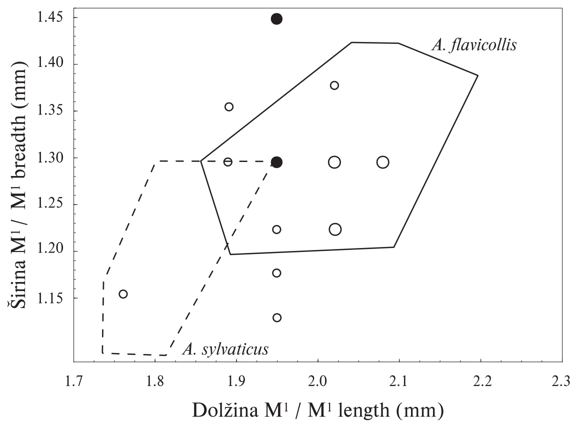
based on characters proposed by Nadachowski (1984b). Triangles T4 and T5 are subequal in *M. arvalis*, while *M. agrestis* is characterized by a larger T5 in comparison to T4. Consequently, a quotient between the lengths of these two triangles (T4/T5), when plotted against the M_1 length, distinguishes fairly reliably these two voles. This approach confirmed the presence of both species in the studied material (*Fig. 4*). The presence of *M. agrestis* is further confirmed by the find of 17 M^2 displaying an additional postero-lingual triangle (T5), despite the fact that even this characteristic is subject to temporal and geographic variation (e.g. Kryštufek 1986, 38).

Specimens from the 2006 camapign conform in M_1 lengths to the material of the same geological age revealed by extensive excavations in years 1990–1999 (Toškan, Kryštufek 2007, Annex 10.1F; Mann-Whitney U test: p = 0.738).

Microtus ex gr. *liechtensteini – subterraneus*

Material: Layer 8/10: sample C/30 (2 teeth); Layer 10: sample C/31 (3 teeth), sample C/32 (4 teeth), sample E/33 (7 teeth); Layer 11: sample A/34 (tooth), sample C/34 (3 teeth), sample E/34 (2 teeth), sample E/35 (4 teeth); Layer 12: sample E/36 (5 teeth); Layer 13: sample D/38 (tooth), sample E/37 (5 teeth).

Pitymoid first lower molars (N = 37) belong either to the common pine vole *Microtus subterraneus* (de Salys-Longchamps, 1836) or Liechtenstein's pine vole *M. liechtensteini* (Wettstein, 1927). The two species clearly differ in their chromosomal sets, however they resemble each other most closely in their morphologies. Although Liechtenstein's pine vole tends towards larger size, the length of isolated molars broadly overlaps (Kryštufek 1997). The *Microtus* ex gr. *liechtenstaini – subterraneus* material revealed by the 2006 campaign match in length of M_1 the specimens originating from extensive excavations in the 1990's (Mann-Whitney U test: p = 0,455).



Sl. 6: Odnos med dolžino prvega zgornjega meljaka in njegovo širino pri *Apodemus* ex gr. *flavicollis* - *sylvaticus* iz Divjih bab I (izkopavanja iz leta 2006, v mm). Poligona obkrožata vrednosti za 35 recentnih primerkov *A. flavicollis* (sklenjena črta) in 35 recentnih primerkov *A. sylvaticus* (prekinjena črta) iz osrednje Slovenije. Pike (•) predstavljajo primerke iz faciesa C (tj. OIS 5a), krogi (○) pa tiste iz faciesa B (tj. OIS 3). Velikost znakov ponazarja število primerkov (N = 1 oz. N = 2).
Fig. 6: Bivariate plot of breadth of 1st upper molar against its length in *Apodemus* ex gr. *flavicollis-sylvaticus* from Divje babe I (excavation campaign 2006, in mm). Polygons enclose extremes for 35 recent *A. flavicollis* (full line) and 35 recent *A. sylvaticus* (dashed line), respectively, from central Slovenia. Dots (•) indicate specimens from facies C (i.e. OIS 5a), open circles (○) those originating from facies B (i.e. OIS 3). The size of points indicates the number of specimens (N = 1 or N = 2).

(Pallas, 1771) v vzorcu ni zastopana, na kar kaže odsotnost tretjih zgornjih meljakov z dodatno mezialnolateralno grbico (t3).

Zanesljivo razlikovanje med vrstama *A. sylvaticus* in *A. flavicollis* na podlagi morfologije zob ni možno (Mayhew 1978; Janžekovič, Kryštufek 2004), poleg tega pa njune populacije izkazujejo še znatno variabilnost v njihovi velikosti (Alcántra 1991). Navkljub temu sva v primeru tukaj obravnavanega gradiva na podlagi dimenzij M^1 in M_1 lahko potrdila prisotnost obeh navedenih vrst (*sl. 5* in *6*), pri čemer naj bi bila *A. sylvaticus* pogostejša v faciesu C (tj. OIS 5a), *A. flavicollis* pa v faciesu B (tj. OIS 3). Izkopavanja konec prejšnjega stoletja so v okviru faciesov B in C dala zgolj en zob rodu *Apodemus*; primerek je bil pripisan navadni belonogi miši (Toškan, Kryštufek 2007, 200).

Družina. Polhi (Gliridae)

Glis glis (Linnaeus, 1766)

Gradivo: plast 10: vzorec C/32 (spodnja čeljustnica, zob*); plast 11: vzorec C/34 (zob); plast 12: vzorec B/35 (spodnja čeljustnica, zob*). Primerki izstopajoče bele barve glede na običajno rumenkastorjavo obarvanost drugih zob so označeni z zvezdo (*).

Navadnemu polhu je pripadalo pet ostankov. Dva[5] (P^4, M_1) izmed skupno treh izoliranih zob sta izrazito bele barve, po čemer se očitno razlikujeta od ostalih najdb malih sesalcev v obravnavanem vzorcu. V času izkopavanj v Divjih babah I so bili približno 20 cm pod površjem (torej pod sigo, ki je holocenskega izvora) dvakrat najdeni speči polhi. V luči navedenega bi lahko tako tudi v primeru obeh zgoraj omenjenih belo obarvanih zob šlo za kontaminacijo z recentnimi živalmi.

Family: Mice and rats (Muridae)

Apodemus ex. gr. *flavicollis* – *sylvaticus*

Material: Layer 8/10: sample A/30 (tooth), sample C/30 (5 teeth); Layer 10: sample A/31 (2 teeth), sample A/32 (3 teeth), sample C/31 (8 teeth), sample C/32 (16 teeth), sample E/33 (2 teeth); Layer 11: sample A/33 (tooth), sample A/34 (3 teeth), sample B/34 (tooth), sample C/33 (2 teeth), sample C/34 (tooth), sample E/34 (6 teeth), sample E/35 (4 teeth); Layer 12: sample D/36 (tooth), sample E/36 (3 teeth); Layer 12/13: sample A/36 (tooth); Layer 13: sample D/37 (3 teeth), sample D/38 (3 teeth), sample E/37 (2 teeth), sample E/38 (3 teeth).

The genus *Apodemus* is represented by 65 isolated teeth. On the basis of size and morphology of the available specimens they were ascribed to two recent species: yellow-necked mouse *A. flavicollis* (Melchior, 1834) and long-tailed field mouse *A. sylvaticus* (Linnaeus, 1758). The presence of the striped field mouse *A. agrarius* (Pallas, 1771) was excluded since all 3rd upper molars display the mesio-lateral cone (t3).

Reliable distinguishing between *A. sylvaticus* and *A. flavicollis* on the basis of check-teeth morphology was shown not to be possible (Mayhew 1978; Janžekovič, Kryštufek 2004). Moreover, populations of these two species are known to be characterized by a considerable size variation (Alcántra 1991). In spite of this, the size of M_1 and M^1 allowed us to ascertain the presence of both species, whereby *A. sylvaticus* seams to be more common in facies C (i.e. OIS 5a) and *A. flavicollis* in facies B (i.e. OIS 3, *Figs. 5, 6*). Excavations in 1990–1999 revealed a single tooth of the genus *Apodemus* originating from facies B and C. It has been ascribed to the long-tailed field mouse (Toškan, Kryštufek 2007, 213 f).

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[5] Primerka nista bila najdena globlje od pril. 10 do 35 cm pod površino.

OSTANKI VELIKIH SESALCEV

Izkopavanja iz leta 2006 so dala tudi več tisoč ostankov velikih sesalcev. Taksonomsko določene kosti in zobe (NISP = 6.577) je bilo mogoče pripisati štirim vrstam iz prav tolikih družin (*tab. 3*), med katerimi je daleč največji delež (tj. > 99,9 %) pripadel jamskemu medvedu *Ursus spelaeus* Rosenmüller, 1794. Preostale tri vrste velikih sesalcev, ki so zastopane v tukaj obravnavanem gradivu, so vse recentne in še vedno naseljujejo območje Slovenije.

Jamski medved je v vzorcu zastopan s 6.544 najdbami. Rezultati razvrščanja podočnikov in dlančnic po spolu[6] so pokazali na višji delež samic v faciesu C v primerjavi s faciesom B (*tab. 4*), čeprav sama razlika sicer ni statistično značilna (χ^2 test; združen vzorec: p = 0,309). Podobna primerjava obeh spolnih struktur, pri kateri pa primerkov iz stratigrafsko problematičnih mejnih sedimentacijskih nivojev med obema faciesoma nisva upoštevala (*tab. 5*), je pokazala na obstoj še očitnejšega odstopanja, ki se že močno približuje meji statistične značilnosti (χ^2 test; združen vzorec: p = 0,093).

Po številu najdb jamskemu medvedu sledi kuna zlatica (*Martes martes* [Linnaeus, 1758]). Omeniti je sicer treba, da skoraj polovica ostankov rodu *Martes* iz leta 2006 ni dopuščala določitve do nivoja vrste (*tab. 6*). Ker pa od taksonomsko determiniranih najdb prav vse pripadajo kuni zlatici, enako pa velja tudi za gradivo iz predhodnih raziskovanj, se zdi pripis vseh kunjih kosti in zob iz Divjih bab I vrsti *M. martes* povsem utemeljen. Toliko bolj zato, ker naj bi bila navedena vrsta v mlajšem pleistocenu sploh edini predstavnik svojega rodu na evropskih tleh; na odprte habitate vezana kuna belica (*M. foina* [Erxleben, 1777]) naj bi se namreč na

Family: Dormice (Gliridae)

Glis glis (Linaeus, 1766)

Material: Layer 10: sample C/32 (mandible, tooth*); Layer 11: sample C/34 (tooth); Layer 12: sample B/35 (mandible, tooth*). Specimens of a distinctly-white colour as compared to the usual yellowish brown are marked with an asterisk (*).

The edible dormouse is represented by five remains. Two (P^4, M_1) out of three isolated check-teeth were of distinctly white colour and thus differed markedly from the rest of the small mammal teeth in the sample. During summer excavations in Divje babe I, living edible dormice were found twice at a depth of about 20 cm below the surface (Kryštufek 1997, 94 f), whereby in the case of the two[5] above mentioned teeth the contamination by intrusive recent dormice cannot be excluded.

LARGE MAMMAL REMAINS

Apart from the small mammal fauna, the 2006 excavation campaign also revealed several thousand macrofaunistic remains. The taxonomically determined teeth and bones (NISP = 6,577) belonged to four species from as many families (*Tab. 3*), but the great majority (i.e. > 99.9 %) were referable to the extinct cave bear *Ursus spelaeus* Rosenmüller, 1794. The rest of the large mammal species represented in the sample are all extant and still occur in Slovenia.

The cave bear is represented by 6,544 finds. From the sexing of canines and metacarpals[6] a higher share of

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[6] Postopek razvrščanja dlančnic med oba spola predstavlja Toškan (2007b, 385 s).

[5] The two teeth were found no deeper than approx. 10 to 35 cm below the surface.

[6] The methodology for sexing cave bear metacarpals is presented in Toškan (2007b, 397 f).

Tab. 3: Število določenih primerkov (NISP) v fosilnih združbah velikih sesalcev iz sklopa plasti 8/10–13 iz Divjih bab I (izkopavanja iz leta 2006). Podano je tudi skupno število izkopanih in pregledanih standardnih vzorčnih enot sedimenta na posamezen sedimentacijski nivo (prostornina posamezne enote je 1 x 1 x 0,12 m oz. 0,12 m^3).
Tab. 3: Number of Identified Speciemens (NISP) in small mammal fossil assemblages from layers 8/10–13 of Divje babe I (excavation campaign 2006). Also given is the total number of excavated and analysed basic samples of sediment per sedimentation level (volume of samples is 1 x 1 x 0,12 m, i.e. 0.12 m^3).

Takson **Taxon**	**Sedimentacijski nivo / Sedimentation levels**									**Σ**
	FACIES B							**FACIES C**		
	28	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	
Ursus spelaeus	192	261	362	517	909	1310	1544	1120	329	6544
Canis lupus			2	2						4
Martes martes							10	4		14
Martes sp.	5	1		1			3	2		12
Rupicapra rupicapra								1		1
SKUPAJ / TOTAL	197	262	364	520	909	1310	1557	1127	329	6575
Št. vzorčnih enot / No. of samples	2	2	3	3	4	5	5	5	3	

Tab. 4: Frekvenca pojavljanja ostankov samcev in samic jamskega medveda iz Divjih bab I (izkopavanja iz leta 2006) po faciesih. Prikazani so podatki o številu dlančnic in podočnikov

Tab. 4: Abundance of remains of male and female cave bears from Divje babe I (excavation campaign 2006) per facies. Shown are the number of canines and metacarpals.

Podočniki **Canines**	**Samci** **Males**	**Samice** **Females**
Facies B	5	6
Facies C	2	8
Dlančnice **Metacarpals**	**Samci** **Males**	**Samice** **Females**
Facies B	4	4
Facies C	5	7
Združeno **Pooled**	**Samci** **Males**	**Samice** **Females**
Facies B	9	10
Facies C	7	15

tem prostoru pojavila šele v holocenu (Wolsan 1993; Crégut-Bonnoure 1996, 191; a glej tudi Bon *et al.* 1991, 202 ss; Döppes 2004, 69).

Gams (*Rupicapra rupicapra* [Linnaeus, 1758]) in volk (*Canis lupus* Lineaus, 1758) sta v vzorcu zastopana zgolj s posameznimi najdbami. Prvemu sva tako pripisala le nartno kost iz vzorca B/37, drugemu pa dve vretenci (vzorca A/32 in C/33), sezamoidno kost (vzorec C/32) in prvo dlančnico (vzorec C/33).

Tab. 5: Število podočnikov in dlančnic samcev in samic jamskega medveda iz Divjih bab I (izkopavanja iz leta 2006) po faciesih brez upoštevanja najdb iz "mejnih" sedimentacijskih nivojev med obema faciesoma (tj. nivojema 33 in 34).

Tab. 5: Number of canines and metacarpals of male and female cave bears from Divje babe I (excavation campaign 2006) per facies, not considering the finds from interfacial boundary sedimentation levels (i.e. levels 33 and 34).

Podočniki **Canines**	**Samci** **Males**	**Samice** **Females**
Facies B (core)	2	3
Facies C (core)	0	5
Dlančnice **Metacarpals**	**Samci** **Males**	**Samice** **Females**
Facies B (core)	3	2
Facies C (core)	1	2
Združeno **Pooled**	**Samci** **Males**	**Samice** **Females**
Facies B (core)	5	5
Facies C (core)	1	7

females in the material from facies C relative to facies B (*Tab. 4*) has emerged, although the difference was not statistically significant (χ^2 test; pooled sample: p = 0.309). The observed discrepancy was even more pronounced when the canines and metacarpals from the interfacial sedimentational levels 33 and 34 were excluded from the analysis (*Tab. 5*), almost skimming the boundary of statistical significance (χ^2 test; pooled sample: p = 0.093).

In the number of finds the cave bear is followed by the pine marten *Martes martes* (Linnaeus, 1758). As a matter of fact, almost half of the remains of the genus *Martes* did not allow identification to the level of species (*Tab. 6*). Nevertheless, those which did were all referable to *Martes martes*, as was the case also with the material revealed by earlier excavations (Toškan,

Tab. 6: Razporeditev najdb kune zlatice (*Martes* cfr. *martes*) iz Divjih bab I (izkopavanja iz leta 2006) po sedimentacijskih nivojih in plasteh. Okrajšave: Mc – dlančnica, Mt – stopalnica.

Tab. 6: Distribution of finds of the pine marten (*Martes* cfr. *martes*) from Divje babe I (excavation campaign 2006) per sedimentation levels and layers. Abbreviations: Mc – metacarpus, Mt – metatarsus.

Sedimentacijski nivo **Sedimentation level**	**Plast** **Layer**	**Mandibula**	**Dentes**	**Vertebrae**	**Radius**	**Ulna**	**Mc 3**	**Mc 4**	**Pelvis**	**Mt 3**	**Tarsalia**	**Phalanges**	**Σ**
28	8/10					1	1	1				2	5
29	10											1	1
31	11											1	1
32	11	1											1
34	12/13 & 13		1	5	1				1	2		2	12
35	13	1	1	1	1	1					1		6
SKUPAJ / TOTAL		2	2	6	2	2	1	1	1	2	1	6	26

Tab. 7: Najmanjše število živali (MNI) v fosilnih združbah malih sesalcev iz sklopa plasti 6–17a1 iz Divjih bab I (izkopavanja iz let 1990–1999). Senčena polja označujejo prisotnost taksona v plasti. Podana sta tudi skupno število določenih primerkov (NISP) za posamezen takson ter skupna prostornina pregledane frakcije sedimenta velikosti 0,5 do 10 mm na plast. Podatki so povzeti po Toškan in Kryštufek (2007, tab. 10.12).

Tab. 7: Minimum Number of Individuals (MNI) in small mammal fossil assemblages from layers 6–17a1 of Divje babe I (excavation campaigns 1990–1999). Shaded cells indicate the presence of taxon in a layer. Also given are the total Number of Identified Specimens (NISP) for individual taxa and the total volume of the removed sediment fraction (particle size 0.5 to 10 mm) per layer, from which the small mammal remains were subsequently extracted. Data taken from Toškan & Kryštufek (2007, Tab. 10.12).

Takson **Taxon**	**7**	**8**	**8/10**	**10**	**10/11**	**11**	**11/12**	**12/13**	**13**	**13/14**	**14**	**15**	**15/16**	**16**	**16 a**	**16a/17a1**	**17 a1**	**Σ MNI**	**Σ NISP**
Erinaceus sp.				1														1	1
S. araneus		1	▨	1														2	3
S. alpinus		1		1							1							3	4
S. araneus/alpinus		▨				▨					▨			▨				–	6
Talpa sp.		▨									1			1				2	5
V. murinus														1				1	1
M. glareolus	1	22	4	16	2	12	4	5	▨	6	18	7	2	48	4	▨	▨	151	874
A. amphib./scherm.	▨	3	▨	3		6	▨	▨	1	3	4	2	2	4	1			29	123
Ch. nivalis		5	3	13	2	7		1	2	2	10	4	5	26	2	1		83	243
M. agrestis/arvalis		1	1	8	1	2	1		2	3	19	9	4	53	15	3		122	226
M. multip./subterr.				1		3					4			3				11	17
Arvicollinae indet.	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	–	845
Apodemus sp.														1				1	1
Sicista cfr. *subtilis*										1								1	1
G. glis	1																	1	1
M. avellanarius										1						1		2	2
SKUPAJ / TOTAL	2	33	8	44	5	30	5	6	5	16	57	22	13	137	22	5	0	410	2353
Vol. sedimenta / Vol. of sedim. (dm^3)	9	194	14	34	10	29	7	8	14	4	15	6	6	25	4	1	24		

PALEOOKOLJE

Skupno so bili v plasteh 8/10 do 13 (tj. v sedimentacijskih nivojih 28–35) Divjih bab I najdeni predmeljaki in meljaki najmanj 211 živali. Polovico (MNI = 98) so jih dala obsežna izkopavanja v 90. letih prejšnjega stoletja (*tab. 7*), preostanek (MNI = 113) pa je bil pridobljen med izkopavanji leta 2006 (*tab. 8*).

Na podlagi ostankov malih sesalcev, ki so bili izkopani konec prejšnjega stoletja, sta Toškan in Kryštufek (2007, 202 ss) poskusila rekonstruirati okolje ob nastopu srednjega würma[7] pred pribl. 70 do 80 tisoč leti. V skladu z njunimi domnevami naj bi na širšem območju Divjih

Kryštufek 2007, 255 f). Consequently, it is very likely that all of the fossil mustelid teeth and bones from Divje babe I are to be ascribed to this species. Even more so since the pine marten was probably the only representative of martens in Europe during the Late Pleistocene, since the open habitat preferring beech marten *Martes foina* (Erxleben, 1777) supposedly only appeared in the Holocene (Wolsan 1993; Crégut-Bonnoure 1996, 191; but see also Bon *et al.* 1991, 202 ff; Döppes 2004, 69).

The chamois *Rupicapra rupicapra* (Linnaeus, 1758) and the wolf *Canis lupus* Linnaeus, 1758 are represented by only a few remains: a tarsal bone from sample B/37 has been ascribed to the former and two vertebrae (samples A/32 and C/33), a sesamoid (sample C/32) and a first metacarpal bone (sample C/33) to the latter.

PALAEOENVIRONMENT

In total, small mammal molars of at least 211 individuals were recovered from layers 8/10–13 (i.e. sedimentation levels 28–35) of Divje babe I. Half of them (MNI = 98) were revealed by extensive excavations

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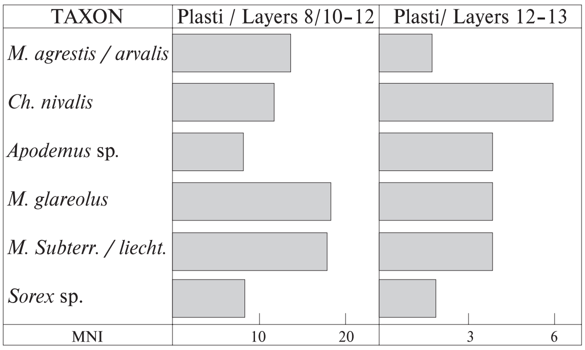
[7] V Divjih babah I je meja med zgodnjim in srednjim würmom sedimentološko dobro opredeljena (Turk *et al.* 2007). Postavljena je med faciesa C in B, pri čemer gre sedimente pod to mejo datirati v zgodnji glacial ali OIS 5 (= facies C), tiste nad njo pa v "visoki glacial" (= "pleniglacial") ali OIS 4–2 (= faciesa A in B). Žal kronocona OIS 4 v tukaj obravnavani jami (enako pa sicer velja za celoten vzhodnoalpski prostor; Preusser 2004) skoraj ni zastopana, saj je takrat prišlo do daljše prekinitve v sedimentaciji. Zaradi istega vzroka v Divjih babah I ni zastopana niti kronocona OIS 2.

Tab. 8: Najmanjše število živali (MNI) v fosilnih združbah malih sesalcev iz sklopa plasti 8/10–13 iz Divjih bab I (izkopavanja iz leta 2006). Senčena polja označujejo prisotnost taksona v plasti. Podana sta tudi število določenih primerkov (NISP) za posamezen takson ter skupna prostornina pregledane frakcije sedimenta velikosti 0,5 do 10 mm na stratigrafski nivo.
Tab. 8: Minimum Number of Individuals (MNI) in small mammal fossil assemblages from layers 8/10–13 of Divje babe I (excavation campaign 2006). Shaded cells indicate the presence of taxon in a layer. Also given are the total Number of Identified Specimens (NISP) for individual taxa and the total volume of the removed sediment fraction (particle size 0.5 to 10 mm) per sedimentation level, from which the small mammal remains were subsequently extracted.

Takson Taxon	**Plast / Layer →**	**8/10**	**10**		**11**		**12**	**12/13 & 13**		**Σ MNI**	**Σ NISP**
	Sed. nivo / level →	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**		
S. minutus							1			1	1
S. araneus		1								1	1
S. alpinus		1		1		1			1	4	5
S. araneus/alpinus		▨	1	3	▨	▨		1		5	16
T. europaea						1				1	2
Chiroptera indet.		▨		▨					▨	-	4
M. glareolus		3	1	2	3	5	2	3	1	20	211
A. amphibious/schermann				2		▨	▨	1		3	7
Ch. nivalis		2	2	2	3	6	1	2	4	22	27
M. agrestis/arvalis		▨	2	4	3	5	1	1	1	17	47
M. liechtensteini/subterraneus		1	2	6	1	6	3	3	1	23	37
Arvicollinae indet.		▨	▨	▨	▨	▨	▨	▨	▨	-	464
Apodemus sp.		1	2	2	3	3		2	1	14	65
G. glis				2		▨		▨		2	5
SKUPAJ / TOTAL		9	10	22	13	29	8	13	9	113	892
Vol. sedim. (dm^3)		0.6	0.85	1.15	1.3	2.25	2.1	2.35	1.4		

bab I takrat razmeroma odprta travniška krajina, ki je bila zelo razširjena še ob koncu zgodnjega würma, prešla v mozaični tip habitata s pretežno iglastimi gozdovi in travniki s kamenišči. Navedene spremembe sta pripisala občutnemu padcu temperatur, ki ga je spremljalo tudi znatno povišanje vlažnosti (glej povečan delež ostankov vrste *M. glareolus* in rovk iz rodu *Sorex*; *tab. 7*). Skladno s tem naj domnevni prevladi travnikov in kamenišč nad gozdnimi habitati v OIS 5a ne bi botrovalo mrzlo



Sl. 7: Grafična predstavitev najmanjšega števila osebkov (MNI) bolje zastopanih taksonov malih sesalcev iz Divjih bab I (izkopavanja iz leta 2006) po faciesih.
Fig. 7: Bar histogram of Minimum Number of Individuals (MNI) for major small mammal taxa from Divje babe I (excavation campaign 2006) per facies.

in the 1990's (*Tab. 7*); the rest of the finds (MNI = 112) originate from the campaign of 2006 (*Tab. 8*).

The study of the assemblage gathered in the 1990's led Toškan and Kryštufek (2007, 214 ff) to the conclusion that the onset of the Middle Würm[7] between 70 ka and 80 ka B.C. saw the rather open grassland habitat of the terminal part of the Early Würm evolving into a mosaic of mixed, predominantly coniferous forest, with meadows and accumulations of rocky boulders. Such a transition was thought to have been triggered by a substantial cooling of the climate accompanied by a significant increase in humidity (note the increased relative abundance of *M. glareolus* and *Sorex* shrews; *Tab. 7*). In line with this, the supposed prevalence of meadows and rocky sites over woodlands in OIS 5a was not seen as a consequence of low temperatures (note the presence of a mole; *Tab. 7*) but more probably as a reflection of

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[7] In Divje babe I the boundary between the Early and Middle Würm is sedimentologically well defined (Turk *et al.* 2007). It is set between sedimentary facies C and B. Below this boundary is the Early Glacial or OIS 5 (= sedimentary facies C), above is the "full glacial" (= "pleniglacial") or OIS 4–2 (= sedimentary facies A and B). Unfortunately, the chronozone OIS 4 is only poorly expressed in Divje babe I (and in Eastern Alps in general; Preusser 2004), since a pause in sedimentation occurred at the time. For the same reason the chronozone OIS 2 is completely missing.

podnebje (da je bilo to dejansko zmerno, med drugim dokazuje prisotnost krta, ki pozimi ne prenese globoko zamrznjenih tal; *tab. 7*), marveč prej sušnost. Najdbi vrst *Sicista subtilis* in *Vespertilio murinus* bi lahko namreč razumeli tudi kot kazalnika sušnih razmer (*tab. 7*).

Ostanki malih sesalcev iz izkopavanj leta 2006 v osnovi potrjujejo zgornje teze (*tab. 8*; *sl. 7*). Dejstvo sicer je, da med najdbami iz končnega dela zgodnjega glaciala (= OIS 5a) delež gozdnih vrst (*M. glareolus*, rovke iz rodu *Sorex*) v dokaj skromnem obsegu presega delež tistih, ki so vezane na odprte habitate (voluharice iz rodu *Microtus*, *Ch. nivalis*). Toliko bolj zato, ker razmeroma pogosti *M.* ex gr. *liechtensteini - subterraneus* (*sl. 7*) nista striktno vezani na travnike in jase, ampak lahko naseljujeta tudi listopadne in iglaste gozdove (Kryštufek 1991, 149 s; 1999). Vendar pa lahko navedeno sliko brez večjih težav zadovoljivo razložimo s podnebnimi nihanji v OIS 5a; najmanj ena od obeh tukaj obravnavanih zgodnjewürmskih plasti (tj. plast 12–13) je namreč nastala v razmeroma vlažni fazi, pravzaprav najbolj vlažni v celotnem OIS 5a–d (Turk *et al.* 2007, 101). Če gre prevlado travnikov in kamenišč nad gozdovi v OIS 5a dejansko prej pripisati sušni klimi kot nizkim temperaturam (glej zgoraj), potem je ugotovljena skromna razlika med deležema zastopanosti gozdnih in travniških vrst malih sesalcev v tukaj obravnavanem gradivu pravzaprav logična.

Na (rahlo) povišanje vlažnosti ob koncu OIS 5a kaže tudi prisotnost frugivornih glodalcev (*G. glis*, *A. flavicollis*; glej *sl. 6*) in torej listavcev (vključno z bukvijo),[8] na katere so ti prehransko vezani. Iz skromnega deleža polha in rumenogrle miši v primerjavi z gozdno voluharico in rovkami iz rodu *Sorex* gre sicer sklepati, da so v takratnih gozdovih vendarle prevladovali iglavci, v prvi vrsti bor (*cf.* Šercelj, Culiberg 1991, 135 ss; Culiberg 2007, 171).

Vrstna sestava gradiva iz faciesa B in pogostnost posameznih taksonov kažeta na prehod v obdobje razmeroma stabilnega vlažnega in hladnega podnebja (*sl. 7*; *tab. 8*). Povišana vlažnost (glej tudi Turk *et al.* 2007, 101) je zelo verjetno pospešila širjenje gozdov, o čemer priča dobra zastopanost gozdnih taksonov *M. glareolus*, *G. glis*, *A. flavicollis* ter rovk iz rodu *Sorex*. Sodeč po maloštevilnih najdbah frugivorov so takratne gozdove domnevno še vedno sestavljali predvsem iglavci, kar se sicer v celoti sklada z izsledki paleobotaničnih raziskav (Šercelj, Culiberg 1991, 142; Culiberg 2007, 174). Ob vrsti *M. glareolus*, ki preferira gosto porasle čistine in robove vlažnih gozodv (Spitzenberger 1999a), na hladno in vlažno podnebje kažeta tudi povišana deleža rovk iz rodu *Sorex* (*cf.* Anděra 1999; Spitzenberger 1999b) ter travniške voluharice iz kompleksa *M.* ex gr. *agrestis - arvalis* (*sl. 4*).[9] Pri tem je slednji podatek pomemben zato,

arid climate (records of *Sicista subtilis* and *Vespertilio murinus* might be indicative of aridity; *Tab. 7*).

The micromammal remains yielded by the excavations of 2006 basically conform to the above thesis (*Fig. 7*; *Tab. 8*). It is true that as far as the OIS 5a period is concerned, the assemblage from the 2006 campaign shows only a minimal predominance of forest dwelling species (*M. glareolus*, *Sorex* shrews) over those depending on open habitats (voles of the genus *Microtus*, *Ch. nivalis*). Even more so since the relatively abundant *M.* ex. gr. *liectensteini – subterraneus* (*Fig. 7*) is not strictly depending on open habitats, but can be found in deciduous and coniferous woodland as well (Kryštufek 1991, 149 f; 1999). Nevertheless, such a picture can be readily explained by climatic oscillations during OIS 5a, as at least one of the two here studied early Würmian layers (i.e. layer 12–13) was formed in a rather humid phase, the most humid of all OIS 5a-d (Turk *et al.* 2007, 120). If the supposed prevalence of meadows and rocky sites over woodlands in OIS 5a is indeed to be ascribed to arid climate rather than low temperatures (see above), then the reduced discrepancy between the share of forest small mammals relative to open habitat species observed in the material excavated in 2006 seems to be logical.

Indicative of a (slightly) greater humidity at the end of OIS 5a is also the presence of frugivorous rodents (*G. glis*, *A. flavicollis*; see *Fig. 6*) and thus of deciduous trees (including beech),[8] although the former's low dominance relative to *M. glareolus* and *Sorex* shrews proves that the then tree vegetation has been throughout dominated by conifers, above all pine (*cf.* Šercelj, Culiberg 1991, 145 f; Culiberg 2007, 182).

The species composition in the material from facies B and their abundance indicate a gradual shift towards a relatively stable mesic and cold climate (*Fig. 7*; *Tab. 8*). The increased humidity (see also Turk *et al.* 2007, 120) is likely to have stimulated a further expansion of forest, as can be inferred from the abundance of forest-dwelling taxa *M. glareolus*, *G. glis*, *A. flavicollis* and *Sorex* shrews. Given the scarcity of frugivores, the tree vegetation of the time was supposedly still dominated by conifers, which is perfectly in line with paleobotanical data (Šercelj, Culiberg 1991, 142; Culiberg 2007, 182). Apart from *M. glareolus*, known to prefer densely covered clearings and margins of mesic forests (Spitzenberger 1999a), an environment of lower temperatures and higher humidity is also indicated by an increased share of *M. agrestis* within the group *M.* ex gr. *agrestis-arvalis* (*Fig. 4*)[9] and of *Sorex* shrews (*cf.* Anděra 1999; Spitzenberger 1999b). The

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[8] To potrjujejo tudi paleobotanične najdbe (Šercelj, Culiberg 1991, tab. 1–2; Culiberg 2007, 171).

[9] Skladen s tem je tudi podatek, da število arvikolinskih

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[8] This is confirmed by paleobotanical data (Šercelj, Culiberg 1991, *Tabs. 1, 2*; Culiberg 2007, 182).

[9] This is confirmed by the number of arvicoline 2nd upper molars with an additional postero-lingual enamel triangle being higher in facies B than in facies C (i.e. N = 13 vs. N = 5), as such specimens can be reliably ascribed to *M. agrestis.*

ker je vrsta *M. agrestis* bolj vezana na vlažne habitate od *M. arvalis* (Zima 1999a; 1999b).

PRIMERJAVA MED VZORCEMA

Vzorca malih sesalcev iz Divjih bab I, pridobljena med obsežnimi izkopavanji ob koncu prejšnejga stoletja in nekajdnevnim terenskim raziskovanjem v letu 2006, izkazujeta primerljive deleže zastopanosti posameznih taksonov (*tab. 9, sl. 8–9*). Posamezna manjša odstopanja komentirava v nadaljevanju.

Na prvi pogled bi enega takšnih odstopanj lahko predstavljal na *sliki 8* jasno izražen nižji delež vrste *M. glareolus* v vzorcu iz leta 2006. Kot je to razvidno s *slike 9,* pa gre pri tem očitno zgolj za artefakt izbranega kazalnika količine najdb (tj. najmanjše število živali; *cf.* Grayson 1984; Klein, Cruz-Uribe 1984); v kolikor namreč namesto MNI uporabimo NISP, se navedena razlika med gradivoma praktično izniči (glej *sl. 9*).

Težje razložljive so razlike, ki so bile ugotovljene med vzorcema v deležu zastopanosti belonogih miši, vrtne oz. ilirske ter snežne voluharice. Vendar pa ta odstopanja, ki sama po sebi niti niso posebej velika, na samo rekonstrukcijo nekdanjega okolja nimajo omembe vrednega vpliva, saj v ničemer ne nasprotujejo splošnemu vtisu o znatni širitvi gozdov ob nastopu srednjega würma.

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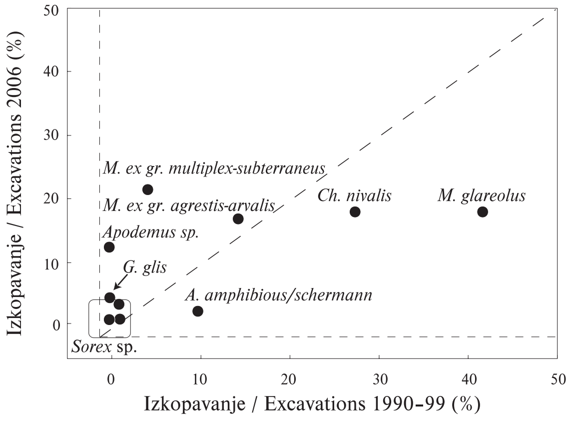
drugih zgornjih meljakov z dodatnim posterolingvalnim skleninskim trikotnikom v okviru faciesa B presega število tistih, ki so bili najdeni v faciesu C (tj. N = 13 nasproti N = 5); navedene zobe gre namreč pripisati vlagoljubni vrsti *M. agrestis*.



Sl. 8: Delež posameznih taksonov malih sesalcev v gradivu iz Divjih bab I za vzorca z izkopavanj v letih 1990–1999 in 2006. Abundanca najdb je izražena kot najmanjše število živali (*Minimum Number of Individuals*; MNI).

Fig. 8: Shares of individual small mammal taxa in two samples from Divje babe I: the first revealed by the excavations in years 1990–1999 and the second yielded by the campaign of 2006. The abundance of individual taxa is expressed as the Minimum Number of Individuals (MNI).

former is important, as the common vole is more dependent on wet habitats than *M. arvalis* (Zima 1999a; 1999b).

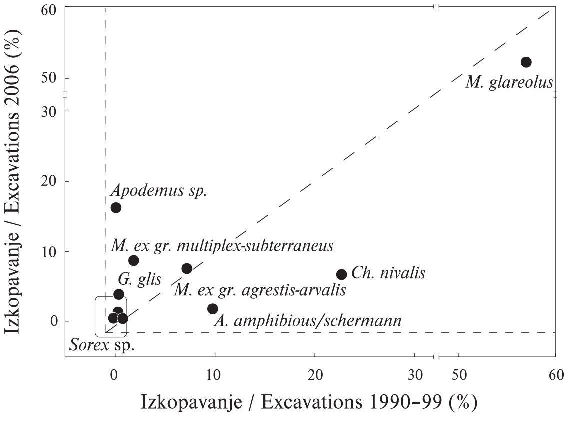
BETWEEN-ASSEMBLAGES COMPARISON

The small mammal assemblages from Divje babe I yielded by the excavations of the 1990's and of 2006 resemble each other fairly closely in the relative abundance of various taxa (*Tab. 9, Figs. 8*, *9*). There are, however, some minor discrepancies, which need to be commented.

At first sight such a case could be represented by a significantly lower share of *M. glareolus* in the assemblage from 2006 that can be observed in *figure 8*. By taking a closer look, however, this discrepancy reveals itself to be nothing but a consequence of the abundance being expressed as MNI (*cf.* Grayson 1984; Klein, Cruz-Uribe 1984); namely, if NISP is used instead, the difference between the two assemblages all but disappears (see *Fig. 9*).

Less straightforward to explain are the between-assemblages discrepancies in the relative abundances of *Apodemus* sp., *M.* ex gr. *multiplex-subterraneus* and *Ch. nivalis*. Nevertheless, these discrepancies – apart from being only minor – do not seem to affect the palaeoenvironmental reconstruction, as they do not in any way contradict the overall impression inferred from the two assemblages of the spread of forests with the onset of the Middle Würm.

The only notable differing point between the two assemblages is thus limited to the somewhat higher share of frugivorous rodents in the sample from 2006, indicative of a possibly more important presence of



Sl. 9: Delež posameznih taksonov malih sesalcev v gradivu iz Divjih bab I za vzorca z izkopavanj v letih 1990–1999 in 2006. Abundanca najdb je izražena kot število določenih primerkov (*Number of Identified Speciemens*; NISP).

Fig. 9: Shares of individual small mammal taxa in two samples from Divje babe I: the first revealed by the excavations in years 1990–1999 and the second yielded by the campaign of 2006. The abundance of various taxa is expressed as the Number of Identified Specimens (NISP).

Tab. 9: Najmanjše število živali (MNI) in skupno število določenih primerkov (NISP) v fosilnih združbah malih sesalcev iz sklopa plasti 8/10–13 iz Divjih bab I (izkopavanja iz let 1990–1999 in 2006). Podana je tudi skupna prostornina pregledane frakcije sedimenta velikosti 0,5 do 10 mm na vsak od obeh vzorcev.
Tab. 9: Minimum Number of Individuals (MNI) and the Number of Identified Specimens (NISP) in small mammal fossil assemblages from layers 8/10–13 of Divje babe I: excavation campaigns 1990–1999 and 2006. Also given is the total volume of the removed sediment fraction (particle size 0.5 to 10 mm) per each of the two samples, from which the small mammal remains were subsequently extracted.

Takson **Taxon**	**Leta / Years 1990-1999**		**Leto / Year 2006**	
	MNI	**NISP**	**MNI**	**NISP**
S. alpinus			1	1
S. araneus/alpinus			1	2
M. glareolus	*5*	*29*	*4*	*38*
A. amphib./ scherm.	*1*	*5*	*1*	*1*
Ch. nivalis	*3*	*7*	6	6
M. agrestis/arvalis	2	5	2	2
M. liecht./subterr.			4	6
Apodemus sp.			3	11
G. glis			0	1
SKUPAJ / TOTAL	11	46	22	68
Vol. sedimenta / Vol. of sedim. (dm^3)	22		3.75	

V luči navedenega tako edino zares relevantno razliko med obravnavanima gradivoma predstavlja nekoliko višji delež frugivorov v vzorcu iz leta 2006. Ugotovitev bi bila namreč lahko argument v prid domnevi o vendarle nekoliko pomembnejši zastopanosti listavcev v gozdni vegetaciji iz rahlo toplejših faz zadnjega glaciala, kot je bilo to mogoče sklepati na podlagi doslej znanih podatkov (*cf.* Toškan, Kryštufek 2007). Navadni polh je bil tako zastopan v plasteh 10 in 11, še številčnejše pa so bile najdbe rumenogrle miši (*tab. 8*). Ker sta obe navedeni vrsti odvisni od plodonosnih listavcev, v čistih sestojih iglavcev ne moreta preživeti. Ob tem je pomembno, da paleobotanične najdbe iz navedenih plasti zajemajo tudi pelod in/ali oglje jesena, jerebike, javorja, topola/vrbe, gabra, jelše in celo bukve (Šercelj, Culiberg 1991, tab. 1–2; Culiberg 2007, tab. 8.1), kar le še dodatno potrjuje izmenjevanje mrzlih stadialov in toplih interstadialov tudi v uvodnem delu kronocone OIS 3 (*cf.* Turk 2007a, 160 s).

Seveda pa v kontekstu interpretacije zgornjih odstopanj ne gre pozabiti na običajne težave, povezane z nizko časovno resolucijo (*cf.* Turk 2007b, 435) in domnevnim premikanjem najdb v sedimentu (*cf.* Culiberg 2007, 171). Nadalje velja upoštevati, da so bile osrednji dejavnik kopičenja ostankov mikrofavne v Divjih babah I sove. To namreč pomeni, da sestava vzorcev med drugim odseva tudi preferenco plenilca do posameznih kategorij plena, njuno starost ter intenzivnost raztapljanja kosti uplenjenih živali v prebavnih sokovih sov (glej npr. Andrews 1990; Chaline *et al.* 1995).

NEODVISNI KAZALNIKI NEKDANJEGA OKOLJA

Tradicionalni paleontološki pristop k paleookoljskim študijam temelji na preslikavi ekoloških toleranc današnjih populacij posameznih vrst na konspecifične populacije iz preteklih obdobij. Ker pa so se sesalci sposobni prilagoditi različnim okoljem, ni nikoli mogoče z gotovostjo vedeti, ali niso nemara v preteklosti poseljevali (tudi) drugačnih habitatov (npr. Musil 1985; Bützler

deciduous trees in the then forest vegetation during slightly warmer phases. Teeth of the edible dormouse were found in layers 10 and 11, with those of yellow-necked mouse being even more numerous (*Tab. 8*). Both species depend on seeds, fruits and similar soft, nutritional foods and cannot survive in pure conifer stands. It is thus significant that palaeobotanical finds in these layers include pollen and/or charcoal of ash, whitebeam, maple, poplar and/or willow, hornbeam, alder and even beech (Šercelj, Culiberg 1991, Tabs. 1, 2; Culiberg 2007, Tab. 8.1), confirming that even the initial part of the chronozone OIS 3 is composed of both cold stadials and warmer interstadials (*cf.* Turk 2007a, 163 f).

When addressing the “whys and wherefores” of the above presented differences between the two studied assemblages originating from facies B, one should also consider the usual problems of low temporal resolution (*cf.* Turk 2007b, 453) and putative mobility of the finds in the sediment (*cf.* Culiberg 2007, 181). In addition to this, the fact that owls were evidently responsible for the bulk of accumulated bones and teeth should also be taken into account. This means that the composition of samples reflects, among others, preferences of the predator towards various prey categories, the age of both predator and prey, the differential solubility of various prey items during digestion etc. (see e.g. Andrews 1990; Chaline *et al.* 1995).

INDEPENDENT PALAEOENVIRONMENTAL INDICATORS

The traditional paleontological approach to paleoenvironmental studies is based on the projection of the ecological tolerance of recent populations of various species to conspecific populations from past periods. Nevertheless, since mammals are capable of adapting to various environments, they may have inhabited different habitats in the past to those in which they live

1986; Van Kolfschoten 1995; Phoca-Cosmetatou 2002). Za gamsa je bilo tako npr. ugotovljeno, da je v poznem glacialu na območju južne Hercegovine naseljeval tudi nealpinska območja, kot je npr. lokalni ekvivalent t. i. “jeznega” krasa (*“angry” karst*; Miracle, Sturdy 1991). Dodaten dokaz za ekološko prilagodljivost gamsa pa je ne nazadnje tudi njegova nedavna znatna širitev na gozdnata območja (t. i. ekotip gozdnega gamsa; Pedrotti, Lovari 1999). Nič boljši kazalnik nekdanjega okolja ni volk. Čeprav danes v Evropi naseljuje predvsem prostrane gozdnate pokrajine in gorovja, ga lahko najdemo tudi na barjanskih območjih, goličavah in v tundri (Sulkava, Pulliainen 1999).

Za rekonstrukcijo nekdanjih okolij je izmed štirih vrst velikih sesalcev, ki so zajeti v obravnavanem vzorcu iz Divjih bab I, najbrž še najprimernejša kuna zlatica. Gre namreč za vrsto, ki se izogiba negozdnim habitatom. Njeno zastopanost v več sedimentacijskih nivojih v skupku plasti 8/10–13 bi lahko torej razumeli kot razmeroma zanesljiv kazalnik obstoja listopadnih in/ali iglastih gozdov v bližini Divjih bab I tako v zaključku kronocone OIS 5a kot v začetnem delu OIS 3 (morda pa celo tudi ob koncu OIS 4; *cf.* Turk 2007a,160). Ugotovitev je pomembna, saj se v celoti ujema z rezultati paleobotaničnih analiz (Šercelj, Culiberg 1991; Culiberg 2007) ter analiz zgoraj predstavljenega vzorca malih sesalcev. Je pa v zvezi s tem vendarle treba opozoriti, da je praviloma na gozd vezano kuno zlatico na zahodnem Irskem ter na Balearih mogoče najti tudi v grmičasti pokrajini, ki jo drugje sicer naseljuje tu manjkajoča kuna belica (Bright 1999). V izboru habitata obeh navedenih vrst torej očitno pomembno vlogo igra tudi kompetitivno izključevanje. Glede na tezo o kuni belici kot holocenskem prišleku v (srednji) Evropi se torej navezava kune zlatice na gozdne habitate za obdobje mlajšega pleistocena vendarle ne zdi več povsem samoumevna.

JAMSKI MEDVED

Iz podatkov o razširjenosti jamskega medveda bi težko sklepali na pretekle klimatske spremembe, saj je bila vrsta na večjem delu svojega območja razširjenosti prisotna tako v glacialnih kot tudi v interglacialnih razmerah (*cf.* Kurtén 1976, 47 ss). Je pa iz najdb te izumrle zveri na nekdanje podnebje domnevno mogoče sklepati nekoliko bolj posredno, tj. preko vedenjskih vzorcev (*cf.* Kurtén 1976, 47 ss) in diahronih nihanj v telesni velikosti (npr. Germonpré, Sablin 2001; Toškan 2007b, 386 ss). Slednjega žal v danem primeru ni bilo mogoče spremljati, saj je razpoložljiv vzorec najdb iz leta 2006 za kaj takega preskromen, je pa bil na drugi strani pridobljen vsaj podatek o deležu samcev in samic med ohranjenimi podočniki in dlančnicami.

Po ugotovitvah Toškana (2006, 152 ss) naj bi podnebne razmere odločilno vplivale na intenzivnost

today (e.g. Musil 1985; Bützler 1986; Van Kolfschoten 1995; Phoca-Cosmetatou 2002). This seems to have occurred with chamois *Rupicapra rupicapra* (Linnaeus, 1758), which was shown locally to have inhabited also non-alpine environments as was the case with the Late Glacial equivalent of “angry karst” in southern Herzegovina (Miracle, Sturdy 1991). The recently occurring substantial dispersal of this species into forested areas (forest chamois ecotype; Pedrotti, Lovari 1999) further demonstrates its ecological adaptability. No better indicator of past environments is the wolf *Canis lupus* Linnaeus, 1758. Namely, although in present-day Europe it occurs mainly in the wide open woodlands and mountains, it can be found also in large bog areas, fells and tundra (Sulkava, Pulliainen 1999).

As far as palaeoenvironmental reconstructions are concerned, of the four large mammal species represented in the here studied assemblage from Divje babe I the most indicative seems to be the pine marten *Martes martes* (Linaeus, 1758), known for its avoidance of non-forest habitats (*cf.* Bright 1999). The presence of the pine marten in several of the sedimentation levels within the complex of layers 8/10–13 is thus to be considered as a rather reliable indicator of the existence of broad-leaved and/or coniferous forest habitats in the vicinity of Divje babe I, both during the final stages of OIS 5a and the initial part of OIS 3 (possibly even the final stage of OIS 4; *cf.* Turk 2007a,163). Such a claim is noteworthy for it is perfectly in line with the results of palaeobotanical analyses (Šercelj, Culiberg 1991; Culiberg 2007) as well as with what has been inferred from the above presented small mammal assemblage. Still, it is worth noting that in western Ireland and the Balearics the otherwise forest-dwelling pine marten occurs also in shrub, that elsewhere would be occupied by the here missing beech marten (Bright 1999). It may thus well be possible that the choice of habitat in these two species is significantly linked to niche release. In view of the supposition that the latter species is a Holocene newcomer to (Central) Europe, the dependence of *M. martes* on forest habitats during the Late Pleistocene might thus not have been complete after all.

THE CAVE BEAR

Far from being a good indicator species of climate change, given its persistence over most of its areal in both glacial and interglacial conditions (*cf.* Kurtén 1976, 47 ff), the cave bear might still be indicative of past climate through its size (Toškan 2008) and ethology (e.g. Germonpré, Sablin 2001; Toškan 2007b, 398 ff) rather than its distribution. While in the case of the material revealed by the 2006 campaign a detailed study of diachronic variations in body size was rendered impossible by the relatively modest number of collected measurable bones per facies, a large enough medspolnega tekmovanja za zimske brloge. Tako naj bi splošno poslabšanje klime (kot je bilo npr. tudi na prehodu iz OIS 5a v OIS 4) skupaj z bolj izraženo sezonsko razpoložljivostjo hrane vplivalo na relativno povečanje števila samcev, ki so prezimovali v jamah s podobno lego in velikostjo kot Divje babe I, in to na škodo samic. V tej luči relativno višji delež njim pripisanih najdb v gradivu iz faciesa C (tj. OIS 5a) v primerjavi s faciesom B (OIS 4? in OIS 3; *tab. 4*) ne bi smel biti presenetljiv. Navsezadnje se takšno stanje lepo ujema tako z izsledki študije ostankov jamskega medveda iz predhodnih izkopavanj (Jambrešić, Turk 2007, sl. 16.4; Toškan 2006, 152 ss 2007b, 386 ss; 2007c, 358) kakor tudi z zgoraj predstavljeno paleoklimatsko rekonstrukcijo, ki temelji na najdbah malih sesalcev.

Rezultati statističnega testiranja so pokazali, da razlika med tukaj predstavljenima (*tab. 4*) spolnima strukturama jamskih medvedov iz obeh obravnavanih kronocon ni statistično značilna, kar pa se pravzaprav niti ne zdi problematično. Takšen rezultat gre namreč po vsej verjetnosti pripisati skromnosti razpoložljivega vzorca. Navsezadnje je bil višji delež samcev med primerki iz faciesa B ugotovljen tako pri podočnikih kot tudi pri dlančnicah, kar seveda zavrača možnost naključja. Poleg tega so podatki v *tabeli 4* do neke mere problematični, saj razmejitev med faciesoma B in C ni popolnoma ostra (Turk 2007c, sl. 1.4). V luči navedenega je seveda uvrstitev podočnikov in dlančnic iz mejnih stratigafskih nivojev 33 in 34 v enega od obeh faciesov do neke mere arbitrarna. V tem smislu se zdijo tako zelo izpovedni rezultati primerjave obeh spolnih struktur, pri kateri primerki iz stratigrafsko problematičnih mejnih sedimentacijskih nivojev niso bili upoštevani (*tab. 5*). Razlika med medvedjima vzorcema iz obeh faciesov postane namreč ob takšnem pristopu še očitnejša in skoraj že dosega mejo statistične značilnosti.

SKLEP

Izrazito interdisciplinarno zastavljeno raziskovanje Divjih bab I ponuja dobre možnosti za kombiniranje paleoklimatskih (paleookoljskih) približkov, temelječih na posameznih najdbah malih sesalcev, s tistimi, ki izhajajo iz drugih paleontoloških, paleobotaničnih in sedimentoloških podatkov. Čeprav ujemanje med posameznimi skupinami najdb kot nosilk informacij ni vedno popolno, pa sama umestitev meje med toplo in suho klimo na eni strani ter mrzlo in vlažno na drugi v obdobje med 70 in 80 tisoč leti pred sedanjostjo[10] ne bi smela biti vprašljiva. Pri tem relativna števičnost na odprte habitate vezanih malih sesalcev (*tab. 7–8*) in peloda trav (Šercelj, Culiberg 1991) v plasteh pod navedeno razmejitvijo priča o prevladi travnatih in

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[10] Stratigrafsko je ta meja postavljena na stik med nivojema 33 in 34 (oz. med plastema 12 in 12/13).

number of sexed metacarpals and canines allowed for the sex ratio to be assessed.

These data are important since the severeness of the climatic conditions is supposed to have influenced the intensity of intersexual competition for winter lairs in the way that the general deterioration of the weather (such as the one occurring at the transition of OIS 5a to OIS 4) together with the increased seasonality of food availability resulted in relatively more males hibernating in caves of the size and position of Divje babe I at the expense of females (Toškan 2006, 152 ff). A more female biased sex ratio observed in the material from facies C (i.e. OIS 5a) relative to facies B (OIS 4? and OIS 3; *Tabs. 4-5*) is thus not to be seen as surprising. After all, it perfectly conforms to the situation observed while studying cave bear remains revealed by earlier excavations (Jambrešić, Turk 2007, Fig. 16.4; Toškan 2006, 152 ff; 2007b, 398 ff; 2007c, 364) as well as to the palaeoclimatic reconstruction based on the small mammal assemblage (see above).

The here (*Tab. 4*) observed difference in the sex ratio estimates not reaching the level of statistical significance is not to be viewed as problematic, since it is most probably an artefact of small sample size. After all, a larger share of males in facies B relative to facies C has been observed in both canines and metacarpals, which speaks against it being fortuitous. Moreover, the results shown in *table 4* are partially corrupted by the fact that the boundary between facies B and C is obviously not perfectly sharp (Turk 2007c, Fig. 1.4), making the attribution of canines and metacarpals originating from interfacial boundary sedimentation levels 33 and 34 to each of the two facies partially arbitrary. It seems thus to be worth noting that the difference emerging from the comparison between facies B and C, from which the remains found in the latter two levels were not taken into account, are indeed substantially more pronounced (*Tab. 5*).

CONCLUSION

The all-round manner to deal with the Divje babe I cave site provides a good opportunity to combine palaeoclimatic (palaeoenvironmental) approximations based on individual remains of mammal microfauna to those emerging from other palaeonotological, palaeobotanical and sedimentological data. Although individual groups of finds as a source of information are not always synchronized, the setting of the boundary between moderate and cold climate, between dry and humid ones, in the period between 70,000 and 80,000 years ago[10] does not seem to be questionable. Below this boundary the relative abundance of small mammals

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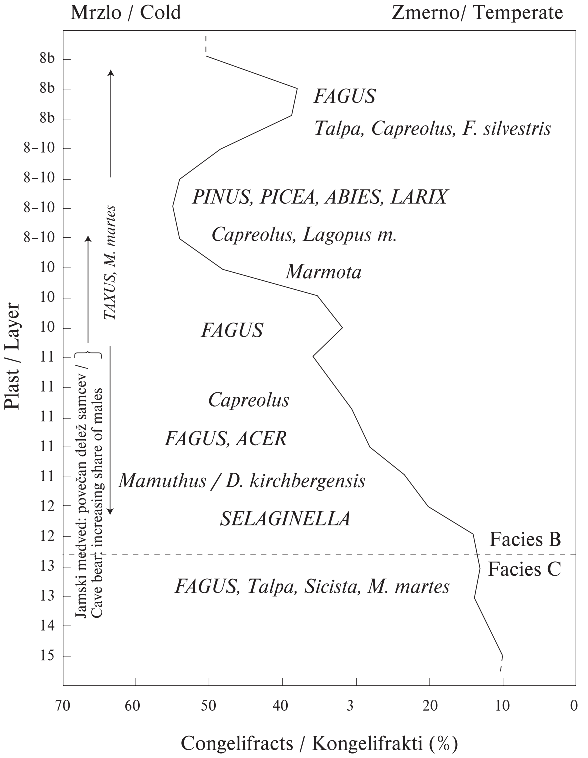
[10] Stratigraphically this boundary is set at the contact of sedimentation levels 33 and 34 (i.e. layers 12 and 12/13).



Sl. 10: Korelacija med izbranimi biostratigrafskimi podatki in približki paleotemperature v profilu Divjih bab I, kjer so kot približek nihanja paleotemperature služili podatki o porazdelitvi talnih zmrzlinskih klastov (t. i. kongelifraktov; *cf.* Turk *et al.* 2007, 74 ss). Modificirano po Turk (2007a, sl. 7.3).

Fig. 10: Correlation between selected biostratigraphical data and palaeotemperature proxis in the profile of Divje babe I; for approximation of variation of palaeotemperature soil congelifracts were used (*cf.* Turk et al. 2007, 110 ff). Modified from Turk (2007a, Fig. 7.3).

skalnih habitatov nad gozdnimi. Temu najbrž niso botrovale nizke temperature[11], ampak sušnost. Prehod v vlažnejšo klimo v sklepnem delu OIS 5a izpričujejo sedimentološki podatki (Turk *et al.* 2007, sl. 5.6.1) pa tudi prisotnost rovk iz rodu *Sorex*, travniške voluharice in frugivornih glodalcev (*G. glis*, *A. lavicollis*). Pri tem najdbe navadnega polha in rumenogrle miši kažejo na prisotnost listavcev, kar so potrdili tudi izsledki paleobotaničnih raziskav (*Fagus*; *sl. 10*).

Nastop mrzle faze na samem začetku srednjega würma dokazujejo najdbe spor alpske drežice (*Selaginella selaginoides*) kot značilnega arktoalpinskega elementa, na padec temperatur pa kažejo tudi sedimentološki podatki (*sl. 10*). Navedenemu mrzlemu dogodku je sledilo obdobje z nekoliko milejšo klimo, o čemer pričajo najdbe vrst *G. glis*, *A. flavicollis* in *T. europaea* kot tudi bukve in javorja. Naslednjo, nekoliko izraziteje mrzlo fazo označujejo najdbe peloda in oglja skoraj izključno iglavcev (bora, smreke, jelke, macesna) kakor tudi prisotnost ostankov snežnega jereba (*Lagopus mutus*) in svizca (*Marmota marmota*) v plasti 8–10. Omembe vredne so tudi najdbe srne (*Capreolus capreolus*), ki kažejo na zgolj zmerno debelino snežne odeje[12] navkljub sicer očitnemu povečanju vlažnosti v OIS 3 glede na OIS 5. Vlažnejšo klimo dokazujejo tudi sedimentološki (Turk *et al.* 2005), paleobotanični[13] in paleontološki[14] podatki. Prav tako bi lahko v to smer kazal večji delež podočnikov in dlančnic samcev jamskega medveda iz faciesa B glede na stanje iz faciesa C (*cf.* Toškan 2006), kar tudi lahko pripišemo prav obilnejši in dlje časa trajajoči snežni odeji. V takšnih razmerah so namreč živali obeh spolov v fazo hibernacije prehajale bolj ali manj sočasno, kar

depending on open habitats (*Tabs. 7-8*) as well as of herbaceous pollen (Šercelj, Culiberg 1991) indicates the prevalence of grassland and rocky habitats over forests. Such an environment was unlikely a consequence of low temperatures[11] but possibly reflects an arid climate. The transition to a more humid phase is evidenced by sedimentological data (Turk *et al.* 2007, Fig. 5.6.1) as well as by the presence of *Sorex* shrews, *M. agrestis* and frugivorous rodents (*G. glis*, *A. flavicollis*) at the end of OIS 5a. The edible dormouse and the yellow-necked mouse are indicative of the presence of deciduous trees, which is confirmed also by palaeobotanical data (*Fagus*; *Fig. 10*).

The transition to the cold phase at the beginning of the Middle Würm is marked by spores of a typical arctoalpine element as is the lesser club moss *Selaginella selaginoides*. Lower temperatures are indicated also by sedimentological data (*Fig. 10*). This cold event is followed by an improved climate marked by finds of *G. glis*, *A. flavicollis*, *T. europaea* as well as *Fagus* and *Acer*. The following, more explicitly cold phase is characterised by pollen and charcoal of almost exclusively conifers (pine, spruce, fir, larch) as well as by the finds of rock ptarmigan *Lagopus mutus* and marmot *Marmota marmota* in layer 8–10. Noteworthy is the presence of roe deer *Capreolus capreolus* indicating a moderate thickness of

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[11] Glej prisotnost krta ter klimatsko-kronološko shemo, temelječo na sedimentoloških podatkih (sl. 10).

[12] Opazovanja srnjadi na Norveškem so pokazala, da ta neko lokacijo sezonsko zapusti, še preden pride do odložitve trajne snežna oddeje. Pri tem se zadnje živali praviloma umaknejo takrat, ko višina snežne oddeje preseže 50 cm (Mysterud 1999, 483).

[13] Glej prisotnost tise v celotnem obdobju OIS 3 (*sl. 10*).

[14] Izpovedni sta relativna pogostnost vrste *M. agrestis* v primerjavi z *M. arvalis* in prisotnost rovk iz rodu *Sorex* (glej zgoraj).

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[11] Note the presence of a mole and the climate-chronological scheme based on selected sedimentological data (*Fig. 10*).

je seveda značilno povečalo medspolno tekmovanje za potencialne jamske brloge. In ker so se samice pri iskanju prezimovališča samcem praviloma izogibale, je opisana zaostritev klime v tem pogledu najbrž favorizirala samce.

Navedeni mrzli fazi za časa nastajanja plasti 8–10 je sledila otoplitev, izpričana z najdbami oglja bukve in drugih listavcev ter krta, divje mačke in srne v plasti 8b. Ker pa so bili v tem obdobju nastali sedimenti na območju izkopnega polja iz leta 2006 odstranjeni že med izkopavanji s konca 90. let prejšnjega stoletja, interpretacija živalskih ostankov iz navedene plasti presega namen tega prispevka.

snow cover,[12] despite the climate in OIS 3 being damper relative to OIS 5. The increase of humidity is evidenced by sedimentological (Turk *et al.* 2005), as well as palaeobotanical[13] and palaeontological[14] data. Moreover, the greater share of male cave bear remains originating from facies B relative to those from facies C might also be indicative of damper climates (*cf.* Toškan 2006). With more abundant and longer-lasting snow cover, males supposedly anticipated their entrance into hibernation to match those of pregnant females, thus significantly increasing intersexual competition for appropriate lairs. Since the latter most probably avoided solitary males when choosing a lair, the onset of climatically severe conditions favoured males.

A new warming following the cold event documented in layer 8–10 is indicated by charcoal of beech and other deciduous trees as well as by the finds of mole, wildcat and roe deer in layer 8b. Nevertheless, since sediments deposited during this phase were removed already by the excavation campaigns of the 1990's, the interpretation of the faunistic remains originating from that layer falls beyond the scope of this paper.

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[12] Roe deer in Norway have been observed to seasonally migrate from a location well in advance of a permanent snow cover, with the latest animals migrating typically when snow depth exceeded 50 cm (Mysterud 1999, 483).

[13] Note the presence of yew throughout OIS 3 (*Fig. 10*).

[14] Indicative is the relative abundance of *M. agrestis* relative to *M. arvalis* as well as the presence of *Sorex* shrews (see above).

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BEARS AND SEDIMENTS AT CAVERNA DEGLI ORSI/ MEDVEDJA JAMA (TRIESTE, ITALY)

MEDVED IN SEDIMENTI V MEDVEDJI JAMI (TRST, ITALIJA)

Giovanni BOSCHIAN, Annamaria DE SANTIS

Abstract

Geoarchaeological studies carried out on the sequence of Caverna degli Orsi/Medvedja jama (Trieste, Italy), corroborate the hypothesis – based on biostratigraphy – that the deposit formed in the time span between the end of the last Interglacial (MIS 5) and the end of the early-middle Pleniglacial (MIS 4). The studied sequence includes ceiling breakdown deposits, loess, debrisfall/ debrisflow, and organic phosphates deriving mainly from the decay of cave bear bones.

Keywords: Cave, sedimentology, soil micromorphology, cave bear, Late Pleistocene, Mousterian, Italy

INTRODUCTION

The environmental change and its relationships with the faunal and human inhabitation during the early Late Pleistocene are poorly known in the Trieste Karst, where very few sites with remains of this age were found and excavated. Unfortunately, no palaeoenvironmental data are available about these sequences, which were completely excavated or even destroyed in the past, and are now unavailable for further studies.

Recent excavations carried out at Caverna degli Orsi/Medvedja jama – a typical cave bear den – brought to light a sequence that can be ascribed to the early Pleniglacial-middle Pleniglacial (MIS 5-4), and which is at present the only "long" succession of this age that

Izvleček

Geoarheološke raziskave sedimentov v Medvedji jami pri Trstu (Italija) so potrdile predhodno hipotezo o starosti sedimentov, ki je temeljila na biostratigrafskih podatkih. Sedimentacija je potekala v času med koncem zadnjega interglaciala (MIS 5) in koncem zgodnjega do srednjega pleniglaciala (MIS 4). Preučevano sedimentno zaporedje sestoji iz podornega grušča, ki se je krušil z jamskega oboda, puhlice, pobočnega (podornega) grušča iz zunanjega okolja, iz debrita (sediment drobirskega toka) in organskega fosfata, katerega vir so predstavljale kosti, ki so trohnele v jami.

Ključne besede: jama, sedimentologija, mikromorfologija jamskih paleotal, jamski medved, pozni pleistocen, musterjen, Italija

UVOD

Okoljske spremembe v poznem pleistocenu na območju Tržaškega krasa in njihov vpliv na tamkajšnje živalstvo ter ljudi so malo znane, saj so bila na tem območju odkrita in izkopana le redka arheološka najdišča iz obravnavanega obdobja. Žal ne razpolagamo z nikakršnimi paleookoljskimi podatki iz teh jam. Sedimenti so bili namreč v preteklosti v celoti izkopani ali celo uničeni. Nadaljnje analize zaradi tega niso možne.

Nova izkopavanja Medvedje jame (tipičnega prezimovališča jamskega medveda v pleistocenu) so omogočila preučevanje sedimentov, ki jih pripisujemo zgodnjemu do srednjemu pleniglacialu (MIS 5–4). Za zdaj je to edino dovolj obsežno sedimentno zaporedje te

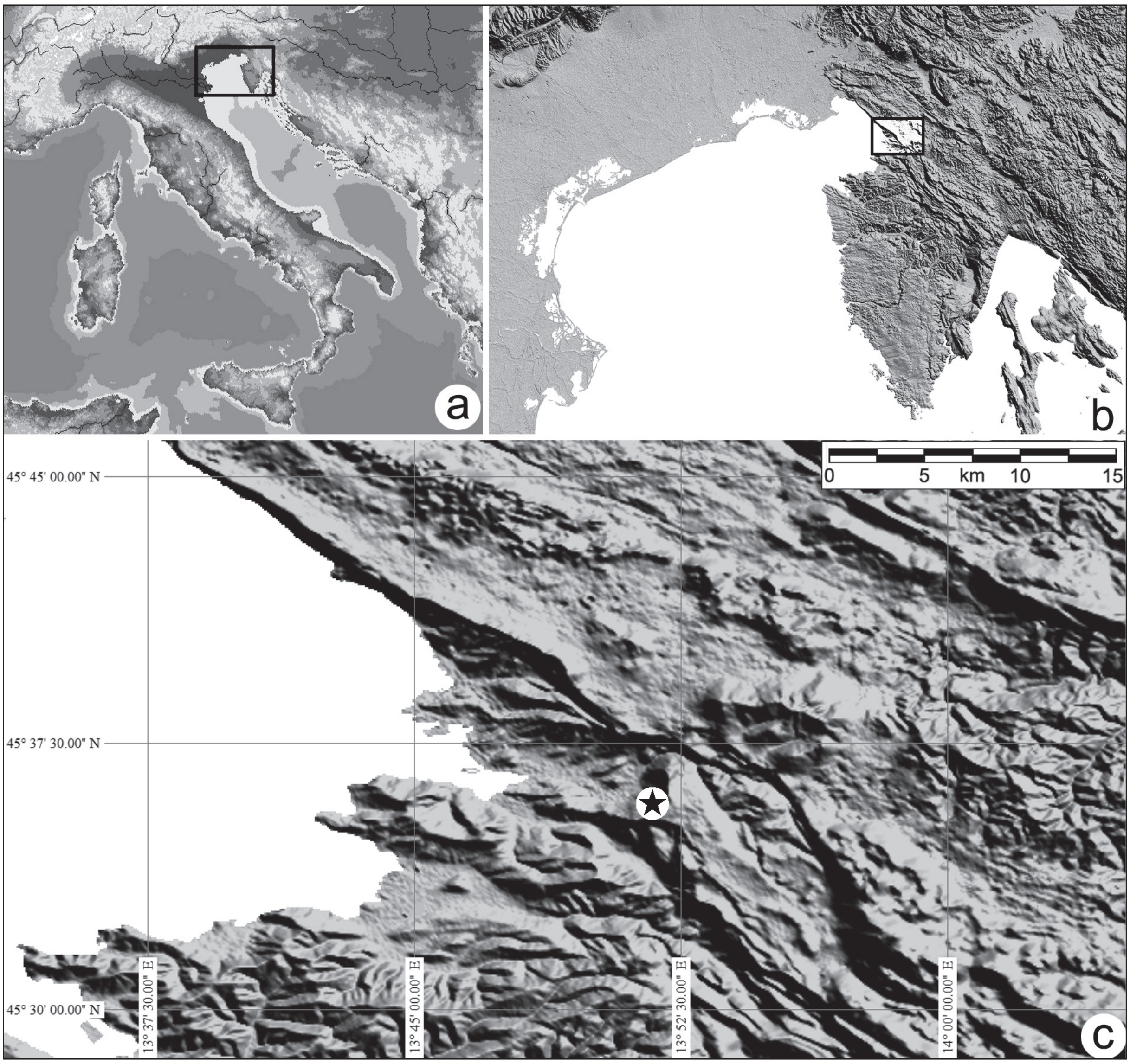


Fig. 1: Location map: a – general situation of the Northern Adriatic region; b – physical map of the Northern Adriatic region; c – DTM of the area surrounding Caverna degli Orsi/Medvedja jama; star – cave location.
Sl. 1: Geografska karta z lokacijo jame: a – jama se nahaja v severnem delu Jadranske regije; b – topografski načrt severno Jadranske regije; c – digitalna topografska karta širše okolice Medvedje jame. Zvezdica označuje natančno lokacijo jame.

can be studied from the palaeoenvironmental point of view in the Karst area (Boschian 1993; Boschian 1998). Moreover, the occurrence of Mousterian stone tools within some levels (Boschian 1999-2000) extends the relevance of the study of this cave to an anthropological and human behavioural perspective.

The aim of this work is to understand the processes that formed the cave infilling, in pursuit of a palaeoenvironmental reconstruction. Stratigraphic, sedimentological and soil micromorphological studies were carried out on the cave sediments, in order to elucidate the relationships between the lithological units, and to evaluate the environmental, or possibly anthropic factors that controlled the palaeo-sedimentary processes;

starosti na Krasu, na podlagi katerega lahko sklepamo na paleookoljske spremembe v času njihovega odlaganja (Boschian 1993; Boschian 1998). V določenih sedimentacijskih nivojih so bila najdena musterjenska kamnita orodja (Boschian 1999–2000), zatorej so raziskave v Medvedji jami pomembne tudi z antropološkega vidika.

Namen članka je razložiti dejavnike, ki so vplivali na odlaganje sedimentov, oziroma rekonstruirati paleookoljske razmere v času njihovega odlaganja. Jamski sedimenti so bili analizirani stratigrafsko in z različnimi sedimentološkimi metodami, nadalje smo preučevali tudi mikromorfološke oblike v nekdanjih jamskih tleh. Namen teh raziskav je bil ugotoviti odnose med različnimi litološkimi enotami in oceniti okoljske

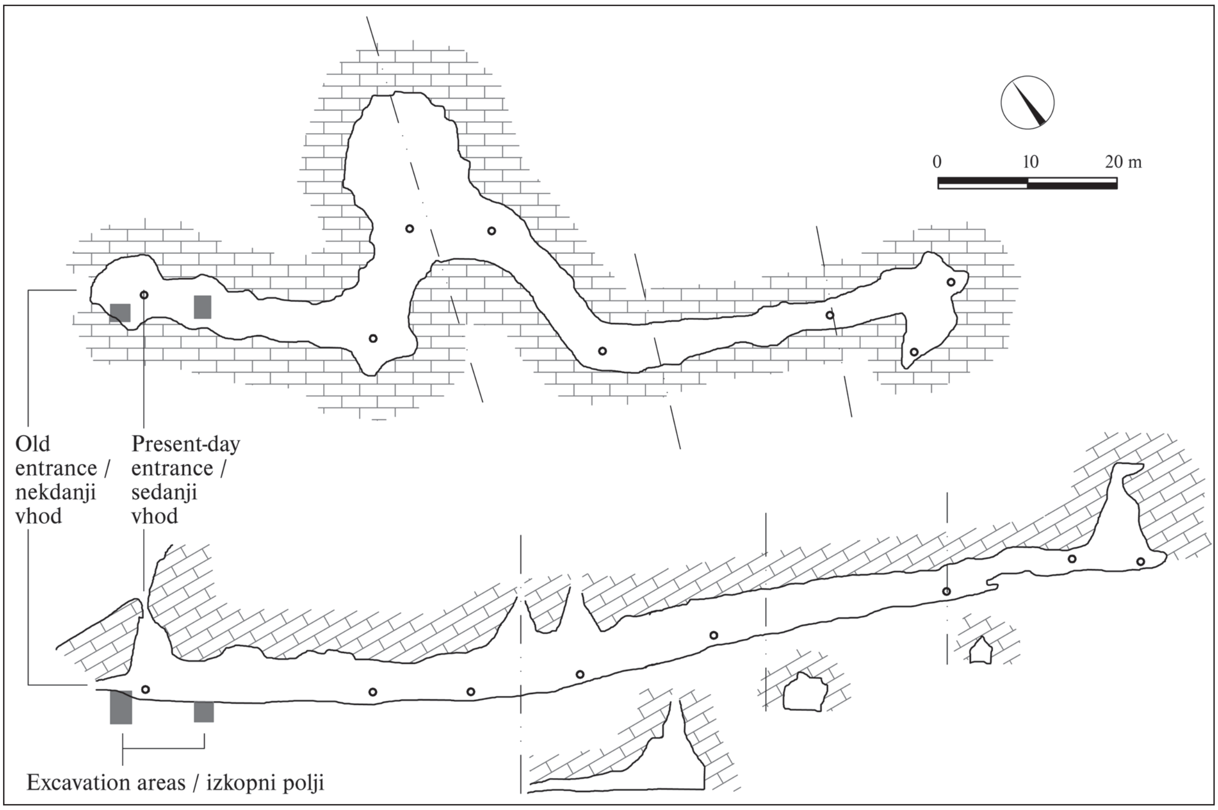


Fig. 2: Caverna degli Orsi/Medvedja jama. Cave map and profiles, with localisation of sondages and profiles.
Sl. 2: Načrt (tloris in profil) Medvedje jame z označenima lokacijama obeh sond .

special attention has been paid to the influence of bear activities on the sediments of the cave.

SITE PRESENTATION

Caverna degli Orsi is situated near S. Dorligo della Valle/Dolina in the Trieste Karst, at 360 m a.s.l. on the steep north-western side of Monte Carso/Mali Kras, on the left of the Rosandra/Glinščica stream (*Fig. 1*); calcareous rocks – Calcari a Miliolidi, Calcari a Nummuliti ed Alveoline (Carulli, 2006) – of Palaeocene-Early Eocene age crop out in the area.

The cave is a sinuous tunnel, about 140 m long and 4-10 m wide, and the height of the ceiling ranges between 1 and 8-10 m. The pavement is subhorizontal in the outer half of the cave, while it climbs gently, with some steeper steps, towards the inner part of the tunnel (*Fig. 2*).

The present-day entrance is situated on a narrow terrace at the base of a cliff corresponding to a fault. In fact, this entrance is an 11 m deep vertical passage that was found by cavers during systematic surveys in the area (Baldi 1994), while the original one is at present completely buried by a debrisfall deposit that covers a wide area of the mountain side.

ali morebitne antropogene dejavnike, ki so vplivali na paleosedimentacijske procese. Jamski sedimenti so bili lahko prizadeti tudi zaradi aktivnosti jamskih medvedov, na to dejstvo smo bili še posebno pozorni.

OPIS NAJDIŠČA

Medvedja jama leži v bližini naselja Dolina (S. Dorligo della Valle) na Tržaškem krasu, natančneje na severozahodnem pobočju vzpetine Mali kras (Monte Carso), levo od potoka Glinščica (Rosandra) (*sl. 1*). Nadmorska višina jamskega vhoda je 360 m. To območje gradijo apnenci paleocenske do starejše eocenske starosti. Apnenci so miliolodni in alveolinsko-numulitni (Carulli 2006). Jama je dolga 140 m, široka 4–10 m, strop je med 1 do 8 oziroma 10 m nad jamskimi tlemi. Jamski rovi so zelo vijugavi. Tla v vhodnem delu jame so skoraj vodoravna, medtem ko se v notranjem rahlo vzpenjajo. Tu je tudi nekaj strmejših talnih pragov (*sl. 2*).

Današnji jamski vhod je na ozki terasi ob vznožju skalnate stene. Vhod pravzaprav predstavlja 11 m globoko brezno, ki so ga odkrili jamarji med sistematičnimi raziskavami širšega območja (Baldi 1994). Prvotni vhod je popolnoma zasut s pobočnim (podornim) gruščem, ki prekriva celotno pobočje vzpetine, v kateri leži jama.

The obstruction of the entrance stopped all clastic sedimentation processes inside the cave – apart from minor ceiling breakdowns – so that only more or less discontinuous speleothem patches developed on the pavement; as a consequence, the features of the cave floor were not buried and their aspect was preserved.

Typical traces of the presence of *Ursus spelaeus* are evident on the floor surface and on the walls: mostly scattered and unarticulated bones, hibernation hollows, scratches and polished rocks (Boschian 1993). Two excavations sondages carried out by the Department of Archaeological Sciences of the University of Pisa brought to light a sequence of levels with bone remains of cave bear and other macro- and micromammalofauna down to a depth of about 4.5 m below the level of the floor (Boschian 1998; Landini 2005); moreover, stone artefacts that can be ascribed to Mousterian industries were found in some levels of both sondages, but the findings are rather scanty and do not allow an accurate attribution of the tool assemblage. As in most cave bear hibernation caves that have also yielded lithic industries, there is no evidence of interaction between bears and humans (Boschian 1999-2000).

MATERIALS AND METHODS

The geoarchaeological study of the sequence of Caverna degli Orsi/Medvedja jama was carried out mostly on the sediments brought to light by two sondages that were excavated inside the cave.

Sondage "A" (*Fig. 3*) – the inner one – was started immediately after the discovering of the cave, and its location was chosen for two basic reasons: a) there were few bone remains lying on the surface floor, and the aims were to assess the size of the bone assemblage in the underlying levels with minimum damage to the surface features; b) the floor was subhorizontal, suggesting that the architecture of the underlying lithological units was reasonably simple. At the end of the excavations, the size of this sondage was 4x2 m, oriented transversally to the tunnel, and about 2.5 m deep.

Sondage "B" (*Fig. 4*) is situated in the outer part of the cave, where the tunnel is obstructed by sediments coming from the outside; it was opened when stone tools were found in "A", mostly because it was presumable that more lithics would have been found in areas closer to the old entrance. It lies at the bottom of the south-western wall, and it is 2.5x2.5 m wide and about 4.5 m deep.

In both sondages, the deposit was divided into lithologic units that were observed and described in 3D during the excavation; the description is based on Catt (1991). The architecture of the units and their stratigraphic relationships were interpreted in relation to the geomorphologic characteristics of the cave.

Zasutje vhoda je preprečilo vse nadaljnje sedimentacijske procese v jami, če zanemarimo manjše krušenje jamskega oboda. Na tleh se je lahko začela bolj ali manj prekinjeno odlagati siga. Talne jamske oblike niso bile zasute, zato se je njihov videz ohranil.

Na jamskih tleh in stenah so ohranjeni značilni sledovi, ki pričajo o prisotnosti jamskega medveda (*Ursus spelaeus*). Večinoma gre za razpršene kosti, ostanke brlogov ter popraskane in zglajene kamne (Boschian 1993). Arheologi z Univerze v Pisi so v jami izkopali dve sondi. Do globine 4,5 m pod jamskimi tlemi so v sedimentni skladovnici odkrili fosilne kosti jamskega medveda ter druge makro in mikro fosilne ostanke različnih sesalcev (Boschian 1998; Landini 2005). V določenih sedimentacijskih nivojih obeh sond so našli tudi kamnita orodja, ki jih glede na tipologijo pripisujejo musterjenski kulturi. Toda najdbe so pičle, zanesljiva določitev kamnitih orodij je zaradi tega problematična. Dokazov o sočasnem bivanju človeka in jamskega medveda v jami ni (Boschian 1999–2000).

GRADIVO IN METODE

Geoarheološka študija Medvedje jame večinoma temelji na sedimentih, ki so jih iz dveh sond izkopali arheologi iz Pise.

Izkopavanje sonde "A" (*sl. 3*), ki je pomaknjena globlje v jamsko notranjost, se je začelo takoj po odkritju jame. Lokacija te sonde je bila izbrana na podlagi dejstva, da je bilo tu na jamskih tleh razmeroma veliko kostnih ostankov. Namen sondiranja je bil določiti obseg kostnega inventarja v sedimentnem zaporedju ob čim manjšem možnem poškodovanju talnih morfoloških oblik. Naslednje dejstvo, ki je vplivalo na lokacijo sondiranja, je bilo, da so tla tu le rahlo nagnjena, kar nakazuje, da je struktura sedimentnega zaporedja razmeroma enostavna. Dimenzije sonde po končanem izkopavanju so bile 4 x 2 m. Sonda je globoka okoli 2,5 m in usmerjena prečno na potek jamskega rova.

Sonda "B" (*sl. 4*) je iz dela jame, ki je bližje nekdanjemu jamskemu vhodu. Tu je jamski rov zapolnjen s sedimenti alohtonega izvora. Za izkop sonde "B" so se odločili po najdbi kamnitih orodij v sondi "A". Domnevali so namreč da bodo tu našli več artefaktov. Sonda "B" je iz vznožja jugozahodne stene, široka je 2,5 x 2,5 m in globoka okoli 4,5 m.

Jamski sedimenti iz obeh sond so bili razvrščeni v več litoloških enot, ki so jih določili med izkopavanjem. Klasifikacija temelji na metodi, določeni po Cattu (1991). Stratigrafsko zaporedje in struktura litoloških enot sta razložena v kontekstu geomorfoloških značilnosti jame.

Vsako litološko enoto smo analizirali granulometrično, analizirali smo tudi vsebnost kalcita. Velikost vzorcev iz različnih litoloških enot ni bila vedno enaka. Delež frakcije, večje od 2 mm, smo določili s pomočjo mokrega

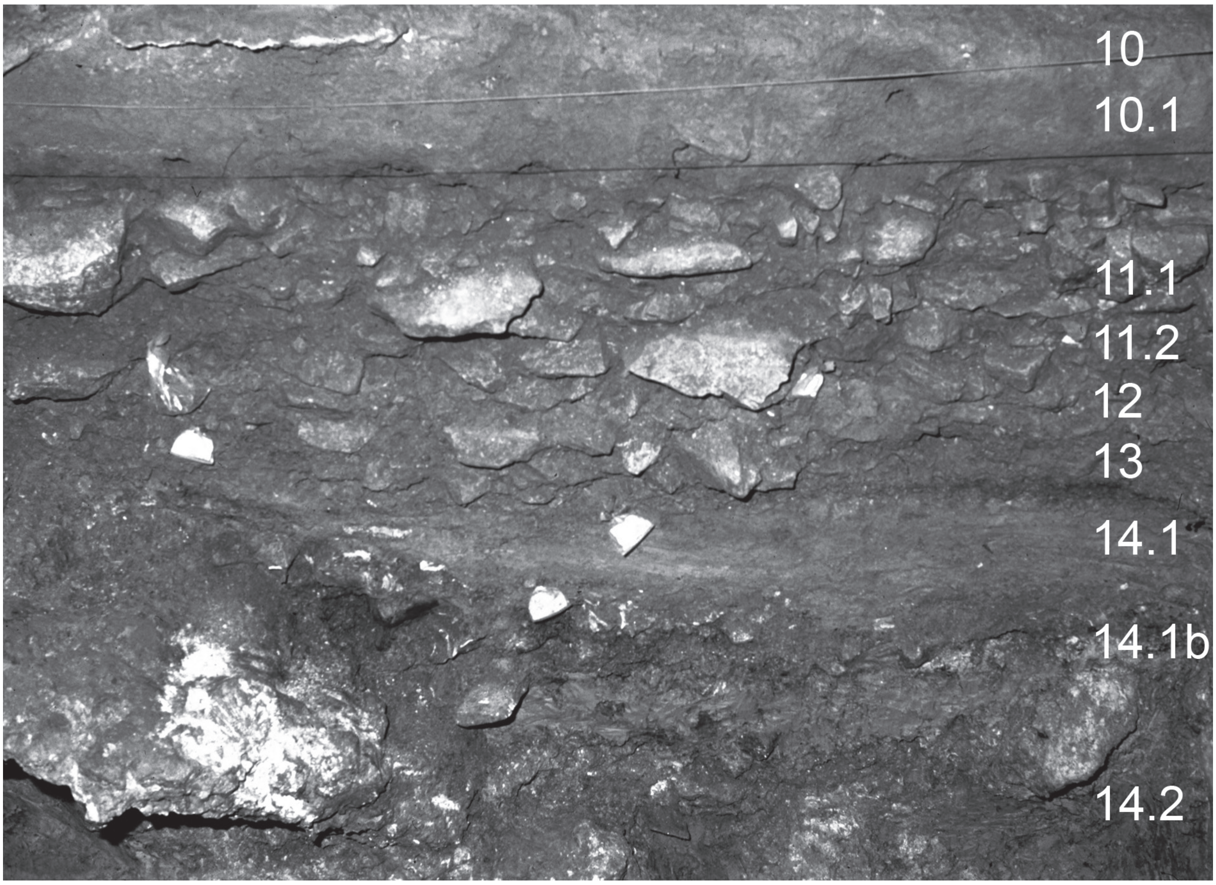


Fig. 3: Caverna degli Orsi/Medvedja jama. Sondage "A". Inclined photograph of part of the NW transverse profile.
Sl. 3: Sonda "A" v Medvedji jami. Fotografija prikazuje del SZ prečnega profila.

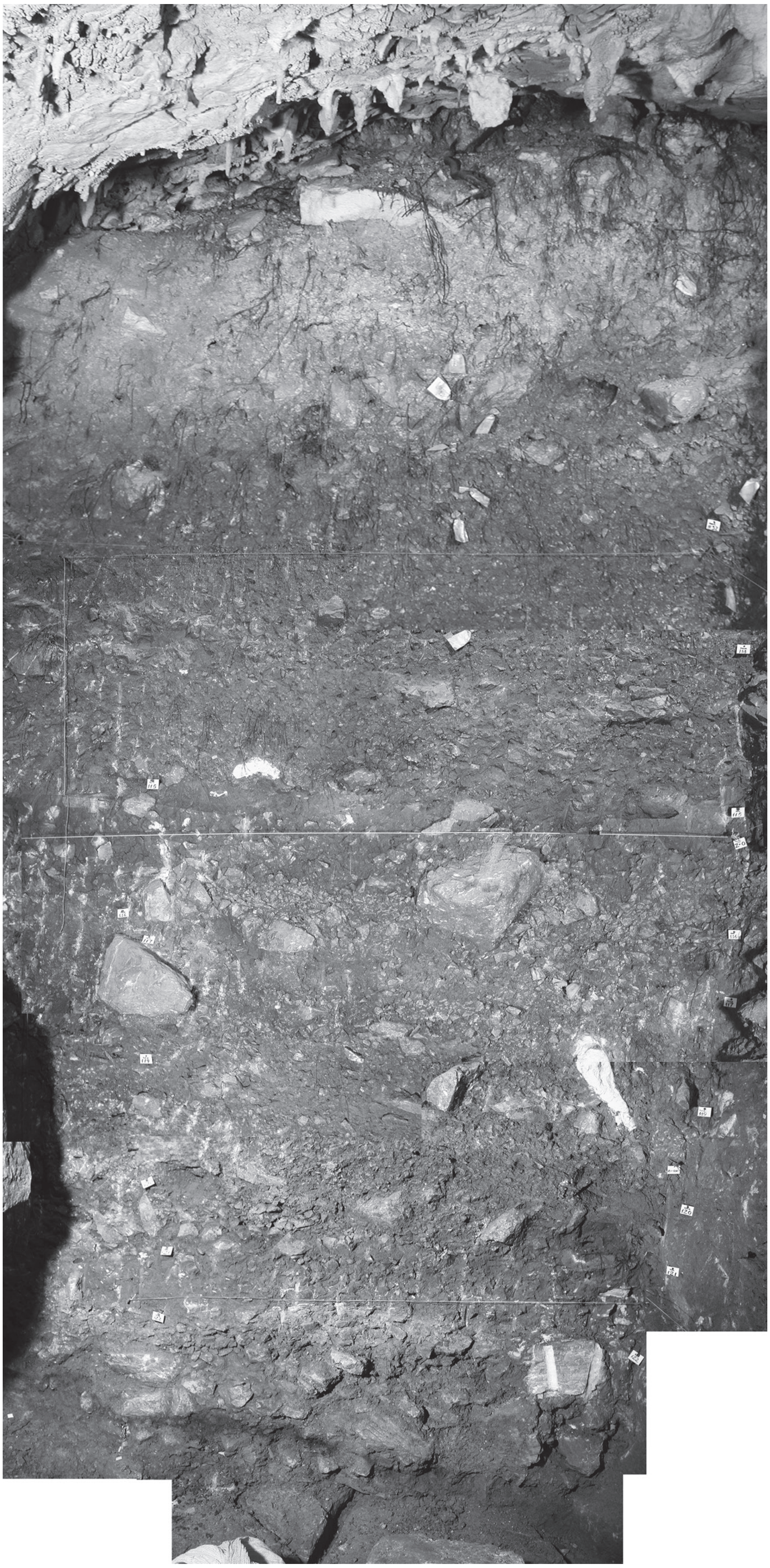
Each lithologic unit was sampled for grain-size and $CaCO_3$ analyses, the size of the bulk sample depending on the grading of the unit. The coarse (> 2 mm) component was measured on the whole sample at 1Φ precision by wet sieving, while aliquots of 50-100 g of the fine component (< 2 mm) were graded at 2Φ by wet sieving for the 2-0.063 mm fraction, and by Bouyoucos aerometer for the < 0.063 mm fraction; grain-size analyses of the fine (< 2 mm) fraction were carried out also on HCl 1N decalcified samples. The fine carbonates were measured by comparison with a pure $CaCO_3$ blank in a Dietrich-Frühling calcimetre, on 0.1-0.2 g aliquots of sediment sieved at 0.5 mm.

Undisturbed sediment monoliths for thin section preparation were also collected, usually one per lithologic unit; the very stony units were not sampled. The monoliths were air-dried at 30 °C in a ventilated oven for 7 days, and then impregnated by low-viscosity acetone-diluted polyester resin under moderate suction; polymerisation was carried out under atmospheric pressure for about 90 days.

The thin sections were cut by a diamond disk and ground to 30 μm by corundum abrasive powders, using petroleum for cooling, and covered by a standard optic

presejanja celotnega vzorca. Natančnost te metode je 1Φ. Frakcija, manjša od 2 mm, se je presejala skozi sita. Ta drobnejši preostanek vzorca (50–100 g) smo nadalje sortirali z mokrim presejanjem (2Φ) na frakcijo 2–0,063 mm in z Bouyoucosovim aerometrom na frakcijo, drobnejšo od 0,063 mm. Granulometrično analizo frakcije, manjše od 2 mm, smo izvedli tudi s pomočjo kisline HCl, vendar samo pri nekarbonatnih vzorcih. Granulometrija drobnozrnatih karbonatov je bila določena na podlagi primerjave 0,1–0,2 g sedimentnega ostanka na sitih 0,5 mm s čistim $CaCO_3$ v Dietrich-Frühlingovem kalciometru.

Iz vsake litološke enote smo vzeli tudi vzorec reprezentativnega intaktnega sedimenta, iz katerega smo izdelali zbrusek za elektronsko mikroskopijo. Litoloških enot, ki so bile zgrajene skoraj v celoti iz podornih blokov in grušča, nismo vzorčili. Vzorce intaktnih sedimentov smo sedem dni sušili na prepihu pri 30 °C. Nato so bili impregnirani z rahlo viskozno poliestrsko smolo, razredčeno z acetonom. Vpijanje vzorcev s tem pripravkom je bilo zmerno. Polimerizacija je potekala pri atmosferskih pogojih, in sicer 90 dni. Preparati so bili odrezani z diamantno žago in brušeni na debelino 30 μm z abrazivnim prahom iz korunda. Hlajeni so bili s petrolejem. Zbruski so bili standardno prekriti z op-



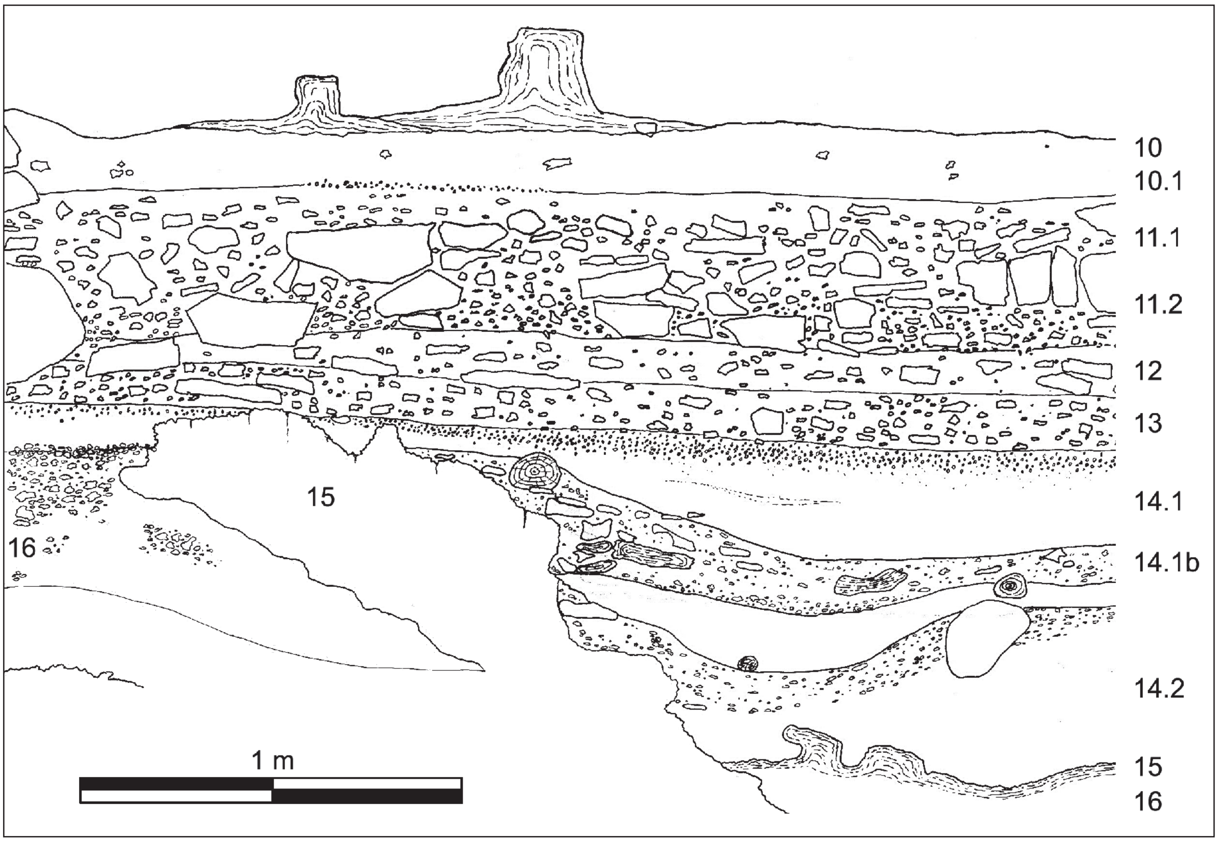


Fig. 5: Caverna degli Orsi/Medvedja jama. Sondage "A". Sketch of the NW transverse profile.
Sl. 5: Sonda "A" v Medvedji jami. Skica SZ prečnega profila.

glass slide. Depending on the monolith size, 90 x 60 mm or 60 x 45 mm thin sections were prepared.

The thin sections were observed under a Leica DM/LP standard petrographic microscope equipped with reflected light and UV/blue epifluorescence kits. The descriptions follow the standard formalised by Bullock *et al.* (1985) and Stoops (2003) for soil thin sections.

SEQUENCE DESCRIPTIONS

Sequence "A" (*Fig. 5*). Unit 16 is the most ancient level brought to light during the excavations, a yellowish to reddish sticky clay occurring also at the bottom of sequence "B"; in this sondage, it was excavated through a thickness of about 30-40 cm, and then bar-probed down to about 1 m without finding its bottom or bring-

tičnim steklom. Velikost zbruskov je bila 90 x 60 mm ali 60 x 45 mm, odvisno od velikosti klasta v sedimentnem vzorcu za pripravo zbruska.

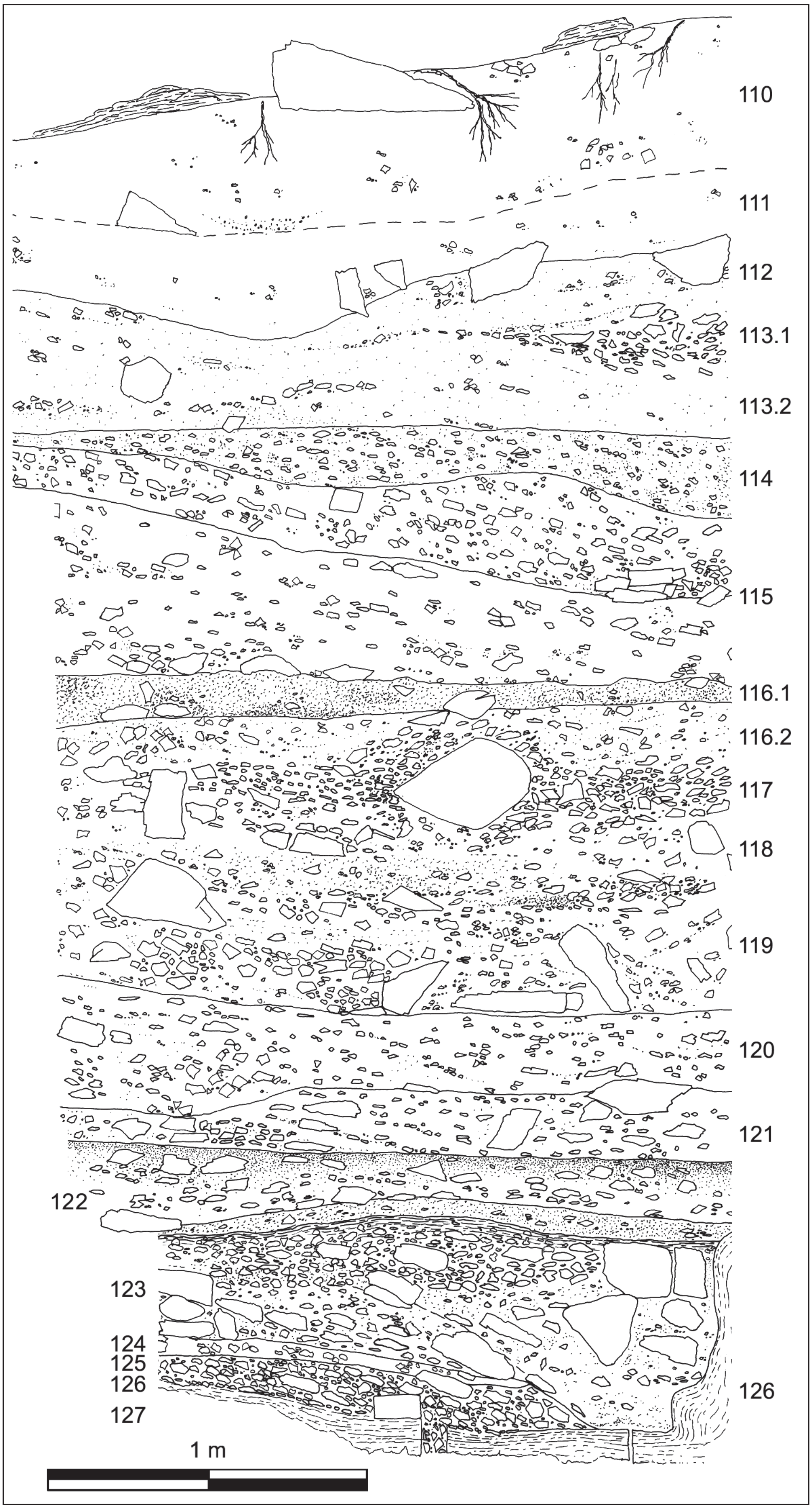
Zbruske smo analizirali z elektronskim mikroskopom Leica DM/LP, opremljenim za gledanje s presevno svetlobo in z ultravijolično modro epiflouroscenco. Zbruski so bili izdelani po postopku, ki ga opisujejo Bullock *et al.* (1985) ter Stoops (2003).

OPIS SEDIMENTNEGA ZAPOREDJA

Sekvenca "A" (*sl. 5*). Litološka enota št. 16 predstavlja najstarejšo izkopano enoto. Gre za rumenkasto rdečkasto lepljivo glino, ki se pojavlja tudi na dnu sekvence "B". V sondi "A" je bila izkopana v debelini 30 do 40 cm, vendar sega vsaj še meter globlje. Menimo, da je debelina gline še precej večja, vendar bi bila nadaljnja

←

Fig. 4: Caverna degli Orsi/Medvedja jama. Sondage "B". Mosaic of photographs of the NW transversal profile. The apparent dip of the levels is null because the profile is cut perpendicular to the axis of the fan; in fact, the layers dip towards the observer, with an increasing angle from the bottom of unit 119 upwards.
Sl. 4: Sonda "B" v Medvedji jami. Fotografija prikazuje SZ prečni profil. Ker je bil profil izkopan pravokotno na osi vršaja, so plasti navidezno vodoravne. V resnici plasti padajo proti mestu, kjer je bila fotografija posneta. Kot plasti narašča od dna enote 119 navzgor.


110
111
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113.1
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115
116.1
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117
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119
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127
126
1 m

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Fig. 6: Caverna degli Orsi/Medvedja jama. Sondage "B". Sketch of the NW transverse profile.
Sl. 6: Sonda "B" v Medvedji jami. Skica SZ prečnega profila.

ing into evidence any relevant lithologic change. Even if the shape of the cross-section of the tunnel suggests that the infilling may be much thicker, it would have been logistically complicated to excavate deeper in this level, therefore the excavation was stopped and this level is considered as the "bedrock" of the sequence.

The top surface of unit 16 plunges at an angle of about 25 ° towards the NE wall of the cave, and is overlain by a 25 to 60 cm thick flowstone (unit 15) whose topography is complex, basically with a ridge, a deep trough, and minor undulations. The flowstone is strongly decalcified, mostly in the deeper part of the trough, because of the contact with low pH clayey deposits and phosphatic solutions, and its surface is stained by discontinuous Fe/Mn-coatings; the crystalline fabric is well preserved only within the core of the crust, in areas where the thickness is maximum.

Units 14.2, 14.1b, and 14.1 are basically lens-shaped and concave-upwards sedimentary bodies that fill up the trough of the underlying flowstone, covering its upper part almost completely; the concavity decreases from the bottom upwards, so that unit 14.1 is almost tabular and its top is a horizontal surface through which the top of the flowstone crops out.

The fine fraction of these units is clay or clay loam, with minor changes; conversely, the skeleton is made up of different materials that characterise each unit. In 14.2 the coarse skeleton is made up of frequent strongly altered speleothem fragments; in some cases stalactites were found broken on the bottom, their fragments still organised in small piles. The finer part of the skeleton includes also whitish-yellowish phosphate concretions that partly cement the sediment. The low pH of the matrix and the circulation of phosphate-rich solutions caused the surface alteration of the carbonatic skeleton, whose surfaces are usually spongy and "sandy".

The skeleton of unit 14.1b is made up of a very large number of bones (mostly cave bear), tightly packed and interwoven in a 25 cm-thick layer, with few stones (mostly speleothem fragments) and phosphate concretions. The bones are almost never broken (nor intentionally fractured) and their shape is usually well preserved, but the bone tissue is strongly dephosphatised, so that their structure is extremely weak; bone phosphates reprecipitated within the matrix, and formed frequent greyish concentric nodules with an outer hard shell and a soft "chalky" core.

Unit 14.1 is an almost pure clay loam, with very few skeleton and bone fragments that occur mostly at the top. Some greyish reduction features also occur, organised in 20-30 cm long sigmoidal lenses.

globinska izkopavanja težavna, zato so bila zaustavljena. Glinena litološka enota torej predstavlja talnino obravnavanega sedimentnega zaporedja.

Vrhnji del enote 16 je nagnjen, in sicer pada pod kotom okoli 25 ° proti severovzhodni jamski steni. Prekriva jo 25 do 60 cm debela siga (enota 15). Topografija sigove enote je kompleksna, večinoma ima grebenasto morfologijo z vmesnimi koriti, v manjši meri je valovita. Siga je močno dekarbonatizirana predvsem tam, kjer se pojavlja globlje (na dnu korit) oziroma kjer se stika z glineno usedlino (ki ima nizek pH) in s fosfatnimi raztopinami. Površina sige je tu perforirana s prekinjenimi železovimi in manganovimi prevlekami. Kristalna zgradba sige je dobro ohranjena le v jedru, torej tam, kjer je njena debelina največja.

Enote 14.2, 14.1b in 14.1 nastopajo v obliki konkavnih sedimentnih leč, ki zapolnjujejo korita v spodaj ležeči sigi. Te sedimentne zapolnitve skoraj popolnoma prekrivajo sigo. Konkavnost upada v smeri od spodaj navzgor. Posledično je litološka enota 14.1 skoraj popolnoma ploščata, njen vrhnji del je vodoraven. Vendar to enoto ponekod prebijajo vrhnji deli spodaj ležeče sige.

Drobnozrnata frakcija v teh litoloških enotah je zastopana z glino oziroma ilovico. Debelozrnata frakcija je zgrajena iz različnega materiala, odvisno od posamezne litološke enote. V litološki enoti 14.2 je zgrajena iz diagenetsko močno spremenjenih sigovih fragmentov (kapnikov). V nekaterih primerih so bili na tleh najdeni zlomljeni stalaktiti, njihovi fragmenti pa nakopičeni v manjše skladovnice. Manjši klasti so sestavljeni iz belo do rumenih fosfatnih konkrecij, ki so deloma cementirale sedimente. Nizka vrednost pH v sedimentni osnovi in cirkulacija vodnih raztopin, bogatih s fosfatom, sta povzročili spremembe na površini karbonatnih zrn. Te površine so po navadi porozne in peščeno mokaste.

Debelozrnata frakcija v litološki enoti 14.1b je zgrajena iz velikega števila kostnih ostankov (večinoma pripadajo jamskemu medvedu), ki so na gosto posejani v 25 cm debeli plasti. Klasti so maloštevilni (večinoma fragmenti kapnikov), pojavljajo se tudi fosfatne konkrecije. Kosti skorajda niso mehansko poškodovane, njihova oblika je večinoma dobro ohranjena. Vendar je kostno tkivo močno defosfatizirano, tako da je struktura kosti zelo šibka. Fosfat, ki se je izlužil iz kostnih ostankov, se je izločil v sedimentni osnovi. Nastali so številni sivi okrogli skupki, s trdo skorjo in mehko sredico.

Litološka enota 14.1 sestoji iz zelo čiste ilovice, klastov in kostnih ostankov je v njej malo, večinoma so v vrhnjem delu. Pojavljajo se tudi posamezne sive, 20 do 30 cm dolge ukrivljene leče kot posledica diagenetskih sprememb zaradi redukcijskih pogojev.

Units 13-10 are subhorizontal tabular sedimentary bodies, with smooth and abrupt limits; minor undulations in the shape of the limits are due to the occurrence of blocks or cobbles.

In units 13-11 the matrix is clay loam, with abundant skeleton; it is also noteworthy that speleothem fragments are common to dominant in 13, decrease in 12, and do not occur in 11.

Unit 10 is a pure clay loam with very few and rather fine skeleton, mostly made up of "cave popcorn" fragments.

Discontinuous flowstone patches and stalagmites – in most cases still active – lie upon the top of the sequence.

Sequence "B" (*Fig. 6*).The lowermost excavated level of this sequence is a 15-20 cm thick flowstone (126) overlying a sticky yellowish silty clay (127) that was auger probed through to about 40 cm. The bases of broken stalagmites are still well identifiable on the top of unit 126, and also some large broken stalactites were found lying on the surface; in the NE corner of the sondage, a thick stalagmite is still in place, about 1 m high and completely embedded within the overlying sediments.

The overlying levels are subhorizontal up to the base of unit 119, with a major disturbance represented by a depression that may be the result of an erosion phase, or simply a cave bear "nest", situated in the NE corner of the sondage. Units 125-123 are made up of coarse calcareous rubble, with subangular elements and often including speleothem fragments; unit 124 is a 5-7 cm thick level characterised by a dark grey to blackish matrix and common charcoal of small size. The deposit structure is partly openwork, as only part of the packing voids between the stones is filled up with clay loam matrix.

Most of the large-size clasts of unit 123 are covered by calcite coatings (flowstone films) that become thicker and thicker towards the top of the unit, which is a laminated flowstone, about 2-5 cm thick. In fact, the whole unit 122 is rather cemented and embeds limestone rubble and speleothem fragments.

The most outstanding characteristic of units 121 to 117 is the dominant limestone rubble, very poorly sorted and with common large blocks (up to 70-80 cm) embedded in an abundant sandy clay loam matrix; "tails" of fine- to medium-size gravel with fewer matrices – partly openwork – are clustered around a block in 117 (*Fig. 4*).

Starting from unit 119, the layers dip towards the inside of the cave, with an angle increasing from the bottom to the top levels.

Unit 116 marks abruptly a change in the texture of the deposit; it is made up of silt loam with some rubble in the bottom part (116.2), while the upper one (116.1) is made up of almost pure brownish silt with very few limestone skeleton elements.

The units overlying 116 are characterised by an increasing dip and by fewer and smaller coarse skeleton

Litološke enote 13–10 so sestavljene iz bolj ali manj vodoravnih ploščatih sedimentnih teles. Meje med njimi so gladke in jasne. Manjša valovanja mejnega horizonta so posledica pojava večjih blokov in kamenja v sedimentih.

Osnovo v litoloških enotah 13–11 sestavlja ilovica, številni so tudi klasti. Značilno je, da fragmenti kapnikov prevladujejo v litološki enoti 13, manj jih je v enoti 12, medtem ko jih v litološki enoti 11 ni več.

Litološka enota 10 je sestavljena iz čiste ilovice, v njej je zelo malo klastov in še ti so drobnozrnati. Na vrhu sekvence "A" ležijo prekinjene krpe sige in stalagmiti (večinoma še vedno rastejo).

Sekvenca "B" (*sl. 6*). Najnižje izkopani nivo iz te sekvence predstavlja 15 do 20 cm debela siga (126), ki leži na lepljivi rumeni meljasti glini (127), ki je bila prevrtana s sondo (svedrom) do debeline okoli 40 cm. Na vrhu enote 126 je jasno razvidna podlaga polomljenih kapnikov (stalagmitov). Na površini so našli tudi nekaj večjih kosov polomljenih stalagmitov. Masiven intakten stalagmit je v severovzhodnem kotu sonde. Visok je okoli 1 m in je popolnoma zasut z okoliškimi sedimenti.

Krovni sedimenti so bolj ali manj vodoravno odloženi vse do začetka enote 119, z izjemo v kotanji, katere nastanek razlagamo z delovanjem erozije. Lahko gre tudi za zimsko ležišče (brlog) jamskega medveda, leži v severovzhodnem vogalu sonde. Enote 125–123 so sestavljene iz debelozrnatega kalcitnega grušča. V njem so pogosti tudi fragmenti kapnikov. Enota 124 je 5 do 7 cm debela. Gre za horizont temno sive do črne osnove in ostankov drobnega oglja. Sedimenti so zelo porozni, le del prostorov med klasti je zapolnjenih z ilovnato osnovo.

Večina večjih klastov v enoti 123 je prekritih s kalcitno prevleko (s tankim sigovim filmom). Debelina prevleke narašča v smeri proti vrhnjemu delu obravnavane enote, kjer je laminirana siga debela 2–5 cm. Sedimenti (apnenčev gušč in sigovi fragmenti) v enoti 122 so precej cementirani.

Značilnost enot 121 do 117 je prevladujoč apnenčev grušč, ki je zelo slabo sortiran. Pojavljajo se tudi večji bloki (premera 70 do 80 cm), in to v peščeno-glineni ilovici (osnovi). Drobno- do srednjezrnat grušč z redko peščeno-glineno osnovo je nakopičen okoli kamnitega bloka v enoti 117 (*sl. 4*).

Plasti v enoti 119 upadajo navzdol v smeri proti notranjosti jame. Kot upada je večji v vrhnjem delu plasti in manjši v spodnjem.

Glede na strukturo se enota 116 zelo razlikuje od ostalih sedimentov. Zastopana je z meljasto ilovico in manjšim deležem drobnega grušča v spodnjem delu (116.2), medtem ko v zgornjem (116.1) močno prevladuje čist rjavkast melj z redkimi kosi apnenčevega grušča.

Podobno kot za litološko enoto 116 tudi za višje ležeče enote velja, da upad plasti narašča po profilu navzgor (višje so bolj nagnjene kot nižje). Grušča je tu elements; the aspect is strongly diamictic, with relatively fine skeleton elements – often platy and lying parallel to the unit boundaries – embedded in brownish matrix. The architecture of the units is slightly more complicated than in the lower levels, because secondary wedge-like bodies of openwork platy gravel are interfingered between the main units.

The uppermost unit of the sequence (110) is poor of skeleton and whitish, and includes chalky aggregates of calcite deriving from the weathering of a discontinuous flowstone that covers the present-day pavement.

GRAIN-SIZE DATA

The grain-size data confirm the correlation between sequences A and B, even if their different locations on the debrisflow fan and in the cave tunnel produced some divergence in the characteristics of the coarse fraction.

Sequence "A". Limestone rubble is the most relevant component of the central part of the sequence; it is almost completely absent in 10 and 10.1, and represents a minor component in levels 14.1 to 14.2. Coarse rubble and blocks are dominant in levels 11 to 13, unsorted, angular or slightly subangular because of surface decarbonatation, and with common platy elements.

Within the fine fraction (*Fig. 7*), sand occurs with a strong peak in level 14.2, whereas it is much less frequent in the other units of the sequence. This peak disappears

razmeroma malo in še ta je bolj drobnozrnat. Po videzu je močno diamiktitičen. Klasti v grušču so pogosto podolgovati in ležijo vzporedno z mejami litoloških enot, posejani so v rjavkasti osnovi. Zgradba teh enot je morda rahlo kompleksnejša kot v spodaj ležečih. Razlog je v dejstvu, da se podolgovati klasti združujejo v klinasta telesa, ki ločujejo glavne litološke enote.

Vrhnja enota 110 je bele barve, v njej je malo klastov. Vsebuje tudi kalcitne agregate, ki so nastali kot posledica preperevanja tiste sige, ki prekriva današnja jamska tla.

GRANULOMETRIČNI PODATKI

Korelacija med sekvencama "A" in "B" je možna in je potrjena z granulometričnimi podatki, čeprav se pojavljajo nekatere razlike v značilnostih debelozrnate frakcije med obema sekvencama. Te razlike so posledica polzenja sedimentov in predvsem njihovega kopičenja, ki ni potekalo enakomerno na dveh različnih lokacijah v jami.

Sekvenca "A". Apnenčev grušč je najbolj značilna komponenta v osrednjem delu te sekvence. Grušč je popolnoma odsoten v nivojih 10 in 10.1, medtem ko predstavlja le manjši delež v nivojih 14.1 do 14.2. Debelozrnati grušč in bloki prevladujejo v nivojih 11 do 13. Grušč je slabo sortiran, ostrorob ali rahlo zaobljen zaradi površinske dekarbonatizacije. Običajno je zastopan s podolgovatimi klasti.

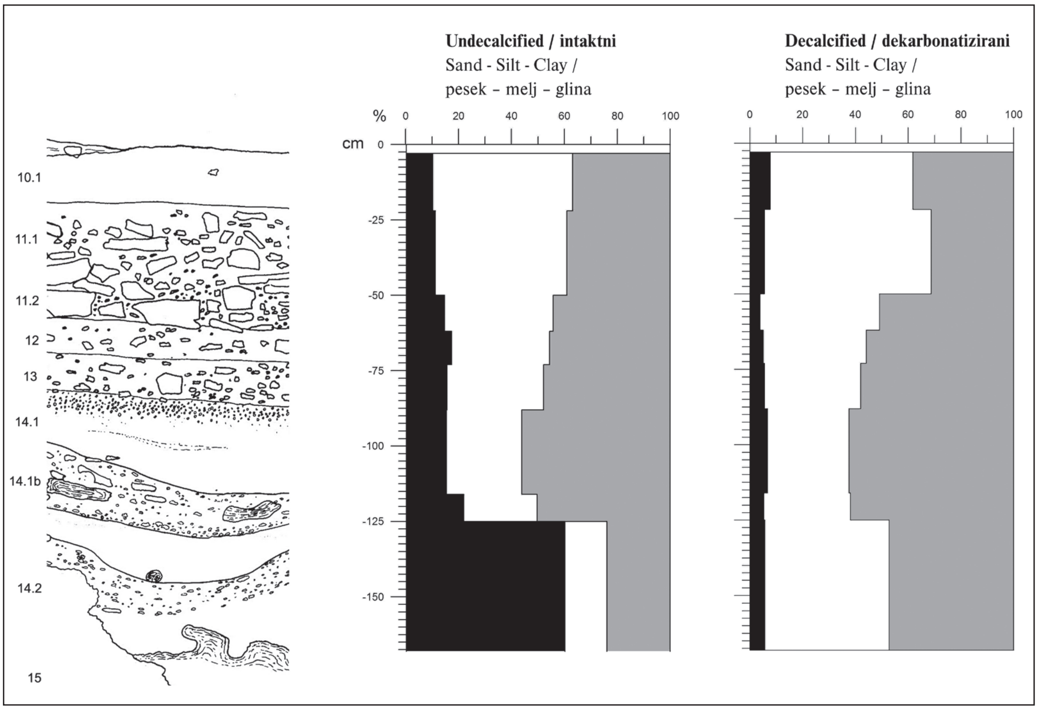
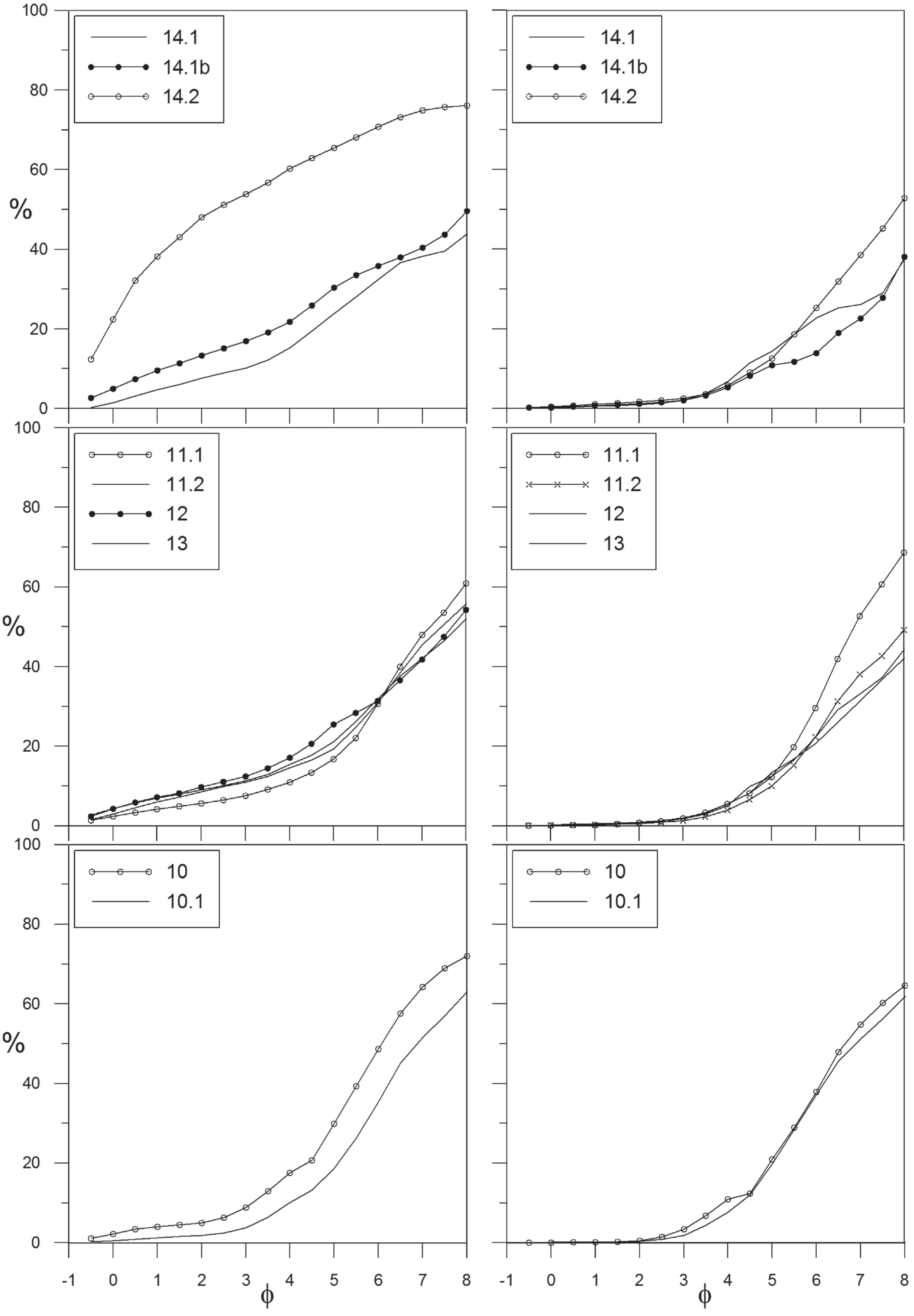


Fig. 7: Caverna degli Orsi/Medvedja jama. Sondage "A". Grain-size of the < 2 mm fraction of sediment samples (undecalcified and decalcified).
Sl. 7: Sonda "A" v Medvedji jami. Granulometrija frakcije < 2 mm (intaktni in dekarbonatizirani vzorci).


14.1
14.1b
14.2
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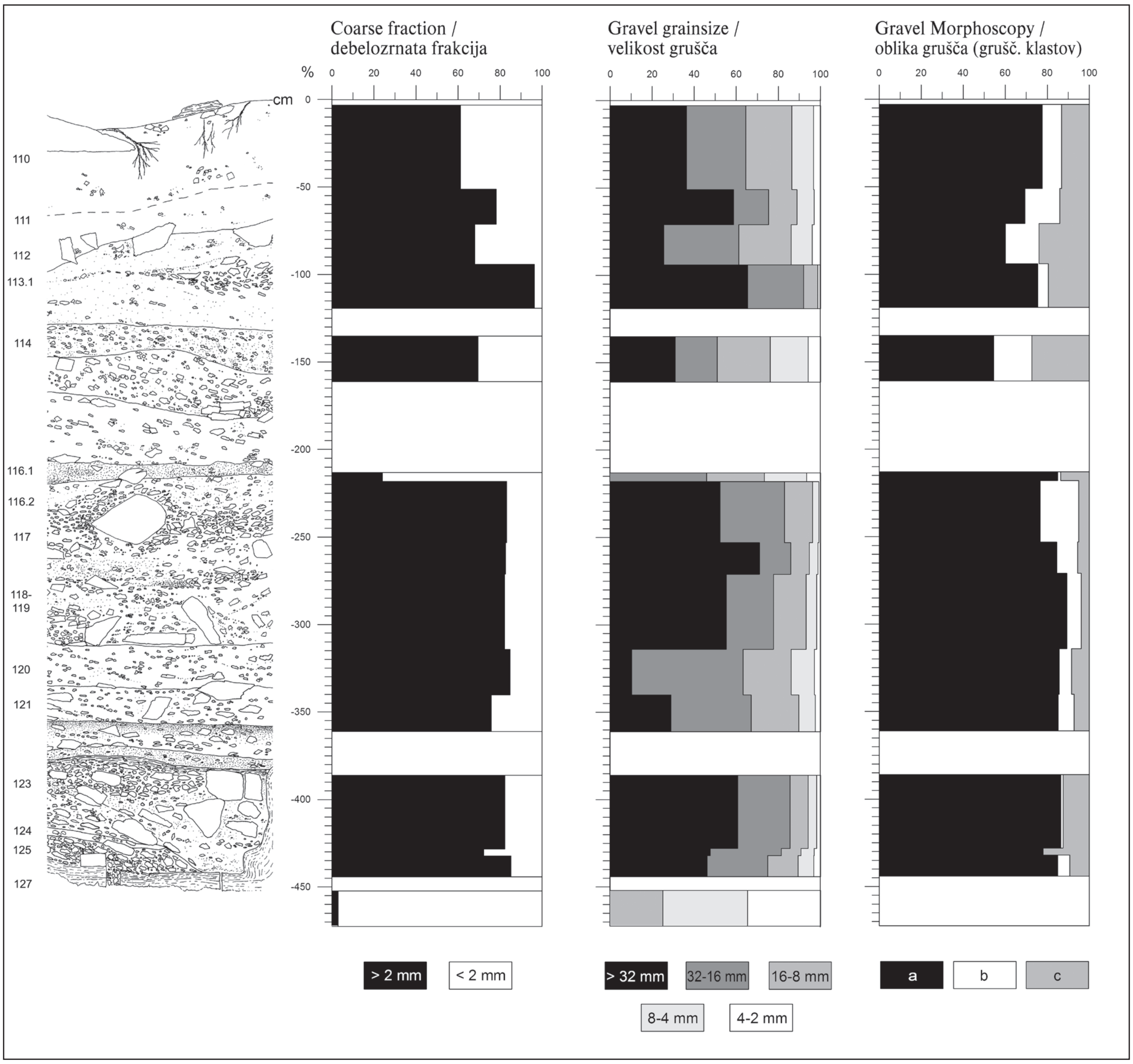


Fig. 9: Caverna degli Orsi/Medvedja Jama. Sondage "B". Grain-size of the > 2 mm fraction of sediment samples: coarse/fine ratio, gravel-grade classes, gravel shapes; a – polyhedra, b – plaquettes, c – flakes.
Sl. 9: Sonda "B" v Medvedji jami. Granulometrija frakcije > 2 mm: razmerje debelozrnati/drobnozrnati vzorci, deleži grušča po različnih frakcijah, oblika grušča; a – poliedričen, b – ploščat c – lističast.

after decalcification, and sand is also generally less frequent in all the decalcified samples, becoming the lesser component throughout the profile. Conversely, clay is always very abundant, mostly in the central part of the sequence, with a maximum corresponding to levels 14.1b-11.2. The silt percentage increases only at the top, in units 11.1 and 10.

The cumulative curves (*Fig. 8*) of the undecalcified samples are all negatively skewed and poorly sorted; a

V drobnozrnati frakciji (*sl. 7*) se pojavlja pesek, izrazit vrh doseže v nivoju 14.2, medtem ko je manj pogost v ostalih enotah sekvence "A". V dekarbonatiziranih sedimentih takšen vrh izgine. Peščena frakcija je torej običajno manj pogosta v vseh dekarbonatiziranih vzorcih. Pesek je celo najbolj redka komponenta v celotnem profilu. Nasprotno je glina zelo pogosta vzdolž celega profila, še posebej pa v osrednjem delu sekvence. Najvišji delež doseže v nivojih 14.1b do 11.2. Odstotek

⟵

Fig. 8: Caverna degli Orsi/Medvedja jama. Sondage "A". Cumulative curves of the < 2 mm fraction. Left – undecalcified, right – decalcified samples.
Sl. 8: Sonda "A" v Medvedji jami. Kumulativne krivulje frakcije < 2 mm. Levo – intaktni vzorci, desno – dekarbonatizirani vzorci.

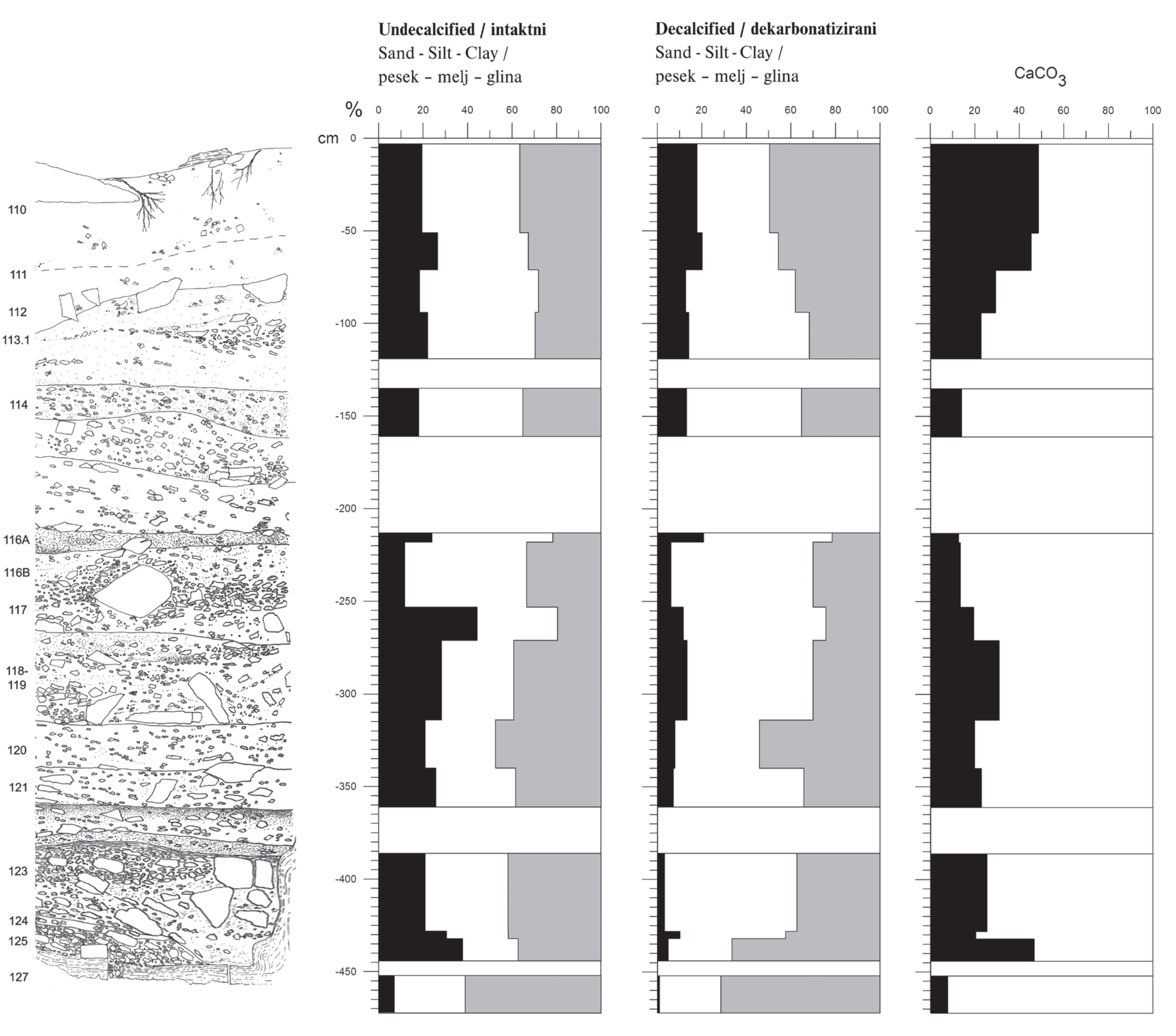


Fig. 10: Caverna degli Orsi/Medvedja jama. Sondage "B". Grain-size of the < 2 mm fraction of sediment samples (undecalcified and decalcified); $CaCO_3$ percentage in the < 0.5 mm fraction.
Sl. 10: Sonda "B" v Medvedji jami. Granulometrija frakcije < 2 mm (intaktni in dekarbonatizirani vzorci); odstotek $CaCO_3$ v frakciji < 0.5 mm.

primary mode is always located within the clay field, while a secondary one is usually situated in the medium or fine silt field. The secondary mode of the very coarse sand occurs only in unit 14.2.

These curves can be divided into three groups:

– units 10 and 10.1, which are better sorted than the others and whose median lies in the fine silt class;

– units 13, 12, 11.1, 11.2 are characterized by $\Phi_{(50)}$ (median) in the very fine silt and by poorer sorting;

– units 14.1 and 14.1b, whose median lies within the clay range.

Unit 14.2 does not fit within these groups because of its median corresponding to 2.5 Φ.

The decalcification basically removes the coarse fraction which is made up of HCl-soluble phosphates –

melja narašča le v vrhnjem delu, v enotah 11.1 in 10. Kumulativne krivulje dekarbonatiziranih vzorcev (*sl. 8*) so vse pozitivno simetrične (težišče je pri manjših zrnih) in slabo sortirane. Primarno težišče glede na granulometrijo je vedno v območju glinene frakcije, medtem ko je sekundarno običajno v sredini oziroma v območju drobnozrnatega melja. Sekundarno težišče se na območju zelo debelozrnatega peska pojavi le v enoti 14.2.

Te krivulje lahko razdelimo v tri skupine:

– Sedimenti v enotah 10 in 10.1 so bolje sortirani kot v ostalih enotah. Mediani v obeh litoloških enotah sta v območju drobnozrnatega melja.

– Za enote 13, 12, 11.1 in 11.2 je značilna vrednost mediane ($\Phi_{(50)}$) v območju zelo drobnozrnatega melja.

mostly in unit 14.2 – and by less frequent sand-size calcareous elements.

Sondage "B". The coarse fraction is the most relevant aspect of this sequence: it represents about 80 % of the whole sediment mass in levels 125 to 116.2, *i.e.* within a large part of the sequence; it drops abruptly in 116.1, but it increases again irregularly to 60-80 % (*Fig. 9*). All the grain-size classes are represented, from the blocks to the granules, always resulting in a very poor sorting.

The fine gravel (< 32 mm) components vary in the same way throughout the profile, with several oscillations and a well-identifiable maximum only in the upper part of unit 127. The lowest percentage of coarse (> 2 mm) fraction corresponds to unit 116.1, and minor changes can be observed through the profile. The decrease of coarse gravel (> 32 mm) usually corresponds to a general decrease in the whole coarse fraction and in its average size, whereas this trend is inverted in levels from 114 upwards, where large cobbles are embedded in a clay-rich matrix with few medium- to fine gravel elements and matrix-supported structure.

The gravel-grade elements are always subangular, due to surface decalcification, or sometimes angular. Their shape is usually polyhedric or prismatic, while low sphericity, and platy/oblate elements (frost slabs) are common in levels 114, 113.1 and 112.

The fine fraction is made up of a balanced mix of the three components, with clay slightly dominating from the bottom up to unit 117; conversely, silt is dominant from 116.2 (*Fig. 10*).

Decalcification often removes large parts of the sand, including its peaks occurring in levels 125 and 117; this decrease is evident in the lower part of the sequence, whereas it is nearly negligible in the upper one – mostly in unit 116.1 – showing that sand is mainly made up of silicate grains in the top part of the profile, and of carbonate elements in the lower one.

Finally, there are clay peaks in units 125, 120 and in the uppermost ones (111 and 110).

The cumulative curves (*Fig. 11*) are negatively skewed and poorly sorted also in this profile. The following sets can be distinguished.

– Bimodal curves that have two relative maxima in the silt fraction. Among these 110, 111, 112 and 116.2 are characterised by the primary mode in very fine silt and $\Phi_{(50)}$ (median) in fine-very fine silt, whereas 113.1 and 114 have the primary mode in coarse-medium silt and $\Phi_{(50)}$ (median) in medium silt, and are therefore slightly coarser and better sorted. Level 116.1 is peculiar, being the only unimodal curve, with a maximum in coarse silt, the median in medium silt, and the lowest clay percentage, *i.e.* about 20 % against 30 % of the others.

– Very poorly sorted and rather wavy curves, with primary mode in the coarse silt field, a secondary one in the sand classes, and median within the very fine silt; only unit 124 shows an inverted trend. Units 117 and

– Za enoti 14.1 in 14.1b je značilno, da mediana leži znotraj območja glinene frakcije.

Enote 14.2 ne moremo uvrstiti v nobeno od treh skupin, ker je vrednost mediane pri 2,5 (Φ). Debelozrnata frakcija, ki je v enoti 14.2 predvsem fosfatne sestave, je bila v veliki meri odstranjena z dekarbonatizacijo (fosfati se topijo v HCl kislini). Redkeje pa so odstranjeni kalcitni elementi v velikosti peska.

Sonda "B". Glede na videz sedimentov je debelozrnata frakcija najbolj značilna komponenta te sekvence. Predstavlja okoli 80 % celotne sedimentne mase v nivojih 125 do 116.2 (oziroma kar v večjem delu sekvence). Njen delež močno upade v nivoju 116.1 in višje ponovno naraste na 60 % do 80 % (*sl. 9*). Zastopani so klasti vseh velikosti, od blokov do manjših, vendar so vsi zelo slabo sortirani.

Delež drobnega grušča (<32 mm) se spreminja v enaki smeri vzdolž profila, vendar se pojavljajo določena nihanja. Izrazit maksimum doseže v vrhnjem delu enote 127. Najnižji odstotek frakcije, večje od 2 mm, sovpada z enoto 116.1, vzdolž profila se pojavljajo le manjše spremembe.

Padec deleža debelozrnatega grušča (>32 mm) običajno sovpada z manjšim deležem vse frakcije, večje od 2 mm. Takšen trend je obrnjen v nivojih od 114 navzgor. Tu se v glineni osnovi pojavljajo kamniti bloki in srednje- do drobnozrnat grušč.

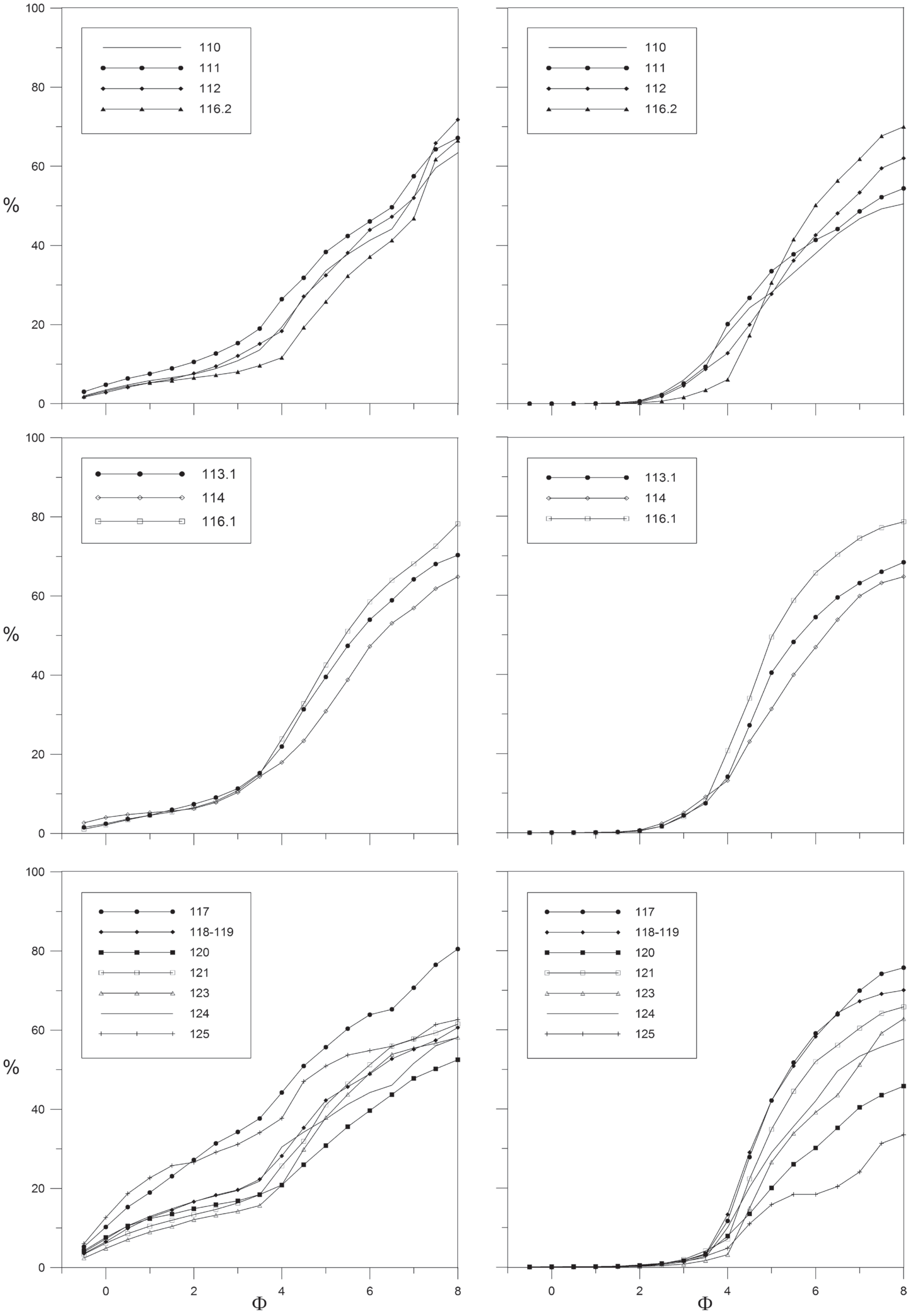
Grušč je večinoma pologlat, kar je posledica površinske dekarbonatizacije. Občasno se pojavlja tudi značilno ostrorobi grušč. Grušč je navadno poliedrične ali prizmatične oblike, sferičnost je slaba. V nivojih 114, 113.1 in 112 so številni ploščati in slabo zaobljeni klasti (nastali kot posledica mehanskega preperevanja ob zmrzovanju).

Drobnozrnata frakcija je zastopana s tremi komponentami (v približno enakih razmerjih). Glina rahlo prevladuje od talnine do enote 117. Nasprotno predstavlja melj prevladujočo komponento od enote 116.2 navzgor (*sl. 10*).

Dekarbonatizacija pogosto odstrani velik delež peska. Vrhovi, ki se pojavljajo v nivojih 125 in 117, so zabrisani. Padec peščene frakcije je očiten v spodnjem delu sekvence, v zgornjem pa je skoraj zanemarljiv. To kaže na dejstvo, da so zrna v vrhnjem delu profila po svoji sestavi predvsem kremenčeva, v spodnjem delu pa karbonatna.

Glinena frakcija doseže izrazit vrh v enotah 125, 120 in v najvišje ležečih enotah (111 in 110). Kumulativne krivulje (*sl. 11*) v obravnavanem profilu so pozitivno simetrične (težišče je pri drobni frakciji) in kažejo slabo sortiranost. Ločimo naslednje nize:

– Bimodalne krivulje imajo dva maksimuma v območju meljaste frakcije. Za enote 110, 111, 112 in 116.2 je značilno, da imajo primarno težišče na območju zelo drobnozrnatega melja in mediano ($\Phi_{(50)}$) v drobno- do zelo drobnozrnatem melju. Medtem ko imata enoti 113.1 in 114 primarno težišče v območju debelozrnatega melja


100
80
60
40
20
0
%
110
111
112
116.2
113.1
114
116.1
117
118-119
120
121
123
124
125
0
2
4
6
8
Φ

←

Fig. 11: Caverna degli Orsi/Medvedja jama. Sondage "B". Cumulative curves of the < 2 mm fraction. Left – undecalcified, right – decalcified samples.
Sl. 11: Sonda "B" v Medvedji jami. Kumulativna krivulja frakcije < 2 mm. Levo – intaktni vzorci, desno – dekarbonatizirani vzorci.

125 are slightly coarser, with the median falling within the medium silt range.

The clay content is usually somewhat higher than in the previous group.

The bulk of the sandy fraction is removed from all these samples after decalcification; the general consequence is a better sorting, with almost no or only moderate clay increase, respectively in sample groups 113.1, 114, 116.1, and 110, 111, 112 and 116.2. Conversely, decalcification causes a progressive clay increase in samples 117-125, from almost null in 117 to quite remarkable in 125, at the bottom of the sequence.

SOIL MICROMORPHOLOGY

The main soil micromorphological characteristics of the sediments are described in this paragraph. It must be pointed out that these data are scanty for sondage "B", because few monoliths were collected successfully from the very stony units.

Sequence "A". Clay is the most relevant component of the fine sediment mass in almost all the units, apart from 10.1 and 10; it gives the micromass a typical stipple-speckled and granostriated b-fabric, or even strial in the lower part of the sequence, where it is dominant. There is an inverse correlation between clay and carbonates: these are completely absent in the fully dacalcified bottom units, appear in unit 13 with few rounded limestone grains and some partly dissolved calcite crystals, and become frequent in 12 and 11 with large sparite crystals (speleothem fragments) and limestone grains; diffuse $CaCO_3$ impregnations are common in 11. In 10.1 and 10 they occur mostly as coatings/hypocoatings. In some areas of unit 10.1, the skeleton grains are organised in thin laminae, alternately rich in clay or in silt to very fine sand-size quartz with mica flakes (*Fig. 12 a, b*), which lie parallel to the layering.

The microstructure of the sediment is directly connected with the amount of clay: it is granular with strongly compacted and thickly granostriated (to the inside) aggregates (*Fig. 12 b, c*) in the units from 14.1b upwards, and becomes massive with few channels in units 12 to 10. The b-fabric is stipple-speckled to crystallitic in the top levels 10.1 and 10, where silt and very fine sand are more abundant.

The bone fragments are ubiquitous up to unit 10.1, where they occur sparsely; their size ranges from fine sand to gravel, but it must be pointed out that also unbroken bones are rather common within almost all

in mediano ($\Phi_{(50)}$) v srednjezrnatem melju. Ti enoti sta zatorej rahlo bolj debelozrnati in bolje sortirani. Nivo 116.1 je poseben, saj ima edini enomodalno krivuljo z maksimumom v debelozrnatem melju, mediano v srednjezrnatem melju in z najnižjim odstotkom glinene frakcije (20 % gline in 30 % ostalih frakcij).

– Zelo slabo sortirane in precej valovite krivulje, s primarnim maksimumom v območju debelozrnatega melja in sekundarnim maksimumom v območju peščene frakcije. Mediana je v območju zelo drobnega melja. Samo enota 124 kaže nasproten trend. Enoti 117 in 125 sta rahlo bolj debelozrnati. Mediana tu pade v območje srednjezrnatega melja. Odstotek glinene frakcije je običajno višji kot v prejšnjih skupinah.

S procesom dekarbonatizacije je odstranjen večji del peščene frakcije iz vseh vzorcev. Posledično so vzorci bolje sortirani, delež glinene frakcije kvečjemu le zmerno naraste. Takšni so vzorci iz skupin 113.1, 114, 116.1 ter 110 111, 112 in 116.2. Nasprotno pa je dekarbonatizacija povzročila stopnjujoče naraščanje deleža glinene frakcije v vzorcih 117–125. V vzorcu 117 je narastek še minimalen, medtem ko je v vzorcu 125 (na dnu sedimentnega zaporedja) že razmeroma visok.

MIKROMORFOLOGIJA JAMSKIH PALEOTAL

V nadaljevanju so opisane glavne mikromorfološke značilnosti talnih sedimentov iz sekvence "A". Podatki, ki se nanašajo na sekvenco "B", so pičli, zato jih tu ne podajamo. V sekvenci "B" nam je iz zelo skalnatih enot uspelo pobrati le malo reprezentativnih intaktnih sedimentnih vzorcev.

Sekvenca "A". Med vso drobno frakcijo predstavlja glina najznačilnejšo komponento v skoraj vseh enotah, izjema sta enoti 10.1 in 10. Sedimenti imajo zaradi prevladujoče glinene frakcije značilno pikasto-lisasto in zrnato mikrostrukturo. Ta je v spodnjem delu sekvence tudi črtasta. Korelacija med glino in karbonati je v teh enotah negativna. V spodnjem delu sekvence, kjer so bile enote popolnoma dekarbonatizirane, je karbonatna komponenta popolnoma odsotna. Karbonati se pojavijo v enoti 13, kjer so redka zaobljena apnenčeva zrna in nekaj deloma raztopljenih kalcitnih kristalov. Karbonati so pogosti v enotah 12 in 11, kjer se pojavljajo veliki sparitni kristali (iz kapniških fragmentov) in apnenčeva zrna. Zrna v enoti 11 so difuzivno impregnirana s $CaCO_3$. V enotah 10.1 in 10 je kalcit v obliki prevlek. Zrna so v posameznih delih enote 10.1 združena v lamine. Lamine,

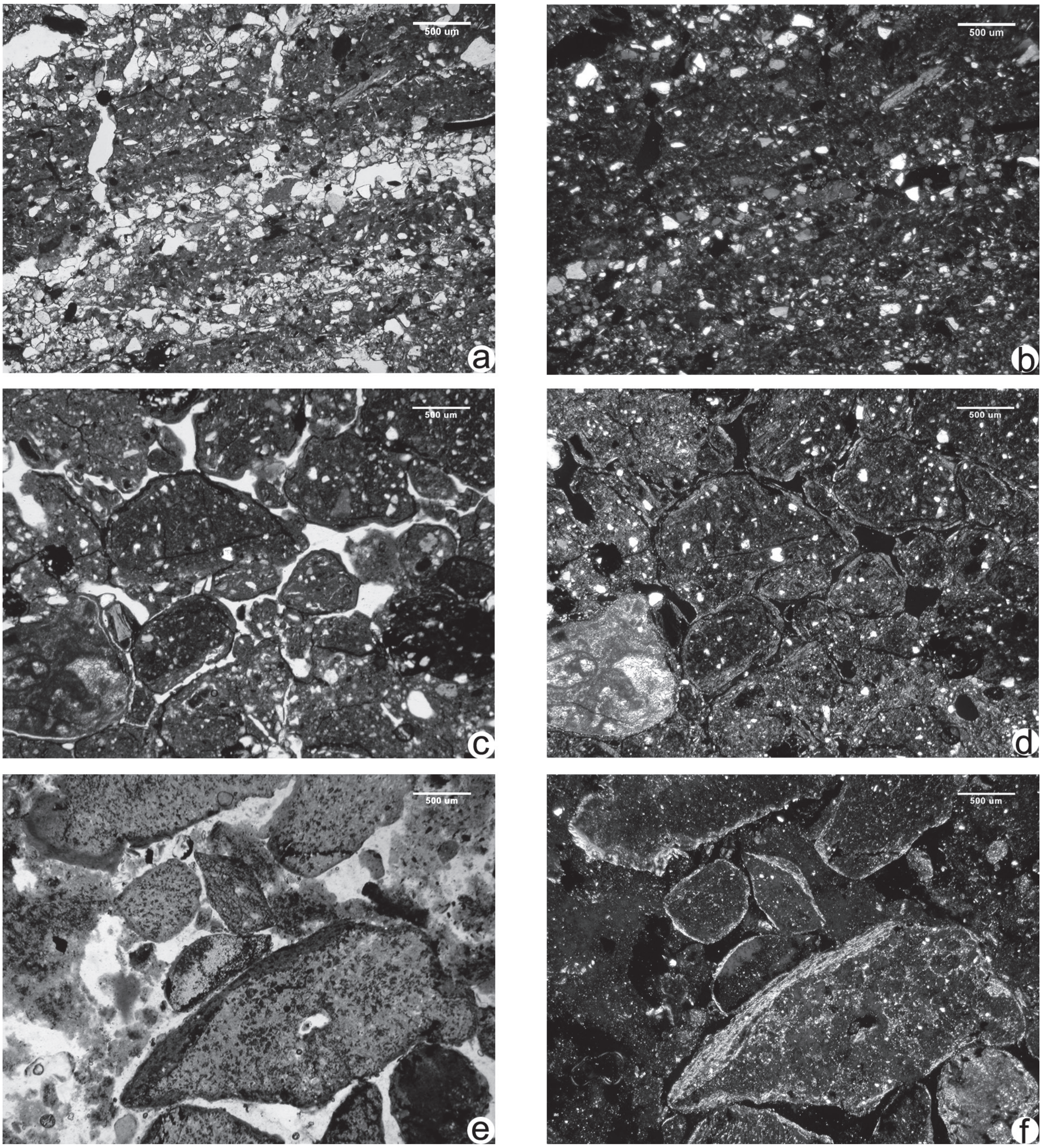


Fig. 12: Caverna degli Orsi/Medvedja jama. Microphotographs of thin sections of cave sediments. **a** – laminated loess, with alternating coarse quartz and mica beds; sondage A, unit 10.1, PPL; **b** – as in a, XPL; **c** – granular microstructure, sondage A, unit 13, PPL; **d** – as in c, with evident granostriated b-fabric around the aggregates, XPL; **e** – clay-coated amorphous phosphate nodules, with very fine quartz skeleton, sondage A, unit 14.2, PPL; **f** – as in e, XPL.

Sl. 12: Mikrofotografija sedimentnih zbruskov iz Medvedje jame. **a** – laminirana puhlica z debelozrnatimi kremenovimi zrni in sljudo, sonda A, enota 10.1, PPL; **b** – enako kot v a, XPL; **c** – zrnata mikrostruktura, sonda A, enota 13, PPL; **d** – enako kot v c, z jasno zrnato mikrostrukturo okoli agregatov, XPL; **e** – amorfni fosfatni skupki z glineno prevleko in z zelo drobnozrnatimi kremenovimi klasti, sonda A, enota 14.2, PPL; **f** – enako kot v e, XPL.

units, except in 14.1, 14.2 and 15. These fragments are usually subangular to subrounded and often coated and/or sometimes internally hypocoated by more or less thick amorphous Fe impregnations; these coatings are more frequent and thicker in the lower units.

bogate z glino in meljem, se menjavajo z laminami iz zelo drobnega kremenčevega peska s sljudnimi lističi (*sl. 12 a, b*). Lamine so vzporedne s plastovitostjo.

Mikrostruktura sedimentov je neposredno povezana s količino glinene frakcije. V enotah od 14.1b navzgor je

Minute charcoal fragments were found in unit 13; their tissue cells are well preserved and recognisable, but only in few cases could the genus (*Pinus* or *Juniperus*) be identified, *i.e.* when the section was cut in a favourable direction.

Pedorelics made up of reddish Fe-stained clay with stipple-speckled b-fabric and fine quartz skeleton occur more or less frequently throughout the sequence. Another sort of pedorelics occurs frequently in 14.1b and sometimes in 14.1. These have the same skeleton as the previous ones, but the micromass is made up of light brown clay with few Fe, showing first-order grey interference colours and stipple-speckled b-fabric. The shape of all the pedorelics is rounded to subrounded and their boundary with the surrounding micromass is always very sharp.

Phosphate nodules can be observed in all units up to 12; these are most frequent in the bottom part of the sequence and dominant in 14.2 (*Fig. 12 e, f*), where the whole sediment mass is thoroughly phosphatised. They evidently derive from the alteration of bone, as in several cases traces of its mineral tissue are more or less preserved within the nodules, with the typical trabecular arrangement. In the bottom units, the phosphates impregnate the sediment and have thoroughly reacted with it; in some areas of 14.2 the whole mass is made up of almost completely amorphous or weakly stipple-speckled aggregates, light brown in PPL and strongly epifluorescent, rounded to subrounded and almost unsorted. These aggregates are commonly coated by thick clay coatings that are also stained by Fe-oxides; these oxides occur also as well impregnated amorphous hypocoatings with dendritic aspect inside cracks and other elongated voids within the aggregates, or as nodules with the same characteristics.

DISCUSSION

The sediments of sequence “A” are mostly organised in horizontal tabular units; only the topography of the flowstone (unit 15) situated at the bottom of the sequence is complex, resulting from combined thickness variations due to local differences in calcite accumulation, and to erosional processes that shaped the surface on which it started growing.

Unit 14 is a thick stack of more or less tabular or concave-upwards subunits that fill up the lows in the topography of the flowstone. Their fine grain-size indicates deposition in a very low-energy or still environment, probably an ephemeral pool that developed on the surface of the flowstone during wet phases.

Unit 14.1b includes a large quantity of bones, with no more than 40-50 % of mineral particles; these are mostly clay, which lowered the pH of the sediment and favoured the mobilisation of the phosphates. These

zrnata, agregati so med seboj močno sprijeti (*sl. 12 b, c*). V enotah 12 do 10 postane mikrostruktura masivna, z redkimi prazninami. Mikrostruktura je pikasto-lisasta oziroma kristalinska v zgornjih enotah 10.1 in 10, kjer sta bolj številno zastopana zelo drobnozrnat pesek in melj.

Kostne fragmente najdemo v vseh sedimentih do enote 10.1, kjer so le še redki. Njihova velikost je različna, od drobcenih fragmentov do večjih kosov. Poudariti je treba, da se v vseh enotah pojavljajo tudi cele kosti razen v enotah 14.1, 14.2 in 15. Kostni odlomki so običajno pologlati do polzaobljeni, pogosto se je nanje odložila bolj ali manj gosta amorfna železova prevleka. Takšne prevleke so pogostejše in debelejše v spodnjih enotah.

V enoti 13 so bili najdeni ostanki oglja. Čeprav gre za zelo drobno oglje, je njegova zgradba dobro ohranjena in prepoznavna. Kljub vsemu je bilo le v nekaj primerih možno določiti rod, in sicer v primerih, ko so bili vzorci odrezani v ustrezni smeri, da smo dobili ugodne prereze. Določeno oglje pripada boru (*Pinus*) in brinu (*Juniperus*).

Pedogeni relikti so zgrajeni iz rdeče gline, bogate z železom, in imajo pikasto-lisasto mikrostrukturo. Pojavljajo se skupaj z drobnimi kremenčevimi zrni. Takšni pedogeni relikti so bolj ali manj pogosti skozi celotno sekvenco. Druga vrsta pedogenih reliktov je pogosta v enoti 14.1b in občasna v 14.1. Ti dve enoti se od ostalih opisanih razlikujeta po drugačni osnovi. Ta v obeh enotah sestoji iz svetlo rjave gline. Glede na interferenčno barvo in mikrostrukturo (pikasto-lisasta) sklepamo, da je železovih primesi v glini malo. Vsi pedogeni relikti so zaobljene do polzaobljene oblike. Meja med sedimentno osnovo in pedogenimi relikti je vedno zelo ostra.

Fosfatni skupki se pojavljajo v vseh enotah do 12. Najpogostejši so v spodnjem delu sekvence, v enoti 14.2 so celo prevladujoči (*sl. 12 e, f*). Tu je celotna sedimentna masa popolnoma fosfatizirana. Izvor fosfatnih skupkov gre nedvoumno pripisati preperevanju kosti. V številnih fosfatnih skupkih lahko najdemo bolj ali manj ohranjeno kostno tkivo. Za spodnje enote je značilno, da so se fosfati impregnirali na površino sedimentov, pri čemer je prišlo tudi do kemičnih reakcij. V nekaterih predelih v enoti 14.2 je celotna sedimentna masa sestavljena skoraj v celoti iz amorfnih ali rahlo marogastih agregatov. Ti so svetlo rjavi in močno epifluorescentni, zaobljeni do polzaobljeni in precej slabo sortirani. Običajno so prekriti z debelo glineno prevleko, ki je obarvana z železovimi oksidi. Tudi ti oksidi nastopajo v obliki amorfnih prevlek ali pa kot skupki. Amorfne prevleke so razpokane in razvejane.

RAZPRAVA

Sedimenti, ki pripadajo sekvenci “A”, so večinoma razporejeni v vodoravne, ploščate enote. Nekoliko kompleksnejša je topografija sige (enota 15), ki leži na dnu izkopane sonde. Vzrok za kompleksnost je spremenljiva debelina sige, ki jo pripisujemo lokalnim were leached through the sequence and impregnated the sediments with amorphous nodules that are mostly frequent at the bottom of unit 14.2, where the leaching was stopped above the impervious surface of the underlying flowstone. These phosphates may derive from the weathering of the bones, as well as from the decay of various organic components that are rather expected in a cave bear den, like the droppings of the bears or the soft parts of their carcasses (Braillard *et al.* 2004). Indeed, all the bones are rather altered, mostly in unit 14, where in some cases they have become soft and fragile even if their shape is preserved, and where phosphate nodules are very common. Small altered bone fragments – possibly also digested – are common throughout the sequence, even if no well-shaped coprolites were found, so that it can be concluded that all the above mentioned options are likely, even if only the origin of phosphates from bones and possibly from droppings can be demonstrated.

From the palaeoenvironmental point of view, these units may testify to a remarkable water input into the cave, probably linked to a relatively wet period; phases of strong increase or decrease of this input are not evident, suggesting a regular yearly regime of precipitations.

It is also likely that the complete and prevalently unbroken bones of unit 14.1b were accumulated within the depression/pool by some cave bear activity; apart some *in situ* fractures that may be due to trampling or sediment compaction, there is no evidence of reworking by flow or other processes.

Levels 13 to 11 are almost perfectly horizontal tabular units, mainly made up of unsorted coarse elements embedded in clay loam matrix. The grain-size of the sediment and the shape of the sedimentary units suggest that the coarse particles fell directly onto the pavement after ceiling or wall breakdowns, while the fine ones were mainly transported into the tunnel by low-energy flow; some of these may also have percolated through clefts and small conduits in the limestone, but this process was probably limited by the relatively thick rock mass overlying the cave. Conversely, there is no evidence of mass transport or solifluxion.

The occurrence of a large number of speleothem fragments in level 13 and their decrease in 12 and 11, paralleled by an increase of limestone blocks, corroborates the hypothesis of a progressive dismantling of the ceiling. This may have been caused by cryoclastic processes acting on the rock mass, even if it may be argued that such a process should be moderate in the inner part of the cave; in fact no evidence of freeze was observed at micromorphological scale within the sediments.

The grain-size and the mineral composition of level 10 are typical of moderately altered loess material, testifying to aeolian processes in a cold and aridic climate; in the lower part of this level, the alternating laminae of fine and relatively coarse grains indicate some

razlikam v akumulaciji kalcita, ter erozijskim procesom, ki so izoblikovali površino, na kateri se je začela siga kasneje odlagati.

Enota 14 je podobna debeli kopi z bolj ali manj ploščatimi in navzdol vbočenimi podenotami, ki zapolnjujejo prostore tik nad sigo. Sedimentacija je potekala v zelo nizkem energijskem okolju, na kar sklepamo na podlagi drobnozrnatih zrn. Verjetno je na površini sige med vlažno klimatsko fazo za kratek čas nastal vodni bazen.

V enoti 14.1b je bila najdena velika količina fosilnih kosti, medtem ko mineralna zrna ne predstavljajo več kot 40–50 % vse snovi v sedimentu. Zrna večinoma pripadajo glini. Glinena frakcija vpliva na nizko vrednost pH v sedimentih in omogoča ugodne razmere za mobilizacijo fosfatov. Ti so se izluževali iz celotne sekvence in so impregnirali sedimente v amorfne skupke. Takšni skupki so najpogostejši na dnu enote 14.2. Izluževanje se je ustavilo nad neprepustno površino, ki jo predstavlja siga. Izvor fosfatov gre iskati v preperevanju kosti ali pa v razkroju različnih organskih komponent (mehkih tkiv), ki jih najdemo v medvedjih brlogih, predvsem po odmrtju živali (Braillard *et al.* 2004). Vse kosti so precej diagenetsko spremenjene, še posebej v enoti 14 in tam, kjer so fosfatni skupki zelo številni. V enoti 14 so kosti v nekaterih primerih postale mehke in krhke, čeprav se je njihova oblika ohranila. Majhni, spremenjeni kostni drobci se pojavljajo vzdolž celotne sekvence. Lahko bi šlo za drobce, ki so jih zveri zgrizle in pojedle, torej so šli skozi prebavni trakt, vendar pravilnih koprolitov nismo našli. Obstaja več možnosti za nastanek fosfata, za zdaj sta najverjetnejši le dve (posledica razpada kosti in razkroja tkiv).

Obravnavane enote morda kažejo na obstoj pomembnega vodnega toka skozi jamo, torej je moralo biti podnebje razmeroma vlažno. Na podlagi podatkov ne moremo sklepati na morebitno večje nihanje pretokov oziroma na občasne poplavne razmere, torej bi morale biti padavine razporejene približno enakomerno vzdolž celega leta. Možno je tudi, da so bile kosti v enoti 14.1b nakopičene v kotanji zaradi aktivnosti jamskega medveda. Dokazov, da bi bile kosti predelane zaradi vodnega toka ali drugih procesov, ni. Nekatere kosti, ki so ohranjene "in situ", so bile lahko zdrobljene na manjše drobce zaradi kompakcijskih procesov v sedimentih ali teptanja, ko so po njih hodili medvedi.

Nivoji 13 do 11 predstavljajo skoraj popolnoma vodoravne, ploščate enote. Večinoma so zastopani s slabo sortirano debelozrnato komponento, ki je posejana v ilovnati osnovi. Velikost zrn in oblika sedimentnih enot kažeta, da so debelozrnati delci avtohtonega izvora in so nastali zaradi krušenja jamskega oboda. Nasprotno so bili drobnozrnati delci večinoma prineseni v jamski rov z nizkoenergijskimi vodnimi tokovi in so torej alohtonega izvora. Nekaj teh delcev je lahko prišlo v jamo s površja skozi večje in manjše razpoke, ki prepredajo kamninsko gmoto nad jamo. Vendar je ta zelo debela,

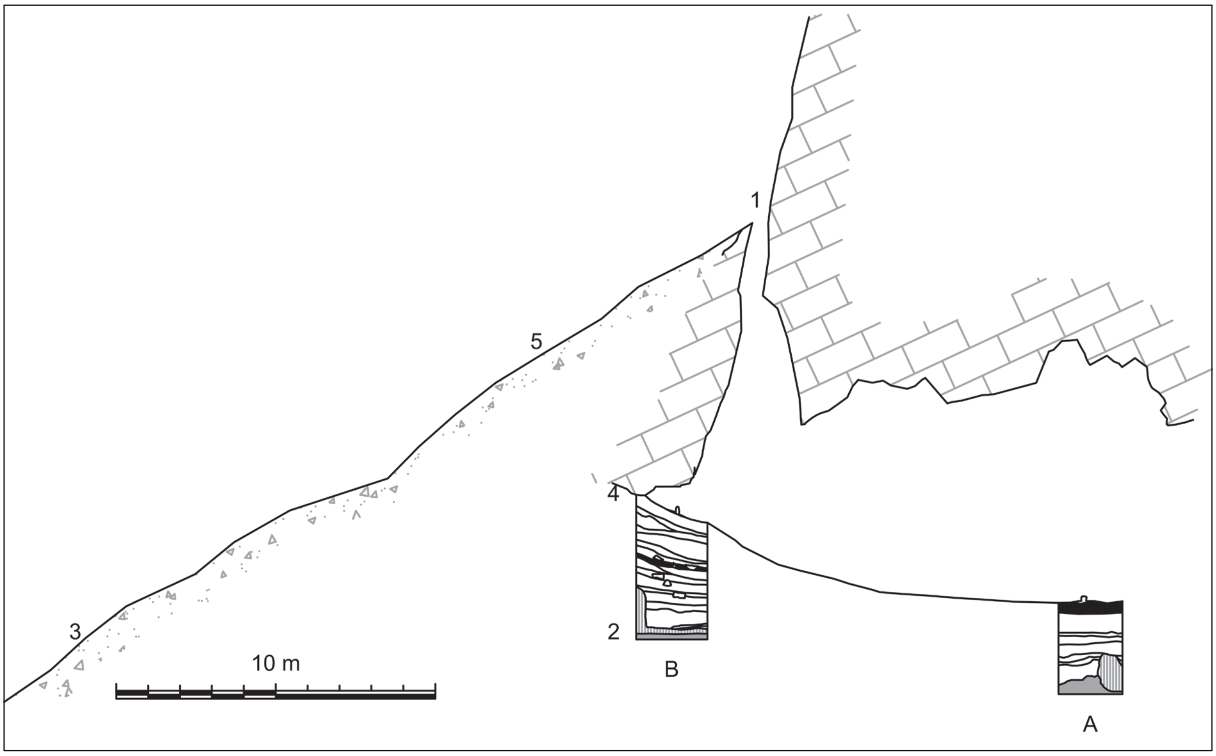


Fig. 13: Caverna degli Orsi/Medvedja jama. Longitudinal cave profile around the entrance area. 1 – present-day entrance; 2 – bottom of stalagmite (unit 126) in sondage "B"; 3 – ideal intersection of the stalagmite pavement (126) with the mountain side; 4 – top of sequence "B", in contact with the cave ceiling; 5 – rockfall/debrisfall deposits obstructing the old entrance. Tentative correlation between sondages: grey – yellow clay; vertical hatch – stalagmite; black – loess.
Sl. 13: Vzdolžni profil jamskega vhoda (Medvedja jama). 1 – današnji jamski vhod; 2 – dno sonde "B" s stalaktiti (enota 126); 3 – domnevno stičišče enote 126 (stalagmiti) z zunanjim pobočjem; 4 – vrh sekvence "B", ki se stika z jamskim stropom; 5 – pobočni (podorni) grušč/debrit (sediment drobirskega toka), ki sta zapolnila prvotni jamski vhod. Poskus koreliranja obeh sond: sivo – rumena glina; črtasta krovnina – stalagmit; črno – puhlica.

transport by pulsating, low-energy surface flow due to sparse precipitations.

Sequence "B" was excavated where the tunnel is completely obstructed by clastic sediments that build up a shape that can be interpreted – at least in the upper part of the sequence – as a small debrisfall fan (*sensu* Blikra, Nemec 1998), whose distal part is situated towards the inside of the cave and can be easily observed at present. On the contrary, the apex of the fan cannot be observed, being located somewhere inside the obstructed part of the tunnel.

At least a part of these sediments was transported from the outside of the cave, where unsorted elements are – and probably were – continuously accumulated by slope processes that originate a scree-slope cover made up of coarse openwork rockfall-debrisfall materials. These probably rolled from the slope, which is rather steep (35 ° for the scree, 75-80 ° for the cliff overlying the cave), into the cave entrance, and from there into the tunnel. The stages of this process may be reconstructed only if the location and shape of the cave entrance and of the tunnel are known; to this purpose, precision topographical surveys and geomorphological observations

tako da je skozi razpoke verjetno prišel v jamo le manjši delež drobnozrnate snovi. Dokazov za masni transport ali soliflukcijo v jami ni.

Pojav velikega števila kapniških fragmentov v nivoju 13 in ponoven upad v nivojih 12 in 11 (upad hkrati sovpada z večjim številom apnenčevih blokov) le potrjuje hipotezo o postopnem, vendar pospešenem krušenju jamskega oboda. Na krušenje ima lahko pomemben vpliv zmrzal oziroma mehansko preperevanje. Vendar načeloma velja, da zmrzal nima večjega vpliva v notranjosti jame, kjer naj bi bilo mehansko preperevanje (oziroma delovanje zmrzali) zelo omejeno v primerjavi z vhodnimi deli jame. Dejstvo je tudi, da na podlagi mikromorfoloških opazovanj jamskih sedimentov nismo našli dokazov o delovanju zmrzali v notranjem delu jame.

Velikost zrn in njihova mineralna sestava v nivoju 10 sta značilna za zmerno spremenjen puhlični material, kar kaže na eolske procese v mrzlem in suhem podnebju. V spodnjem delu tega nivoja se menjavajo fine lamine in razmeroma debelozrnata zrna, kar kaže na občasen (glede na suho podnebje) transport z nizkoenergijskimi površinskimi vodnimi tokovi.

have been carried out inside and outside the cave. It resulted that about 17 m separates the bottom of sondage "B" from the outside, if measured along a horizontal line (*Fig. 13*, in between the points 2 and 3), while its top is about 5 m far from the outside, if measured along a line perpendicular to the outside surface (*Fig. 13*, in between the points 4 and 5). These data and the shape/dip of the cones suggest that the ceiling of the tunnel does not extend very much towards the outside, and that the entrance is rather wide, probably also with rock-shelters at its sides; such a hypothesis is corroborated by the occurrence of some other shelters within few tens of metres from the cave.

During the first stages of the infilling of the outer tunnel, sediments accumulated in a widely open catchment on the pre-existing pavement and originated horizontal units; the occurrence of a thick flowstone (level 126) overlain by coarse, partly openwork rubble units including frequent speleothem fragments (crusts, stalactites, etc., levels 125-123) suggests also that in this phase the ceiling, that had probably been more extended towards the outside, was collapsing and undergoing strong breakdown, probably because of climatic factors. During this phase, the input of colluvial facies deposits was probably limited by remains of the wood cover, which benefited from the favourable exposition of the hill slope. Following the collapse of the outer ceiling, it is likely that a colluvial fan developed in front of the cave entrance, including unsorted elements originated by slope processes, mainly debrisflow, the fine fraction deriving from the erosion of pre-existing soils. The growth of the fan, and its consequent expansion towards the inside of the tunnel continued with the contribution of slope processes and of ceiling breakdown; changes in the size of the coarse fraction (*Fig. 9*) of the units (122-116.2) depend mostly on climatic fluctuations in terms of aridity versus temperature, which affected the mode of rock weathering. Plaquettes and other platy elements, which should indicate short cycles of freeze-and-thaw, are not particularly common, probably as a consequence of the tectonic fracturing of the rock, but occur mainly in level 116.2 which is overlain by a loess level with a very few coarse (> 2 mm) skeleton (116.1). Nevertheless, some "tails" of medium-fine gravel around the blocks in 116.2 indicate also some tractive processes within the fan, suggesting a mix of slope and frost shattering processes. Finally, the grain-size and the shape of the units suggest that mostly debrisflow and possibly some debrisfall were the main processes, while evidence of waterflow has not been observed.

From this level upwards, the increasing dip of the units testifies to the progressive growth of the fan and to the reduction of the size of the cave entrance. The decrease of the skeleton quantity and size, paralleled by an increase in platy elements probably indicates that

Sonda "B" je bila izkopana na mestu, kjer je jamski rov popolnoma zapolnjen s klastičnimi sedimenti. Te sedimente lahko glede na njihovo obliko (vsaj v zgornjem delu sekvence) interpretiramo kot majhen vršaj pobočnega (podornega) grušča, ki se je v jamo prikotalil od zunaj oziroma s pobočij (*sensu* Blickra, Nemec 1998). Distalni del tega vršaja je obrnjen proti notranjosti jame in je dobro viden še danes. Nasprotno pa vrhnja plast vršaja ni vidna, saj leži nekje znotraj zapolnjenega dela jamskega rova.

Slabo sortiran material je zaradi pobočnih procesov zvezno akumuliran. Ti procesi so ustvarili pobočni gršč, ki tvori pokrov, zgrajen iz debelozrnatega, poroznega podorno-pobočnega materiala. Takšen material se je verjetno kotalil po strmem pobočju (naklon melišča znaša 35 °, naklon stene nad jamo pa 75–80 °) v vhodni del jame in od tod naprej v jamski rov. Rekonstrukcija različnih faz, ki opisujejo ta proces, je mogoča le v primeru, če sta znana lokacija in oblika jamskega vhoda in jamskega rova. V ta namen so bili opravljeni natančne topografske raziskave in geomorfološka opazovanja v jami in zunaj nje. Rezultati kažejo, da znaša razdalja med dnom sonde "B" in zunanjostjo okoli 17 m, merjeno vzdolž horizontalne linije (*sl. 13*, razdalja med točkama 2 in 3), medtem ko je vrh sonde "B" okoli 5 m oddaljen od zunanjega okolja, merjeno vzdolž linije, ki je pravokotna na zunanje površje (*sl. 13*, razdalja med točkama 4 in 5). Ti podatki skupaj z obliko in vpadom podornega stožca nakazujejo, da je zasuti jamski rov razmeroma kratek in da je bil nekdanji vhod precej širok. Ob straneh nekdanjega vhoda so bili verjetno izraziti spodmoli. V bližini jame so tudi drugi spodmoli, od nekdanjega vhoda so oddaljeni le nekaj 10 m.

V prvi fazi zapolnjevanja vhodnega dela jamskega rova (sekvenca "B") so se sedimenti kopičili v obsežnih depresijah (kotanjah) v jamskih tleh, posledično so nastale horizontalne enote. Pojav debele sige (v nivoju 126), ki je prekrita z debelozrnatim, deloma predelanim gruščem in s številnimi sigovimi fragmenti (skorjo, stalaktiti itd. v nivojih 125–123), kaže, da se je v tej fazi jamski obod močno krušil. Razloge za močno podiranje jamskega oboda gre morda pripisati klimatskim dejavnikom. V tej fazi je bil vnos koluvialnega materiala v jamo verjetno zelo omejen, predvsem zaradi kopičenja drevesnih ostankov na pobočju. Po podoru oboda ob vhodnem delu se je koluvialni vršaj razvil pred jamskim vhodom. V vršaju je veliko slabo sortiranega materiala, katerega izvor gre pripisati pobočnim procesom (večinoma drobirskemu toku), in drobnozrnate frakcije (ki izvira iz erozijskih procesov v nekdanjih tleh). Večanje vršaja oziroma njegovo širjenje proti notranjosti jamskega rova se je nadaljevalo zaradi pobočnih procesov in podorov jamskega oboda. Spremembe v velikosti debelozrnate frakcije (*sl. 9*), ki jih zaznamo v enotah 112–116.2, so večinoma odvisne od klimatskih sprememb, tj. vlažnosti in temperature, ki vplivata na način preperevanja kamnine. Ploščati klasti, ki običajno nastanejo zaradi the contribution of the slope processes to the inside fan growth had decreased, as a consequence of the progressive closing of the entrance. In the uppermost units (112-110) the (almost?) complete obstruction of the entrance is suggested by the increase in clay within the fine fraction, due to percolation through narrow conduits and from the shaft overlying the excavation area; here, the remarkable increase in fine $CaCO_3$, which is mostly the result of still moderate evolution of the sediment, probably also indicates some process of ceiling/wall decalcification.

The correlation between sequences "A" and "B" is not immediate, as two different sedimentary environments characterised (and characterise also at present) the two areas; it must also be pointed out that the distance (12 m) between the sondages is remarkable in terms of cave geomorphology and sedimentology, so that it may be stratigraphically dangerous to link units cropping out in the two loci.

As a consequence, few units (or short unit sequences) can be used as stratigraphic markers.

Thick flowstones (units 15 in "A" and 126 in "B") overlying yellowish to reddish clay loam (units 16 and 127 respectively) are situated at the bottom of the explored sequences of both sondages; these units share several characteristics and can therefore be directly used as guide levels (*Fig. 13*), the top of the flowstone being an allostratigraphic boundary (NASC 2005).

Other correlations are much less certain. Unit 116 of sondage "B" can be interpreted as a loess, as well as unit 10 of sondage "A", therefore a tentative correlation can be hypothesised because there is only one loess level in each sequence. This hypothesis is corroborated also by some similarities of the underlying units, like the decrease in speleothem fragments from level 13 to 11 and from 122 to 117 within two sequences that are generally rich in coarse skeleton. Also the presence of lithic industry, respectively in levels 118-119 and 13-11, is apparently in accordance with these data.

This aspect suggests that all the upper part of sequence "B", *i.e.* approximately from unit 115 upwards, is the result of debris flow accumulation of rubble and fine matrix coming from the outside of the cave.

As to the dating of the sequence, no geochronometric data are available at present, therefore any inference is based on pedostratigraphic and biostratigraphic information.

From the pedostratigraphic point of view, the sequences can be located within a time span ranging between the end of a warm stage (flowstone layers 15 and 126) and the end of the following cold one, including a phase of strong frost shattering that can probably be correlated with a glacial peak. The composition of the faunal assemblage is in accordance with this hypothesis, showing an evolution from warm and wood environment *taxa* (*Dama*, *Capreolus*, *Glis*, *Eliomys*) to relatively

mehanskega preperevanja ob menjavanju kratkih ciklov zmrzovanja in ponovnega tajanja, niso zelo pogosti. Razlog gre morebiti iskati v tektonski razpokanosti kamnine. Ploščati klasti se pojavljajo večinoma v nivoju 116.2, ki ga prekriva puhlični nivo z zelo redkimi klasti, večjimi od 2 mm (116.1). Nekateri ostanki srednje- do drobnozrnatega grušča in proda, nakopičenega okoli skalnih blokov v enoti 116.2, kažejo na nekatere natezne procese v vršaju, kar bi povzročilo mešanje pobočnih in zmrzlinskih procesov (produktov mehanskega preperevanja). Dokazov o vodnem toku nismo zasledili, glede na obliko enot in velikost zrn sklepamo, da sta bila vir materiala v jami drobirski tok in verjetno tudi kotaljenje podornega materiala iz zunanjega okolja.

Za višje enote je značilno, da njihov naklon navzgor narašča, na podlagi česar lahko sklepamo na postopno rast vršaja in posledično na manjšanje jamskega vhoda. Število zrn se zmanjša, upade tudi njihova velikost, hkrati pa klasti postajajo bolj ploščate oblike. Vse to kaže, da pobočni procesi niso imeli več pomembnega vpliva na rast vršaja. Razlog je bil v postopnem zapiranju jamskega vhoda. Najvišje enote (112–110) predstavljajo (skoraj?) popolno zapolnitev jamskega vhoda. Tu v drobnozrnati frakciji naraste delež gline, kar je posledica prenikanja gline skozi ozke razpoke in jašek v stropu. Tu značilno naraste tudi delež drobnega karbonata, kar je posledica diagenetskih procesov. Verjetno tudi dekarbonatizacije jamskega oboda.

Neposredna korelacija sekvenc "A" in "B" ni možna, saj sta iz dveh ne popolnoma enakih sedimentacijskih mikrookolij. Razdalja med sondama znaša 12 m, kar je za jamsko geomorfologijo in sedimentologijo precejšnja razdalja. Stratigrafska povezava dveh obravnavanih sekvenc je lahko delno problematična.

Le malo enot lahko uporabimo kot stratigrafske markerje. Debela siga (enoti 15 v "A" in 126 v "B"), ki prekriva rumeno do rdečo jamsko ilovico (enoti 16 v "A" in 127 v "B"), je na dnu obeh izkopanih sond. Omenjene enote imajo podobne značilnosti v obeh sondah, zatorej jih lahko uporabimo kot referenčne nivoje (*sl. 13*).

Vse ostale korelacije so manj zanesljive. Enoti 116 iz sonde "B" in 10 f iz sonde "A" lahko razlagamo kot puhlico. Takšna korelacija je hipotetično možna, ker imamo v sedimentnem zaporedju le eno plast puhlice. To hipotezo lahko podkrepimo z nekaterimi podobnostmi obeh sond, ki se pojavljajo v spodaj ležečih enotah. Na primer zmanjšanje deleža kapniških fragmentov med nivojema 13 do 11 (sekvenca "A") in med nivojema 122 do 117 (sekvenca "B"). Debelozrnata zrna so sicer pogosta v obeh sekvencah.

Kamnita orodja, ki so v nivojih 118–119 in 13–11, tudi potrjujejo omenjeno korelacijo.

Celoten vrhnji del sekvence "B" (približno od enote 115 navzgor) je nastal kot posledica akumulacije zaradi drobirskega toka (grušč in drobna osnova, ki ju je v jamo nanosil drobirski tok iz zunanjega okolja).

cold and open environment species (*Ibex, Chionomys nivalis*) in the uppermost levels. The occurrence of *Allocricetus bursae* in level 14 suggests (Chaline, Marquet 1976) that these two phases may correspond to the late MIS 5 and to MIS 4 (Boschian 1999-2000).

CONCLUSIONS

Caverna degli Orsi/Medvedja jama is at present the only site of early Late Pleistocene age whose sequence can be studied in terms of palaeoenvironmental evolution in the Trieste Karst area. Even if no geochronometric datings are available at present, the age of the sequence has been estimated by biostratigraphy, and considering that Mousterian tools – *i.e.* about pre-40 ka BP – were also found.

The pedostratigraphic data obtained from the sedimentological and soil micromorphological study of the two excavated sequences have been interpreted in terms of climate phases (Laville 1976; Cremaschi 1990), which were then fitted within the general age framework. These are the following, from the bottom upwards.

1) A period of warm and wet climate, testified by the deposition of a thick flowstone and apparently no clastic sediments. Even if no dating remains were found within this unit, it may be reasonably inferred that it corresponds to some phase of the Last Interglacial (MIS 5), most likely the last one.

2) A phase of environmental deterioration, probably still rather wet and corresponding to the early onset of a cold period; colluvia of fine clay filled up the pools that had developed above the flowstone. These sediments of clastic origin suggest that erosion processes dismantled soils developed on the hill sides, probably because of strong seasonal rains acting on areas exposed by the shrinkage of the wood cover.

3) A stadial phase, characterised by gravelly sediments originated by frost shattering processes that disaggregated the cave ceiling and walls. This phase probably corresponds to the Early Pleniglacial (*sensu* Ravazzi 2003), or to a subphase of this period.

It is noteworthy that no deep seasonal freeze pedofeatures were observed in the sediments of the cave, as also in the other caves of the Karst for a large part of the Pleistocene; this may indicate relatively high temperatures (partially in contrast with strong frost shattering), and/or somewhat aridic conditions.

4) Loess deposition, with clear evidence of reworking/colluvium but not of weathering, marks the end of the inner sequence.

All these phases are best represented in the inner sequence, whereas the outer one is somewhat complicated by the occurrence of almost ubiquitous and abundant rubble, even if its basic characteristics are the same as in the inner sequence. This aspect is not surprising

Za zdaj sekvenca še ni bila datirana, kronologija temelji le na pedo- in biostratigrafskih podatkih. Glede na pedostratigrafske podatke lahko sekvenco uvrstimo v časovno obdobje, ki obsega konec tople dobe (sigovi plasti 15 in 126) do konca naslednje mrzle dobe. Obdobje močnega mehanskega preperevanja zaradi zmrzovanja (ki je tudi zaobjeto) lahko koreliramo z glacialnim maksimumom. Živalski ostanki so v skladu s to hipotezo, saj razpolagamo z ostanki, ki so značilni za topla in gozdnata območja (*Dama*, *Capreolus*, *Glis*, *Eliomys*), in v vrhnjih plasteh z ostanki, ki so značilni za razmeroma hladno klimo in prostrana travnata območja (*Ibex, Chionomys nivalis*). V nivoju 14 se pojavlja *Allocricetus bursae* (Chaline, Marquet 1976), ki kaže, da bi obravnavani klimatski fazi lahko pripadali poznemu MIS 5 in MIS 4 (Boschian 1999–2000).

SKLEP

Medvedja jama je za zdaj edino najdišče iz zadnjega obdobja poznega pleistocena, kjer lahko preučujemo sedimentno zaporedje z namenom ugotavljanja paleookoljskih sprememb na območju Tržaškega krasa. Za zdaj še ne razpolagamo z geokronometričnimi datacijami. Starost sedimentov je bila ocenjena na podlagi biostratigrafskih podatkov in glede na prisotnost musterjenskega orodja (najdena so bila orodja, ki so glede na tipologijo starejša od približno 40.000 let).

Pedostratigrafski podatki, ki so bili pridobljeni s pomočjo sedimentološke in mikromorfološke raziskave v dveh izkopanih sedimentnih sekvencah (sondah), so služili kot osnova za paleookoljsko interpretacijo (Laville 1976; Cremaschi 1990). Rezultate oziroma določene klimatske faze smo nato uvrstili v splošen časovni okvir.

Faze so naslednje (razvrščene od najstarejše do najmlajše):

1. Obdobje tople in vlažne klime, ki je izpričano z odlaganjem debele sige in s popolno odsotnostjo klastičnih sedimentov. Čeprav v enotah, ki pripadajo tej fazi, nismo našli nobenih fosilnih ostankov, potrebnih za datacije, lahko precej zanesljivo sklepamo, da gre za obdobje zadnjega interglaciala (MIS 5), zelo verjetno prav za zadnjo fazo v tem obdobju.
2. Faza, pri kateri je prišlo do postopnega zaostrovanja podnebja. Verjetno je bila precej vlažna in predstavlja zgodnji začetek hladne dobe. Koluvij, ki pripada drobni glini, je zapolnil depresije, ki so se razvile nad zasigano površino. Takšni sedimenti alohtonega izvora nakazujejo, da je bila prst, ki je prekrivala pobočja okoli jame, odstranjena zaradi erozije. Razlog gre iskati v sezonskih padavinah, ki so prizadele posebej slabo poraščena območja, brez gozdnega rastja.
3. Stadial, na katerega sklepamo na podlagi grušča, odloženega kot posledica delovanja zmrzali oziroma krušenja jamskega oboda. To fazo lahko uvrstimo v

because slope processes acting outside the cave, mainly debrisflow and some debrisfall, contributed strongly to the input of coarse calcareous rubble into the cave.

If unit 116.1 of the outer sequence can really be correlated with the loess top level of the inner one, then all the units overlying 116.1 are more recent than the end of the Early Pleniglacial, even if their age cannot be reliably estimated because of the scantiness of the faunal assemblage.

5) Therefore, the last depositional unit of the Caverna degli Orsi/Medvedja jama sequence, which is made up of about 2 m of layered rubble, is probably testifying to alternating colder and relatively warmer cycles that may tentatively be ascribed to part of the Middle Pleniglacial Stadial-Interstadial phase (MIS 3). This deposit also closed definitively the old entrance, indirectly stopping the clastic deposition inside the cave.

As to the palaeoclimatic meaning of this evidence, it has been demonstrated that "stratigraphic *changes* in colluvial facies assemblages reflect significant climatic changes" (Blikra, Nemec 1998:952); generally speaking, strong production of these sediments must result first of all from the shrinkage of the wood cover during cold and/or moderately aridic phases. Deeper insights into climate change are difficult to obtain for Caverna degli Orsi/Medvedja jama because of the peculiar sedimentary environment, and of the mixing with standard frost shattering processes. Nevertheless, it is likely that slope processes like high density debrisflow dominated during the earlier stages of deposit formation, indicating moderately wet conditions with strong seasonality; conversely, the relevance of frost shattering increased steadily until the entrance was almost completely closed.

Apparently, no anthropic features were brought into evidence by the sedimentological and soil micromorphological study of the cave sequence, whereas some stone artefacts were found in both sondages, associated with little charcoal. This aspect is common in caves used by *Ursus spelaeus* for hibernation (Stiner *et al.* 1996; Bona *et al.* 2007), and suggests that the inside of the cave was visited only sporadically by humans, who probably preferred to dwell in the outer part of the cave, where some evidence of rock-shelters can be inferred from the geomorphology of the area. Nevertheless, it must also be pointed out that these remains may have been reworked into the cave by debrisflow processes, which involved materials coming from the outside of the cave.

The intense frequentation by cave bears, who used the cave as a hibernation den, caused the deposition of bones which were then weathered, originating strong amorphous phosphate mineralisations that cemented part of the sequence; part of these phosphates may have been originated also by the alteration of the soft mass of the bears, but no way to differentiate the two sources has yet been found.

zgodnji pleniglacial (po Ravazziju 2003) ali v kakšno podfazo tega obdobja.

Značilno je, da pedogene oblike, nastale kot posledica sezonskega zmrzovanja razmeroma globoko v jamskem sedimentu, niso opazne. Podobno velja tudi za ostale jame na Krasu (mišljeno za večji del pleistocena). To dejstvo morda kaže na razmeroma visoke temperature (v nasprotju z zmrzlinskimi klasti, nastalimi zaradi mehanskega preperevanja) in suhe razmere.

4. Puhlične usedline z jasnimi znamenji predelave koluvija, toda brez znakov preperevanja. Te usedline zaznamujejo konec sekvence "A".

Vse te obravnavane faze so najlepše zastopane v sedimentih sonde "A", medtem ko je sedimentno zaporedje v sondi "B" kompleksnejše. Razlog za večjo kompleksnost je v grušču, ki je obilen in povsod navzoč, vendar ima v osnovi enake značilnosti kot grušč v sekvenci "A". To dejstvo nikakor ni presenetljivo, saj pobočni procesi, ki delujejo zunaj jamskega okolja (predvsem krušenje in podiranje na strmih pobočjih ter deloma tudi drobirski tok), močno prispevajo k vnosu debelega apnenčevega grušča v jamsko okolje.

V primeru, da enoto 116.1 (iz sonde "B") res lahko koreliramo s puhlico v sami krovnini sekvence "A", potem velja, da so vse enote, ki ležijo nad 116.1, mlajše od konca zgodnjega pleiniglaciala. Vendar zaradi redkih fosilnih živalskih ostankov njihove starosti ne moremo zanesljivo oceniti.

5. Zadnja enota v sedimentnem zaporedju iz Medvedje jame je zgrajena iz okoli 2 m debelega plastovitega grušča. Verjetno kaže na menjavanje mrzlih in razmeroma toplih klimatskih ciklov, ki bi jih lahko pripisali srednjepleniglacialni fazi (stadial-interstadial, MIS 3). Ti sedimenti so popolnoma zapolnili in zaprli star jamski vhod in so torej posredno preprečili nadaljnje odlaganje klastičnih sedimentov v jami.

Paleoklimatska intepretacija sedimentov potrjuje, da "stratigrafske spremembe v koluvialnem faciesu odsevajo pomembne klimatske spremembe" (Blikra, Nemec 1998, 952). Velika produkcija koluvija mora biti najprej predvsem posledica krčenja gozdnih površin v času mrzle in zmerno aridne klimatske faze. Nadaljnja interpretacija klimatskih razmer v Medvedji jami je težavna. Sedimentno jamsko okolje je namreč specifično. Problem predstavlja tudi prepletanje koluvija s produkti mehanskega preperevanja ob delovanju zmrzali. Vendar pobočni procesi, kot je zgoščen drobirski tok, prevladujejo predvsem v zgodnjesedimentacijskih fazah. To kaže na zmerno vlažno podnebje z jasno izraženimi letnimi časi. Nasprotno pa je intenzivnost mehanskega preperevanja zaradi zmrzali stalno naraščala, vse dokler ni bil prvotni jamski vhod skoraj popolnoma zapečaten.

Sedimentološka in mikromorfološka raziskava sedimentov nista našli dokazov o prisotnosti človeka v jami. Vendar je bilo v obeh sondah najdenih nekaj

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Thanks go to the City Administration of S. Dorligo della Valle/Dolina, and to all the several Majors who followed during the long time of the excavations, for kind assistance and help in many circumstances, and for funding.

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kamnitih orodij in v njihovi bližini redko oglje. Redke sledi niso presenetljive glede na dejstvo, da gre za jamo, v kateri je bival oziroma prezimoval jamski medved (Stiner *et al.* 1996; Bona *et al.* 2007). Človek je obiskoval notranje dele jame le občasno, bolj se je zadrževal v vhodnem delu oziroma pod spodmolom, ki danes ni ohranjen, nanj pa sklepamo na podlagi geomorfologije bližnje okolice. Vendar ne smemo zanemariti možnosti, da so lahko ostanki kamnitih orodij in oglje prišli (oziroma so se prikotalili) v jamo skupaj s pobočnim (podornim) gruščem. Ta grušč namreč izvira iz zunanjega okolja.

Jamski medved je jamo zelo pogosto uporabljal kot prezimovališče oziroma brlog. Zaradi tega najdemo v jami velike količine kosti, ki so tekom časa preperevale in prihajalo je do močne mineralizacije amorfnega fosfata, ki je služil kot cement. Del fosfatne snovi lahko izvira tudi iz razkroja mišičnega in ostalega tkiva medvedov takoj po njihovem poginu. Vendar za zdaj še ne moremo ločiti dveh morebitnih izvorov fosfatne snovi.

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Prevod: Janez Turk

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KLIMATOSTRATIGRAFSKA UMESTITEV SEDIMENTOV V ZAHODNEM SEKTORJU POTOČKE ZIJALKE NA PODLAGI REKONSTRUKCIJE SNEŽNIH RAZMER V ČASU NJIHOVEGA ODLAGANJA

CLIMATOSTRATIGRAPHIC CLASSIFICATION OF SEDIMENTS IN THE WESTERN SECTOR OF POTOČKA ZIJALKA, BASED ON RECONSTRUCTION OF SNOW CONDITIONS AT THE TIME OF THEIR DEPOSITION

Janez TURK

Izvleček

Vzdolžni profil pleistocenskih in holocenskih sedimentov v vhodnem delu Potočke zijalke kaže določene posebnosti. Holocenski talusni sedimenti (na nasipnem stožcu neposredno ob jamskem vhodu) so razmeroma debeli, protalusni sedimenti (v zaledju današnjega nasipnega stožca v smeri proti jamski notranjosti) pa so razmeroma tanki. Obratno je pri pleistocenskih sedimentih, ki so razmeroma debeli v protalusnem delu. To dejstvo smo poskušali razložiti s snežnimi razmerami, ki so bile v pleistocenu drugačne kot v holocenu. V hladni in vlažni klimi se je neposredno ob jamskem vhodu kopičil sneg, izoblikoval se je snežni stožec, ki je lahko segal deset in več metrov v jamsko notranjost. Menimo, da je bilo trajanje snežnega stožca zaradi ostrih in dolgotrajnih zim dolgotrajno, popolnoma se je lahko stopil šele poleti, morda pa niti tedaj ne. Grušč, ki se je krušil z jamskega oboda ob vhodu v jamo, je zdrsnil po snežni odeji navzdol na vznožje snežnega stožca (talusa). Tedaj so se torej akumulirali predvsem protalusni sedimenti. V toplih klimatskih obdobjih, kakršen je holocen, pa se sedimenti kopičijo neposredno pri vhodu v jamo, zato je nastal nasipni stožec (talus). Sneg se v holocenu pred jamo zadržuje le nekaj mesecev na leto (pozimi), tako da ne vpliva pomembneje na akumulacijo sedimentov.

Ključne besede: pleistocen, holocen, talus, orinasjen, Karavanke, Slovenija

Abstract

Cave sediments in Potočka zijalka are of Pleistocene and Holocene age. The longitudinal profile through sediments at the anterior part of the cave exhibits some peculiarities. Holocene sediments are relatively thick at the talus (sedimentary cone directly at the cave mouth), while they are relatively thin at the protalus section. The protalus appears at the base of the talus, in the cave. The spatial distribution of Pleistocene sediments is just the reverse. We tried to interpret this characteristic of sediments by considering the snow conditions. These conditions were totally different in the Pleistocene than in the Holocene. During cool and humid climatic periods, snow was accumulating directly at the entrance to the cave. Consequently, a snow cone was formed. It could extend ten or more metres far into the cave. The snow cone could persist for the major part of the year due to the severe and long winters. It presumably didn't melt and disappear totally before the summer; occasionally it might even not disappear at all. Clastic material (debris), which spalled from the cave ceiling and walls around the cave mouth, did not accumulate on the snow cone. It rather slid down the slope of the snow cone and accumulated at the base of the snow slope (cone). Hence protalus sediments accumulated. In warm periods, such as the Holocene, the accumulation is different, with the sediments accumulating directly at the cave mouth. Hence the sediment cone (talus) formed there. In these times the snow persists for only a few months per year in front of the cave (in winters). For this reason it does not have any significant influence on the distribution of debris deposition.

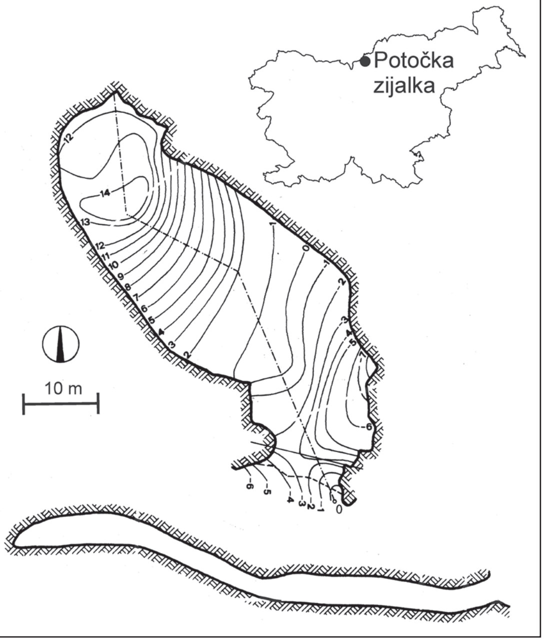
Key words: Pleistocene, Holocene, talus, aurignacien, Karavanke, Slovenia.

UVOD

Potočka zijalka je znano paleolitsko in paleontološko najdišče v Karavankah, 1700 m visoko na južnem pobočju Olševe (1930 m). Paleolitske najdbe, med katerimi izstopajo koščene konice, pripadajo orinasjenski kulturi (okoli 30.000 let pred sedanjostjo – OIS 3). Jama, ki je razvita v zgornjetriasnem (dachsteinskem) tektonsko močno pretrtem apnencu, je dolga 115 m in široka do 40 m. Prva polovica jame je skoraj horizontalna, nato pa se dvigne za 14 metrov (*sl. 1*; Brodar, S. in M. 1983; Kralj, Pohar 2001; Pohar, Pacher 2004).

V obravnavanem prispevku smo se osredotočili na analizo sedimentov v območju jamskega vhoda, ki sta ga S. in M. Brodar (1983) razdelila na zahodni in vzhodni sektor. Oba sektorja sta med seboj ločena z velikimi podornimi bloki (*sl. 2*). Preučevali smo predvsem lego in debelino plasti v zahodnem jamskem sektorju. V tem sektorju je debelina pleistocenskih sedimentov razmeroma velika, medtem ko so pleistocenski sedimenti v vzhodnem sektorju precej tanjši in nepregledni. Za debelino holocenskih sedimentov velja ravno nasprotno (Brodar, S. in M. 1983).

Neposredno pri vhodu v jamo lahko opazimo izrazit nasipni stožec ali talus, ki se z vrha spušča približno deset metrov daleč proti jamski notranjosti (profil 24–28; Brodar, S. in M. 1983). Akumulacija nastaja zaradi krušenja jamskega oboda, ki je pri vhodu zelo intenzivno zaradi delovanja zmrzali. Zaradi nižjega stropa pri vhodu, in ker se jama v notranjosti dvigne, se v njeni notranjosti zadržuje relativno topel zrak in zmrzal tu nima več vpliva (Mihevc 2001). Hkrati pa se s stene nad jamo kruši grušč, ki se prav tako lahko akumulira pred njo in prispeva k tvorjenju nasipnega stožca.



Sl. 1: Tloris in vzdolžni prerez Potočke zijalke (povzeto po Brodar, S. in M. 1983).
Fig. 1: Ground plan and longitudinal section of Potočka zijalka (from Brodar, S. & M. 1983).

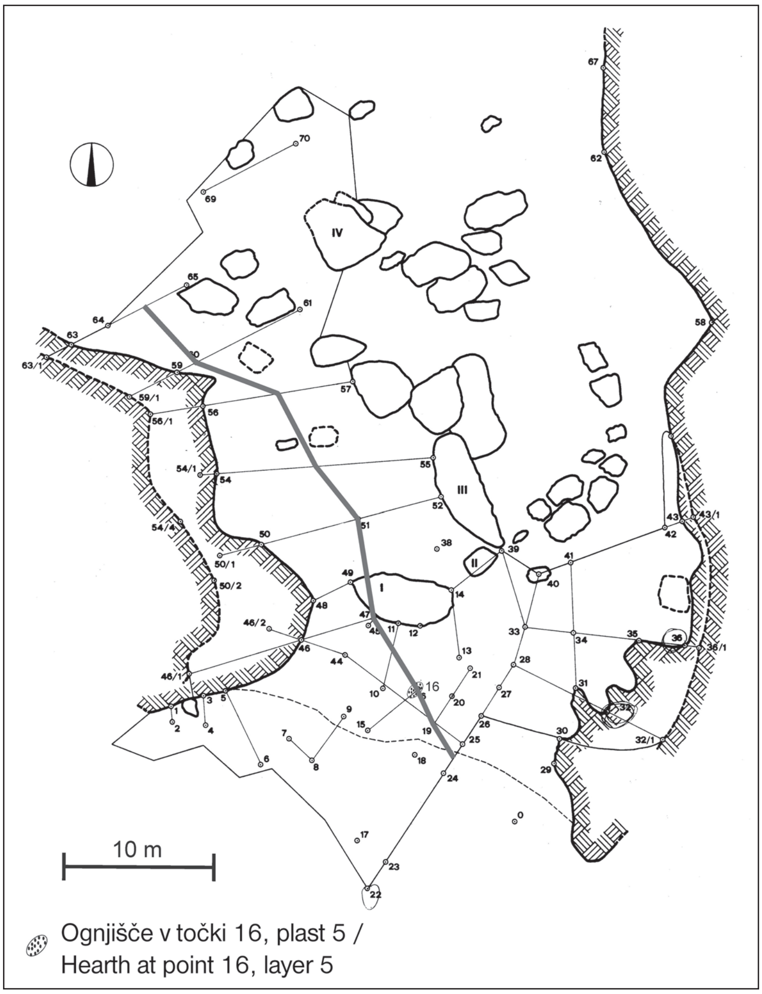
INTRODUCTION

Potočka zijalka is a well known archaeological and palaeontological site in the Karavanke Mountains. The cave is situated 1700 m high, on the southern slope of Mt. Olševa (1929 m). Palaeolithic finds (mainly stone artifacts and bone points) belong to aurignacien culture. The cave is formed in Upper Triassic (Dachstein) limestone, which is tectonically fractured. Cave is 115 m long and up to 40 m wide. The first half of the cave is almost horizontal, then the cave floor rises steeply for 14 m (*Fig. 1*; Brodar, S. & M. 1983; Kralj, Pohar 2001; Pohar, Pacher 2004).

In this paper, we have focused on the interpretation of sediments at the anterior part of the cave. According to S. and M. Brodar (1983), this part of the cave was divided into the eastern and western sector. Both sectors are separated by boulders (rock-fall), which spalled down from the cave ceiling (*Fig. 2*). We studied the position and thickness of sediments (layers) in the western cave sector. The thickness of Pleistocene sediments is relatively abundant there, while Pleistocene sediments are relatively thin and hard to follow in the eastern cave sector. The distribution of Holocene sediments is just the reverse in the two sectors discussed (Brodar, S. & M. 1983).

There is a characteristic sedimentary talus cone at the cave mouth in Potočka zijalka. The slope of the talus stretches around ten metres toward the cave interior (profile 24-28; Brodar, S. & M. 1983). Accumulation of sediments at the talus takes place due to the mechanical weathering of the cave ceiling and walls (frost action), spalling and breaking off rock fragments of different sizes. Frost action is very effective at the cave mouth. Frost action does not affect interior parts of the cave, where relatively warm air is retained. This is a direct consequence of cave morphology. The cave ceiling is relatively low at the anterior part and the cave floor rises in the interior part of the cave (Mihevc 2001). The debris, which rolls down the cliff above the cave, also contributes to the accumulation of sedimentary talus at the cave mouth.

The protalus is formed by debris, which slides down the snow-slope. Debris accumulates at the base of such a slope. The protalus is therefore characteristic for such regions, where severe winters occur. The snow cover should be abundant, long lasting or even permanent (McKenzie 1970). Potočka zijalka is situated at a relatively high altitude, where snow cover conditions are significantly prolonged, even during only slightly



Sl. 2: Tloris vhodnega dela jame s profili (povzeto po Brodar, S. in M. 1983). Odebeljeno je označen potek tu obravnavanega vzdolžnega profila.
Fig. 2: Ground plan of the anterior part of the cave with profiles marked (from Brodar, S. & M. 1983). The longitudinal profile discussed in the paper is marked with a thick line.

Protalus predstavlja podorni grušč, ki se je odkotalil po zaledenelem ali zasneženem pobočju in se trajno akumuliral ob vznožju takšnega nasipa (talusa). Protalus je torej značilen za tista območja, kjer so zime dolgotrajne in vsako leto bogate s snežno odejo, oziroma tam, kjer je snežna odeja stalna (McKenzie 1970). Ker Potočka zijalka leži na visoki nadmorski višini, kjer se snežne razmere bistveno podaljšajo že ob manjši zaostritvi klime, bi tudi tu pričakovali protalusne sedimente.

STRATIGRAFSKI PODATKI ZAHODNEGA SEKTORJA JAMSKEGA VHODA

Srečko in Mitja Brodar (1983) sta določila in opisala stratigrafijo sedimentov v vhodnem delu jame. Povzemamo stratigrafijo zahodnega jamskega sektorja, na katerega se nanaša v nadaljevanju obravnavani vzdolžni profil.

severe climatic conditions. Hence we could expect the occurrence of protalus sediments in Potočka zijalka.

STRATIGRAPHIC DATA FROM THE WESTERN SECTOR OF THE CAVE ANTERIOR

Srečko and Mitja Brodar (1983) determined and described the stratigraphy of sediments at the anterior part of the cave. Here, we summarize the stratigraphy of the western cave sector, to which the longitudinal profile (discussed in the continuation) refers.

Sediments, which belong to a given layer, are supposed to be temporally equivalent (even in the case when their composition changes). Where some of the layers thin out, it is not possible reliably to define the layers. Brodar S. and M. (1983) incorporated such sediments in a complex of several neighbor layers.

Sedimenti, ki pripadajo določeni plasti, naj bi bili časovno ekvivalentni, tudi v primeru, kadar se njihova sestava spremeni. Kjer se plasti izklinjajo, jih ni bilo možno povsem zanesljivo določiti. Tak sediment sta S. in M. Brodar (1983) združila v več sosednjih plasti.

Za zahodni jamski sektor je značilno, da je debelina holocenskih plasti (1 in 2) zelo tanka v primerjavi z debelino pleistocenskih plasti (9 do 3). Pleistocenski sedimenti se proti zahodni jamski steni zelo odebelijo ali pa izklinijo. Velika večina najdb v zahodnem jamskem sektorju je bila v plasti 7, nekaj pa tudi v plasteh 8, 5 in 3. Edino te štiri plasti se štejejo za arheološke.

Sedimenti večinoma pripadajo avtohtonemu grušču iz dachsteinskega apnenca, ki gradi jamski obod. Holocenski sedimenti so pomešani s prstjo, pleistocenski grušči pa z rjavkastordečo ilovico. S. in M. Brodar (1983) sta pleistocensko starost določila glede na vsebnost fosilnih ostankov jamskega medveda in seveda na podlagi arheoloških najdb.

Radiokarbonske datacije so bile opravljene kasneje, med izkopavanji v letih 1997–2000 (Rabeder, Pohar 2004). V celoti so opravili 15 datacij v različnih jamskih sektorjih Potočke zijalke, ki pa so pokazale razmeroma majhen časovni razpon pleistocenskih sedimentov v njej (okoli 10.000 let). Plast 7, kjer so arheološke najdbe najštevilčnejše, naj bi bila stara okoli 30.000 let, plast 8 pa približno 32.600.

METODA

Srečko in Mitja Brodar (1983) sta objavila predvsem prečne in nekaj vzdolžnih profilov jamskih sedimentov v vhodnem delu jame. Iz zgoraj omenjenih razlogov se večina razpoložljivih podatkov nanaša na zahodni sektor jamskega vhoda, precej manj pa na vzhodni. Na podlagi teh podatkov smo rekonstruirali daljši vzdolžni profil, ki sega od vrha nasipnega stožca v notranjost jame do konca njenega vhodnega dela. Vzdolžni profil je omejen na zahodni sektor jamskega vhoda, kjer so pleistocenske plasti debelejše in bolje razčlenjene kot v vzhodnem sektorju.

Za rekonstrukcijo enotnega vzdolžnega profila skozi celoten vhodni jamski del zahodnega jamskega sektorja (od vhoda približno 36 m proti notranjemu delu jame) smo uporabili podatke o debelinah plasti, ki smo jih odčitali iz objavljenih prečnih profilov. Razpolagali smo z devetimi prečnimi profili. Določene točke iz teh prečnih profilov smo povezali med seboj, da smo dobili en vzdolžni profil. Debeline plasti na določenih lokacijah so znane, torej smo na vzdolžnem profilu lahko sledili spreminjanje debeline plasti v smeri od vhoda proti notranjosti jame. Vhodne točke ležijo neposredno na nasipnem stožcu, nekaj vmesnih na njegovem pobočju, notranje pa v njegovem jamskem zaledju. Med seboj smo povezali naslednje vzorčne točke iz prečnih profilov:

It is characteristic, that the thickness of Holocene layers (1 and 2) is very thin in the western sector, in comparison with the thickness of Pleistocene layers (9 to 3). The thickness of Pleistocene layers increases in lateral direction, toward the western cave wall, while some layers thin out. The great majority of finds in the western sector appeared in layer 7, but some rare finds were also situated in layers 8, 5 and 3. These four layers are considered as archaeological.

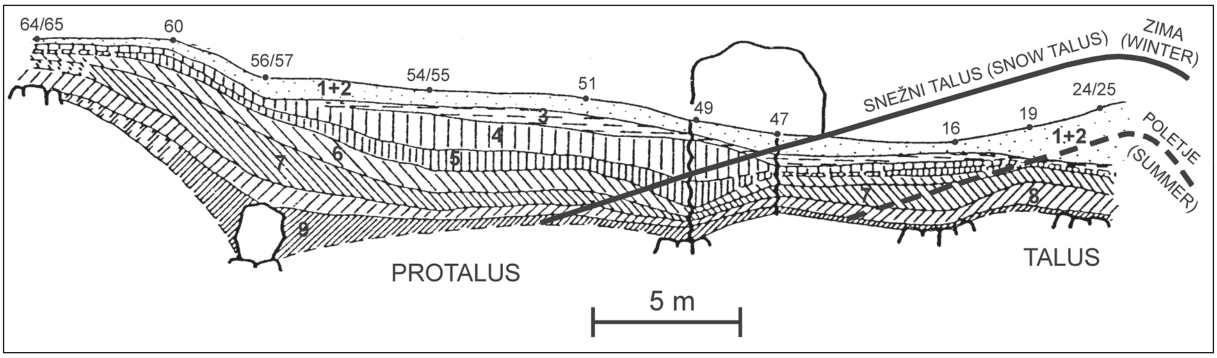
Sediments consist mainly of autochthonous debris - Dachstein limestone, which builds the cave walls and ceiling. Holocene sediments are mixed with soil, while Pleistocene debris is mixed with brown-reddish loam. Brodar S. and M. (1983) determined the Pleistocene age on the basis of archaeological finds and bone assemblage (*Ursus spelaeus*).

Radiocarbon datings (AMS) were performed later, during the 1997-2000 excavations (Rabeder, Pohar 2004). Alltogether, 15 radiocarbon datings were performed on bones and teeth from different sectors. Datings show a relatively low time span of Pleistocene sediments in Potočka zijalka (only around 10,000 years). Layer 7, where the majority of archaeological finds occurred, was deposited around 30,000 BP and layer 8 around 32,600 BP.

METHODOLOGY

Srečko and Mitja Brodar (1983) published mainly lateral and a few short longitudinal profiles of cave sediments at the anterior part. For the already mentioned reasons, the majority of data refer to the western sector. On the basis of published profiles, we reconstructed the longitudinal profile, which stretches from the summit of the sedimentary talus (at the cave mouth) to the end of the so called anterior part of the cave (*Fig 2*). The longitudinal profile is limited exclusively to the western sector. Pleistocene layers are thicker and more characteristic here than in the eastern sector.

We applied the data, which we obtained from the published lateral profiles (in the western sector), to reconstruct the thickness of layers in longitudinal direction (from the cave mouth, approximately 36 m far into the inside of the cave). All together data from nine lateral profiles were applied. Certain points from the lateral profiles were connected to reconstruct the discussed longitudinal profile. The thicknesses of layers are known at such points. Hence, we followed the variability of thickness of layers in longitudinal direction from the cave mouth toward the inside of the cave. Points, near the cave mouth, are situated directly at the sedimentary talus cone. Some points are situated at the slope of the talus cone and the rest of the points are situated farther inside the cave. Discussed points which were connected from nine lateral profiles are: 24-25 (point at the middle), 19, 16, 47, 51, points at the middle of lateral profiles 54-55 and 56-57 as well as



Sl. 3: Vzdolžni profil v zahodnem sektorju jamskega vhoda. Označena je rekonstrukcija obsega snežnega talusa v hladnih obdobjih pleistocena (za zimo in zgodnje poletje). Avtor skice je Ivan Turk (1996)

Fig. 3: Longitudinal profile in the western sector of the anterior part of the Potočka zijalka. The reconstruction of the snow talus in cool climatic periods of the Pleistocene is depicted (for winter and early summer). The author of the sketch is Ivan Turk (1996).

24–25 (točka na sredini), 19, 16, 47, 51, ter točke na sredini profilov: 54–55, 56–57, in točko 60 ter točko na sredini profila 64–65 (*sl. 2*; *cf.* Brodar, S. in M. 1983).

REZULTATI

Očitno je, da je prostorska razporeditev holocenskih in pleistocenskih sedimentov v vzdolžni smeri obratno sorazmerna. Holocenski sedimenti so najbolj debeli na vrhu današnjega nasipnega stožca, torej neposredno pri vhodu v jamo, v njegovem zaledju (v smeri proti jamski notranjosti) pa njihova debelina upade. Pri pleistocenskih sedimentih je ravno nasprotno. Celotna debelina teh sedimentov je razmeroma tanka na območju današnjega nasipnega stožca, močno pa se odebelijo v jamski notranjosti (Turk 1996).

Vendar tudi same pleistocenske plasti kažejo na razlike v debelini oziroma vzdolžni razporeditvi. Izstopata predvsem plasti 7 in 8, katerih spremenljivost debeline v vzdolžni smeri je deloma podobna kot pri holocenskih sedimentih (*sl. 3*).

RAZPRAVA

Vzrok za neenakomerno akumulacijo pleistocenskih in holocenskih sedimentov bi najlažje iskali v snežnih razmerah, ki so vladale v času odlaganja določenih plasti (Turk 1996). Nesporno je, da se v zimskem času pred jamo akumulira tudi snežni stožec, ta v današnjem času pred vhodom v Potočko zijalko prekrije sedimentnega. Snežni stožec nastane tudi v primeru, kadar spodaj ni nasipnega stožca oziroma je slabo razvit. Primer je Mokriška jama v Kamniških Alpah na podobni nadmorski višini (1500 m). Tu lahko pozimi opazujemo, kako se sneg akumulira na zelo podoben način kot sedimenti. Snežna odeja se s pomočjo vetra

point 60 and the one at the middle of the profile 64-65 (*cf.* Brodar, S. & M. 1983), to reconstruct the longitudinal profile, which is discussed in this paper (*Fig. 2*).

RESULTS

It is evident that the spatial distribution of Holocene and Pleistocene sediments is just the reverse, if we observe them in longitudinal profile. Holocene sediments are the thickest at the top of the present sediment cone, i.e. directly at the cave mouth. Their thickness is lower at the base of the cone i.e. in direction further into the cave (in the protalus section). The thickness of Pleistocene sediments is just the reverse. The total thickness of these sediments is relatively low at the location of the present sediment cone, but is thicker inside the cave, behind the sedimentary cone (Turk 1996).

However, also the Pleistocene layers exhibit differences in their thickness and longitudinal distribution, respectively. This is characteristic especially for layers 7 and 8. In longitudinal direction, their thickness varies similarly as does the thickness of Holocene layers (*Fig. 3*).

DISCUSSION

The reason for the irregular accumulation of Pleistocene and Holocene sediments may be argued by considering snow conditions, which governed at the time of deposition of different layers (Turk 1996). Nowadays during winters, a snow cone accumulates in front of Potočka zijalka, covering the sedimentary one. A snow cone forms even if there is no sedimentary cone (or if the later one is poorly developed). Such an example is the cave of Mokriška jama, situated only 200 m lower than Potočka zijalka, where in the winter time the accumulation of snow just in front of the cave entrance in snežnih plazov (na pobočju nad jamo) izrazito kopiči pred jamskim vhodom. Kopičenje in trajanje snega sta odvisna od količine padavin (snega), vetra in seveda trajanja mrzlega obdobja (Hvidtfeldt Christiansen 1998).

V današnjem času (holocenu) se snežni stožec pred Potočko zijalko ali na primer Mokriško jamo obdrži le nekaj mesecev na leto (zgolj pozimi), nato pa hitro popolnoma skopni. V pleistocenu, ko so bile klimatske razmere veliko ostrejše, pa je snežni stožec lahko obstal veliko večino leta, morda se je lahko občasno ohranil tudi poleti. Snežni stožec je bil lahko zelo velik in je segal razmeroma globoko v jamo.

Mehansko preperevanje predela nad jamskim vhodom je moralo biti v hladnih pleistocenskih fazah zelo intenzivno, in sicer kot posledica neposredne izpostavitve soncu podnevi in zmrzovanja ponoči (proces je še posebno značilen za pomladansko obdobje). Sklepamo, da jama ni bila nikoli dalj časa vkovana v ledeni oklep, vsaj ne v času, v katerem so se odložile tu obravnavane jamske pleistocenske in holocenski plasti (od 32.000 let pred sedanjostjo do danes). Obstajajo pa tudi nasprotne razlage (Pohar, Brodar 1998). V kolikor je jama popolnoma zaledenela, sedimentacija v takšnem primeru ni možna. To razlago ne štejemo za verjetno, saj jama leži na južnem, sončnem pobočju Olševe. Menimo, da je bila snežna meja v tem času nad višino jame. Snežna meja je bila v bližnjih Julijskih Alpah v obdobju würma III nekaj 100 m višje, kot je višina Potočke zijalke (Venturini 2003). Julijske Alpe pa imajo tudi nekoliko bolj gorski značaj kot Karavanke.

Vprašanje je torej, zakaj je debelina pleistocenskih sedimentov na območju današnjega talusa večinoma tanka, čeprav je bilo tedaj mehansko preperevanje intenzivnejše kot v holocenu (holocenski sedimenti na talusu pa so razmeroma debeli). Menimo, da je akumulacijo avtohtonih sedimentov (grušča) na talusu v hladnih fazah pleistocena preprečevala snežna odeja, ki je povzročila, da so sedimenti zdrseli po pobočju talusa. Del sedimentov je zdrsel po zunanjem pobočju in se odkotalil proti dolini, del pa je zdrsel po notranjem pobočju do vznožja snežnega stožca v notranjem delu jame. V takšnih snežnih razmerah se sedimenti kopičijo ob vznožju snežnega stožca v jami, gre za t. i. protalus (*sl. 3*).

Debelina holocenskih sedimentov v nasipnem stožcu je znatna. Klimatske razmere v holocenu se niso tako izrazito spreminjale, vsaj v daljšem obdobju ne, kot v pleistocenu. Torej lahko sklepamo, da je v zadnjih 10.000 letih sneg prekrival sedimente na vhodu v jamo večinoma manjši del leta (pozimi, ob ostrih zimah deloma tudi spomladi, zgodaj poleti pa le zelo redko). Akumuliranje novih avtohtonih sedimentov na talusu je bilo lahko večinoma neposredno na že obstoječe. Da je vpliv snežne odeje na akumulacijo sedimentov v holocenu zanemarljivo majhen, dokazujejo protalusni sedimenti, ki so neprimerno tanjši od talusnih.

can be observed. The accumulation of snow ressemble the accumulation of sedimentary cone, which formed in many mountainous palaeolithic caves (e.g. Potočka zijalka). In Potočka zijalka, the accumulation of snow cover at the cave mouth is caused by wind and by avalanches and depends on the amount of precipitation (snow), wind and the duration of winter (Hvidtfeldt Christiansen 1998).

Nowadays, in the Holocene, the snow cone persists in front of Potočka zijalka or Mokriška jama for a few months per year only (in winter time). It melts and disappears rapidly in the spring. Contrary to this, the snow cone could persist for a major part of the year in the Pleistocene, when climatic conditions were severe. It is possible that occasionally it did not totally disappear not even in the summer. The snow cone was probably very extensive in the winter and in early spring and extended ten or more metres far inside the cave.

Mechanical weathering of the cave ceiling and walls was very intensive during cool climatic phases in the Pleistocene. It is a consequence of direct solar insulation in the day and freezing in the night. Such a process is characteristic especially for the spring. We presume that the cave was never totally frozen, at least not during the period of deposition of the discussed Pleistocene and Holocene layers (32,000 years BP till the present). However, there is also a different hypothesis (Pohar, Brodar 1998): i.e., there is no sedimentation in the cave, if the cave is totally frozen. We think that such conditions did not occur in Potočka zijalka. The entrance to the cave is situated on the southern, sunny slope of Mt. Olševa. We believe that the snow line was above the altitude of the cave entrance at 1700 m. The snow line in the near Julian Alps was at least 2000 m a.s.l. in Würm III (Venturini 2003), with the Julian Alps representing a more alpine environment than the Karavanke.

The low thickness of Pleistocene sediments at the location of the talus needs to be explained, due to the fact that mechanical weathering was more intensive in the Pleistocene than in the Holocene (but Holocene sediments are thick at the location of the talus). The accumulation of autochthonous sediments (debris) on the talus was impeded by the snow cone in the cool climatic phases of the Pleistocene. Sediments simply slid down the slope of the snow cone. The sediments, which slid down the external slope of the snow cone, rolled down toward the valley, while those which slid down the internal slope of the snow cone accumulated at its base in the cave. This is the so called protalus (*Fig. 3*).

The thickness of Holocene sediments is abundant at the cave mouth (i.e. at the talus). Climatic conditions have not altered significantly, at least not for relatively long periods, as happened in the Pleistocene. Hence, we can presume that snow covered the sedimentary cone at the cave mouth only for a minor part of the year (during winter months, in the spring only occasionally, Sklepamo, da so bile snežne razmere obilne v času odlaganja pleistocenskih plasti 9, 6, 4, 5, in 3. Te plasti so tanke na vrhu nasipnega stožca, vendar se v protalusnem delu odebelijo. To še posebej velja za plasti 6 in 4, morda tudi plast 9, manj izrazito je to pri plasteh 5 in 3 (*sl. 3*). Torej bi lahko sklepali, da je snežni stožec v letnih ciklih, ko so se odlagale te plasti, nastal prej kot nastane danes in se ohranil do pozne pomladi. Zato je velika večina odloženega avtohtonega klastičnega materiala zdrsela po snegu navzdol in se kopičila v protalusnem delu.

Vse to kaže, da je bila v času odlaganja omenjenih plasti klima razmeroma hladna in humidna v primerjavi s holocensko. Da so bile klimatske razmere v času odlaganja plasti 6 in 4 ostre, potrjuje dejstvo, da v njih ni bilo najdenih sledi o obisku človeka v jami (Brodar, S. in M. 1983). Številne močno preperele kosti v plasti 6 (Brodar, S. in M. 1983) kažejo ne samo na hladno, temveč tudi na zelo vlažno klimo.

Za plasti 4 in 3 v zahodnem sektorju sta tudi Rabeder in Pohar (2004) sklepala, da nakazujeta hladnejšo klimatsko fazo. V teh plasteh so bili najdeni nekateri predstavniki arktične favne, kot so rosomah (*Gulo gulo*), moškatno govedo (*Ovibos moschatus*) in snežna jerebica (*Lagopus* sp.).

V plasti 5 so našli ognjišče, in sicer v točki 16 (profil 15–16; *sl. 2*; Brodar, S. in M. 1983). Točka 16 je na talusnem delu profila, tu je plast 5 tanka. Glede na pojav ognjišča v tankem delu plasti 5 bi lahko sklepali, da erozije tu ni bilo, oziroma zmanjšanje debeline pleistocenskih plasti na talusnem delu naj ne bi bilo posledica erozijskih procesov.

Ker pa se je plast 5 po naši interpretaciji odlagala v hladnem obdobju, bi lahko sklepali, da se je snežni stožec poleti stalil. Možno je sicer tudi, da so ljudje kurili neposredno na snegu. Ognjišče dokazuje, da so tedaj jamo ljudje obiskovali vsaj občasno.

Mihevc (2001) trdi, da vrhnji sloj jamskih tal počasi polzi iz jame in da bi bila zaradi tega potrebna nova interpretacija arheoloških plasti. S tem se ne strinjamo. V kolikor bi resnično prihajalo do izrazitega polzenja, bi bila ognjišča v arheoloških plasteh popolnoma razpršena oziroma se sploh ne bi ohranila. Ognjišče v točki 16 v plasti 5 je koncentrirano na točno določeno globino in obseg. Večjega premikanju sedimentov tu zagotovo ni bilo. Podobno velja za ostala ognjišča, ki so predvsem v plasti 7. Arheološke najdbe so skoncentrirane na neposredno bližino ognjišč.

Med pleistocenskimi plastmi izstopata plasti 7 in 8, ki sta podobno kot holocenske razmeroma debeli na območju današnjega nasipnega stožca, v protalusnem delu sta tanjši, v distalnem delu pa kažeta ponovno odebelitev. Torej bi lahko sklepali, da so bile snežne razmere za časa odlaganja teh dveh plasti podobne kot v holocenu. Ugodne klimatske razmere v času odlaganja teh plasti potrjujejo številne arheološke najdbe, ki so najpogostejše prav v plasti 7. V vhodnem delu jame je

early in the summer very rarely) in the last 10,000 years. Accumulation of autochthonous sediments on the talus took place directly onto the sediments earlier deposited. In the Holocene, the influence of the snow cover on the accumulation of sediments was negligible, as can be presumed due to the protalus sediments, which are much thinner than the talus sediments.

We presume that snow conditions were abundant in the period when the deposition of layers 9, 6, 5, 4 and 3 took place (in the Pleistocene). These layers are relatively thin at the summit of the sedimentary cone, but become thicker just behind the talus, within the cave. This is especially characteristic for layers 6 and 4, maybe also for layer 9, while such distribution is less distinctive for layers 5 and 3 (*Fig. 3*). When the deposition of the discussed layers took place (i.e. in Late Pleistocene), an earlier beginning of winter and of the formation of the snow cone relative to nowadays may be presumed. Moreover, the snow cover persisted late into the spring, maybe till summer. For this reason, the majority of clastic material (debris), which spalled from the cave ceiling near the cave mouth, slid down the snowy slope and accumulated as the protalus. This indicates that the climate was cool and humid, in comparison with the Holocene climate. Severe climatic conditions in the period of deposition of layers 6 and 4 may be corroborated by the fact that they contain no traces of human visits (Brodar, S. & M. 1983). Numerous weathered bones within layer 6 (Brodar, S. & M. 1983) are not only an indicator of a cool, but also of a very humid climate.

Some representatives of arctic fauna (*Gulo gulo*, *Ovibos moschatus*, *Lagopus* sp.) were found in layers 4 and 3. Hence Rabeder and Pohar (2004) concluded that layers 4 and 3 were deposited in a cool period.

A hearth was found in layer 5, exactly at point 16 (profile 15-16; *Fig. 2*; Brodar, S. & M. 1983). This point is situated at the talus part of the profile, where layer 5 is very thin. Due to the occurrence of the hearth within the thin part of layer 5, we may presume that there was no erosion, which could affect the thickness of layer 5.

According to our interpretation, layer 5 was deposited in a cool period. The snow cone might have disappeared in the summer, when people visited the cave and made a fire. It is also possible that they made a fire directly on the snow. However, the hearth indicates that they visited the cave at least occasionally in this period, interpreted as a cool one.

Mihevc (2001) wrote that the upper part of the cave floor slides slowly from the cave and that there is a need for a new interpretation of the archaeological layers. We do not agree with him. If significant sliding really did occur, then certainly the hearths within the archaeological layers would be scattered, or the hearths would not be preserved at all. The hearth at point 16 in layer 5 is concentrated at an exactly defined depth and extent. Hearths do not indicate significant movement of sediments. Similar statements bilo v plasti 7 odkrito precej koščenega orodja in več kot 300 kamenih artefaktov oziroma njihovih fragmentov (Brodar, S. in M. 1983).

SKLEP

Potočka zijalka leži na visoki nadmorski višini, kjer prevladuje razmeroma ostro gorsko podnebje. Zaradi tega je mehansko preperevanje kamnine pri vhodu intenzivno tudi v holocenu oziroma v današnjem času.

Sklepamo, da je bila v hladnih obdobjih würma II in III snežna meja nekoliko nad višino vhoda v jamo. Dolgotrajne zime z obilnimi snežnimi padavinami so povzročile, da se je sneg akumuliral pri jamskem vhodu in tvoril snežni stožec, ki se je širil v smeri proti notranjosti jame (Turk 1996). Snežni stožec je imel pomembno vlogo pri akumulaciji grušča, ki se je predvsem zaradi mehanskega preperevanja krušil z jamskega stropa. Preprečeval je akumulacijo sedimentov na talusnem predelu, ti so se kopičili ob vznožju snežnega stožca v jami (protalusu).

Plasti 9 in 5 do 3 so se odlagale v mrzli in hladni klimi. Protalusna razporeditev sedimentov v plasteh 6 in 4 vzdolžnega profila je očitna. Nekoliko bolj nepravilna je razporeditev sedimentov iz plasti 9, 5 in 3, kjer protalusna odebelitev ni tako jasna. Razlog gre iskati tudi v problematični določitvi mej med plastmi, kar je še posebno težavno pri jamskih sedimentih.

Nasprotno pa sta se plasti 8 in 7 odlagali v relativno toplih klimatskih okoliščinah, ko snežne razmere pri vhodu v jamo niso imele vpliva na razporeditev sedimentov v njenem vhodnem delu. Tedaj so se kopičili predvsem talusni sedimenti, mehansko preperevanje v notranjem delu jame pa je bilo manj intenzivno, posledično so tam tudi manj debeli sedimenti. Takšne razmere prevladujejo tudi danes oziroma so prevladovale v večjem delu holocena.

Na podlagi sicer redkih radiokarbonskih datacij (Rabeder, Pohar 2004) lahko poskušamo nekoliko bolj osvetliti klimatostratigrafski položaj pleistocenskih sedimentov.

Plast 8 in 7 sta bili datirani v obdobje med 32.000 do 29.000 let pred sedanjostjo. Časovno gre za obdobje OIS 3, oziroma za interstadial ki ustreza denekampu. Razporeditev talusnih sedimentov v plasteh 8 in 7 kaže na razmeroma ugodne klimatske razmere. S takšno klimatsko interpretacijo so skladni tudi drugi kazalniki, ki temeljijo na arheoloških najdbah (Brodar, S. in M. 1983).

Čeprav neposrednih datacij za ostale mlajše pleistocenske plasti (6, 5, 4 in 3) nimamo, bi jih lahko uvrstili v hladno fazo stadiala würm II. Siga v plasti 4c (pojavlja se v prečnih profilih 56–57, 59–61 in 63–65; Brodar, S. in M. 1983) nakazuje otoplitev.

Natančnejša kronostratigrafska razporeditev pleistocenskih plasti 6 do 3 ni možna. Glede na razpoložljive

may also be made for other hearths, which were found mainly in layer 7. All archaeological finds are concentrated on the direct surroundings of the hearths.

Layers 8 and 7 deviate in comparison with other Pleistocene layers. They are relatively thick on the area of the present talus and thinner in the protalus area, similar to the Holocene layers. But they become thicker again in the distal part, within the cave. We may presume the snow conditions during the deposition of layers 8 and 7 to have been very similar to those from the Holocene. This is corroborated also by numerous archaeological finds, which are characteristic especially for layer 7. In the anterior part of the cave, numerous bone tools and over 300 stone artifacts or their fragments were found in layer 7 (Brodar, S. & M. 1983).

CONCLUSION

Potočka zijalka is situated at high altitude, where relatively severe climatic conditions occur. For this reason, mechanical weathering at the anterior part of the cave is intense also in the Holocene.

We presume that the snow limit was above the cave in the cool periods of the Würm II and Würm III stadials. Snow was accumulating at the cave mouth due to the long lasting winters and abundant snow precipitation. A snow talus was formed and it was spreading in the cave (Turk 1996). The snow talus had an important role in the accumulation of debris, which spalled and broke down the ceiling (walls) at the anterior part of the cave because of the frost action. The snow cover prevented accumulation of debris on the talus; it accumulated rather at the base of the talus (protalus).

Layers 9 and 5 to 3 were deposited in cool climate conditions. Distribution of sediments in layers 6 and 4 is characteristic, and sediments are abundant in the protalus. Distribution is less characteristic in layers 9, 5 and 3, where the protalus is not so clear. However, the reason may be found in the not well defined boundaries among the layers. Defining layers may be a very problematic task, especially in caves.

Layers 8 and 7 were deposited in a relatively warm climate, when snow conditions at the cave mouth did not have any significant influence on the distribution of sediments at the anterior part of the cave. Sediments were accumulated mainly on the talus. Mechanical weathering was relatively less intense further into the cave; hence sediments are less abundant in the protalus. Similar conditions may be observed in the geological present (Holocene).

On the basis of rare radiocarbon (AMS) datings (Rabeder, Pohar 2004), we tried to elucidate the climatostratigraphic situation of Pleistocene sediments in Potočka zijalka.

Layers 8 and 7 were dated to 32,000 – 29,000 years BP. This period belonged to OIS 3, more accurately to datacije in njihov razmeroma majhen časovni razpon bi lahko sklepali, da so se vse te plasti odlagale v OIS 3 oziroma v stadialu würm II, verjetno pa tudi v OIS 2 (würm III).

Zahvala

Na problematiko debeline pleistocenskih in holocenskih plasti v vhodnem delu Potočke zijalke je prvi opozoril moj oče Ivan Turk v svojem doktorskem delu. Objavo je prepustil meni. Za koristne nasvete se mu lepo zahvaljujem.

the Denekamp interstadial. The distribution of talus sediments in the two layers discussed indicates relatively favorable climatic conditions. This is in accordance with some other indicators, which are based on archaeological finds (Brodar, S. & M. 1983).

In spite of the fact that no direct radiocarbon datings are available for more recent Pleistocene layers (6, 5, 4 and 3), these layers were presumably deposited in a cool period – Würm II stadial. Flowstone, which occurs in layer 4c (it may be followed in lateral profiles 56-57, 59-61 and 63-65; Brodar, S. & M. 1983), indicates a warm climate.

More accurate chronostratigraphic determination of Pleistocene layers 6 to 3 is not possible so far. According to the available datings and relatively low time span of these dates, we could presume that these layers were deposited in OIS 3 (Würm II stadial), probably also in OIS 2 (Würm III stadial).

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PALEOBOTANIČNE RAZISKAVE V PALEOLITSKIH NAJDIŠČIH V SLOVENIJI

PALAEOBOTANICAL RESEARCH AT PALAEOLITHIC SITES IN SLOVENIA

Metka CULIBERG

Izvleček

V številnih paleolitskih najdiščih v Sloveniji je bil ugotovljen tudi paleobotanični material, lesno oglje in/ali pelod. V musterjenskem najdišču Divje babe I je bilo v plasteh, ki pripadajo srednjemu würmu, obdobju od približno 80.000 do 40.000 let pred sedanjostjo, ugotovljenih več kot 20 ognjišč z bogato vsebino oglja. Od tod je bilo analiziranih več tisoč primerkov oglja. Ugotovili smo, da je bila v okolici najdišča tudi v tedanjem času prisotna drevesna vegetacija, v kateri so prevladovali iglavci (*Pinus*, *Picea*, *Abies*, *Larix*, *Taxus*, *Juniperus*), v toplejših obdobjih glaciala pa so se jim pridružili različni listavci, med njimi tudi bukev (*Fagus*). Sedimenti 9 m globokega profila so bili tudi pelodno analizirani. Paleobotanične najdbe iz drugih, večinoma mlajšepaleolitskih najdišč so sicer veliko bolj redke, vendar kažejo, da je tudi v zadnjem würmskem stadialu (W III) v bližini najdišč zagotovo uspeval *Pinus*, v poznem glacialu pa so se mu pridružili še drugi iglavci, zelo kmalu tudi listavci, z bukvijo vred.

Ključne besede: arheobotanika, paleolitska najdišča, Slovenija

V Sloveniji je bilo odkritih in raziskanih že več kot 50 paleolitskih najdišč. Človek, ki je morda bival v jamah ali se le občasno zadrževal v njih in si zakuril ogenj, je s svojo prisotnostjo ustvaril pomemben arhiv podatkov, ki nam zdaj vsaj delno dopolnjujejo poznavanje vegetacijskih, posredno pa tudi klimatskih razmer tistega časa. Z analizo oglja izvemo, kakšno drevje je uspevalo v bližini najdišč, kajti lesa za kurjavo človek gotovo ni nosil od daleč. Po količini ugotovljenih vrst oglja sicer ne moremo sklepati, tako kot je to mogoče pri pelodni

Abstact

Palaeobotanic material, such as wood charcoal and/or pollen has been found in numerous Palaeolithic sites in Slovenia. More than 20 charcoal rich hearths were discovered in the Mousterian cave site Divje Babe I from the Middle Würm (approximately 80,000 to 40,000 BP). Thousands of specimens of charcoal were analysed from this site. It was established that conifers (*Pinus*, *Picea*, *Abies*, *Larix*, *Taxus*, *Juniperus*) dominated the vegetation in the area of the site during that period, which were joined in warmer periods of the Glacial by various deciduous species, including beech (*Fagus*). Pollen analysis was also performed on sediments from the 9-meter deep profile. Palaeobotanical finds from other, mostly Upper Palaeolithic sites are much more scarce; however, it can be seen that *Pinus* was present in the vicinity of the sites in the last Würm stadial (W III), and was joined by other conifers in the Late Glacial and, soon afterwards, by deciduous trees, including beech.

Keywords: archaeobotany**,** Palaeolithic sites, Slovenia

More than 50 Palaeolithic sites have already been discovered and researched in Slovenia. Man, who perhaps lived in caves or stayed in them occasionally and lit fires, created an important archive of data with his presence, which at least partially supplement an understanding of the vegetation and, indirectly, also the climatic conditions of those times. We know from analysis of charcoal what kind of trees grew in the vicinity of a site, since man certainly didn't carry wood for burning very far. Although we cannot conclude from the quantities analizi, kakšen gozd je uspeval v okolici najdišča, in še manj, kako je bila porastla daljna okolica, izvemo pa vsaj za nekatere vrste drevja, da so tedaj tam zagotovo uspevale.

Večina paleolitskih najdišč v Sloveniji je bila raziskovanih v drugi polovici preteklega stoletja, vendar so raziskovalce tedaj zanimale predvsem kulturne ostaline in živalske kosti kot indikator podnebnih in okoljskih razmer. Najdbe oglja so bile večinoma redke, morda bolj naključne, včasih niso bile niti stratigrafsko opredeljene in še manj radiometrično datirane. Tako imamo kljub razmeroma velikemu številu odkritih in bolj ali manj raziskanih paleolitskih najdišč od tod skromnejše paleovegetacijske podatke.

OGLJE IN PELOD V PALEOLITSKIH NAJDIŠČIH (*sl. 1*)

Babja jama

Poleg epigravetjenskega tipa orodja so bila ugotovljena tudi ognjišča (Osole 1971; Pohar 1985). V petih vzorcih kulturnega horizonta (plast 5) je bilo opredeljenih več kot 60 primerkov oglja. Vsi so pripadali boru (*Pinus*) in le eden jerebiki (*Sorbus*; Šercelj, Culiberg 1985). V. Pohar (1997, 121) favnistične najdbe opredeljuje v pozni glacial (böllinški interstadial).

Betalov spodmol

V 10 m globoki sedimentni zapolnitvi je S. Brodar ugotovil paleolitske stratume od pramusterjena do poznega gravetjena. Osole (1990a), ki je obdelal zbrano gradivo, je 16 plasti združil v 6 kompleksov. V kompleksu 3, ki kulturno pripada srednjemu paleolitiku (levallois-musterjen), so ugotovili pelod bora (*Pinus*), lipe (*Tilia*), hrasta (*Quercus*), bresta (*Ulmus*), gabra (*Carpinus*), vrbe (*Salix*) in topola (*Populus*) ter oglje bora (*Pinus*), lipe (*Tilia*) in jelše (*Alnus*), kar bi lahko ustrezalo časovni opredelitvi v interglacial riss/würm. V 4. kompleksu (mlajši paleolitik, končni musterjen), ki bi ustrezal interstadialu W I/W II, je bil ugotovljen pelod lipe (*Tilia*), v 5. kompleksu z orinasjensko kulturo in časovno opredelitvijo v drugi würmski stadial (W II), pa je bilo ugotovljeno oglje bora (*Pinus*). Sedimente je pelodno analizirala A. Budnar-Tregubov (1951, interno poročilo).

Ciganska jama

V profilu sta bila ugotovljena dva kulturna horizonta s kamnitimi in koščenimi najdbami, značilnimi za tardigravetjen (Brodar, M. 1974–1975). Oglje bora (*Pinus*) in kosti severnega jelena (*Rangifer tarandus*; Pohar 1994) v spodnjem horizontu (plast 5) kažejo na tundrsko pokrajino v tretjem würmskem stadialu. V zgornjem horizontu (plast 3), tudi kulturno bogatejšem, sicer še vedno prevladuje bor (*Pinus*), posamični primerki listavcev jerebike (*Sorbus*), javorja (*Acer*) in gabra (*Carpinus*) pa bi lahko kazali že na popuščanje

of species of charcoal found, as is possible with pollen analysis, what kind of forest grew in the vicinity of a site, and still less what the tree cover was in the more distant surroundings, we know at least for some species that they certainly grew there at that time.

The majority of the Palaeolithic sites in Slovenia were investigated in the second half of the last century but researchers then were primarily interested in cultural remains and animal bones as an indicator of climatic and environmental conditions. Finds of charcoal were for the most part rare, perhaps more by chance, sometimes they were not even stratigraphically defined and still less radiometrically dated. Despite the relatively large number of discovered and more or less researched Palaeolithic sites, therefore, we have relatively modest palaeovegetational data from them.

CHARCOAL AND POLLEN IN PALAEOLITHIC SITES (*Fig. 1*)

Babja jama

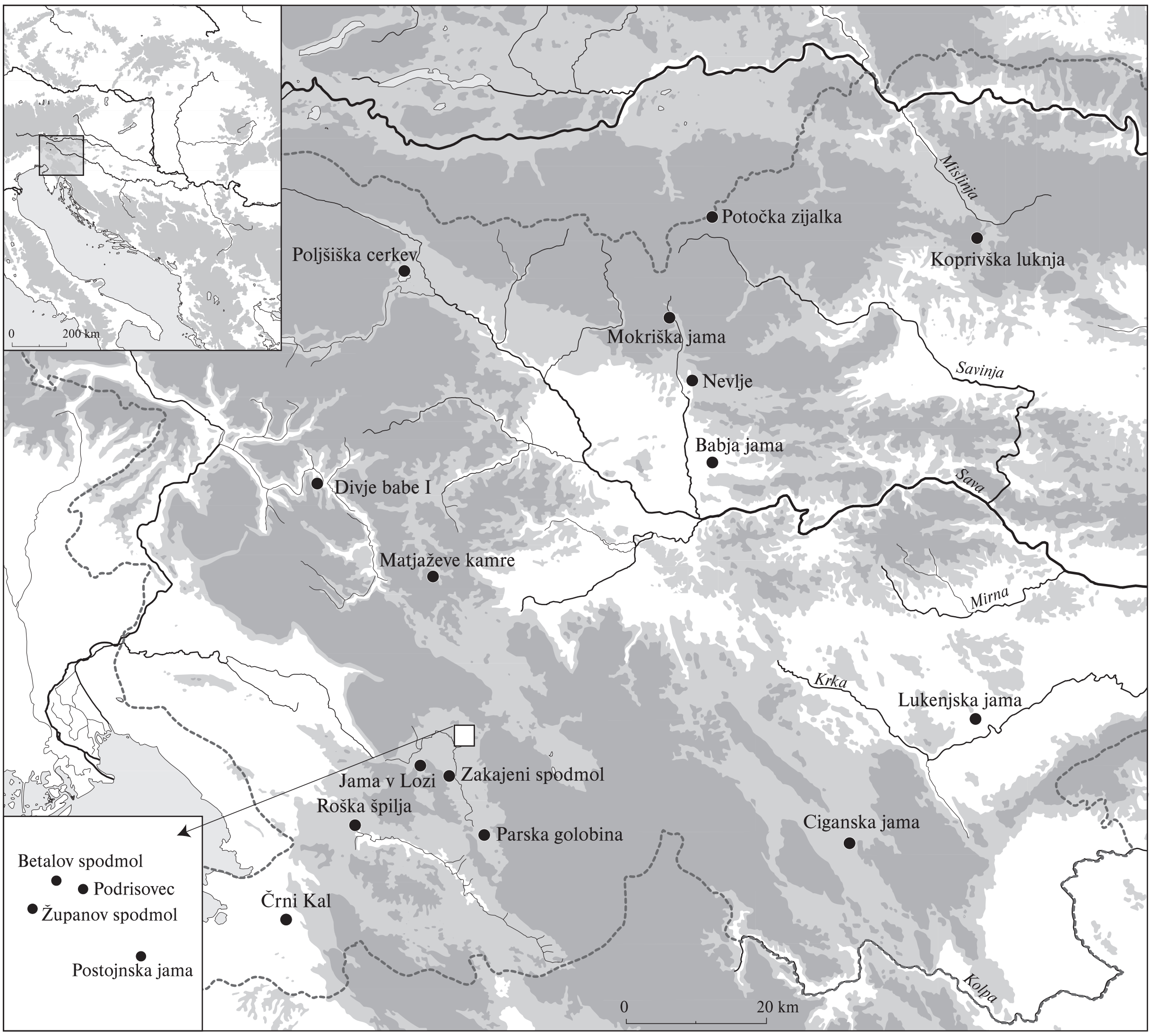
In addition to *Epigravettian* type tools, some hearths were found (Osole 1971; Pohar 1985). In five samples of the cultural horizon (layer 5) more than 60 samples of charcoal were identified. All belonged to *Pinus* except for one *Sorbus* (Šercelj, Culiberg 1985). V. Pohar (1997, 121) identified the finds of fauna to the Late Glacial (Bölling interstadial).

Betalov spodmol

S. Brodar identified palaeolithic strata in the 10 m deep sedimentary filling, from *Pre-Mousterian* to late *Gravettian*. Osole (1990a), who processed the collected material, combined the 16 layers into 6 complexes. In complex 3, which belongs in cultural terms to the Middle Palaeolithic (*Levallois-Mousterian*), the pollen of *Pinus*, *Tilia*, *Quercus*, *Ulmus*, *Carpinus*, *Salix* and *Populus* as well as the charcoal of *Pinus*, *Tilia* and *Alnus* was found, which could correspond to a chronological determination to the interglacial R/W. In complex 4 (Upper Palaeolithic, *final Mousterian*), which would correspond to the interstadial W I/W II, the pollen of *Tilia* was found, and in complex 5, from the *Aurignacian* culture and determined as the second Würm stadial (W II), charcoal of *Pinus* was found. The sediments were analysed by A. Budnar-Tregubov (1951, internal report).

Ciganska jama

Two cultural horizons with stone and bone finds characteristic of the *Tardigravettian* were identified (Brodar, M. 1974-1975). Charcoal of *Pinus* and the bones of reindeer (*Rangifer tarandus*; Pohar 1994) in the lower horizon (layer 5) indicate a tundra landscape in the third Würm stadial. In the upper horizon (layer 3), which was also culturally richer, *Pinus* still predominates but individual specimens of broadleafs: *Sorbus*, *Acer* and *Carpinus* may indicate a let up of glacial conditions.



Sl. 1. Paleolitska najdišča v Sloveniji s paleobotaničnimi najdbami.
Fig. 1. Palaeolithic sites in Slovenia with palaeobotanical finds.

glacialnih razmer. Do podobne ugotovitve je prišla V. Pohar (1992), ko je glede na prisotnost kostnih ostankov divje svinje sklepala, da je vrhunec hladnega sunka W III že minil.

Črni Kal

V kamnolomu nad Črnim Kalom je bila odkrita jama z musterjenskimi kulturnimi plastmi (Brodar, S. 1958). V njih so bili drobci oglja bora (*Pinus*) in nedoločljivih listavcev. Avtor časovno opredeljuje najdbe v starejši würm.

Jama v Lozi

Kamnito in koščeno orodje iz plasti 5 je Osole (1979, 181) uvrstil v tardigravetjen. Kurišč ni bilo, najdeni so bili le posamezni koščki oglja. Poleg bora (*Pinus*) je Šercelj (1963) ugotovil tudi naslednje termofilne vrste listavcev: bukev (*Fagus*), lesko (*Corylus*) in črni bezeg (*Sambucus*), kar kaže na končno obdobje würma, s poznim glacialom (tardigravetjen) vred.

V. Pohar (1992) came to a similar conclusion when, in view of the presence of bone remains of wild boar, he concluded that the maximum of the cold shock of W III had already passed.

Črni Kal

A cave with Mousterian cultural layers was found in a quarry Črni Kal (Brodar, S. 1958). There were fragments of charcoal of *Pinus* and unidentifiable broadleafs found in the layers. The author dated the finds to the Older Würm.

Jama v Lozi

Osole (1979, 181) classified the stone and bone tools from layer 5 into the *Tardigravettian*. There were no hearths, only individual pieces of charcoal were found. In addition to *Pinus*, Šercelj (1963) identified the following thermophilous species of broadleaf: *Fagus*, *Corylus* and *Sambucus*, which indicates the final period of the Würm, including the Late Glacial (*Tardigravettian*).

Koprivška luknja

Skupaj s skromnimi sledovi litične kulture je bilo v dveh horizontih najdenih tudi nekaj drobcev oglja. V spodnjem horizontu A, v globini 340 cm, je bilo ugotovljeno oglje bora (*Pinus*) in smreke ali macesna (*Picea/Larix*), v zgornjem horizontu B, v globini 120 cm, pa jelke (*Abies*) in bukve (*Fagus*), kar tudi po kulturi kaže že na mezolitik. Starejša kultura ni opredeljena.

Lukenjska jama

Arheološke najdbe (Osole 1990b), poznoglacialna favna (Pohar 1983), rastlinski ostanki ter radiokarbonska datacija oglja iz kurišča v spodnjem kulturnem horizontu plasti 4 (12.580 ± 250 BP) časovno opredeljujejo to plast v toplejši presledek poznega glaciala, v böllinški interstadial (epigravetjen). Prevladuje oglje bora (*Pinus)*, nekaj primerkov pa je pripadalo tudi listavcema jesenu (*Fraxinus*) in bukvi (*Fagus*) (Šercelj, Culiberg 1985).

Matjaževe kamre

Obljudenost jame je bila ugotovljena vsaj v dveh, časovno precej razmaknjenih obdobjih (Osole 1976a). Prvič že v starejšem würmu W I (srednji paleolitik, musterjen), na kar kažejo najdbe kamnitega orodja in ostankov kosti večinoma jamskega medveda, in drugič v poznem glacialu (mlajši paleolitik, epigravetjen). Nekaj drobcev oglja od tod kaže na hladnodobno vegetacijo (Šercelj, Culiberg 1985). Ugotovljen je bil izključno bor (*Pinus*).

Mokriška jama

V jami je bila ugotovljena podobna drevesna vegetacija kot v Potočki zijalki (Brodar, M. 1959). Iz sporadičnih najdb oglja v plasti 4 so bile tudi tu ugotovljene enake vrste iglavcev: bor (*Pinus*), smreka (*Picea*) in macesen (*Larix*; Šercelj 1963, 396). Obe, verjetno sočasni orinasjenski visokoalpski najdišči sta bili glede na geografsko lego lahko obljudeni le v toplejšem, interstadialnem obdobju, vendar glede na njuno nadmorsko višino – 1.700 m Potočka zijalka in 1.500 m Mokriška jama – ni mogoče pričakovati drugačne vegetacije kot iglasto.

Nevlje

Ob regulaciji Nevljice leta 1938 je bilo približno 2,4 metra pod površjem najdeno tudi okostje mamuta. Rastlinske ostanke je raziskala A. Budnar-Lipoglavšek (1944). Ugotovila je les smreke (*Picea*) in bora (*Pinus*), s pelodno analizo plasti, v kateri je bilo najdeno mamutovo okostje, pa so bile ugotovljene tudi naslednje drevesne vrste: prevladoval je bor (*Pinus*), precej je bilo tudi vrbe (*Salix*) in topola (*Populus*). Razmeroma malo je bilo breze (*Betula*), macesna (*Larix*) in smreke (*Picea*). Le nekajodstotno udeležbo pa so dosegli gaber (*Carpinus*), bukev (*Fagus*), brest (*Ulmus*) in hrast (*Quercus*). Sileks, najden poleg mamutovega okostja, sta M. Brodar in Osole (1979) uvrstila v tardigravetjen, mamutovo plast pa v W III. Vegetacija vsekakor kaže že na manj ostre podnebne razmere v poznem glacialu.

Koprivška luknja

Together with modest traces of the lithic culture, some fragments of charcoal were also found in two horizons. In the lower horizon A, at a depth of 340 cm, charcoal of *Pinus* and either *Picea* or *Larix* was found, in the upper horizon B, at a depth of 120 cm, *Abies* and *Fagus*, which also indicates the Mesolithic in terms of culture. The older culture was not identified.

Lukenjska jama

Archaeological finds (Osole 1990b), late glacial fauna (Pohar 1983), plant remains and radiocarbon dating of charcoal in the lower cultural horizon of layer 4 (12,580 ± 250 BP) define this layer chronologically to the warmer interval of the Late Glacial, to the Bölling interstadial (*Epigravettian*). *Pinus* charcoal predominates but there are also some specimens of the broadleafs, *Fraxinus* and *Fagus* (Šercelj, Culiberg 1985).

Matjaževe kamre

It was established that the cave was populated in at least two, fairly widely spaced time intervals (Osole 1976a). The first was already in the Würm W I (Middle Palaeolithic, *Mousterian*), which was indicated by finds of stone tools and bone remains, for the most part of cave bear, and secondly in the Late Glacial (Upper Palaeolithic, *Epigravettian*). Some fragments of charcoal from here indicate cold period vegetation. Exclusively *Pinus* was found (Šercelj, Culiberg 1985).

Mokriška jama

The same species of conifers as in Potočka zijalka were also found here from sporadic finds of charcoal in layer 4: *Pinus*, *Picea* and *Larix* (Šercelj 1963, 396). Both, probably contemporary *Aurignacian* high alpine sites (Brodar, M. 1959), in view of the geographic location were probably only populated in the warmer interstadial period, but in view of the altitude, 1,700 m Potočka zijalka and 1,500 m Mokriška jama, other vegetation than conifer is not to be expected.

Nevlje

An open air site in which mammoth bones were found approximately 2.4 metres below the surface. Plant remains were studied by A. Budnar-Lipoglavšek (1944). She found the wood of *Picea* and *Pinus* and pollen analysis of the mammoth layer identified the following tree species: *Pinus* predominated, there was also a fair amount of *Salix* and *Populus*. There was relatively little *Betula*, *Larix* and *Picea*. *Carpinus*, *Fagus*, *Ulmus* and *Quercus* achieved only a few percentage share. M. Brodar and Osole (1979) placed the silex found in addition to the mammoth bones, into the *Tardigravettian* and the mammoth layer into W III. The vegetation certainly indicates the already less severe climatic conditions in the Late Glacial.

Ovčja jama

F. Osole (1974) found a number of hearths in layers 3 and 4 (*Tardigravettian*), in addition to silex and the remains of Pleistocene fauna. The charcoal belonged

Ovčja jama

V plasteh 3 in 4 (tardigravetjen) je F. Osole (1974) našel poleg sileksov in ostankov pleistocenskega živalstva tudi več ognjišč. Oglje je pripadalo izključno iglavcem, in to rdečemu boru (*Pinus* t. *sylvestris*), en košček pa cemprinu (*Pinus* t. *cembra*) (Šercelj 1963), kar kaže na hladnodobno vegetacijo v obdobju zadnje würmske poledenitve (W III). Radiokarbonska analiza oglja iz ognjišč je dala starost 19.540 ± 500 BP.

Parska golobina

V 5,5 m debeli seriji sedimentov je Osole (1961) opredelil več kulturnih horizontov, od srednjega paleolitika (levallois-musterjen) do mlajšega paleolitika (gravetjen). To so horizonti od 7–3, v katerih so bila tudi kurišča. V posameznih plasteh je bilo ugotovljeno oglje (Šercelj 1963, 397):

– v plasti 3: jelka (*Abies*); W II/III

– v plasti 4: smreka (*Picea*), brin (*Juniperus*), črni gaber (*Ostrya*); W II

– v plasti 5: črni gaber (*Ostrya*), leska (*Corylus*), kostanj (*Castanea* ?); W I/II

– v plasti 6: gaber (*Carpinus*); W I

– v plasti 7: jelka (*Abies*), lipa (*Tilia*), leska (*Corylus*); starejši würm.

Podrisovec

je plano najdišče v bližini Betalovega spodmola. Po kulturi ga M. Brodar (1985) uvršča v gravetjen. Le nekaj primerkov oglja pripada izključno boru (*Pinus*), kar kaže na stadialne razmere ob koncu würma.

Poljšiška cerkev

Poleg sledov epigravetjenske kulture (Brodar, M. 1966; Pohar 1991) je bilo najdenih tudi nekaj drobcev oglja in pri vseh so bile ugotovljene anatomske značilnosti borovega lesa (*Pinus*; Šercelj, Culiberg 1985).

Postojnska jama

Najdbe pleistocenske favne v Postojnski jami so bile znane že iz 19. stoletja, leta 1951 pa je S. Brodar izkopal več sond v različnih delih jame in našel kosti pleistocenskih sesalcev, največ jamskega medveda. Najdbe kronološko niso natančneje opredeljene (srednji paleolitik?), oglje je pripadalo večinoma boru (*Pinus*) in nekaj tudi smreki (*Picea*) (Šercelj, Culiberg 1985).

Potočka zijalka

je prvo odkrito in raziskano paleolitsko najdišče na Slovenskem. Tu je že leta 1928 začel izkopavati Srečko Brodar in našel pomembne materialne dokaze o navzočnosti ledenodobnega človeka (Brodar, S. in M. 1983). Poleg kostnega in kamnitega orodja je odkril tudi več ognjišč, bogatih z ogljem. Nekaj primerkov tega oglja je analizirala E. Hoffman z Univerze na Dunaju in ugotovila dve vrsti iglavcev, bor (*Pinus*) in smreko (*Picea*). Ves ostali material, shranjen v Celju, je bil med 2. svetovno vojno uničen. Ob ponovnih izkopavanjih v Potočki zijalki med letoma 1997 in 2000, ki sta jih opravila Oddelek za geologijo Univerze v Ljubljani in Inštitut za paleontologijo Univerze na Dunaju (Pohar, Pacher

exclusively to conifers, specifically *Pinus* t. *sylvestris*, and one piece of *Pinus* t. *cembra* (Šercelj 1963), which indicates cold period vegetation in the period of the final Würm glaciation (W III). Radiocarbon analysis of the charcoal from hearths gave a dating of 19,540 ± 500 BP.

Parska golobina

In the 5.5 m thick series of sediments, Osole (1961) identified a number of cultural horizons, from the Middle Palaeolithic (*Levallois-Mousterian*) to the Upper Palaeolithic (*Gravettian*). These are horizons from 7–3, in which hearths were also found. Charcoal was identified in individual layers (Šercelj 1963, 397):

– in layer 3: *Abies*; W II/III

– in layer 4: *Picea*, *Juniperus*, *Ostrya*; W II

– in layer 5: *Ostrya*, *Corylus*, *Castanea* ?; W I/II

– in layer 6: *Carpinus*; W I

– in layer 7: *Abies*, *Tilia*, *Corylus*; Early Würm.

Podrisovec

was an open air site in the vicinity of Betalov spodmol. In terms of culture, M. Brodar (1985) placed it in the *Gravettian*. The few specimens of charcoal belong exclusively to *Pinus*, which indicates stadial conditions at the end of the Würm.

Poljšiška cerkev

In addition to traces of the *Epigravettian* culture (Brodar, M. 1966; Pohar 1991), some fragments of charcoal were found, all of which had the anatomical characteristics of *Pinus* (Šercelj, Culiberg 1985).

Postojnska jama

Finds of Pleistocene fauna in Postojnska jama were already known from the 19th century and in 1951, S. Brodar excavated a number of exploratory trenches at various places in the cave and found the bones of Pleistocene mammals, mostly cave bear. The finds have not been precisely defined chronologically (Middle Palaeolithic?) but the charcoal belongs for the most part to *Pinus* with some *Picea*, too (Šercelj, Culiberg 1985).

Potočka zijalka

The cave was the first Palaeolithic site discovered and researched in Slovenia in which in 1928 Srečko Brodar already began to excavate and found important material evidence of the presence of Pleistocene man (Brodar, S. & M. 1983). In addition to bone and stone tools, he also discovered a number of hearths rich in charcoal. Some specimens of this charcoal were analysed by E. Hoffman from the University of Vienna and two species of conifer were established: *Pinus* and *Picea*. All the other palaeontological material, which was stored in Celje, was destroyed during the Second World War. During re-excavation of Potočka zijalka between 1997 and 2000, which was performed by the Department of Geology of the University of Ljubljana and the Institute of Palaeontology of the University of Vienna (Pohar, Pacher 2004), finds of charcoal were modest but three species of conifer were identified, in addition to *Pinus* and *Picea*, there was also *Larix*. Some samples from the

2004), so bile najdbe oglja skromnejše, ugotovljene pa so bile tri vrste iglastega drevja, poleg bora (*Pinus*) in smreke (*Picea*) še macesen (*Larix*). Nekaj vzorcev iz kulturnih plasti je bilo tudi pelodno analiziranih, a peloda drevesnih vrst ni bilo, bil je le pelod alpinske travniške vegetacije (Culiberg 2004).

Roška špilja

je jama, ki je le del podzemeljskega sistema Škocjanskih jam. Plasti od 1 do 8a vsebujejo mezolitski kulturni inventar, v plasteh 8b in 9 pa je ugotovljena epigravetjenska kultura. Dvaindvajset primerkov oglja iz teh plasti pripada boru (*Pinus*), le dva listavcem, od tega bi morda eden lahko pripadal javorju (*Acer*) (Šercelj, Culiberg 1985). Časovna opredelitev: pozni glacial.

Zakajeni spodmol

Osole (1967) je tu ugotovil epigravetjensko kulturo. Oglje iz spodnjega dela plasti 2 pripada gabru (*Carpinus*) in hrastu (*Quercus*), iz plasti 3 pa boru (*Pinus* sp.), od tega je nekaj primerkov oglja cemprina (*Pinus* t. *cembra*) (Šercelj, Culiberg 1985). Časovno je plast 2 opredeljena v allerödski interstadial, plast 3 pa v starejši dryas.

Županov spodmol

F. Osole (1976b) je opredelil dva kulturna horizonta: musterjen in epigravetjen. Oglje iz kurišč v plasti 2, ki pa so iz kulturnih horizontov različne starosti, je skoraj izključno pripadalo boru (*Pinus*), ugotovljenih je bilo le še nekaj posameznih primerkov bukve (*Fagus*) in lipe (*Tilia*). Radiokarbonska analiza je dala starost 16.830 ± 150 BP in 12.460 ± 70 BP, kar kaže na prehod W III v pozni glacial (Pohar 1997, 121).

OGLJE IN PELOD V DIVJIH BABAH I

Posebno mesto v raziskavah slovenskega paleolitika zagotovo pripada musterjenskemu jamskemu najdišču Divje babe I. V obdobju dolgoletnih izkopavanj, ki jih je začel M. Brodar (1978–1986), po nekajletni prekinitvi pa sta jih nadaljevala Ivan Turk in Janez Dirjec (1989–1999), je bilo zbranih veliko arheoloških in paleontoloških najdb. Pri terenskem raziskovanju so bile uporabljene že znane, predvsem pa tudi nove in izvirne metode in tehnike pridobivanja podatkov. Na podlagi sedimentoloških analiz in številnih radiometričnih datacij (AMS ^{14}C in ESR) je I. Turk izdelal tudi paleoklimatsko krivuljo (Turk 2007, 160), ki je v veliki meri primerljiva z globalnimi klimatskimi krivuljami (Blackwell *et al.* 2007, 146), s čimer so postale Divje babe I najnatančneje kronološko opredeljeno paleolitsko najdišče v Sloveniji.

Vzporedno z arheološkimi raziskavami so potekale tudi paleobotanične. Oglje, pridobljeno z mokrim sejanjem sedimenta in flotacijo, je bilo sproti analizirano in rezultati tudi sočasno objavljeni (Turk *et al.* 1988–1989; Šercelj, Culiberg 1991; Culiberg, Šercelj 1997; Culiberg 2007). Skupno je bilo analiziranih več tisoč primerkov oglja iz vseh plasti več kot 9 m globokega profila. V času

cultural layers were also subjected to pollen analysis, but there was no pollen of tree species, only pollen of alpine grassland vegetation (Culiberg 2004).

Roška špilja

is a cave that is only part of the subterranean system Škocjanske jame. Layers from 1 to 8a contain a Mesolithic cultural inventory, and in layers 8b and 9 the *Epigravettian* culture was identified. Twenty-two specimens of charcoal from these layers belong to *Pinus*, and only two broadleafs, one of which was perhaps *Acer* (Šercelj, Culiberg 1985). The dating is the Late Glacial.

Zakajeni spodmol

Osole (1967) identified the *Epigravettian* culture here. Charcoal from the lower part of layer 2 belongs to *Carpinus* and *Quercus* and from layer 3, *Pinus* sp., of which there are a few specimens of *Pinus cembra* (Šercelj, Culiberg 1985). Layer 2 is placed in the Alleröd interstadial and layer 3 to the Older Dryas.

Županov spodmol

F. Osole (1976b) identified two cultural horizons: *Mousterian* and *Epigravettian*. Charcoal from hearths in layer 2, which are from cultural horizons of various ages, belonged almost exclusively to *Pinus*, only a few individual specimens of *Fagus* and *Tilia* were found. Radiocarbon analysis gave ages of 16,830 ± 150 BP and 12,460 ± 70 BP, which indicates the transition of W III to the Late Glacial (Pohar 1997, 121).

CHARCOAL AND POLLEN IN DIVJE BABE I

The *Mousterian* cave site Divje babe I certainly has a special place in research of the Slovene Palaeolithic. Over the course of the lengthy excavations, which were started by M. Brodar (1978–1986) and, after a short break continued by Ivan Turk and Janez Dirjec (1989–1999), a large number of archaeological and palaeontological finds were collected, and both already known and, above all, new and original methods and techniques of obtaining data were used. On the basis of sedimentological analysis and numerous (AMS ^{14}C and ESR) datings, I. Turk also elaborated a palaeoclimatic curve (Turk 2007, 160), which is to a large extent comparable to global climatic curves (Blackwell *et al.* 2007, 146), whereby Divje babe I became the most precisely chronologically determined Palaeolithic site in Slovenia.

Palaeobotanical research also took place in parallel with the archaeological investigations. Charcoal, obtained by wet sieving of sediments and flotation, was concurrently analysed and the results also concurrently published (Turk *et al.* 1988–1989; Šercelj, Culiberg 1991; Culiberg, Šercelj 1997; Culiberg 2007). Altogether, several thousand specimens of charcoal were analysed from all layers of the more than 9 metres deep profile. During the period of excavation, samples were also izkopavanj so bili večkrat odvzeti tudi vzorci za pelodno analizo, saj so že prvi testni poskusi pokazali, da so sedimenti pelodonosni. Tako se Divje babe I odlikujejo tudi po tem, da so edino paleolitsko najdišče v Sloveniji s pelodno analiziranim profilom. Ob koncu izkopavanj v Divjih babah I so bili na pobudo in pod vodstvom Ivana Turka iz celotnega odkopanega profila še enkrat odvzeti vzorci za pelodno analizo; to gradivo je prvič predstavljeno na tem mestu. Iz zgornjih, mlajših plasti so bili vzorci odvzeti v sektorjih globlje v jami, zato je bila pelodna vsebina po pričakovanju skromnejša kljub pregledanemu večjemu številu mikroskopskih preparatov. Pelodnega diagrama v tem primeru ni bilo mogoče izdelati, zato je prisotnost taksonov v posameznih vzorcih predstavljena v tabeli v absolutnih vrednostih (*tab. 1*).

ZDRUŽENI REZULTATI PELODNIH IN ANTRAKOTOMSKIH ANALIZ IZ DIVJIH BAB I PO PLASTEH

V plasteh 2–3 je prevladovalo oglje listavcev, predvsem jesena (*Fraxinus*) in bukve (*Fagus*), manj je bilo oglja iglastega drevja, medtem ko je bilo v sedimentu ugotovljenega največ peloda travniške vegetacije in le sporadično tudi peloda naslednjih drevesnih vrst: bora, breze, jelše, vrbe, lipe, gabra in leske (*Pinus*, *Betula*, *Alnus*, *Salix*, *Tilia*, *Carpinus* in *Corylus*). Da je oglje recentno, je potrdila radiokarbonska analiza oglja bukve iz plasti 2–3: 141 ± 27 BP (KIA19850), in oglja iz plasti 3–4: 103 ± 21 BP (KIA 19849).

Plast 4–5a. Oglje bukve (*Fagus*) in jelke (*Abies*) v plasti 4 je zelo verjetno tudi še recentne starosti. V plasti 5a so bili ugotovljeni pelod smreke (*Picea*) in spore praproti. Na podlagi sedimentne analize naj bi se ta plast odložila v zmerno hladnem, predvsem pa ne preveč vlažnem podnebju.

Plast 5. V ognjišču je prevladovalo oglje iglavcev, največ je bilo borovega (*Pinus*) in smrekovega (*Picea*), nekaj primerkov je pripadalo tudi jelki (*Abies*), tisi (*Taxus*) in brinu (*Juniperus*), od listavcev pa le bukvi (*Fagus*). S pelodno analizo je bil ugotovljen pelod bora (*Pinus*) in smreke (*Picea*) ter jelše (*Alnus*) in lipe (*Tilia*).

Plast 6. Tu je bilo več ognjišč, ki pa so bila slabše ohranjena. Oglje je bilo razpršeno okoli kurišč. Od iglaste vegetacije so bili ugotovljeni bor, smreka, jelka, macesen, brin in tisa (*Pinus*, *Picea*, *Abies*, *Larix*, *Juniperus*, *Taxus*). Največ je bilo oglja tise in jelke. Oglje listavcev je pripadalo jesenu, brestu in javorju (*Fraxinus*, *Ulmus*, *Acer*). V treh vzorcih iz plasti 6 je bil ugotovljen le pelod bora in smreke in eno pelodno zrno jelše (*Pinus*, *Picea*, *Alnus*). Sedimentna analiza za to plast predvideva zelo mrzlo in suho podnebje.

several times taken for pollen analysis because the first tests already showed that the sediments contained pollen. Divje babe I is thus also distinguished in being the only Palaeolithic site in Slovenia with a pollen analysed profile. At the end of excavations in Divje babe I, on the initiative and under the leadership of Ivan Turk, samples for pollen analysis were taken once more from the entire excavated profile; these data are presented here for the first time. From the upper, more recent layers, samples were taken in sectors deep in the cave, so the pollen content, as expected, was more modest, despite the exemplary large number of microscopic preparations. It was not possible in this case to produce a pollen diagram so the presence of taxa in individual samples is presented in the table in absolute values (*Tab. 1*).

COMBINED RESULTS OF POLLEN AND ANTHRACOTOMIC ANALYSES FROM DIVJE BABE I BY LAYERS:

Layers 2–3. Charcoal of broadleafs predominated, mostly of *Fraxinus* and *Fagus*; there was less charcoal of conifers, while the most pollen of grassland vegetation was identified in the sediment and only sporadically also pollen of the following tree species: *Pinus*, *Betula*, *Alnus*, *Salix*, *Tilia*, *Carpinus* and *Corylus*. That the charcoal is recent was confirmed by radiocarbon analysis of *Fagus* from layers 2–3: 141 ± 27 BP (KIA19850) and charcoal from layers 3–4: 103 ± 21 BP (KIA 19849).

Layer 4–5a. Charcoal of *Fagus* and *Abies* in layer 4 is probably also of recent age. In layer 5a, though, the pollen of *Picea* and the spore of ferns were found. On the basis of sedimentary analysis, this layer should be placed in the relatively cold and, above all, not too humid climate.

Layer 5. Charcoal of conifers predominated in the hearth, of which there was most *Pinus* and *Picea*, with some specimens also belonging to *Abies*, *Taxus* and *Juniperus* and, of broadleafs, only *Fagus*. Pollen analysis identified the pollen of *Pinus* and *Picea* and *Alnus* and *Tilia*.

Layer 6. There were a number of hearths here but they were poorly preserved. Charcoal was scattered around the places where it was burnt. Of coniferous vegetation, *Pinus*, *Picea*, *Abies*, *Larix*, *Juniperus* and *Taxus* were identified. There was most charcoal of *Taxus* and *Abies*. Charcoal of broadleafs belonged to *Fraxinus*, *Ulmus* and *Acer*. In three samples from layer 6, only the pollen of *Pinus* and *Picea* was found and one pollen grain of *Alnus*. Sedimentary analysis of this layer suggests a very cold and dry climate.

Tab. 1. Divje babe I. Pelodni spektri vzorcev iz plasti 2–23.
Tab. 1. Divje babe I. Pollen spectra of samples from layers 2–23.

Plast / Layer	Globina / Depth	*Pinus*	*Picea*	*Abies*	*Larix*	*Juniperus*	*Ephedra*	*Betula*	*Alnus*	*Corylus*	*Carpinus*	*Tilia*	*Quercus*	*Ulmus*	*Fagus*	*Salix*
2	-0,38	6							1	1						
2	-0,61		1								1					1
3	-0,62	1	3													
3	-0,76	2							1							
3	-0,91	3						1	1			1				
4	-1,06	1	2							1						
4	-1,25		1								1					
5a	-1,06			1												
5a	-1,25	5	2													
5a	-1,38		2													
5a	-1,51	1	1						1							
5a	-1,66	1	1													
5	-1,81	1	2													
5	-1,96	5														
5	-2,33	8	16													
6	-2,11	2	3						1							
6	-2,26															
7	-2,32	2	5	1										1		
8	-2,51	2	4			1				1					1	
8	-2,57	4	1						1						1	
8	-2,72	3	3		1				1	1		1			1	2
8b	-2,83	2	2													
8b	-3,08	14					1		2	3		1	1			
8b	-3,20	4	1						1	3						
8b	-3,38	14	9							1						
8b	-3,44	1	5							1						
8b*	-3,44	5	4		4	2		2								
8b-10	-3,49	1														
10	-3,61	1					1									
10	-3,67	2	1				1		1							
11	-3,79		1													
12	-3,98	4	1													
13	-4,23	2	1					1								
13	-4,24	1														
14	-4,42	14														
15	-4,50	5	1													
16a	-5,16	1														
16a	-5,42	2	1						1	1	1					
16a	-5,57	4														
17a1	-5,62															
17	-5,84										1					
17a2	-6,12															
17a2	-6,29									3					1	
17a2	-6,55	1									1				1	
17a3	-6,66	2	2							1					3	

Plast / Layer	Globina / Depth	*Compos.lig.*	*Compos-tub.*	Graminenae	Umbelliferae	Caryophyllaceae	Chenopodiaceae	Dipsacaceae	Cyperaceae	Campanulaceae	*Artemisia*	*Helianthemum*	*Polygonum*	*Sporae tril.*	*Selaginella sel.*	*Sporae monol.*	Indeterm.
2	-0,38	270	55	24	2	10		1			2	1	1	1	19	25	
2	-0,61	20	8	4			1			2	1	1				20	
3	-0,62		3	3		1		3			1			1		10	
3	-0,76		8			1				1				1		2	
3	-0,91	5	42	7	6	1		3	1		2	1				8	
4	-1,06	1	4			1	1			1						3	
4	-1,25		2						1							5	
5a	-1,06															2	
5a	-1,25		3					1								18	
5a	-1,38			1				1								1	
5a	-1,51		1					1								1	
5a	-1,66							1								5	
5	-1,81															1	
5	-1,96	1	1					3								1	
5	-2,33	8	17	3	5					4			1	2		19	
6	-2,11		1	1					1							18	
6	-2,26															2	
7	-2,32	2	2	1							3					97	
8	-2,51	1	4	1	5											3	7
8	-2,57	13	15	2	13	4					1				1	6	
8	-2,72	14	16	2	5	8	1			1	6		3		1	1	
8b	-2,83		3			2		1								3	
8b	-3,08	22	49	4	33	30		7					1		1	21	5
8b	-3,20	5	13	2		9		1								16	2
8b	-3,38	2	6											1		30	
8b	-3,44	2	21	8	2	7		6			6					17	
8b*	-3,44	9	29	30	20	10	4	6	10		9	1	1			23	11
8b-10	-3,49		8	1										1		14	
10	-3,61		2	4	3	1					1					45	
10	-3,67		13	20	1	7	1				5					26	
11	-3,79		3		1			1			1					14	
12	-3,98					1										35	
13	-4,23							1								29	
13	-4,24															8	
14	-4,42		1	2			1				1					25	
15	-4,50	219	57	14	1	5	3	1			2	1			24	26	
16a	-5,16		4	1													
16a	-5,42	1		1												19	
16a	-5,57		5	3						1	1		4			15	
17a1	-5,62																
17	-5,84		1				1									1	
17a2	-6,12																
17a2	-6,29																
17a2	-6,55																
17a3	-6,66			2												2	

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Plast / Layer	Globina / Depth	*Pinus*	*Picea*	*Abies*	*Larix*	*Juniperus*	*Ephedra*	*Betula*	*Alnus*	*Corylus*	*Carpinus*	*Tilia*	*Quercus*	*Ulmus*	*Fagus*	*Salix*
17a3	-6,75	5	1									1				
17-18	-6,87														1	
17-18	-6,92	1								1						
18	-7,07	1	1						1						1	
18	-7,11															
18	-7,26		1								2					
18	-7,40		2													
18	-7,60	2	1													
19	-7,73															
19	-7,82	2							1							
19	-8,11		1													
19	-8,28	1								1						
19	-8,46	2	1													
19/20	-8,61		1													
20	-8,87	2	3			1				1						
21	-9,08	3	2													
22	-9,28	1														
23	-9,42	2	2													

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Plast 7. Slabo ohranjenega ognjišča ni bilo mogoče zagotovo umestiti v plast 6 ali v plast 7. Oglja je bilo malo, največ ga je pripadalo smreki (*Picea*), manj boru, tisi, jelki in brinu (*Pinus*, *Taxus*, *Abies*, *Juniperus*). V enem samem vzorcu sedimenta je bilo tudi malo peloda iglavcev bora, smreke in jelke (*Pinus*, *Picea*, *Abies*), od listavcev eno samo pelodno zrno bresta (*Ulmus*), veliko pa je bilo spor praproti.

Plast 8. Ta plast je bila bogata s kurišči. Razdeljena je bila v zgornjo, plast 8a, v kateri je bila ob enem izmed ognjišč najdena koščena piščal, in spodnjo, plast 8b, kjer je bilo tudi najbolje ohranjeno paleolitsko ognjišče v Divjih babah I.

V plasti 8a sta bili v isti ravni dve, z ogljem bogati ognjišči. Ugotovljene so bile vse vrste iglavcev: bor, smreka, jelka, tisa, macesen in brin (*Pinus*, *Picea*, *Abies*, *Taxus*, *Larix*, *Juniperus*), od listnatih vrst pa gaber, jerebika, jesen in bukev (*Carpinus*, *Sorbus*, *Fraxinus*, *Fagus*). Prisotnost bukve potrjuje tudi pelodna analiza, saj je bil njen pelod ugotovljen v treh vzorcih iz te plasti. Od drugih listavcev je bil ugotovljen še pelod lipe, jelše, vrbe in leske (*Tilia*, *Alnus*, *Salix*, *Corylus*). Sedimentna analiza predvideva za to plast toplo in vlažno podnebje.

Plast 8b. V zgornjem delu te plasti je bilo ognjišče, iz katerega je bilo pregledanih več kot 500 primerkov oglja, izključno iglavcev. Največ je bilo oglja bora, smreke in macesna (*Pinus*, *Picea*, *Larix*), nekoliko manj pa jelke in tise ter brina (*Abies*, *Taxus*, *Juniperus*). Oglje in ožgani

Layer 7. A poorly preserved hearth could not with certainty be placed in layer 6 or layer 7. There was little charcoal, but most belonged to *Picea*, with less *Pinus*, *Taxus*, *Abies* and *Juniperus*. In one sample of sediment there was also a little pollen from *Pinus*, *Picea* and *Abies* and of broadleafs only a single pollen grain of *Ulmus* but there was a great deal of spore of ferns.

Layer 8. This layer was rich in hearths. It was divided into an upper, layer 8a, in which a bone flute was found beside one of the hearths, and a lower, layer 8b, in which the best preserved Palaeolithic hearth in Divje babe I was also found.

In layer 8a, two, charcoal rich hearths were found on the same level. All species of conifer were found: *Pinus*, *Picea*, *Abies*, *Taxus*, *Larix* and *Juniperus* and, of broadleaf species, *Carpinus*, *Sorbus*, *Fraxinus* and *Fagus*. The presence of *Fagus* was also confirmed by pollen analysis, since its pollen was found in three samples from this layer. Of other broadleafs, the pollen of *Tilia*, *Alnus*, *Salix* and *Corylus* was identified. Sedimentary analysis indicates a warm and humid climate for this layer.

Layer 8b. There was a hearth in the upper part of this layer, from which more than 500 specimens of charcoal were examined, exclusively coniferous. There was most charcoal of *Pinus*, *Picea* and *Larix* and slightly less *Abies*, *Taxus* and *Juniperus*. Charcoal and charred bone fragments were strongly calcified and almost 200

Plast / Layer	Globina / Depth	*Compos.lig.*	*Compos-tub.*	Graminenae	Umbelliferae	Caryophyllaceae	Chenopodiaceae	Dipsacaceae	Cyperaceae	Campanulaceae	*Artemisia*	*Helianthemum*	*Polygonum*	*Sporae tril.*	*Selaginella sel.*	*Sporae monol.*	Indeterm.
17a3	-6,75										1					3	1
17-18	-6,87															2	
17-18	-6,92					1										5	
18	-7,07	1					9										
18	-7,11																
18	-7,26																
18	-7,40																
18	-7,60															5	
19	-7,73																
19	-7,82		1									1					
19	-8,11			2			4		1								
19	-8,28						1									1	
19	-8,46															8	3
19/20	-8,61															2	
20	-8,87													2		12	
21	-9,08													1		9	1
22	-9,28															3	
23	-9,42										1			1		6	

kostni fragmenti so bili močno kalcinirani; pri skoraj 200 primerkih oglja je bilo mogoče ugotoviti le to, da pripadajo iglavcem. Tudi pelodna analiza vzorca z dna ognjišča (*tab. 1*: vzorec 8b*) z izjemo dveh pelodnih zrn breze (*Betula*) kaže na vegetacijo iglavcev, bilo pa je tudi nekoliko več peloda zeliščne vegetacije. Na podlagi sedimentne analize se za raven z ognjiščem predvideva zelo mrzla in vlažna klimatska faza.

V spodnjem delu plasti 8b je bilo oglje bolj ali manj razpršeno. Največ ga je pripadalo iglavcem boru, smreki, jelki, macesnu in brinu (*Pinus*, *Picea*, *Abies*, *Larix*, *Juniperus*), nekaj primerkov pa tudi listavcem bukvi, jesenu in jerebiki (*Fagus*, *Fraxinus*, *Sorbus*). Pelodna analiza je pokazala tudi pelod leske (*Corylus*). Takšni vegetaciji bi ustrezalo toplejše in vlažnejše podnebje, kot ga predvideva tudi sedimentna analiza.

Prehoda med plastmi od 8b do 10 ni bilo mogoče zanesljivo ločiti. Oglje je bilo razpršeno in je pripadalo izključno iglavcem boru, smreki, jelki, tisi in brinu (*Pinus*, *Picea*, *Abies*, *Taxus*, *Juniperus*). Od peloda so bili ugotovljeni le eno zrno bora (*Pinus*) in nekaj zrn zeliščne vegetacije ter spore praproti. Po sedimentološki analizi bi ta plast ustrezala mrzli klimatski fazi, moti le prisotnost jelke (*Abies*).

Plasti 10, 11, 12. Oglje iz domnevnega ognjišča v plasti 10 je pripadalo zlasti iglavcem, največ je bilo oglja jelke (*Abies*), od listavcev pa oglja bukve, jesena,

specimens could only be identified as conifers. Pollen analysis of samples from the floor of the hearth (*Tab. 1*: sample 8b*), with the exception of two pollen grains of *Betula,* indicate coniferous vegetation and there was also slightly more pollen of herb vegetation. On the basis of sedimentary analysis for the level of the hearth, a very cold and damp climatic phase is envisaged.

In the lower part of layer 8b, the charcoal was more or less dispersed. Most belonged to the conifers *Pinus*, *Picea*, *Abies*, *Larix* and *Juniperus* but there were also some specimens of the broadleafs *Fagus*, *Fraxinus* and *Sorbus*. Pollen analysis additionally showed the pollen of *Corylus*. Such vegetation corresponds to a warmer and more humid climate, which is also indicated by sedimentary analysis.

The transition between layers from 8b to 10 could not be reliably distinguished. Charcoal was dispersed and belonged exclusively to the conifers *Pinus*, *Picea*, *Abies*, *Taxus* and *Juniperus*. Only one grain of *Pinus* pollen was identified and a few grains of herb vegetation and the spore of ferns. According to sedimentary analysis, this layer corresponds to a cold climatic phase, only the presence of *Abies* does not fit.

Layers 10, 11, 12. Charcoal from a presumed hearth in layer 10 belonged in particular to conifers. There was most charcoal of *Abies* and, of broadleafs, charcoal of *Fagus*, *Fraxinus*, *Acer* and *Sorbus*. Pollen analysis identijavorja in jerebike (*Fagus*, *Fraxinus*, *Acer*, *Sorbus*). S pelodno analizo je bilo ugotovljenega zelo malo peloda drevesnih vrst, nekaj več le peloda zeliščne vegetacije. V dveh vzorcih iz plasti 10 je bil prvič v Divjih babah I ugotovljen tudi pelod metlinke ali *Ephedre* (*tab. 1*), pritličnega lesnatega grmiča, ki uspeva le na suhih skalnih ali peščenih in soncu izpostavljenih rastiščih. V pelodnih diagramih pleistocenskih sedimentov tudi z območij severno od Alp je vedno najti njen pelod, v sedanjosti pa jo zasledimo šele globoko v Sredozemlju. V plasteh 11 in 12 ni bilo oglja, v vzorcih je bilo le nekaj pelodnih zrn bora (*Pinus*) in smreke (*Picea*).

Plasti 13–23 so bile raziskane le v vhodnem delu jame, zato so najdbe oglja in peloda v sedimentnih plasteh skromne. V vseh je bilo najti le bor in smreko (*Pinus*, *Picea*), v posameznih plasteh sta bila ugotovljena še macesen (*Larix*) in jelka (*Abies*), od listavcev pa jesen, gaber, lipa, hrast, jelša, leska, topol ali vrba in tudi bukev (*Fraxinus*, *Carpinus*, *Tilia*, *Quercus*, *Alnus*, *Corylus*, *Populus/Salix*, *Fagus*).

OGLJE TISE V DIVJIH BABAH I

V Divjih babah I je vzbudilo pozornost oglje tise (*Taxus*). Ugotovljeno je bilo v več ognjiščih od plasti 5 do plasti 10. Morda si lahko mislimo, da lesa tise, ki je trden in prožen in se dobro obdeluje, človek ni prinesel v jamo za kurjavo, ampak zato, da bi si iz njega naredil orodje ali orožje (konice, bate, držala), na ogenj pa je odvrgel le odpadni les. Na takšno misel še posebno napeljuje nedavna najdba okoli 40.000 let stare domnevne lesene konice iz tisovine v strugi Ljubljanice (Gaspari *et al.* 2011). Ob tem je nenavadno, da v sedimentih ni bilo niti enega pelodnega zrna tise, čeprav ob cvetenju sprošča velike množine peloda. Morda so drobna pelodna zrna s tanko celično steno v sedimentu sčasoma propadla ali pa je bilo rastišče tega vlagoljubnega in sencoljubnega iglavca zastrto s krošnjami drugega drevja in se zato pelod ni dvignil v ozračje. Mogoče je seveda tudi, da je tisa uspevala le kje bolj daleč od najdišča.

VEGETACIJA

Divje babe I so zagotovo tudi po vsebini paleobotaničnega materiala najbogatejše paleolitsko najdišče v Sloveniji. Profil obsega 23 plasti. Spodnje plasti, 23–13, so bile odkopane le v vhodnem delu jame, zato so najdbe oglja in peloda tu veliko skromnejše. Celoten spekter plasti 23–13 pripada kronoconi zgodnjega würma oz. zgodnjega glaciala (tj. OIS 5a–d), ko so v razmeroma toplem in suhem do zmerno vlažnem podnebju poleg bora (*Pinus*) in smreke (*Picea*) lahko uspevali številni listavci, tudi bukev (*Fagus*).

fied very little pollen of tree species, only rather more pollen of herb vegetation. In two samples from layer 10, for the first time in Divje babe I pollen was found of *Ephedra* (*Tab. 1*), a ground-hugging woody shrub that only grows on dry rocky or sandy and sunny habitats. In pollen diagrams of Pleistocene sediments, including from areas north of the Alps, its pollen is always found but in the present it is only found far in the Mediterranean. There was no charcoal in layers 11 and 12, and only some pollen grains of *Pinus* and *Picea* in samples of sediment.

Layers 13–23 were only investigated in the entrance part of the cave. So finds of charcoal and pollen in the sediment layers were modest. Only *Pinus* and *Picea* were found throughout but, in individual layers, also *Larix* and *Abies* and, of broadleafs, *Fraxinus*, *Carpinus*, *Tilia*, *Quercus*, *Alnus*, *Corylus*, *Populus* or *Salix* and *Fagus*.

CHARCOAL OF *Taxus* IN DIVJE BABE I

The charcoal of *Taxus* excited attention in Divje babe I. It was identified in a number of hearths from layer 5 to layer 10. We could perhaps imagine that humans did not bring the wood of *Taxus*, which is hard and flexible and is easily worked, into the cave for burning but to make tools or weapons from it (points, clubs, handles) and threw only waste wood onto the fire. Such thinking is particularly tempting in view of the recent find of a presumed wooden point made of *Taxus*, around 40,000 years old, in the bed of the River Ljubljanica (Gaspari *et al.* 2011). In addition, not a single pollen grain of *Taxus* was found in the sediments, although it releases a great mass of pollen during flowering. Perhaps the tiny pollen grains, with thin cell walls, disintegrated in the sediment over time or the habitats of this humidity and shade loving conifer were screened by the crowns of other trees and so the pollen did not rise into the air, or *Taxus* only grew further away from the site.

VEGETATION

In terms of the content of palaeobotanical material, Divje babe I is certainly the richest Palaeolithic site in Slovenia. The profile includes 23 layers. The lower layers, 23-13, were only excavated in the entrance part of the cave, so finds of charcoal and pollen were much more modest here. The entire spectrum of layers 23-13 belongs chronologically to the Early Würm or Early Glacial (i.e. OIS 5a-d), when, in the relatively warm and dry to moderately humid climate, in addition to *Pinus* and *Picea*, numerous broadleafs could have grown, including *Fagus*.

Večinski del oglja izhaja iz zgornjih plasti, 12–2. Odkopane so bile v večjem obsegu in tudi temeljiteje raziskane. Celoten spekter teh plasti pripada kronoconi srednjega würma (tj. OIS 3), za katero so bila značilna večja klimatska nihanja, povezana s spremembami temperature in vlažnosti. V celoti pa manjkajo sedimenti mlajšega würma, saj se je sedimentacija v jami končala že prej.

Paleoklimatske spremembe, ki jih na podlagi sedimentoloških raziskav ugotavlja Ivan Turk (Turk 2007, 160), v veliki meri podpirajo tudi rezultati paleobotaničnih raziskav. Za obdobje, ko je bila na prehodu zgodnjega würma v srednji, pred okoli 80.000 do 70.000 leti pred sedanjostjo, na podlagi sedimentne analize zaznana prva močnejša ohladitev, je bila s pelodno analizo ugotovljena izključno vegetacija iglavcev z borom (*Pinus*) in smreko (*Picea*), na bolj ali manj odprte sestoje pa je kazal pelod alpske drežice (*Selaginella selaginoides*). Ob ponovni kratkotrajni otoplitvi podnebja so se znova pojavili bukev (*Fagus*) in drugi listavci (plast 10), s pelodno analizo pa je bila prvič v Divjih babah I ugotovljena tudi prisotnost izrazito heliofilnega lesnatega grmiča *Ephedra*. Hladna faza pred nekaj več kot 60.000 leti je drevesno vegetacijo ponovno skrčila izključno na iglavce. Za obdobje najdaljše otoplitve v srednjem würmu, pred okoli 60.000 do 50.000 leti, generična sestava oglja iz ognjišč v plasti 8a in tudi še v plasti 7 kaže pestro drevesno vegetacijo listavcev, prisotnost bukve pa dokazujeta tako oglje kot tudi pelod v vseh vzorcih plasti 8a. S tem je nenazadnje skladna tudi najdba ostankov polha v plasti 7 (Toškan, Kryštufek 2007, 201), živali, ki se hrani s plodovi ali semeni listavcev, najraje z žirom. Toplejšemu interstadialnemu obdobju naj bi sledila kratka mrzla in suha klimatska faza (plast 6), v kateri so bili poleg večinoma vegetacije iglavcev ugotovljeni tudi listavci jesen (*Fraxinus*), brest (*Ulmus*) in javor (*Acer*), ki razmeroma dobro prenašajo hladnejše podnebje. Dvomljive so jelka (*Abies*) in tisa (*Taxus*) pa tudi smreka (*Picea*), ki bi v takšnih podnebnih razmerah težje uspevale, saj so precej zahtevne vrste, zlasti glede večje vlažnosti. V spodnji ravni plasti 5 (5b), ko naj bi bilo še toplejše in bolj suho podnebje, je sicer prevladovala vegetacija iglavcev, najti pa je bilo tudi bukev (*Fagus*) in druge listavce. V zgornjih plasteh 2–4 je bilo največ oglja listavcev, zlasti jesena (*Fraxinus*) in bukve (*Fagus*). Zanj je bilo z radiokarbonsko analizo ugotovljeno, da je recentne starosti in je verjetno s posredovanjem živali (polhov) prišlo v nižje plasti; pelodna analiza vzorcev iz teh plasti je namreč pokazala, da sta tedaj (tj. pred približno 40.000 leti) uspevala bor (*Pinus*) in smreka (*Picea*), verjetno v redkih sestojih, saj je močno prevladoval pelod alpinske travniške vegetacije. V plasteh 2 in 3 je bil ugotovljen pelod bora (*Pinus*) in nekaterih listavcev: hrasta (*Quercus*), lipe (*Tilia*), leske (*Corylus*) in gabra (*Carpinus*). Takšno stanje bi lahko ustrezalo toplejšemu in bolj suhemu podnebju pred okoli 35.000

The majority of the charcoal comes from the upper layers, 12-2. They were excavated to a larger extent and also more thoroughly investigated. The entire spectrum of these layers belongs to the chronozone of the Middle Würm (i.e. OIS 3), for which major climatic oscillations are characteristic, connected with changes in temperature and humidity. However, sediments of the Late Würm are completely missing because sedimentation in the cave had already ended before this.

Palaeoclimatic changes ascertained by Ivan Turk (Turk 2007, 160) on the basis of sedimentological analysis, are also to a large extent supported by the results of palaeobotanical research. When, at the transition of the Early to the Middle Würm, about 80,000 to 70,000 years BP, the first major cooling was noted on the basis of sedimentary analysis, exclusively coniferous vegetation was found by pollen analysis, with *Pinus* and *Picea*, and the pollen of *Selaginella selaginoides* indicated more or less open stands. During a fresh, brief climatic warming, *Fagus* and other broadleafs reappeared (layer 10) and pollen analysis identified for the first time in Divje babe I also the presence of the explicitly heliophilous woody shrub *Ephedra*. The cold phase slightly more than 60,000 years ago, again reduced the tree vegetation exclusively to conifers. For the period of the longest warming in the Middle Würm, around 60,000 to 50,000 years ago, the generic composition of charcoal from hearths in layer 8a and also in layer 7 indicates varied tree vegetation of broadleafs and the presence of beech is indicated by both charcoal and pollen in all samples of layer 8a and, not least, also the finds of remains of edible dormouse in layer 7 (Toškan, Kryštufek 2007, 201), an animal which feeds on the fruit or seeds of broadleafs, preferably beech mast. The warmer interstadial period would have been followed by a brief cold, dry climatic phase (layer 6) in which, in addition to the majority coniferous vegetation, the broadleafs *Fraxinus*, *Ulmus* and *Acer* were also identified, which survive in a colder climate relatively well. *Abies* and *Taxus* are more uncertain, as well as *Picea*, which grow with more difficulty in such climatic conditions because they are fairly demanding species, especially in relation to humidity. In the lower level of layer 5 (5b), when it is thought to have been a warmer and drier climate, although coniferous vegetation predominated, *Fagus* and other broadleafs were also found. In the upper layers 2–4, most charcoal of broadleafs was found, especially *Fraxinus* and *Fagus*. Radiocarbon dating established that it is of recent age and was probably carried to lower layers by animals (dormice). Namely pollen analysis of samples from these layers showed that, at that time (i.e. about 40,000 years ago), *Pinus* and *Picea* grew, probably in thin stands since the pollen of alpine grassland vegetation greatly predominated. In layers 2 and 3, the pollen of *Pinus* was identified, as well as some broadleafs: *Quercus*, *Tilia*, *Corylus* and *Carpinus*, which would correspond to a warmer and drier climate around 35,000 years ago, but these data are leti, vendar ti podatki kljub vsemu niso zanesljivi. Takrat se je namreč sedimentacija v jami že končala, in ker so bile te plasti v stadialu izpostavljene mrazu in vlagi, so se gubale in premešale.

Sedimentov zadnjega würmskega stadiala (tj. OIS 2) in poznega glaciala v jami Divje babe I ni, zato smo skušali vegetacijske razmere v mlajšem paleolitiku dopolniti s sicer skromnimi rezultati paleovegetacijskih raziskav iz drugih arheoloških najdišč, ki so na podlagi kulturne stopnje, ugotovljene favne in flore, kronostratigrafsko opredeljena po Grossovi (1964, 196) in Woldstedtovi (1962) razdelitvi würmskega glaciala in poznega glaciala.

Že v drugi polovici würmskega interstadiala W I/W II musterjen nasledi nova kulturna stopnja orinasjen. V dveh orinasjenskih najdiščih pri nas (v Potočki zijalki in Mokriški jami) je bila glede na njuno visokogorsko lego kljub verjetno toplejšim klimatskim razmeram po pričakovanjih ugotovljena le vegetacija iglavcev. Pred okoli 25.000 leti, v würmskem interstadialu W II/W III, se že začne nova kulturna stopnja: gravetjen. V najdiščih z vrhunca W III, kot so Ciganska jama, Podrisovec (?), Ovčja jama, Jama v Lozi in zgornje plasti v Betalovem spodmolu, sta bila ugotovljena le bor (*Pinus*) ali smreka (*Picea*), kar ustreza mrzlim podnebnim razmeram. Še pred koncem stadiala se začne nova kulturna stopnja epigravetjen, ki je trajala do okoli 12.000 let pred sedanjostjo. To je bilo že v poznem glacialu, za katerega so bila značilna kratkotrajna nihanja hladnih in toplejših obdobij. Vegetaciji iglavcev so se tedaj pridruževali že tudi listavci. V najdiščih Poljšiška cerkev, Babja jama, Lukenjska jama, Zakajeni spodmol in drugih je bila poleg bora ugotovljena tudi vrsta listavcev, od jerebike (*Sorbus*), leske (*Corylus*), gabra (*Carpinus*), hrasta (*Quercus*), črnega bezga (*Sambucus*) vse do bukve (*Fagus*).

ZA KONEC

V prispevku so povzeti rezultati paleobotaničnih raziskav v Divjih babah I. Večina jih je bila že objavljena (Turk *et al.* 1988–1989; Šercelj, Culiberg 1991; Culiberg, Šercelj 1997; Culiberg 2007) in so tu zdaj dopolnjeni z doslej še neobjavljenimi rezultati pelodne analize celotnega profila (*tab. 1*). Obravnavani so bili tudi rezultati starejših paleobotaničnih raziskav iz mlajšepaleolitskih najdišč. Končamo lahko z dvema pomembnima ugotovitvama:

– da je tudi v najhladnejših obdobjih srednjega würma na območju najdišča Divje babe I in tudi drugih najdišč ves čas uspevala drevesna vegetacija, tedaj sicer skrčena le na bor (*Pinus*) in smreko (*Picea*)

– da se je ob vsakem izboljšanju klimatskih razmer poleg drugih drevesnih vrst vedno znova uveljavila tudi bukev (*Fagus*). Njena prisotnost je predvsem z ogljem iz

not reliable. At that time, namely, sedimentation in the cave had already ended and because these layers were exposed to cold and damp in the stadial they were folded and intermixed.

There are no sediments of the final Würm stadial (i.e. OIS 2) and Late Glacial in Divje babe I cave, so we attempted to supplement vegetation conditions in the Upper Palaeolithic with the somewhat modest results of paleovegetational research from other archaeological sites. These are chronostratigraphically defined according to Gross (1964, 196) and Woldstedt (1962) division of the Würm Glacial and Late Glacial, based on the cultural level and the identified flora and fauna. Already in the second half of the Würm interstadial, W I/W II, *Mousterian* is followed by a new cultural stage, *Aurignacian*. In the two *Aurignacian* sites in Slovenia, Potočka zijalka and Mokriška jama, in view of the high mountain location, despite the probably warmer climatic conditions, only coniferous vegetation could be expected. Around 25,000 years ago, in the Würm interstadial W II/W III, a new cultural stage is already beginning, the *Gravettian*. In sites from the height of W III, such as Ciganska jama, Podrisovec (?), Ovčja jama, Jama v Lozi and the upper layers in Betalov spodmol, only *Pinus* or *Picea* were identified, which corresponds to cold climatic conditions. Even before the end of the stadial, a new cultural stage was beginning, *Epigravettian*, which lasted to around 12,000 BP. This was already in the Late Glacial, for which brief oscillations of cold and warmer periods were characteristic. The coniferous vegetation was also then joined by broadleafs. In the sites Poljšiška cerkev, Babja jama, Lukenjska jama, Zakajeni spodmol and others, in addition to *Pinus* a range of broadleafs was found, from *Sorbus*, *Corylus*, *Carpinus*, *Quercus* and *Sambucus* to *Fagus*.

CONCLUSION

The contribution summarises the results of palaeobotanical research in Divje babe I. They have for the most part already been published (Turk *et al.* 1988–1989; Šercelj, Culiberg 1991; Culiberg, Šercelj 1997; Culiberg 2007) but are here supplemented by unpublished results of pollen analysis of the entire profile (*Tab. 1*). The results of earlier palaeobotanical research from early Palaeolithic sites have also been discussed. We can conclude at the end with two important findings:

– that even in the coldest periods of the Middle Würm, tree vegetation grew throughout in the area of the site Divje babe I as well as other sites, although it was then reduced only to *Pinus* and *Picea*,

– that at the time of each improvement of climatic conditions, in addition to other tree species, *Fagus* also re-established itself. Its presence is indisputably confirmed mainly by charcoal from hearths in layer 10, the lower part of layer 8b, layer 8a and layer 5, which ognjišč v plasti 10, spodnjem delu plasti 8b, plasti 8a in plasti 5 nesporno potrjena, kar zagotovo pomeni, da je mrzla obdobja lahko preživela le kje v bližnjem zavetju, od koder se je lahko vsakič znova hitro razširila.

NAMESTO ZAHVALE

Vesela sem, da sem dolga leta sodelovala s kolegom in prijateljem Ivanom Turkom. Vedno sem cenila njegove odlike, predvsem strokovnost, poštenost, iskrenost in popolno predanost raziskovalnemu delu. Zato sem tudi vse njegove kritične pripombe, ki jih seveda ni manjkalo, vedno razumela kot dobronamerne in vzpodbudne. Z umikom iz aktivnega raziskovalnega dela se je najino sodelovanje izteklo, ostalo pa mi bo vedno v lepem spominu.

certainly means that it must have survived in nearby refuges, from which it could again quickly spread.

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Translation: Martin Cregeen

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POZNOGLACIALNA VEGETACIJA V OKOLICI BLEJSKEGA JEZERA IN GRIBELJ (BELA KRAJINA): PRIMERJAVA V ZADNJEM STADIALU POLEDENELE IN NEPOLEDENELE POKRAJINE

Maja ANDRIČ

Izvleček

Na začetku poznoglacialnega interstadiala (14.300 cal. BP) je v okolici Blejskega jezera in Gribelj uspevala precej enotna vegetacija, redek gozd bora in breze (*Pinus, Betula*), povečanje peloda mezofilnih listavcev (*Quercus, Tilia, Ulmus*) ter breze (*Betula*) in smreke (*Picea*) okrog 13.800 cal. BP pa nakazuje klimatsko otoplitev in večanje razlik med regijama. Medtem ko sta bili v toplejši jugovzhodni Sloveniji lipa (*Tilia*) in breza (*Betula*) pogostejši, je pelodni influks teh dveh taksonov na pelodnem diagramu Blejskega jezera, ki leži v hladnejši in ob vrhuncu zadnje poledenitve z ledom prekriti severozahodni Sloveniji, veliko nižji. V obeh regijah upad peloda dreves in porast zelišč (Poaceae, Chenopodiaceae in *Artemisia*), ki sta sledila otoplitvi, nakazuje hladnejšo in bolj suho klimo mlajšega driasa.

Ključne besede: palinologija, pozni glacial, lipa (*Tilia*), Slovenija, Blejsko jezero, Griblje

UVOD

Slovenija leži v bližini ledenodobnih območij iglastih in listnatih drevesnih vrst (e. g. Cheddadi *et al.* 2006; Culiberg 1991; Magri *et al.* 2006; Petit *et al.* 2003; Willis *et al.* 2000; Willis, van Andel 2004), zato je bila v poznem glacialu prekrita z zelo pestro vegetacijo. Na začetku poznega glaciala je na območju Slovenije uspevala stepa z redkimi drevesi (e.g. *Pinus, Betula*), kasneje pa so se s klimatsko otoplitvijo tu razširili tudi mezofilni listavci (e.g. *Quercus, Tilia, Corylus, Ulmus*) (Culiberg 1991; Culiberg, Šercelj 1998; Šercelj 1970). Palinološke raziskave kažejo, da je bila poznoglacialna vegetacija Slovenije razmeroma enotna, z manjšimi

LATEGLACIAL VEGETATION AT LAKE BLED AND GRIBLJE MARSH (SLOVENIA): A COMPARISON OF (IN LAST GLACIAL MAXIMUM) GLACIATED AND NON-GLACIATED LANDSCAPES

Abstract

The results of pollen analysis suggest that at the beginning of the Lateglacial interstadial (14300 cal. BP) an open woodland (*Pinus, Betula*) was growing at both study sites, but an increase of mesophilous deciduous trees (*Quercus, Tilia, Ulmus*), *Betula* and *Picea* at ca. 13800 cal. BP indicated further climatic warming, and the differences between study sites became apparent. Whereas in warmer southestern Slovenia (Griblje) *Tilia* and *Betula* were more abundant, pollen influx for these two taxa was much lower at Lake Bled, which was located in colder northwestern Slovenia in glaciated landscape and mountains. At both study sites a decline of tree taxa and an increase of herbs (Poaceae, Chenopodiaceae and *Artemisia*) suggest colder and drier conditions in the Younger Dryas.

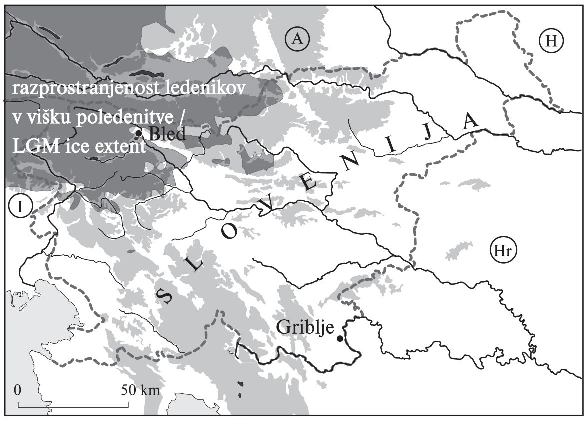
Keywords: palynology, Lateglacial, lime (*Tilia*), Slovenia, Lake Bled, Griblje

INTRODUCTION

Slovenia is located in the vicinity of glacial refugia for coniferous and deciduous tree taxa (e.g. Cheddadi *et al.* 2006; Culiberg 1991; Magri *et al.* 2006; Petit *et al.* 2003; Willis *et al.* 2000; Willis, van Andel 2004), so Lateglacial vegetation in the area was very diverse. At the beginning of the Lateglacial, a steppe with few trees (e.g. *Pinus, Betula*) was growing in Slovenia, but with climatic warming mesophilous deciduous trees (e.g. *Quercus, Tilia, Corylus, Ulmus*) expanded (Culiberg 1991; Culiberg, Šercelj 1998; Šercelj 1970). Palynological research also suggests that, although Lateglacial vegetation seems quite uniform, minor differences in vegetation composition observed at razlikami v sestavi vegetacije na najdiščih v osrednji in severozahodni Sloveniji, ki so bile verjetno posledica različne mikroklime in lokalne topografije (Culiberg 1991). V tem prispevku predstavljena raziskava primerja med seboj pelodni zapis dveh paleoekoloških najdišč, ki ležita v danes klimatsko zelo različnih območjih Slovenije. Prvo najdišče, Blejsko jezero, leži v alpski fitogeografski regiji severozahodne Slovenije, ki je bila ob vrhuncu zadnje poledenitve prekrita z ledom, medtem ko drugo najdišče, močvirje v okolici Gribelj (Bela krajina), ni bilo prekrito z ledom. Rezultati pelodne analize vrtine z Blejskega jezera so bili že objavljeni kot del multidisciplinarne študije poznoglacialne klime, vegetacije in hidrologije (Andrič *et al.* 2009), preliminarni rezultati podrobne palinološke raziskave pri Gribljah pa so v tem prispevku predstavljeni prvič. V članku bom primerjala samo zgornji del obeh vrtin (8–232 cm za Blejsko jezero in 0–270 cm za Griblje), datiran v obdobje po pribl. 14.300 cal. BP. Starejši, spodnji del vrtine z Blejskega jezera (232–521 cm), kjer je pelodna koncentracija nizka, ohranjenost peloda pa slaba, radiokarbonsko ni bil datiran, medtem ko spodnji del vrtine v Gribljah (270–600 cm) še ni bil analiziran. Rezultati te raziskave imajo tudi arheološke implikacije: pomagali nam bodo razumeti, kako so poznoglacialna klimatska nihanja vplivala na sestavo vegetacije in življenje paleolitskih, lovsko-nabiralniških prebivalcev Slovenije.

OPIS PALEOEKOLOŠKIH NAJDIŠČ

Blejsko jezero (površina 1,45 km^2, največja globina 30 m) leži v severozahodni Sloveniji (46°22'N; 14°06' E) na nadmorski višini 475 m na apnenčasti in dolomitni geološki podlagi (*sl. 1*). Jezero je ledeniškega nastanka in obkroženo s pleistocenskimi morenami; čelne morene, ki so verjetno nastale v zadnjem stadialu, ležijo vzhodno od jezera (Grimšičar 1955; Radinja *et al.* 1987). Današnja klima v regiji je zmerna, s submediteranskim padavinskim režimom (1300–2800 mm letno, padavinski maksimum jeseni). Povprečna temperatura najhladnejšega meseca je med –3 °C in 0 °C, povprečje najtoplejšega meseca pa med 15 °C in 20 °C (Ogrin 1996). Bukovi (*Fagus sylvatica*) gozdovi uspevajo zahodno in severno od jezera, s posamičnimi sestoji belega gabra (*Carpinus betulus*) in vrbe na vzhodu (*Salix* sp.) ter travniki in polji v bližini jezera.



Sl. 1: Geografska lokacija paleoekoloških najdišč z vrisano razprostranjenostjo ledenikov okoli 20.000 cal. BP (po Pohar 1994).
Fig. 1: Geographical position of study sites with Last Glacial Maximum ice extent (after Pohar 1994).

sites mostly located in central and northwestern Slovenia might be a consequence of various microclimate and local topography conditions (Culiberg 1991). This study aims to investigate these differences by comparing pollen records (percentage and pollen influx data) of two study sites located in areas with contrasting climatic conditions. The first site, Lake Bled, is located in the Alpine area of northwestern Slovenia, which in the last glacial maximum was covered by a glacier, whereas the second site, Griblje marsh, located in more continental southeastern Slovenia, was not glaciated (*Fig. 1*). The results of pollen analysis at Lake Bled have already been published as a part of multi-proxy research concerning Lateglacial climate, vegetation, and hydrology (Andrič *et al.* 2009), whereas the preliminary results of high-resolution pollen analysis at Griblje (GRIB 1 site) are presented here for the first time. In this paper only the upper sections of the cores (8-232 cm at Bled and 0-270 cm at Griblje), dated after ca. 14300 cal. BP, are compared. The lower part of the Lake Bled core (232-521 cm) was not radiocarbon-dated and has low pollen concentration and poor pollen preservation (Andrič *et al.* 2009), whereas the pollen record in the lower section of the Griblje core (270-600 cm) has not yet been analysed. The results of this study have also archaeological implications for understanding how rapid Lateglacial climatic fluctuations influenced vegetation composition and affected the Palaeolithic, hunter-gatherer populations of Slovenia.

STUDY AREA

Lake Bled (area 1.45 km^2, max. depth 30 m) is located in northwestern Slovenia (46°22'N; 14°06' E) at 475 m a.s.l. on limestone and dolomite bedrock (*Fig. 1*). The lake developed in a depression shaped by a glacier. It is surrounded by moraines, with Last Glacial Maximum terminal moraines located east of the lake (Grimšičar 1955; Radinja *et al.* 1987). The climate today in the area is temperate, with a submediterranean precipitation regime (1300-2800 mm annual precipitation, with maximum in autumn). The average temperatures of the coldest month

Močvirje v bližini vasi Griblje (GRIB 1) leži v jugovzhodni Sloveniji (Bela krajina) (*sl. 1*). Današnja klima v Beli krajini je zmerna, kontinentalno-subpanonska, s submediteranskim padavinskim režimom (1200–1300 mm padavin letno) in vročimi poletji. Povprečna temperatura najhladnejšega meseca se giblje med –3 °C in 0 °C, najtoplejšega pa med 15 °C in 20 °C (Bernot 1984; Ogrin 1996; Plut 1985). Palinološka vrtina je bila zvrtana v osrednjem delu manjšega, z rogozom (*Typha latifolia*) preraščenega močvirja (s premerom pribl. 20 m), na 160 m nadmorske višine, pribl. 1 km zahodno od vasi Griblje (45° 34' 03" N; 15° 16' 55" E). Močvirje obdajajo polja in travniki, z manjšimi krpami gozda z brezo (*Betula pendula*), rdečim borom (*Pinus sylvestris*) in hrastom (*Quercus petraea*), ter številna manjša močvirja (pribl. 0,5–1 km severno in severovzhodno), nekatera prerasla s šaši (Cyperaceae) ali jelšo (*Alnus glutinosa*), vrbo (*Salix* sp.) in brezo (*Betula pendula*).

METODE

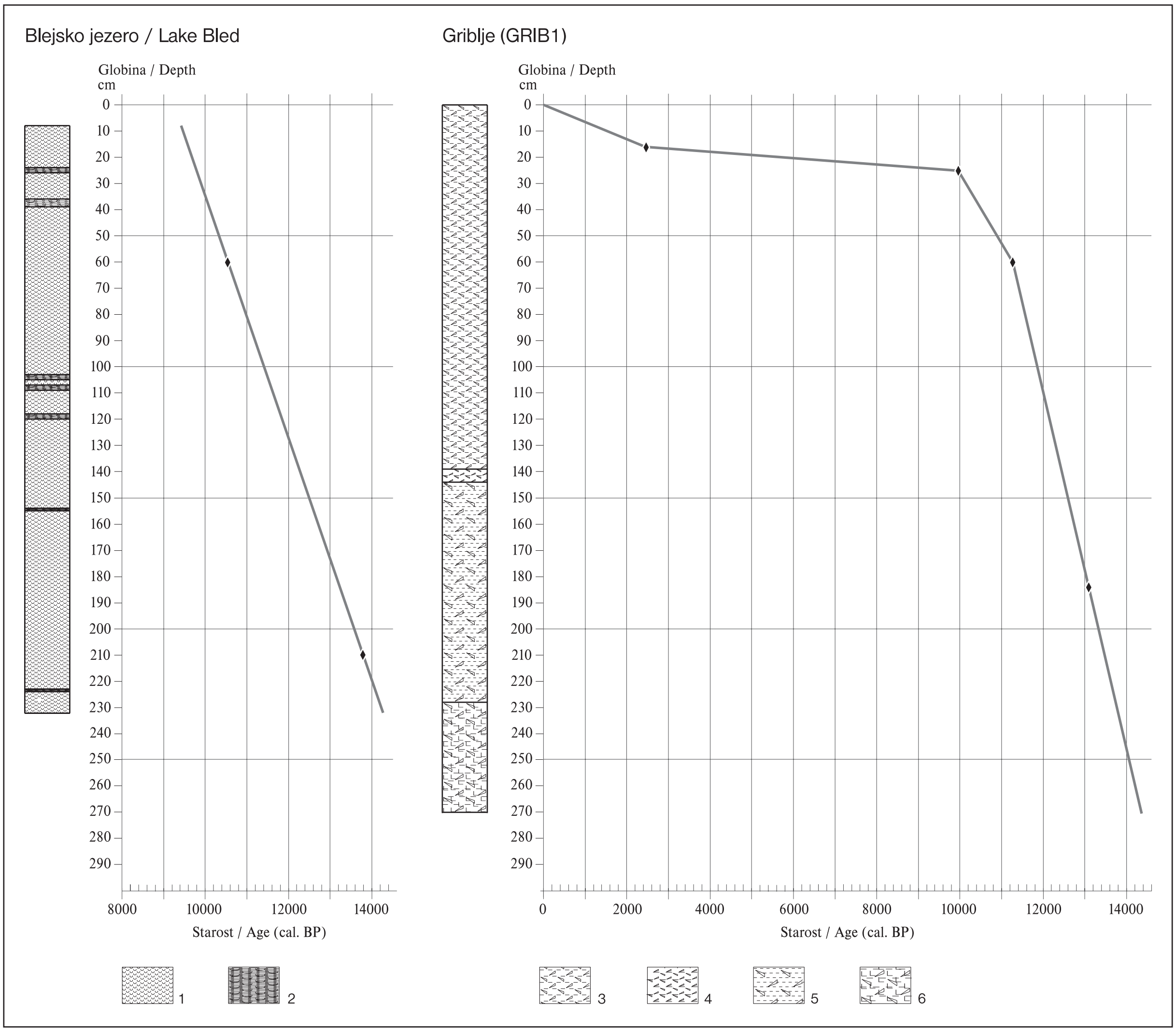
Vrtina iz Blejskega jezera je bila zvrtana z vrtalno opremo Livingstone (modifikacija po Merktu in Streifu, 1970, s premerom cevi 4,8 cm) s platforme, postavljene v jugozahodnem delu jezera (Andrič *et al.* 2009). Za vrtanje močvirja pri Gribljah (GRIB 1) smo uporabili vrtalno opremo Livingstone (modifikacija 'Stitz') s premerom 8,4 cm, vezano na električno kladivo in prenosni generator. Na obeh lokacijah smo 1 m dolge segmente vrtine zavili v folijo na terenu in shranili v hladilnici pri +4 °C. Starost paleoekološkega zapisa v vrtinah je bila določena s pomočjo AMS-radiokarbonskega datiranja (*tab. 2*) makrofosilov kopenskih rastlin (Blejsko jezero) in organskega sedimenta (Griblje). Konvencionalni datumi C14 so bili kalibrirani z računalniškim programom CALIB rev 5.0.1 (CALIB 5.0 Website; Stuvier, Reimer 1993), ob uporabi podatkovne baze IntCal 04 (Reimer *et al.* 2004). Za določanje starosti sedimenta je bilo uporabljeno modeliranje s pomočjo linearne interpolacije skozi srednje cal. BP vrednosti (*sl. 2*). Opis litologije (*tab. 1*) je bil opravljen po Troels-Smithu (1955). Vzorci za pelodno analizo (vsakič 1 cm^3 sedimenta) so bili pripravljeni po standardnem laboratorijskem postopku (Bennett, Willis 2002). Pred laboratorijsko pripravo so bile sedimentu dodane tablete spor *Lycopodium* za določanje pelodne koncentracije (Stockmarr 1971). Koncentracija mikroskopskega oglja je bila določena po Clarkovi točkovni ('point count') metodi (Clark 1982). Pelodna zrna so bila identificirana s pomočjo svetlobnega mikroskopa Nikon Eclipse E400 pri 400-kratni povečavi, pri čemer je bila minimalna vsota preštetih pelodnih zrn kopenskih rastlin in spor (praproti in mahov) 500 na vzorec. Rezultati pelodne analize (*sl. 3, 4 in 5*) so bili matematično obdelani in zrisani s pomočjo programa PSIMPOLL 3.00 (http://chrono.qub.ac.uk/psimpoll/psimpoll.html).

are between -3 °C and 0 °C, while the average for the warmest month is between 15 °C and 20 °C (Ogrin 1996). Beech (*Fagus sylvatica*) forests grow west and north of the lake, patchy woodlands of hornbeam (*Carpinus betulus*) and willow (*Salix* sp.) to the east. Meadows and fields are also located in the vicinity of the lake.

Griblje (GRIB 1) marsh is located in the Bela krajina region of southeastern Slovenia (*Fig. 1*). The climate today in the area is moderate continental-subpannonian with a sub-mediterranean precipitation regime (1200-1300 mm annual precipitation) with hot summers. The average temperatures of the coldest month are between -3 °C and 0 °C, while the warmest month average is between 15 °C and 20 °C (Bernot 1984; Ogrin 1996; Plut 1985). The sedimentary core GRIB 1 was collected in marsh area, which developed in a small depression (diameter ca. 20 m) at 160 m a.s.l., ca. 1 km west of the Griblje village (45° 34' 03"; 15° 16' 55"). Reed-mace (*Typha latifolia*) grows at the coring location, which is surrounded by meadows and fields, with patchy woodlands of birch (*Betula pendula*), pine (*Pinus sylvestris*), and oak (*Quercus petraea*). Several small marshy areas, some overgrown with sedges (Cypearceae) or alder (*Alnus glutinosa*), willow (*Salix* sp.) and birch (*Betula pendula*) are located around the Griblje village, ca. 0.5-1 km to the north and northeast of the coring location.

METHODS

Lake Bled was cored from a platform in the southwestern part of the lake with a Livingstone piston corer modification after Merkt and Streif (1970), with tube diameter of 4.8 cm (Andrič *et al.* 2009), while the Griblje (GRIB 1) site was cored with a 'Stitz' Livingstone modification with tube diameter 8.4 cm, attached to an electric hammer and portable generator. At both sites, core sections 1 m long were extruded from the piston corer in the field, wrapped in thick plastic, and stored in a dark coldstore at + 4 °C. The age was determined by AMS radiocarbon dating (*Tab. 2*) of terrestrial plant macrofossils (Lake Bled) and organic sediment (Griblje). Conventional ages were calibrated by CALIB rev 5.0.1 (CALIB 5.0 Website; Stuvier, Reimer 1993) on IntCal 04 calibration dataset (Reimer *et al.* 2004). Linear interpolation through median cal. BP values was used for age-depth modeling (*Fig. 2*). Sediment composition (*Tab. 1*) was described according to Troels-Smith (1955). For the pollen analysis 1 cm^3 samples of sediment were prepared with standard laboratory procedures (Bennett, Willis 2002); *Lycopodium* tablets were added to determine the pollen concentration (Stockmarr 1971), and microscopic charcoal concentration in both cores was established with Clark's (1982) point count method. The pollen was identi-



Sl. 2: Modeliranje starosti (linearna interpolacija) za Blejsko jezero in Griblje (GRIB 1). Litoligija: 1 – karbonatni melj (jezerska kreda); 2 – plasti mahov, 3, 5 – organski sediment s preperelim rastlinskim materialom; 4 – organski sediment, zelo bogat s preperelim rastlinskim materialom; 6 – organski sediment z meljem in preperelim rastlinskim materialom.

Fig. 2: Age-depth modelling (linear interpolation) for Lake Bled and Griblje (GRIB 1). Lithology: 1 - calcareous silt (lake marl); 2 - moss layers; 3, 5 - organic sediment with plant detritus; 4 - organic sediment very rich in plant detritus; 6 - organic sediment with silt and plant detritus.

REZULTATI

OPIS SEDIMENTA IN RADIOKARBONSKO DATIRANJE

Sediment vrtin se zaradi različnih naravnih značilnosti bazenov med seboj močno razlikuje. Vrtina iz Blejskega jezera vsebuje veliko sivkastega meljastega sedimenta (jezerske krede) s posameznimi plastmi mahov (iz družin *Scorpidium, Pseudocalliergon* in *Calliergon*) na naslednjih globinah: 24–29 cm, 107–155 cm in 223–315 cm (Andrič *et al.* 2009). Vrtina iz Gribelj vsebuje veliko organskih snovi (z ostanki preperelega rastlinskega materiala na 139–144 cm), pod 228 cm pa nekoliko manj organskih snovi kot v zgornjem delu

fied with a Nikon Eclipse E400 light microscope at 400x magnification. At least 500 terrestrial pollen grains and spores were counted per sample. Pollen data (*Figs. 3-5*) were analysed and plotted with the PSIMPOLL 3.00 program (http://chrono.qub.ac.uk/psimpoll/psimpoll.html).

RESULTS

SEDIMENT DESCRIPTION AND RADIOCARBON DATING

Due to contrasting natural characteristics of the basins studied, the sedimentary composition of paly-

Tab. 1: Opis sedimenta po Troels-Smith (1955).
Tab. 1: Troels-Smith (1955) description of the sediment.

Globina / Depth	**Troels Smith oznaka / Troels Smith symbol**	**Opis sedimenta (Munsellova barvna lestvica) / Sediment description (Colour Munsell soil chart)**
Blejsko jezero (C) / Lake Bled (C)		
0-232 cm	Lc4	Karbonaten siv melj (jezerska kreda) / Calcarous grey silt (lake marl)
S plastmi mahov na sledečih globinah / With moss layers at 24-26, 36-39, 103-105, 107-109, 118-120, 154-155 and 223-224 cm	Lc1 Tb3	Karbonaten siv melj (jezerska kreda) z mahovi / Calcarous grey silt (lake marl) with moss macrofossils
Griblje (GRIB 1)		
0-139 cm	Dh2 Sh2	Črn sediment z organskimi snovmi in preperelim rastlinskim materialom / Organic black sediment with plant detritus
139-144 cm	Dh3 Sh1	Črn sediment, zelo bogat z organskimi snovmi in preperelim rastlinskim materialom / Organic black sediment, very rich in plant detritus
144-228 cm	Dh1 Sh3	Temno rjav organski sediment s preperelim rastlinskim materialom / Organic very dark brown sediment, with plant detritus
228-270 cm	Dh1 Sh1 As2	Meljast temno sivorjav organski sediment / Organic very dark greyish brown sediment with silt

(*tab. 1*). Čeprav je razlika v sestavi sedimenta med obema paleoekološkima najdiščema velika, je hitrost sedimentacije primerljiva: pribl. 0,046 cm na leto v Blejskem jezeru in med 0,027 in 0,068 cm na leto v poznoglacialnem delu vrtine iz Gribelj. Medtem ko v vrtini iz Blejskega jezera (ki je datirana v zgodnji holocen in pozni glacial med pribl. 9400–14.300 cal. BP) manjka večina holocenskega sedimenta, je ta v vrtini iz Gribelj v celoti ohranjen, vendar izjemno plitev (75 cm). Počasna sedimentacija v zgornjem delu vrtine iz Gribelj (pribl. 0,001–0,006 cm na leto) je verjetno posledica bolj suhih hidroloških razmer v srednjem in poznem holocenu zaraščajočega se jezera.

PELODNA ANALIZA

Rezultati pelodne analize za izbrane taksone so prikazani na dveh kratkih odstotkovnih pelodnih diagramih (*sl. 3 in 4*). V prvotni objavi je bil pelodni diagram vrtine iz Blejskega jezera razdeljen na pet statistično pomembnih pelodnih con s pomočjo metode optimalnega razcepa po obsegu informacije ('optimal splitting by information content') (Bennett 1996). Glavna značilnost zgornjega dela pelodne cone B-3 (*sl. 3*, 232–200 cm) je visok odstotek peloda bora (*Pinus*, pribl. 75–95 %) in veliko nižji delež peloda zelišč kot v prejšnjih dveh conah (B-1, B-2 in spodnjem delu B-3, ki niso prikazane na *sl. 3*). Na začetku pelodne cone B-4 (200–115 cm) odstotek bora začne upadati, medtem ko

nological cores is very dissimilar. The Lake Bled core is rich in greyish calcareous silt (lake marl) with distinct moss layers (belonging to genera *Scorpidium, Pseudocalliergon* and *Calliergon*) at 24-29 cm, 107-155 cm and 223-315 cm (Andrič *et al.* 2009). The Griblje core, on the other hand, is rich in organic material (with lots of plant detritus at 139-144 cm), whereas below 228 cm the amount of organic material is less and the sediment contains more clay (*Tab. 1*). Despite these differences the sedimentation rates at both sites are comparable, with ca. 0.046 cm yr^{-1} at Lake Bled and between 0.027 cm yr^{-1} and 0.068 cm yr^{-1} in the Lateglacial part of the Griblje core. Wereas at Lake Bled (dated to the early Holocene and Lateglacial, ca. 9400-14300 cal. BP) most of the Holocene sediment is missing, at Griblje a complete but extremely short (ca. 75 cm) Holocene sequence was deposited. This slow mid- and late-Holocene sedimentation rate at Griblje (ca. 0.001-0.006 cm yr^{-1}) is most probably a consequence of drier hydrological conditions in the final, successional phase of the infilling lake.

POLLEN ANALYSIS

The results of pollen analysis are presented in two short percentage pollen diagrams of selected taxa (*Figs. 3-4*). In the original publication (Andrič *et al.* 2009) the Lake Bled pollen diagram was divided into five statistically significant pollen zones by the method of optimal splitting by information content (Bennett

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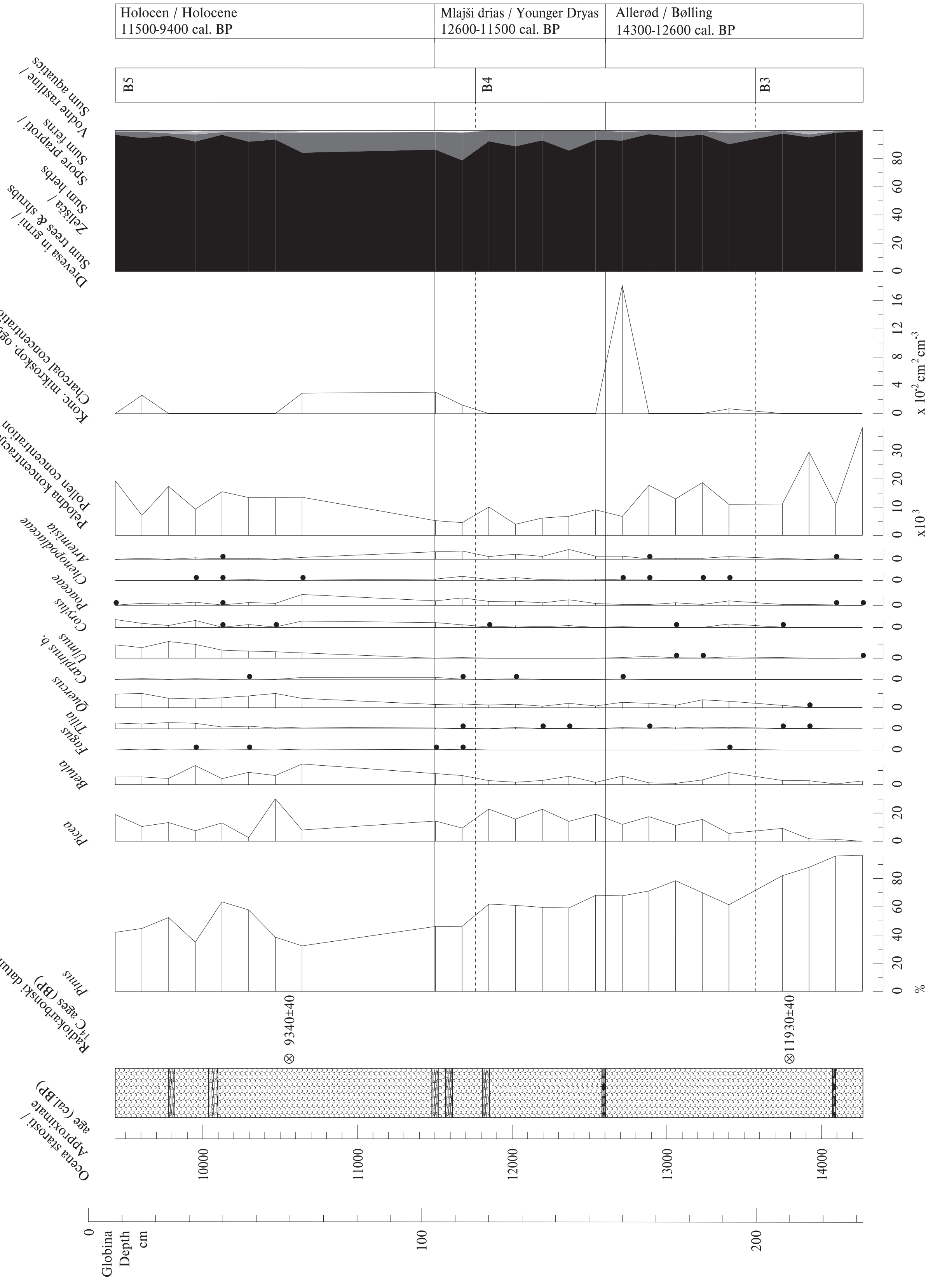
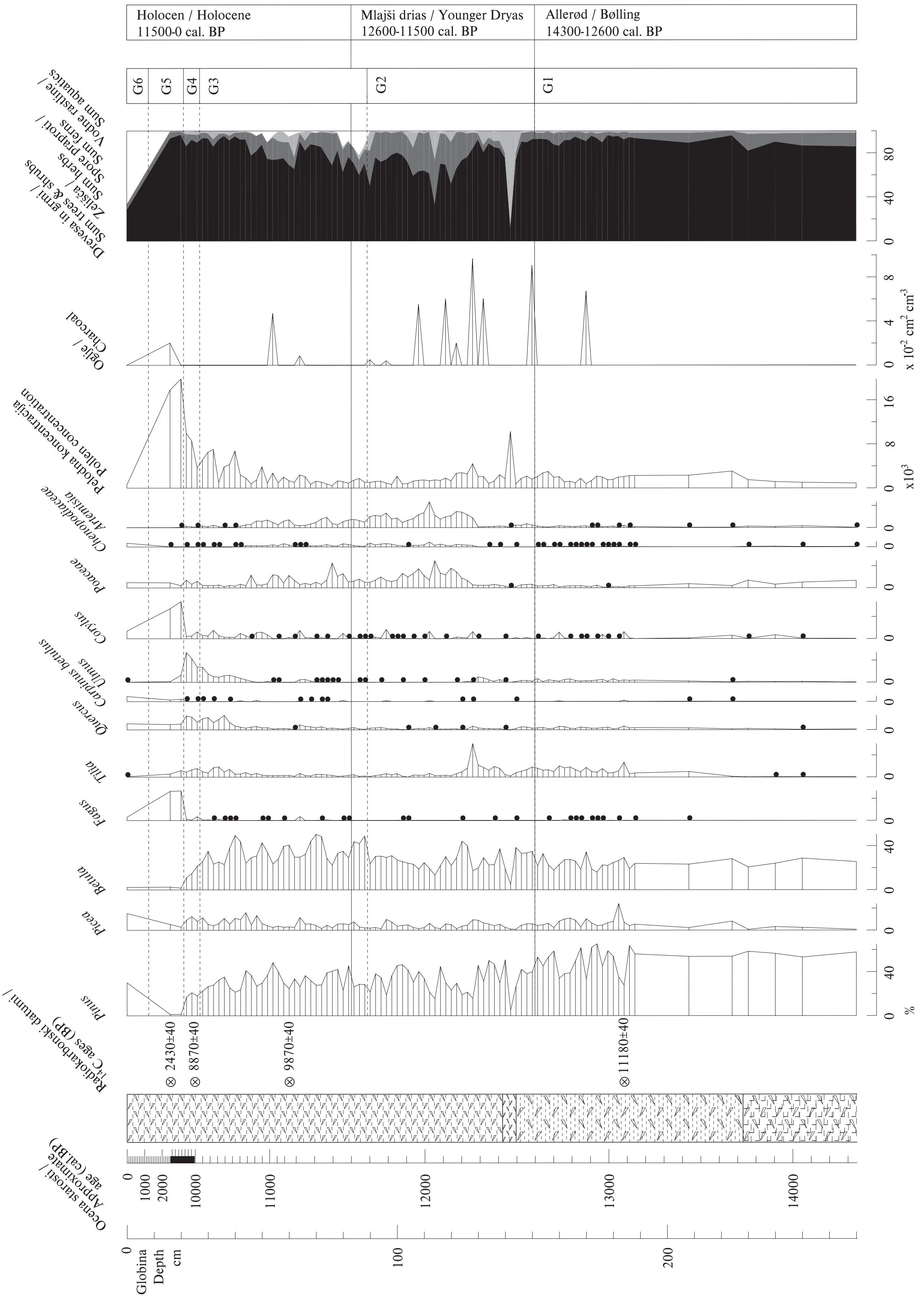
Sl. 3: Blejsko jezero. Odstotkovni pelodni diagram za izbrane taksone: *Pinus* (bor), *Picea* (smreka), *Betula* (breza), *Fagus* (bukev), *Tilia* (lipa), *Quercus* (hrast), *Carpinus betulus* (beli gaber), *Ulmus* (brest), *Corylus* (leska), Poaceae (trave), Chenopodiaceae (metlikovke), *Artemisia* (pelin).
Fig. 3: Lake Bled. Percentage pollen diagram of selected taxa: *Pinus* (pine), *Picea* (spruce), *Betula* (birch), *Fagus* (beech), *Tilia* (lime), *Quercus* (oak), *Carpinus betulus* (hornbeam), *Ulmus* (elm), *Corylus* (hazel), Poaceae (grasses), Chenopodiaceae (goosefoot), *Artemisia* (wormwood).

Tab. 2: Radiokarbonski datumi za Blejsko jezero in Griblje (GRIB 1). Radikarbonska datuma za Blejsko jezero z globine 40 cm (Beta-189953 in Poz-3123, organski sediment) nista bila uporabljena pri modeliranju starosti vrtine zaradi domnevnega vpliva starejšega ogljika, ki izvira iz geološke podlage bazena ('reservoir' efekta).
Tab. 2: Radiocarbon dates for Lake Bled and Griblje (GRIB 1). Lake Bled radiocarbon dates at 40 cm (Beta-189953 and Poz-3123, organic sediment) were not used for age-depth modelling due to errors presumably caused by reservoir effect.

Številka vzorca / Sample number	**Globina (cm) / Depth (cm)**	**Datirani material (laboratorijski postopek) / Material dated (pretreatment)**	**Konvencionalni radiokarbonski datum / Conventional C14 age**	**13C/12C delež / 13C/12C ratio**	**2 sigma kalibracija (cal. BP, Intcal 04) / 2 sigma calibration (cal. BP, Intcal 04)**	**Median (BP) / Median (BP)**
Bled C						
Beta-222472	60 cm	iglice macesna (*Larix*), del storža in krilca semen iglavcev (spiranje kislina/baza/kislina) / *Larix* leaves, part of cone scale and wings of coniferous seeds (acid/alkali/acid)	9340 ± 40 BP	-26.9 ‰	10679-10426	10555
Beta-217805	210 cm	vejica in iglice macesna (*Larix*) (spiranje kislina/baza/kislina) / *Larix* twig and needles (acid/alkali/acid)	11930 ± 40 BP	-28.2 ‰	13908-13699	13790
Beta-189953	40 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	13860 ± 100 BP	-33.8 ‰		
Poz-3123	40 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	15430 ± 80 BP	/		
Griblje (GRIB 1)						
Beta-182668	16 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	2430 ± 40 BP	-28.8 ‰	2351-2702	2475
Beta-189851	25 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	8870 ± 60 BP	-27.9 ‰	9737-10184	9993
Beta-183924	60 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	9870 ± 40 BP	-27.4 ‰	11206-11386	11262
Beta-182669	184 cm	organski sediment (spiranje s kislino) / organic sediment (acid washes)	11180 ± 60 BP	-28.7 ‰	12946-13202	13083


Holocen / Holocene
11500-9400 cal. BP
Mlajši drias / Younger Dryas
12600-11500 cal. BP
Allerød / Bølling
14300-12600 cal. BP
B5
B4
B3
Drevesa in grmi / Sum trees & shrubs
Zelišča / Sum herbs
Spore praproti / Sum ferns
Vodne rastline / Sum aquatics
0
20
40
60
80
Konc. mikroskop. oglja / Charcoal concentration
0
4
8
12
16
x 10^{-2} cm^{2} cm^{-3}
Pelodna koncentracija / Pollen concentration
0
10
20
30
x10^{3}
Artemisia
Chenopodiaceae
Poaceae
Corylus
Ulmus
Carpinus b.
Quercus
Tilia
Fagus
Betula
Picea
Pinus
%
Radiokarbonski datumi / ^{14}C ages (BP)
⊗ 9340±40
⊗11930±40
Ocena starosti / Approximate age (cal BP)
10000
11000
12000
13000
14000
Globina
Depth
cm
0
100
200


Holocen / Holocene
11500-0 cal. BP
Mlajši drias / Younger Dryas
12600-11500 cal. BP
Allerød / Bølling
14300-12600 cal. BP
G6
G5
G4
G3
G2
G1
Drevesa in grmi / Sum trees & shrubs
Zelišča / Sum herbs
Spore praproti / Sum ferns
Vodne rastline / Sum aquatics
Oglje / Charcoal
x 10^{-2} cm^{2} cm^{-3}
Pelodna koncentracija / Pollen concentration
x10^{3}
Artemisia
Chenopodiaceae
Poaceae
Corylus
Ulmus
Carpinus betulus
Quercus
Tilia
Fagus
Betula
Picea
Pinus
%
0
40
80
4
8
16
Radiokarbonski datumi / ^{14}C ages (BP)
2430±40
8870±40
9870±40
11180±40
Ocena starosti / Approximate age (cal BP)
0
1000
2000
10000
11000
12000
13000
14000
Globina Depth cm
0
100
200

←
Sl. 4: Griblje (GRIB 1). Odstotkovni pelodni diagram za izbrane taksone: *Pinus* (bor), *Picea* (smreka), *Betula* (breza), *Fagus* (bukev), *Tilia* (lipa), *Quercus* (hrast), *Carpinus betulus* (beli gaber), *Ulmus* (brest), *Corylus* (leska), Poaceae (trave), Chenopodiaceae (metlikovke), *Artemisia* (pelin).
Fig. 4: Griblje (GRIB 1). Percentage pollen diagram of selected taxa: *Pinus* (pine), *Picea* (spruce), *Betula* (birch), *Fagus* (beech), *Tilia* (lime), *Quercus* (oak), *Carpinus betulus* (hornbeam), *Ulmus* (elm), *Corylus* (hazel), Poaceae (grasses), Chenopodiaceae (goosefoot), *Artemisia* (wormwood).

delež drugih drevesnih taksonov (*Picea, Larix, Tilia, Ulmus, Quercus* in *Corylus*) narašča. V zgornji polovici zone B-4 (160–115 cm) delež dreves za kratek čas upade, vendar spet naraste na začetku zone B-5 (115–8 cm).

Pelodni diagram vrtine iz Gribelj (*sl. 4*) je razdeljen na šest pelodnih con s pomočjo metode binarnega razcepa po vsoti kvadratov (‘binary splitting by sum of squares’) v PSIMPOLLU. Glavna značilnost spodnje pelodne cone (G-1, 270–150 cm) je razmeroma visok odstotek peloda bora (*Pinus,* pribl. 30–60 %) in breze (*Betula,* pribl. 20–30 %), delež peloda ostalih listavcev (e.g. *Tilia, Quercus, Ulmus*) pa proti vrhu cone narašča. Glavna značilnost pelodne cone G-2 (150–90 cm) je nižji odstotek peloda dreves (e.g. *Tilia, Quercus* in *Ulmus* upadejo na pribl. 130 cm) in porast deleža peloda zelišč (e.g. Poaceae, Chenopodiaceae in *Artemisia*). V coni G-3 (150–21 cm) delež peloda dreves spet začne naraščati, medtem ko so spremembe v conah G-4, G-5 in G-6 povezane s spremembami holocenske vegetacije.

Primerjava vrednosti za pelodni influks na obeh najdiščih (*sl. 5*) kaže najvišje vrednosti za bor (*Pinus*, pribl. 200–1600 pelodnih zrn na 1 cm^2 na leto) za obdobje med pribl. 14.300 in 12.600 cal. BP. V Gribljah je plodni influks breze (*Betula,* pribl. 200–600 pelodnih zrn na 1 cm^2 na leto) in lipe (*Tilia,* 50–200 pelodnih zrn na 1 cm^2 na leto med 13.450 in 12.600 cal. BP) veliko večji kot v Blejskem jezeru (oba taksona < 50 pelodnih zrn na 1 cm^2 na leto). Po 12.600 cal. BP pelodni influks bora na obeh najdiščih upade. Upad deleža ostalih drevesnih vrst (e.g. *Tilia, Quercus, Ulmus*) in porast deleža zelišč (e.g. Poaceae, *Artemisia*) okrog 12.300 cal. BP sta izrazitejša v Gribljah. Porast pelodnega influksa drevesnih vrst na obeh najdiščih okrog 10.600 cal. BP je povezan s holocensko klimatsko otoplitvijo.

RAZPRAVA

POZNOGLACIALNI INTERSTADIAL (BØLLING IN ALLERØD, PRIBL.14.300–12.600 CAL. BP)

Okrog 14.300 cal. BP je v okolici obeh najdišč verjetno uspeval redek mešani gozd. Na podlagi fosilnega pelodnega zapisa je zelo težko rekonstruirati nekdanjo pokrajino; še zlasti težko je potegniti ločnico med odprtim borealnim gozdom in tundro ali stepo (Pelánková *et al.* 2008; Seppä, Hicks 2006). Rezultati

1996). The main characteristic of the upper pollen zone B-3 (*Fig. 3*, 232-200 cm) is the high percentage of *Pinus* pollen (ca. 75-95 %) and much lower percentage of herb pollen than in the previous two zones (B-1, B-2 and lower B-3, not presented in *Fig. 3*). At the beginning of pollen zone B-4 (200-115 cm) the percentage of *Pinus* starts to decline, whereas other tree taxa (*Picea, Larix, Tilia, Ulmus, Quercus* and *Corylus*) increase. There is a short decline of tree taxa in the upper half of the zone (160-115 cm), but at the beginning of zone B-5 (115-8 cm) tree taxa increase again.

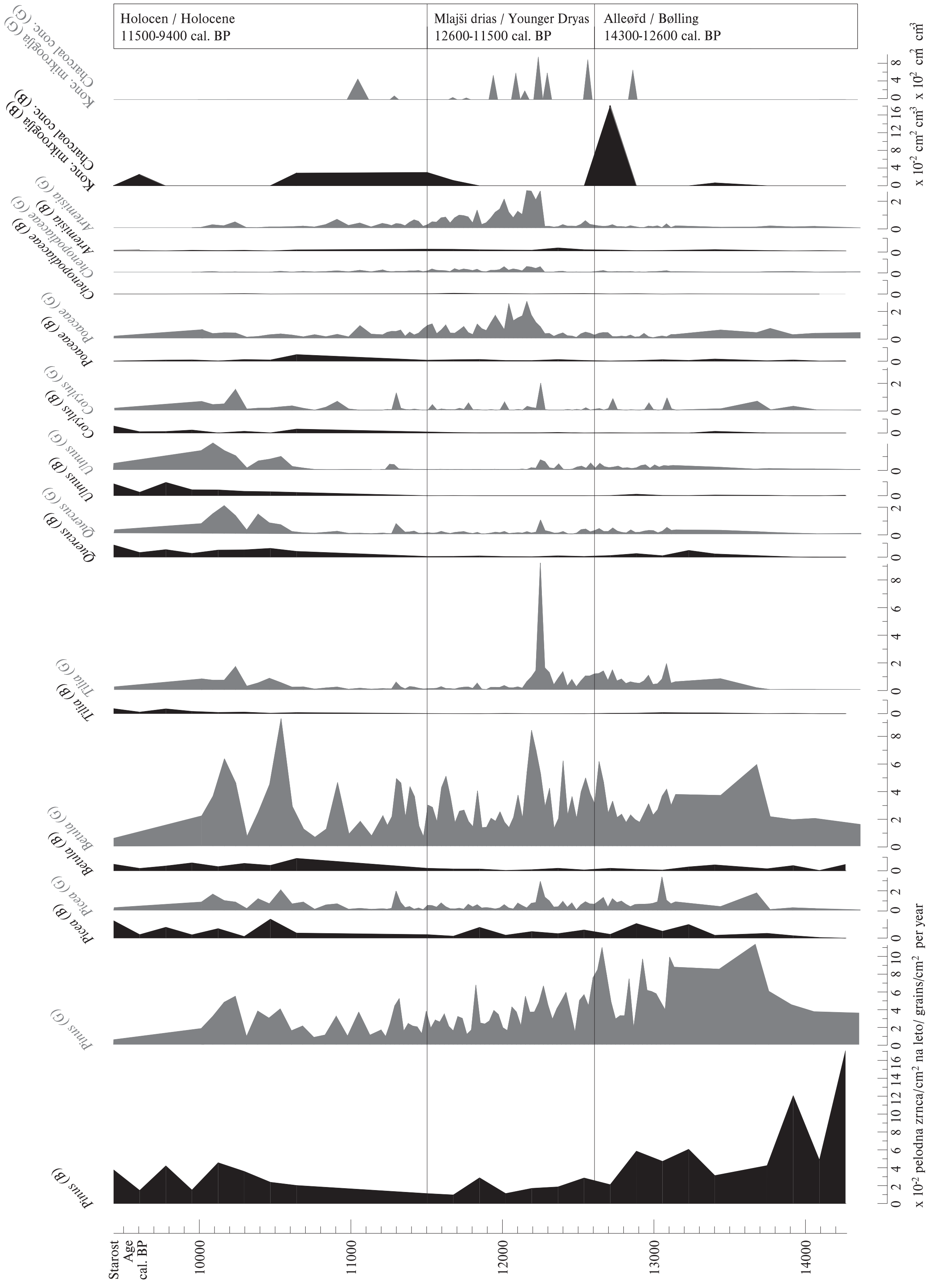
The Griblje pollen diagram (*Fig. 4*) is divided into six pollen zones with the ‘binary splitting by sum of squares’ option in PSIMPOLL. The main characteristic of the lowest pollen zone (G-1, 270-150 cm) is the rather high percentage of *Pinus* (ca. 30-60 %) and *Betula* (ca. 20-30 %) with pollen of other deciduous tree taxa (e.g. *Tilia, Quercus, Ulmus*) increasing towards the top of the zone. The main characteristic of pollen zone G-2 (150-90 cm) is the lower percentage of tree pollen (e.g. *Tilia, Quercus* and *Ulmus* decline at ca. 130 cm) and an increase of herbs (e.g. Poaceae, Chenopodiaceae and *Artemisia*). In zone G-3 (150-21 cm) trees start to increase again, whereas changes in zones G-4, G-5, and G-6 are associated with changes of vegetation composition in the Holocene.

The comparison of pollen influx values for the two sites (*Fig. 5*) shows highest pollen influx values for *Pinus* (ca. 200-1600 grains cm^{-2} per year) ca. 14300-12600 cal. BP. At Griblje, *Betula* (ca. 200-600 grains cm^{-2} yr^{-1}) and *Tilia* (50-200 grains cm^{-2}yr^{-1} between 13450 and 12600 cal. BP) pollen influx is much higher than at Lake Bled (both taxa < 50 grains cm^{-2}yr^{-1}). After 12600 cal. BP *Pinus* pollen influx at both study sites decreases. The decline of other tree taxa (e.g. *Tilia, Quercus, Ulmus*) and an increase of herbs (e.g. Poaceae, *Artemisia*) at ca. 12300 cal. BP are more pronounced at Griblje. Finally, an increase of tree pollen influx at 10600 cal. BP is associated with the Holocene climatic warming.

DISCUSSION

LATEGLACIAL INTERSTADIAL (BØLLING AND ALLERØD, CA. 14300-12600 CAL. BP)

At ca. 14300 cal. BP open woodland of deciduous and needle-leaved taxa was probably growing at both



Sl. 5: Primerjava pelodnega influksa za Blejsko jezero (B, črno) in Griblje (G, sivo).
Fig. 5: Comparison of pollen influx at Lake Bled (B, black) and Griblje (G, grey) study sites.

analize rastlinskih makrofosilov iz Blejskega jezera (Andrič *et al.* 2009) kažejo na lokalno prisotnost breze (*Betula*) in macesna (*Larix*), presenetljivo pa v vrtini ni bilo rastlinskih makrofosilov bora (*Pinus*), čeprav visoke vrednosti peloda v nekaterih vzorcih presegajo vrednosti, značilne za lokalno prisotnost bora (= 500 pelodnih zrn na 1 cm^2 na leto) glede na raziskave modernega pelodnega influksa (Seppä, Hicks 2006; van der Knaap *et al.* 2001). V Gribljah, kjer analiza rastlinskih makrofosilov ni bila opravljena, pelodni zapis kaže podobno sliko kot v primeru Blejskega jezera. Edina razlika med najdiščema so nižje odstotkovne in influksne vrednosti za bor v Gribljah med 14.300 in 13.800 cal. BP (ki pa bi lahko bile posledica premajhnega števila radiokarbonskih datumov v spodnjem delu cone G-1) in precej večje vrednosti za brezo v Gribljah (*sl. 5*).

Porast vrednosti za hrast (*Quercus*), lipo (*Tilia*), brezo (*Betula*), brest (*Ulmus*) in smreko (*Picea*) okrog 13.800 cal. BP na obeh najdiščih (*sl. 3 in 4*) je verjetno povezan z nadaljnjo otoplitvijo klime. Breza in lipa sta bili mnogo bolj številčno zastopani v Gribljah. Lipa tvori malo peloda in je na pelodnih diagramih običajno slabo zastopana (Faegri, Iversen 1989). Tudi v primeru, ko so vrednosti lipe na pelodnem diagramu zelo nizke (< 2 %, pribl. 2 pelodni zrni na 1 cm^2 na leto; Giesecke 2005), je ta drevesna vrsta vseeno lahko prisotna lokalno. Visoke odstotkovne (5–25 %) in influksne (50–900 pelodnih zrn na 1 cm^2 na leto) vrednosti za lipo v Gribljah (*sl. 5*) torej kažejo, da je v okolici Gribelj verjetno uspevalo kar veliko lokalne lipe. Vrednosti za lipo na pelodnem diagramu iz Blejskega jezera (0,5–1 %, 1 pelodno zrno na 1 cm^2 na leto) so v nasprotju z Gribljami precej nižje, kar je verjetno posledica hladnejše klime v severozahodni Sloveniji, čeprav ne bi smeli zanemariti tudi vpliva različnih naravnih značilnosti bazenov. Veliko manjše močvirje v Gribljah je namreč tudi veliko bolj občutljivo za beleženje lokalnih sprememb vegetacije (*sensu* Jacobson, Bradshaw 1981) in lažje zazna vpliv manjše populacije lokalne lipe.

Vrednosti za lipo v Gribljah so višje tudi od vrednosti na nekaterih drugih paleoekoloških najdiščih zahodno od Slovenije, na primer na najdišču Palughetto (70 x 90 m, 1040 m n.m., *Tilia* ≤ 10 %, Vescovi *et al.* 2007), ki leži na večji nadmorski višini in ima hladnejšo klimo. Tudi na vzhodu, na Madžarskem in v Romuniji, so poznoglacialne vrednosti za lipo, ki je bila verjetno prisotna na nekaterih izoliranih lokacijah in se je močneje razširila šele na prehodu poznega glaciala v holocen, nizke (e.g. pribl. ≤ 2 % na najdišču Sarrett; Feurdean *et al.* 2007; Willis *et al.* 2000). Borovi gozdovi so prevladovali na območjih z nizko nadmorsko višino na madžarski ravnici v celotnem poznem glacialu, najverjetneje zaradi sušne klime (Feurdean *et al.* 2007).

Zakaj so pelodne vrednosti za lipo v Gribljah višje kot na sosednjih območjih? Klima v jugovzhodni Sloveniji je bila verjetno toplejša kot na območju

study sites, although the reconstruction of past landscapes from fossil pollen assemblages is very difficult, especially for distinguishing between open boreal forest and grassland or tundra (Pelánková *et al.* 2008; Seppä, Hicks 2006). The results of plant-macrofossil analysis at Lake Bled (Andrič *et al.* 2009) suggest local presence of *Betula* and *Larix*. Surprisingly, no *Pinus* macrofossils were discovered, although *Pinus* pollen-accumulation rates (PAR) in some samples exceed the threshold values (= 500 pollen grains cm^{-2}yr^{-1}) for local presence according to modern PAR studies (Seppä, Hicks 2006; van der Knaap *et al.* 2001). At Griblje, where no plant-macrofossil analysis was carried out, pollen-percentage and influx values suggest a vegetation composition similar to that in the Lake Bled area. The only difference between the study sites is lower *Pinus* percentage and influx values at Griblje between 14300 and 13800 cal. BP (which might be affected by lack of radiocarbon dating in the lower part of Griblje zone G1), whereas *Betula* values at Griblje are much higher than at Lake Bled (*Fig. 5*).

At ca. 13800 cal. BP an increase of *Quercus, Tilia, Betula, Ulmus* and *Picea*, which could be associated with further climatic warming, was detected at both study sites (*Figs. 3-4*). *Betula* and *Tilia* were much more abundant at Griblje. *Tilia* is a poor pollen producer and thus under-represented in pollen diagrams (Faegri, Iversen 1989). It could be present locally even when percentage and PAR values are very low (< 2 %, ca. 2 grains cm^{-2} per year; Giesecke 2005). High *Tilia* percentage (5-25 %) and PAR (50-900 grains cm^{-2} per year) values at Griblje (*Fig. 5*) therefore suggest that a significant local population of *Tilia* was growing around the study site. In contrast to Griblje, *Tilia* values at Lake Bled are much lower (0.5-1 %, 1 grain cm^{-2} per year). It seems that this is a consequence of a presumably colder climate in northwestern Slovenia, although the impact of basin size should not be ignored, whereby the much smaller Griblje basin would more likely 'pick up' pollen of the small, local *Tilia* population (*sensu* Jacobson, Bradshaw 1981).

If we compare Griblje with other study sites, located farther west, *Tilia* values at Palughetto basin (70 x 90 m, 1040 m a.s.l.) are lower (≤ 10 %) than at Griblje (Vescovi *et al.* 2007), presumably because of the colder climate at higher altitude. Also on the east, in Hungary and Romania, where Lateglacial *Tilia* values are very low (e.g. ca. ≤ 2 % at Sarrett), *Tilia* was most probably present in a few isolated places throughout the Lateglacial and rapidly expanded at the Lateglacial - Holocene transition (Feurdean *et al.* 2007; Willis *et al.* 2000). It was suggested that *Pinus*-dominated woodlands on the Hungarian plain throughout the Lateglacial are a consequence of drier climatic conditions at lower elevations (Feurdean *et al.* 2007).

What was the main reason for the high *Tilia* values at Griblje in comparison with neighbouring regions?

Alp (ki so bile na vrhuncu glaciala poledenele) in verjetno tudi manj ekstremno suha kot na vzhodu, kjer paleoklimatske ocene za območje severozahodne Romunije predvidevajo kontinentalno, veliko bolj suho poznoglacialno klimo s precej hladnejšimi zimami in le rahlo hladnejšimi poletji kot danes (Feurdean *et al.* 2008). Pelod lipe potrebuje za kalitev visoke temperature (Pigott, Huntley 1981), vendar pa se lahko lipa razmnožuje tudi vegetativno (Pigott 1991), preživi nizke temperature (Pigott 1991) in je odpornejša na poletno sušo kot leska (*Corylus*), jelša (*Alnus*) ali brest (*Ulmus*) (Diekmann 1996). V tem času je klima verjetno postala tudi bolj sušna, kar nakazujejo nizki nivoji jezer na območju južno od Alp (e.g. Magny *et al.* 2006; Vannière *et al.* 2004; Vescovi *et al.* 2007). Ostanki insektov (chironomida) in plasti mahov v Blejskem jezeru nakazujejo hidrološko plitvejše razmere (Andrič *et al.* 2009), medtem ko je v Gribljah opazna sprememba litologije (manjša vsebnost ilovice in povečanje količine organskih snovi) okrog 13.750 cal. BP, kar bi lahko povezali s hidrološko spremembo in stabilizacijo pokrajine zaradi gostejše vegetacije. Poznoglacialni interstadial se je končal s fazo, za katero so značilni pogosti gozdni požari (pribl. 13.900–13.600 cal. BP) in rahel porast deleža peloda zelišč.

MLAJŠI DRIAS (PRIBL. 12.600–11.500 CAL. BP)

Za začetek mlajšega driasa je značilna povečana koncentracija mikroskopskega oglja in peloda zelišč, čemur je sledila sprememba v sestavi sedimenta (plast mahov v vrtini iz Blejskega jezera (*sl. 3*) in plast s povečano vsebnostjo organskih snovi in povišano pelodno koncentracijo v Gribljah). Tudi delež *Assulina muscorum* in spor mahov *Sphagnum* (ni prikazano na *sl. 4*) naraste. Vse to kaže na hladnejšo in bolj suho klimo. Odstotek *Quercusa, Ulmusa* in *Tilie* v Blejskem jezeru (kjer je začetek mlajšega driasa natančno določen s spremembo v sestavi kisikovih stabilnih izotopov, Andrič *et al.* 2009) upade na začetku mlajšega driasa (pribl. 12.600 cal. BP), v Gribljah pa šele nekaj stoletij kasneje (pribl. 12.250 cal. BP). Vendar pa sta pri ocenjevanju starosti vrtine iz Gribelj, kjer hitrost sedimentacije ni linearna (litološka sprememba in porast koncentracije peloda na 142 cm), potrebna previdnost in dodatno radiokarbonsko datiranje. Vegetacija v okolici Gribelj je bila verjetno manj občutljiva na poslabšanje klime v mlajšem driasu in je morda reagirala kasneje, vendar pa je bila bolj občutljiva na sušne razmere. Porast deleža zelišč (Poaceae, Chenopodiaceae, *Artemisia*) in mikroskopskega oglja je bil izrazitejši v jugovzhodni Sloveniji, ki je bolj odprta proti Panonski nižini in ima danes bolj kontinentalno klimo kot Blejsko jezero. Termofilne drevesne vrste so se spet razširile s klimatsko otoplitvijo in domnevno vlažnejšimi razmerami na začetku holocena.

Climatic conditions in southeastern Slovenia were probably warmer than in the vicinity of the glaciated Alpine region, but probably also less extremely dry than farther east, where palaeoclimatic estimations for northwestern Romania suggest a more continental Lateglacial climate with much colder winters and only slightly colder summers and a drier climate (Feurdean *et al.* 2008). *Tilia* requires high summer temperatures for the growth of the pollen tube (Pigott, Huntley 1981), but it has a good capacity for vegetative reproduction (Pigott 1991), is tolerant of very low temperatures (Pigott 1991) and is more resistant to summer drought than *Corylus, Alnus* or *Ulmus* (Diekmann 1996). It is possible that the climate also became drier, as suggested by lower lake levels in the area south of the Alps (e.g. Magny *et al.* 2006; Vannière *et al.* 2004; Vescovi *et al.* 2007). At Lake Bled the chironomid record and moss layers indicate a lower lake level (Andrič *et al.* 2009), whereas at Griblje the change in lithology (lower clay and higher organic material content) at ca. 13750 cal. BP could be also associated with hydrological change and landscape stabilisation due to the denser vegetation cover. The Lateglacial interstadial ended with a phase of more frequent forest fires (ca. 13900-13600 cal. BP) and a slight increase in herb taxa.

YOUNGER DRYAS (CA. 12600-11500 CAL. BP)

The onset of Younger Dryas (YD) is associated with an increased concentration of microscopic charcoal and herb pollen, followed by a change of sediment composition (moss layer at Lake Bled (*Fig. 3*), a layer with increased plant detritus and pollen concentration at Griblje). Also *Assulina muscorum* and *Sphagunum* spores increase (not presented in *Fig. 4*), suggesting a colder and drier climate. Whereas *Quercus, Ulmus* and *Tilia* at Lake Bled, where the onset and end of YD is sharply defined by the changes in oxygen isotopes (Andrič *et al.*, 2009), start to decline at the beginning of the YD (ca. 12600 cal. BP), at Griblje they appear to decline only a few centuries later (ca. 12250 cal. BP). However, caution is needed when interpreting the age of the Griblje core, since the sedimentation rate might not be linear (lithological change and an increase in pollen concentration at 142 cm). Additional radiocarbon dating is needed. The vegetation around Griblje, therefore, seems to be less susceptible to YD climatic cooling and possibly reacted later, but it seems that it was more affected by the dryness. An increase of herbs (Poaceae, Chenopodiaceae, *Artemisia*) and microscopic charcoal is more pronounced in southeastern Slovenia, which is more open towards the Pannonian plain and today has a more continental climate than Lake Bled. With the Holocene climatic warming and presumably also wetter conditions, thermophilous tree taxa spread again.

POZNOGLACIALNO OKOLJE IN PLEISTOCENSKI LOVCI IN NABIRALCI

Poznoglacialna klimatska nihanja in razširitev listnatega gozda so vplivali tudi na favno. Ostanki sesalske makrofavne na arheoloških najdiščih v Sloveniji kažejo, da je delež vrst, značilnih za tundro (e.g. severni jelen), ki so bile najštevilčnejše v zadnjem stadialu (pribl. 20.000 cal. BP), upadel, medtem ko je delež vrst, značilnih za gozdne habitate (e.g. jelen, los, divja svinja) narasel (Pohar 1994; 1997). V Poljšiški cerkvi (najdišče je datirano na prehod mlajšega driasa v preboreal), ki leži v bližini Blejskega jezera, so v nasprotju z drugimi arheološkimi najdišči ostanki gamsa in kozoroga številni. Favna alpskega okolja, tundre in stepe je pogostejša kot gozdne vrste, verjetno zaradi bližine gora in ledenikov (Pohar 1991; 1997). V Judovski hiši v Beli krajini sta jelen in divja svinja pogosta, kar nakazuje gozdnato pokrajino in toplejšo klimo, čeprav so bili najdeni tudi ostanki alpskega svizca, ki verjetno sodijo v hladnejša obdobja poznega glaciala. Najdišče ni bilo radiokarbonsko datirano, na podlagi tipologije kamenega orodja, ostankov favne in litologije je domnevno poznoglacialne starosti (Pohar 1985; 1997). Rezultati analize favne se tako ujemajo s palinološkimi podatki, ki nakazujejo bolj gozdnato pokrajino v okolici Gribelj kot v okolici Blejskega jezera v poznoglacialnem interstadialu.

Poleg zgoraj opisanih medregionalnih razlik v sestavi vegetacije je ena od glavnih značilnosti poznoglacialnega okolja tudi to, da so bile spremembe vegetacije razmeroma hitre. V Gribljah, na primer, je pretežno borovo-brezov gozd okrog 13.600 cal. BP nadomestila lipa. Ni jasno, kako so te hitre (= v pribl. 100 letih) spremembe v sestavi gozda vplivale na favno in ali so morale lokalne lovsko-nabiralniške skupnosti spremeniti svoje ekonomske strategije. Potem ko je bila lipa okrog 12.250 cal. BP najbolj razširjena, se je pokrajina spet spremenila; postala je bolj odprta, domnevno zaradi hladnejše in bolj suhe klime mlajšega driasa. Upad lipe je povezan s povečano koncentracijo mikroskopskega oglja (*sl. 4*), kar nakazuje, da so lipov gozd uničili naravni požari zaradi suhe klime (kar je verjetneje) ali pa so ga namerno požgali lokalni lovci in nabiralci. Požiganje pokrajine je pomembna strategija za povečanje količine rastlinskih in živalskih virov hrane (e.g. Clarke 1979; Mellars 1976; Simmons 1996; Šercelj 1970; Zvelebil 1994) in v Beli krajini je bila ta praksa pogosta tudi še kasneje, ves holocen (Andrič 2007). Da pa bi bolje razumeli poznoglacialne spremembe okolja, v prihodnosti potrebujemo podrobnejše multidisciplinarne paleoekološke in arheološke raziskave. Intenzivne arheološke raziskave nekdanje ekonomije s podrobno datiranimi poznoglacialnimi fazami so bistvene za razumevanje odzivov ljudi in ekosistemov na poznoglacialna klimatska nihanja.

LATEGLACIAL ENVIRONMENT OF PLEISTOCENE HUNTERS AND GATHERERS

Lateglacial climatic fluctuations and the spread of deciduous woodland are reflected also by the faunal composition. The remains of mammal macrofauna discovered in archaeological sites suggest that tundra representatives (e.g. reindeer), which were most numerous in the Last Glacial maximum (at ca. 20000 cal. BP) were declining, whereas populations of species, characteristic of forest habitats (e.g. red deer, moose, wild boar) were increasing (Pohar 1994; 1997). At Poljšiška cerkev (dated to Younger Dryas-Preboreal transition), located in the vicinity of Lake Bled, in contrast to other sites, chamoix and ibex remains are numerous. The fauna of alpine, tundra and steppe habitats are more abundant than forest taxa, probably due to proximity to mountains and glaciers (Pohar 1991; 1997). At Judovska hiša in Bela krajina (estimated to be of 'Lateglacial' age on the basis of stone tool typology, fauna and lithology), on the other hand, red deer and wild boar suggest a wooded, warmer habitat, although remains of alpine marmot, which probably lived here in colder phases of the Lateglacial (site was not radiocarbon dated), were also discovered (Pohar 1985; 1997). These results are in accordance with palynological data suggesting a more wooded landscape at Griblje in the Lateglacial interstadial.

In addition to these interregional differences, palynological results also suggest rapid changes of vegetation composition. At Griblje, for example, at ca. 13600 cal. BP predominantly *Pinus-Betula* woodland was replaced by *Tilia* forest. It is not clear how this change in forest composition and more wooded landscape affected Lateglacial animals and local human populations and whether they had to change their hunting and gathering strategies. After the *Tilia* peak at ca. 12250 cal. BP the landscape changed again, for it became more open, presumably due to the colder and drier Younger Dryas climate. The *Tilia* decline is associated with an increase in microscopic charcoal (*Fig. 4*), suggesting that *Tilia* forest was destroyed either by natural fire due to a drier climate (which is more likely) or by intentional landscape burning by local hunter-gatherers. Landscape burning was used as a significant strategy to increase plant and animal food resources in the landscape (e.g. Clarke 1979; Mellars 1976; Simmons 1996; Šercelj 1970; Zvelebil 1994) and in Bela krajina landscape burning was an important forest-clearance strategy also later, throughout the Holocene (Andrič 2007). However, in the future more detailed, multi-proxy palaeoecological and archaeological research is needed to understand better the reasons for Lateglacial environmental changes. Intensive archaeological research with more precisely dated Lateglacial phases and focused on the past economy is essential for tackling the question of how people and ecosystems responded to Lateglacial climatic fluctuations.

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NEANDERTALSKA PIŠČAL IZ DIVJIH BAB I: STARA IN NOVA SPOZNANJA

NEANDERTHAL FLUTE FROM DIVJE BABE I: OLD AND NEW FINDINGS

Matija TURK, Ljuben DIMKAROSKI

Izvleček

Preluknjana stegnenica jamskega medveda iz jamskega paleolitskega najdišča Divje babe I (zahodna Slovenija) je bila od odkritja leta 1995 dalje predmet mnogih polemik, ali gre za izdelek nenadertalca ali za posledico zverskih ugrizov. Poskusi luknjanja svežih stegnenic rjavega medveda z odlitki zverskih zobovij, ugotovitve eksperimentalne arheologije in računalniška tomografija sporne piščali, so potrdili umetni izvor lukenj. Dodatno ga potrjujejo nove muzikološke raziskave, ki prinašajo nova spoznanja o glasbenih zmogljivostih piščali. Potekale so na avtentični repliki piščali, kjer je bil ožji, proksimalni del uporabljen kot ustnik, širši, distalni del pa kot kot odmevnik. Razporeditev luknjic in ohranjena dolžina najdbe tvorijo sistem, ki omogoča široko paleto zvočnosti in melodijskega gibanja, in kaže, da gre za glasbilo v pravem pomenu besede. V zvočnem zaporedju dvanajst tonske lestvice doseže dve oktavi in pol, v prepihavanju pa njegov obseg znaša več kot tri oktave. Tehnične zmogljivosti glasbila v smislu izraznosti ne dopuščajo domneve o slučajnosti nastanka luknjic in njihove razporeditve na inštrumentu. Plast, v kateri je bila najdena piščal, je z metodo ESR datirana v čas med 60.000 in 50.000 leti pred sedanjostjo (= p. s.). Piščal iz Divjih bab je danes najstarejše glasbilo in prvo, ki ga poznamo iz rok neandertalca. S svojo tehnološko dovršenostjo kaže na visoke kognitivne sposobnosti neandertalcev.

Ključne besede: Slovenija, Divje babe I, srednji paleolitik, neandertalci, koščena piščal, glasba

Abstract

The perforated femur of a cave bear, found in 1995 in the Palaeolithic cave site of Divje babe I (western Slovenia), has been the subject of many a heated discussion on its origin since its discovery. Whereas some advocate a natural origin of holes, the consequence of carnivore gnawing, others argue for an artificial origin and see in it the product of a Neanderthal. The results of experimental piercing of fresh brown bear femurs using casts of carnivore teeth, the results of experimental archaeology as well as computer tomography of the disputed flute confirm the latter, that is artificial origin of the holes. This is further confirmed by the latest musicological research, which brings new findings on the musical capacity of the flute. This research was carried out on an authentic replica of the flute, whereby the proximal part of the flute served as the mouthpiece and the distal, broader part as the bell. The disposition of holes and the preserved length of the flute form a system, which enables a wide range of sonority and melodic motion and thus reveals the object as an instrument in the proper sense of the word. In the sound sequence of a twelve-tone scale, the instrument has a two and a half octave compass, which extends to over three octaves by over-blowing. The technical capacity of the instrument in terms of expression thus leaves no doubt as to the artificial origin of holes and their deliberate alignment. The layer, in which the flute was found, is ESR dated to between 60 and 50 ky in the past. The flute from Divje babe I is today considered the oldest instrument and the first known to have been made by Neanderthal hands. Its technological perfection points to high cognitive abilities of Neanderthals.

Keywords: Slovenia, Divje babe I, Middle Palaeolithic, Neanderthals, bone flute, music

Slovenski paleolitik je širšo prepoznavnost dosegel že na samem začetku raziskav, z odkritjem visokogorske mlajšepaleolitske orinasjenske postojanke v jami Potočki zijalki v Karavankah leta 1928 (Brodar, S. in M. 1983). Z odkritjem kulturnih ostankov paleolitskega človeka je postala Potočka zijalka prvo odkrito paleolitsko najdišče na slovenskem, njen raziskovalec Srečko Brodar pa velja za nestorja slovenske paleolitske arheologije. V najdišču, ki je poleg svoje visokogorske lege posebno predvsem po izjemnem številu koščenih konic, so izkopali tudi spodnjo desno čeljust jamskega medveda s tremi luknjami, interpretirano kot orinasjensko piščal (Omerzel-Terlep 1996).

Skoraj sedemdeset let pozneje je slovenski paleolitik znova pretresel paleolitsko znanstveno srenjo, tokrat ne samo v evropskem, temveč v svetovnem merilu. V jami Divje babe I (zahodna Slovenija) je bila leta 1995 v srednjepaleolitski plasti najdena preluknjana stegnenica mladega jamskega medveda: neandertalska piščal. V nadaljevanju bomo predstavili prispevek Ivana Turka k odkritju in razjasnitvi nastanka lukenj na prvi najdeni neandertalski piščali. Na koncu kot novost predstavljamo muzikološke ugotovitve akademskega glasbenika Ljubena Dimkaroskega, ki piščal iz Divjih bab I postavljajo v novo luč.

PALEOLITSKO NAJDIŠČE DIVJE BABE I IN OKOLIŠČINE ODKRITJA NEANDERTALSKE PIŠČALI

Skoraj vsa slovenska paleolitska najdišča so bila odkrita v jamah, kjer med favnističnimi ostanki prevladuje jamski medved. Najdbe fosilnih ostankov jamskega medveda v Divjih babah I so bile tudi povod za prvo arheološko sondiranje, ki ga je na pobudo Mitje Brodarja z Inštituta za arheologijo ZRC SAZU leta 1978 opravil prav I. Turk (*sl. 1*). Na podlagi rezultatov sondiranja se je M. Brodar odločil za sistematična arheološka izkopavanja, ki jih je na terenu vodil I. Turk. Ko je M. Brodar odšel v pokoj, je celotno vodenje prepustil I. Turku. Izkušnje, pridobljene z dolgoletnim terenskim delom, so mu narekovale lastno vizijo raziskav in uporabo interdisciplinarnih metod, usmerjenih v čim bolj natančno in objektivno pridobivanje vseh razpoložljivih informacij o najdišču. Na prvi pogled je bilo to predvsem vidno z uvedbo mokrega sejanja vseh izkopanih sedimentov ter z arbitrarnim izkopavanjem po režnjih debeline 12 cm. Slednje mu je omogočilo razvrstitev plasti v sedimentacijske nivoje in skupaj z radiometričnimi datacijami oceniti hitrost odlaganja sedimentov v jami (Turk 2003; 2007a). Radiometrično datiranje vseh paleolitskih horizontov in analize zmrzlinskih klastov (kongelifraktov) so bili podlaga za izdelavo regionalne klimatske krivulje za obdobje mlajšega pleistocena (Turk 2007b; Blackwell *et al.* 2009). Prava vrednost predanega dela I. Turka in

Sl. 1: Jama Divje babe I v času izkopavanj. Foto: Ivan Turk.
Fig. 1: The cave of Divje babe I during excavation. Photo: Ivan Turk.

The Slovene Palaeolithic achieved wide recognition at its very beginning, with the 1928 discovery of a Upper Palaeolithic (Aurignacian) site in the high alpine cave of Potočka zijalka in the Karavanke Mountains (Brodar, S. & M. 1983). The discovery of cultural remains of the Palaeolithic man made Potočka zijalka the first uncovered Palaeolithic site in Slovenia and Srečko Brodar, its excavator and researcher, nestor of the Slovene Palaeolithic archaeology. The site, characterized by its location in the high Alps, but even more so by the extraordinary number of bone points, has also revealed the right mandible of a cave bear with three holes in it, interpreted as an Aurignacian flute (Omerzel-Terlep 1996).

Nearly seventy years on, the Slovene Palaeolithic again provided a find that reverberated across the Palaeolithic scientific community, this time not only in Europe, but across the world. The find is a perforated femur of a juvenile cave bear, a Neanderthal flute, which was found in 1995 in the cave of Divje babe I (western Slovenia), in a Middle Palaeolithic layer. The paper below focuses on Ivan Turk and his contributive role in the discovery of the flute and the explanation of how the holes on the first uncovered Neanderthal flute were made. The paper concludes with a presentation of musicological številnih sodelavcev različnih strok pa je danes predvsem v tem, da so Divje babe I paleolitsko najdišče z najbolje izdelano kronologijo in stratigrafijo v Sloveniji in kot tako idealno referenčno najdišče v regiji. Arheološka izkopavanja v Divjih babah I so se končala leta 1999.

Paleolitski lovci in nabiralci, ki so jamo Divje babe I občasno uporabljali kot zavetišče, so za seboj pustili okoli 700 kamenih artefaktov, izdelanih predvsem iz lokalnega tufa in roženca, 14 koščenih artefaktov in 20 kurišč (Turk, Kavur 1997; Horusitzky 2007; Culiberg 2007). Na podlagi koncentracije arheoloških ostankov je bilo določenih 14 paleolitskih horizontov. Vsi paleolitski horizonti razen najvišje ležečega pripadajo srednjemu paleolitiku (musterjenu), ki ga povezujemo z neandertalcem. Najvišje ležeči paleolitski horizont pripada mlajšemu paleolitiku (orinasjenu), ki ga povezujemo z anatomsko modernim človekom. Časovni razpon paleolitskih horizontov, določen z ESR-datiranjem, sega od 40.000 do 116.000 let v preteklost.

Značilnost srednjepaleolitskih orodij iz Divjih bab I je, da so majhnih dimenzij, kar je posledica velike obrabe. Med kamenimi orodji, ki so sicer tipološko težko določljiva, prevladujejo strgala, izjede in nazobčana orodja. Prisotni so tudi mlajšepaleolitski tipi orodij, kot so praskala in vbadalo. Robovi orodij so intenzivno retuširani z izmenično strmo ali polstrmo retušo. Preučevanje retuše in poškodb na vzorcu kamenih artefaktov skupaj s poskusnimi preverjanji nakazuje, da so neandertalci z njimi verjetno intenzivno obdelovali les (Bastiani *et al.* 2000).

V srednjepaleolitskih horizontih je bilo odkritih več odlomkov koščenih konic ter atipičnih koščenih šil (Horusitzky 2007; Turk *et al.* 2001, t. 1: 1–8, t. 2: 1–6). Najstarejši fragment koščene konice je bil odkrit v plasti 20, stari okoli 110.000 let. V edinem mlajšepaleolitskem horizontu je bilo odkritih le nekaj kamenih in koščenih orodij, med njimi konica z razcepljeno bazo (Turk, Kavur 1997, t. 10.1: 1).

Vsa kurišča so bila odkrita v srednjepaleolitskih horizontih. Bila so brez posebnih struktur, le nekatera so bila plitvo vkopana v tla. V njih je prevladovalo oglje borovca *(Pinus)* in drugih iglavcev, pojavlja pa se tudi oglje listavcev, z bukvijo *(Fagus)* vred. Med ogljem je bilo ugotovljeno veliko oglja tise *(Taxus)*, ki so jo v paleolitiku uporabljali za izdelavo sulic (Turk, Kavur 1997; Culiberg 2007).

Jama je bila v mlajšem pleistocenu stalen brlog jamskega medveda *(Ursus spelaeus)*, ki mu pripada kar 99 % vseh favnističnih ostankov v najdišču. Posebnost so fosilizirane dlake jamskega medveda, ki so se ohranile v zlepljenih skupkih zemlje (agregatih). Med ostalimi zastopanimi zvermi velja omeniti volka *(Canis lupus)*, rjavega medveda *(Ursus arctos)*, jamskega leva *(Panthera spelaea)*, leoparda *(Panthera pardus)*, risa *(Lynx lynx)* in polarno lisico *(Alopex lagopus)* (Toškan 2007).

findings by Ljuben Dimkaroski, an academic musician, which shed new light on the flute from Divje babe I.

THE PALAEOLITHIC SITE OF DIVJE BABE I AND THE FLUTE'S FIND CIRCUMSTANCES

Almost all Slovene Palaeolithic sites were uncovered in caves, where fauna remains are predominantly represented by those of the cave bear. The finds of fossil cave bear remains led to the first archaeological trial trenching also at Divje babe I, conducted in 1978 by Ivan Turk on the incentive of Mitja Brodar from the Institute of Archaeology of the Scientific Research Centre, Slovene Academy of Sciences and Arts (*Fig. 1*). Based on the trenching results, Brodar decided on systematic archaeological excavation conducted on the field by I. Turk. When Brodar retired, I. Turk took over as head of the entire operation. Experience, gained through the long years of field work, dictated a particular vision of how to conduct the investigation and the use of interdisciplinary methods aimed at as accurate and objective gathering of all available data on the site as possible. This is primarily visible in the introduction of wet sieving of all excavated sediments and the arbitrary excavation method with 12 cm thick spits. The latter enabled the distribution of layers into sedimentation levels and, together with radiometric dates, assessment of the speed of sedimentation in the cave (Turk 2003; 2007a). Radiometric dates of all the Palaeolithic horizons and analyses of congelifracts constituted the basis for the production of a regional climate curve for the Late Pleistocene (Turk 2007b; Blackwell *et al.* 2009). The real value of the devoted work by I. Turk and numerous collaborators of different professions, however, is today primarily discernible in that Divje babe I represents the Palaeolithic site with most elaborate chronology and stratigraphy in Slovenia and is, as such, the ideal reference site for the region. Archaeological excavation in Divje babe I was concluded in 1999.

The Palaeolithic hunters and gatherers, who occasionally used the cave as a shelter, left behind around 700 stone artefacts, made predominantly of local tuff and chert, furthermore 14 bone artefacts and 20 fireplaces (Turk, Kavur 1997; Horusitzky 2007; Culiberg 2007). The concentration of archaeological remains enabled 14 Palaeolithic horizons to be defined. With the exception of the topmost, all layers date to the Middle Palaeolithic (Mousterian), which is tied to Neanderthals. The topmost layer dates to the Upper Palaeolithic (Aurignacian), which is tied to the anatomically modern man. The Palaeolithic horizons span from 40,000 to 116,000 years in the past, as determined by ESR dating.

The characteristic of the Middle Palaeolithic tools from Divje babe I is their small size as the consequence

Sl. 2: Originalna piščal iz Divjih bab I in njena rekonstrukcija, izdelana na fosilni stegnenici jamskega medveda, na katero igra Ljuben Dimkaroski (zgoraj posteriorna, spodaj anteriorna stran). Foto: Tomaž Lauko, Narodni muzej Slovenije.
Sl. 2: The original flute from Divje babe I and its reconstruction made on a fossil femur of the cave bear. The latter played by Ljuben Dimkaroski (posterior side above, anterior below). Photo: Tomaž Lauko, National Museum of Slovenia.

Piščal (*sl. 2*) je odkopal Turkov dolgoletni sodelavec Janez Dirjec med izkopavanjem v notranjosti jame (Turk *et al.* 1995). Ležala je zacementirana v breči v srednjepaleolitski plasti 8a (paleolitski horizont D-1). Plast 8a se je odložila v zmerni in vlažni klimatski fazi v prvi polovici OIS 3. Ohranjena dolžina piščali je 11,5 cm. Izdelana je iz leve stegnenice mladega jamskega medveda. Na posteriorni strani sta dve luknji ohranjeni v celoti in ena delno. Na anteriorni strani je delno ohranjena še četrta luknja. Na obeh koncih površinsko inkrustirane kosti, ki je povsem brez spongioze, manjkata epifizi. Metafizi sta zalomljeni do obeh delno ohranjenih lukenj.

Najdba je ob odkritju vzbudila pozornost zaradi lukenj, razporejenih v ravni vrsti na sredini diafize. Kot taka je bila na videz povsem podobna mlajšepaleolitskim piščalim, izdelanim iz cevastih kosti (Leocata 2000–2001). V času odkritja je bila na voljo le radio-

of heavy use-wear. The typological determination of the stone tools is very difficult, nevertheless there is a predominance of side scrapers, notches, and denticulated tools. Also present are Upper Palaeolithic tool types, such as endscrapers and a burin. The tool edges are intensely retouched using the alternate abrupt or semi-abrupt retouch. The study of retouches and damage on a selection of stone artefacts together with the experimental tests indicates that Neanderthals probably used these tools to work wood (Bastiani *et al.* 2000).

The Middle Palaeolithic horizons revealed several fragments of bone points and atypical bone awls (Horusitzky 2007; Turk *et al.* 2001, T. 1: 1-8, T. 2: 1-6). The oldest fragment of a bone points was uncovered in layer 20, which is roughly 110,000 years old. The only Upper Palaeolithic horizon revealed only a few stone and bone tools, among which include a split-based point (Turk, Kavur 1997, T. 10.1: 1).

The fireplaces were all uncovered in the Middle Palaeolithic horizons. They did not reveal any particular structure, with the exception of some being slightly sunken into the ground. The predominant wood remains uncovered in them, in the form of charcoal, belong to pine *(Pinus)* and other conifers, also appearing is the charcoal of deciduous trees including beech *(Fagus)*. There was furthermore a lot of charcoal of yew *(Taxus)*, used in the Palaeolithic for making spears (Turk, Kavur 1997; Culiberg 2007).

During the Late Pleistocene, the cave served as a permanent lair to the cave bear *(Ursus spelaeus)*, represented with as much as 99 % of all the site's fauna remains. A special find at the site is the fossilized cave bear hair, preserved within clusters of soil or aggregates. Other carnivores present in the cave include wolf *(Canis lupus)*, brown bear *(Ursus arctos)*, cave lion *(Panthera spelaea)*, leopard *(Panthera pardus)*, Eurasian lynx *(Lynx lynx)* and arctic fox *(Alopex lagopus)* (Toškan 2007).

The flute (*Fig. 2*) was excavated by Janez Dirjec, I. Turk's long-time co-worker, in the cave's interior (Turk *et al.* 1995). It lay cemented within breccia, in Middle Palaeolithic layer 8a (Palaeolithic Horizon D-1). The layer was deposited in a temperate and humid climate phase in the first half of OIS 3. The preserved length of the flute is 11.5 cm. It is made of the left femur of a juvenile cave bear. The posterior side shows two completely and one partially preserved hole. The anterior side has a fourth hole, partially preserved. The bone has surface incrustation and is completely devoid of spongiosis. Neither of the epiphyses are preserved. The metaphyses on both sides are fractured up to the partially preserved holes.

The find immediately attracted attention due to the holes perforated in a straight line along the diaphysis. It looked very similar to the Upper Palaeolithic flutes made on tubular bones (Leocata 2000-2001). At the time of discovery, only the radiocarbon date of the layer, in which the flute was found, was available, which pointed karbonska datacija plasti, v kateri je ležala piščal, ki je pokazala starost 46.000 let. Nove, radiometrične datacije ESR plast s piščaljo postavljajo globlje v preteklost, v čas med 60.000 in 50.000 leti p.s. (Blackwell *et al.* 2009).

VPRAŠANJE NASTANKA LUKENJ

Odkritje preluknjane kosti, domnevne neandertalske piščali, v Divjih babah I je pritegnilo veliko pozornost strokovnjakov iz Evrope in ZDA. Umetniški in drugi izdelki neandertalcev, ki presegajo potrebe vsakdanje borbe za preživetje in imajo drugačen, abstraktni pomen, so izredno redki, njihov umetni izvor pa pogosto postavljen pod vprašaj (Bednarik 1994; Soressi, D'Errico 2007). Ohranjene arheološke najdbe nam dejansko dajejo vtis, da se je paleolitska umetnost v Evropi pojavila šele s prihodom anatomsko modernih ljudi. Po ustaljenem prepričanju naj bi bil anatomsko moderni človek tudi prvi, ki je izvajal glasbo. Dokaz za to naj bile številne mlajšepaleolitske koščene piščali. Najstarejše med njimi, najdene v nemških najdiščih Geissenklösterle, Hohle Fels in Vogelherd, so stare med 30.000 in 40.000 let (Conard *et al.* 2009).

Najdba iz Divjih bab I bi lahko bila prvi dokaz o glasbenem ustvarjanju neandertalcev. Problem je nastal, ker na luknjah ni bilo vidnih sledov izdelave s kamenimi orodji, na obeh koncih odlomljene kosti pa so bile prisotne poškodbe, ki bi lahko nastale pri zverskem grizenju. Na mlajšepaleolitskih piščalih so sledovi umetne izdelave vidni, saj so bile luknje izdolbene ali izvrtane s kamenimi orodji. Kljub neobičajni legi in številu lukenj na diafizi je večina znanstvene javnosti zavzela stališče, da so luknje posledica zverskega grizenja in da najdba ni artefakt oz. piščal (Chase, Nowell 1998; D'Errico *et al.* 1998; Albrecht *et al.* 2001). V takšnem prepričanju je izzvenela tudi znanstvena konferenca, ki jo je leta 1998 I. Turk organiziral v Spodnji Idriji (Kavur 1998). Strokovnjaki, ki so nasprotovali hipotezi o piščali, so kot temeljni dokaz za zverski izvor lukenj navajali sledove grizenja. Pri tem niso izpostavili možnosti, da bi zver lahko kost obgrizla, preden so bile ali potem ko so bile luknje umetno izdelane. Kategorično so zanikali možnost, da bi luknje izdelal človek, zato tudi niso razmišljali, kako bi bilo možno na umeten način izdelati ustrezne luknje. Nezadovoljen s takšnimi enostranskimi in poenostavljenimi razlagami se je I. Turk odločil, da bo s pomočjo praktičnih poskusov preveril možnost naravnega (zver) in umetnega (neandertalec) nastanka lukenj na sporni kosti. Problematike se je lotil nepristransko, zato je najdbo, vse dokler ni imeli dovolj argumentov v prid umetnega izvora lukenj, vedno in povsod dosledno imenoval domnevna piščal.

to the age of 46,000 years. New, ESR dates have since then set the layer with the flute further back into the past, in the time between 60,000 and 50,000 years ago (Blackwell *et al.* 2009).

ON HOW THE HOLES WERE MADE

The discovery of the perforated bone, the presumed Neanderthal flute, at Divje babe I, attracted a great deal of attention of experts from both Europe and the United States. Art objects as well as other artefacts made by Neanderthals that surpass the daily survival needs and have a different, abstract significance, are extremely rare and their artificial origin is often questioned (Bednarik 1994; Soressi, D'Errico 2007). The archaeological finds uncovered so far rather give the impression that art in the Palaeolithic only appeared in Europe with the arrival of the anatomically modern man. It is also an accepted belief that it was the latter that was the first to practice music, an evidence of which is seen in the numerous Upper Palaeolithic bone flutes. The oldest flutes, found in the German sites of Geissenklösterle, Hohle Fels and Vogelherd, are between 30,000 and 40,000 years old (Conard *et al.* 2009).

The find from Divje babe I could offer the first evidence of musical creativeness of Neanderthals. There are, however, certain features of the flute that give doubts about its artificial origin. One is the absence of stone tool marks around the holes and the damage on both broken ends of the bone that could have occurred by carnivores gnawing on the bone. The Upper Palaeolithic flutes bear visible tool marks, since the holes were either carved out or bored in using stone tools. In spite of the unusual position and number of holes on the diaphysis, therefore, most in the scientific community interpreted the holes as the consequence of carnivore gnawing and the find not an artefact and thereby not a flute (Chase, Nowell 1998; D'Errico *et al.* 1998; Albrecht *et al.* 2001). It was in this spirit that proceeded the scientific conference that I. Turk organized in 1998 in Spodnja Idrija, Slovenia (Kavur 1998). The experts opposed the flute hypothesis, with gnawing traces as their basic argument for a carnivore origin, whereby the possibility of a carnivore gnawing on the bone before or after the holes being made artificially was not mentioned. They categorically dismissed the possibility of the holes as man-made and, consequentially, did not consider how the appropriate holes could have been made artificially. Dissatisfied with such one-sided and simplified explanations, I. Turk decided to verify the possibility of natural (carnivore) versus artificial (Neanderthal) origin of the holes on the bone in question by conducting practical experiments. He approached the problem unbiased and consistently addressed the find as the supposed flute until he had enough arguments in favour of the artificial origin.

HIPOTEZA O NARAVNEM IZVORU LUKENJ

V Divjih babah I so bili odkriti fosilni ostanki jamskega in rjavega medveda, volka, leoparda in jamskega leva, ki bi hipotetično lahko naredili luknje v stegnenico mladega jamskega medveda. Zagovorniki zverskega porekla lukenj so izpostavili še jamsko hijeno, čeprav njeni ostanki v najdišču niso bili odkriti. Zveri, kot sta jamska hijena in volk, kosti glodata in drobita z namenom, da prideta do hranljivega kostnega mozga. Ostale zveri se s kostmi ne prehranjujejo, lahko pa jih poškodujejo med lovom, razkosavanjem ali hranjenjem. Jamska hijena in volk kosti glodata z derači. Glodati jih začneta vedno na epifizi in se z drobljenjem epifize in metafize postopno približata diafizi. Na epifizi in metafizi je kostna kompakta najtanjša in kost zaradi spongioze najbolj elastična, zato je večina lukenj in sledov grizenja tako na fosilnih kot na recentnih kosteh ohranjena prav na epifizah in metafizah (Brodar 1985). Diafiza je zaradi debele kostne kompakte toga in se pri grizenju hitro razkolje, kar je tudi glavni namen zveri, ki uživajo kostni mozeg. Zato so luknje na diafizah skrajno redke, kar je razvidno tudi na fosilnih kosteh iz Divjih bab I. Med izkopavanji v notranjosti jame je bilo pobranih skupaj 1.009 juvenilnih stegnenic jamskega medveda (963 fragmentiranih in 46 z ohranjenim proksimalnim in distalnim delom). Med njimi sta samo dva primerka z luknjami: piščal in stegnenica s preluknjano proksimalno metafizo. Med skoraj 90.000 pregledanimi določljivimi kostmi iz notranjega dela jame sta to še vedno edina primerka z luknjami (Turk, Dirjec 2007).

Že ta pregled fosilnih ostankov je pokazal, da so luknje na diafizi nekaj neobičajnega. V primeru, da bi luknje na piščali naredila zver, bi vsekakor pričakovali več podobno preluknjanih kosti. Kljub temu je I. Turk želel natančno preveriti, kakšne so možnosti zverskega nastanka lukenj na diafizi. S kovinskimi odlitki zobovij jamskega medveda, hijene in volka je v sodelovanju s Strojno fakulteto v Ljubljani opravil poskusno luknjanje recentnih juvenilnih medvedjih stegnenic (*sl. 3*) (Turk *et al.* 2001). Glede na obliko lukenj na piščali se je pokazalo, da bi bile te lahko narejene edino s kanini. Poizkusne luknje, narejene z derači volka in jamske hijene, so bile bolj ovalne ali romboidne oblike.

Poskusno luknjanje je pokazalo, da volk nima dovolj močne čeljusti in kaninov, da bi predrl 3–4 mm debelo kostno kompakto diafize. Hijena ima dovolj močno čeljust in zobovje, da bi lahko preluknjala kost, vendar razdalje med luknjami ne ustrezajo razmiku in okluziji kaninov. Enako velja za ugriz leoparda in jamskega leva. Ker med favnističnimi ostanki daleč najbolj prevladuje jamski medved, je med zagovorniki zverskega izvora lukenj obveljal kot najverjetnejši “krivec”.

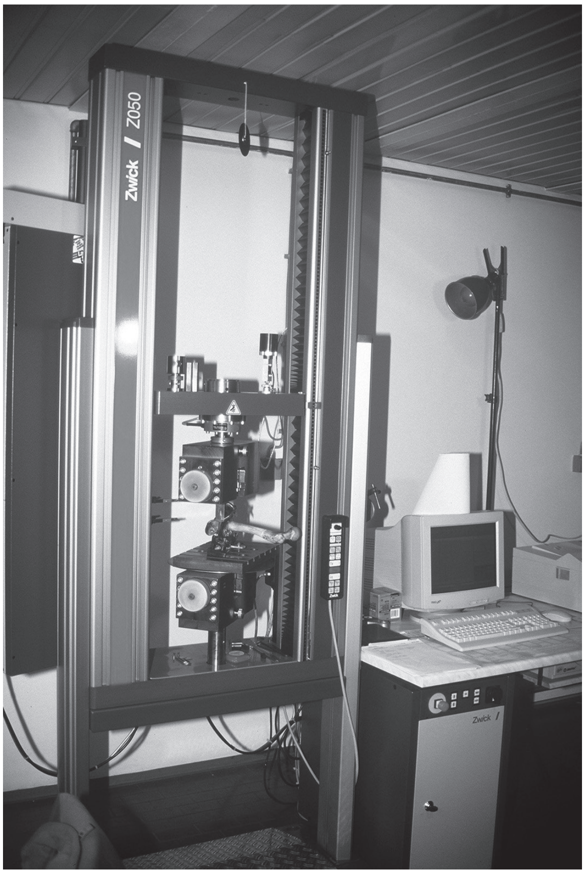
Pri skoraj polovici poskusnih luknjanj z odlitkom zobovja jamskega medveda je kostna kompakta na

HYPOTHESIS ON THE NATURAL ORIGIN OF THE HOLES

The Divje babe I site revealed fossil remains of the cave bear, brown bear, wolf, leopard and cave lion, which could all hypothetically pierce holes in the femur of a juvenile cave bear. The advocates of a carnivore origin also mentioned cave hyena, though its remains had not been found at the site. Carnivores such as cave hyena and cave lion gnaw on and crush bones so as to get to the nutritious bone marrow. Other carnivores do not feed on bones, but can damage them through hunting, dismemberment or feeding. Cave hyena and cave lion gnaw on bones with their carnassials. They always begin gnawing on the epiphysis and gradually, by crushing the epiphysis and metaphysis, move towards the diaphysis. The compact bone is thinnest on the epiphysis and metaphysis and the bone there is most elastic due to the spongiosis. For that reason, most holes and gnaw marks on both fossil and recent bones is preserved on epiphyses and metaphyses (Brodar 1985). The diaphysis is stiff due to the thick compact bone and is prone to splitting when gnawed on; this is also the main intention of the carnivore that feeds on bone marrow. Holes on diaphyses are therefore extremely rare, which is also visible on the fossil bones uncovered at Divje babe I. The excavation in the cave’s interior revealed 1009 juvenile cave bear femurs (963 fragmented and 46 with preserved proximal and distal parts). Only two of those had holes, namely the flute and a femur with perforated proximal metaphysis. Among the almost 90,000 inspected determinable bones from the cave’s interior, these two are still the only examples of bones with holes (Turk, Dirjec 2007).

This alone clearly shows that bones with holes on the diaphysis are unusual finds. In the case of carnivores making the holes, we would certainly expect more similarly perforated bones. Searching for further proof, I. Turk continued to explore the possibility of a carnivore origin of the holes on the diaphysis. In cooperation with the Faculty of Mechanical Engineering in Ljubljana, he conducted a test perforation of recent juvenile bear femurs using metal casts of the teeth of the cave bear, hyena and wolf (*Fig. 3*) (Turk *et al.* 2001). The test showed that the form of the holes on the flute could only have been produced by canine teeth. Test holes made with carnassials of a wolf and cave hyena were more oval or rhomboid in shape.

The test perforation showed that a wolf does not possess jaws and canines strong enough to pierce through the 3-4 mm thick compact bone of the diaphysis. A hyena does have the necessary strength, but the spaces between the holes do not match the distance between and the occlusion of its canines. The same goes for the leopard and cave lion. Attention was then directed towards the cave bear, the remains of which largely predominate among the site’s fauna and is there-



Sl. 3: Luknjanje svežih stegnenic rjavega medveda z odlitki zverskih zobovij na Strojni fakulteti v Ljubljani. Foto: Ivan Turk.
Sl. 3: Piercing fresh brown bear femurs with casts of carnivore teeth at the Faculty of Mechanical Engineering in Ljubljana. Photo: Ivan Turk.

diafizi po celotni dolžini počila na obeh straneh. Da je topi medvedji kanin preluknjal recentni femur rjavega medveda, je bila potrebna sila 6.493 N, za zgolj razločen odtisek zoba pa 3.308 N. Glede na izračune moč ugriza kanina jamskega medveda pri odraslih samcih ni presegla 1.476,2 N (Grandal-d'Anglade 2010). To je podatek, ki vsekakor ne govori v prid zverskemu izvoru lukenj na diafizah cevastih kosti.

Bistvena ugotovitev teh poskusov je bila, da je praktično neverjetno, da bi medved na diafizi naredil dve luknji ali več, ne da bi se kost zdrobila. Izkazalo se je, da ni verjetno, da bi medvedu ali kateri koli drugi zveri, ki bi kost grizla samo s kanini, uspelo pri več zaporednih ugrizih poravnati vse luknje v ravno vrsto, tako kot so na piščali. Spodnja in zgornja kanina zaradi različne dolžine in ukrivljenosti nista v osi. Zato sveža ovalna kost pri takšnem grizenju med zobmi spodrsava, kar dodatno onemogoča razporeditev lukenj v ravno vrsto.

fore considered as the most probable "culprit" by the advocates of the holes' carnivore origin.

In almost half of the test perforations using metal casts of cave bear teeth, the compact bone on the diaphysis broke along the entire length on both sides. For the blunt bear canine to pierce through a recent brown bear femur, it took the force of 6493 N, while it took 3308 N for it to only leave a discernible tooth impression. According to calculations, the bite force of a cave bear canine in adult males did not exceed 1476.2 N (Grandal-d'Anglade 2010). This information does not speak in favour of a carnivore origin of holes on the diaphyses of tubular bones.

The key finding of these experiments is that is it practically impossible for a bear to make two or more holes into a diaphysis without breaking it. Furthermore, it showed it to be improbable for a bear or any other carnivore, gnawing the bone only with canines, to succeed in aligning the holes made in several successive bites, as is the case on the flute. The upper and lower canines do not stand in axis due to different lengths and curvatures. This, together with the fact that oval bone is slippery when fresh, makes it even harder to align holes.

HYPOTHESIS ON THE ARTIFICIAL ORIGIN OF HOLES

The absence of stone tool marks on the flute's holes is not yet evidence of the object not being an artifact. Tool marks on some of the Upper Palaeolithic points from Divje babe I as well as bone artifacts from other sites are also either not visible or not preserved, and yet no one doubts in their anthropogenic origin. What has to be taken into account here is that the flute was subjected to heavy abrasion, as is visible on the rounded fractures on both ends of the diaphysis. Abrasion could also be the reason why eventual tool marks on the flute have not been preserved.

The explanation of the holes' artificial origin is mostly credited to Giuliano Bastiani, experimental archaeologist, and François Zoltán Horusitzky, archaeologist. The first step in favour of the hypothesis of artificial origin was made by Bastiani (*Fig. 4*) (Bastiani, Turk 1997). Using replicas of pointed stone tools, found also in the layer with the flute, he perforated a recent bear bone in a manner thus far unknown to archaeologists. He used the tool both as a chisel and a piercing tool that he hit by a wooden mallet. By combining chiselling and piercing he was able to produce holes similar to the ones on the flute. The important finding of this experiment was that the method used left no visible tool marks on most of the holes, which meant that it was possible to make holes without visible tool marks. However, the interior side of the holes made by Bastiani showed no distinct tapering, such as is visible on the holes of the flute.

HIPOTEZA O UMETNEM IZVORU LUKENJ

Odsotnost sledov izdelave oz. sledov kamenih orodij na luknjah piščali še ne dokazuje, da predmet ni artefakt. Na nekaterih mlajšepaleolitskih konicah iz Divjih bab I kot tudi na koščenih izdelkih iz drugih najdišč sledovi izdelave niso vidni oz. ohranjeni, pa kljub temu nihče ne dvomi o njihovem antropogenem poreklu. Upoštevati moramo, da je bila piščal podvržena močni abraziji, kar kažejo zaobljeni prelomi na obeh koncih diafize. Abrazija je lahko vzrok, da se morebitni sledovi orodij niso ohranili.

Pri pojasnitvi umetnega nastanka lukenj imata zasluge predvsem eksperimentalni arheolog Giuliano Bastiani in arheolog François Zoltán Horusitzky. Prvi korak v prid hipotezi o umetnem izvoru lukenj je uspel G. Bastianiju (*sl. 4)* (Bastiani, Turk 1997). Z replikami koničastih kamenih orodij, ki so bila najdena tudi v plasti s piščaljo, je preluknjal recentno medvedjo kost na način, ki arheologom doslej ni bil znan. Koničasto kameno orodje je uporabil kot dleto in hkrati kot prebijač, po katerem je udarjal z lesenim tolkačem. S kombinacijo klesanja in prebijanja je izdelal podobne luknje, kot so na piščali. Pomembno je bilo spoznanje, da sledovi orodij niso bili vidni na večini tako izdelanih lukenj, kar je pomenilo, da je možno izdelati luknje brez sledov izdelave. Vendar na notranji strani lukenj, ki jih je izdelal Bastiani, ni bilo izrazitega lijaka, ki je prisoten na luknjah na piščali.

Pri luknjanju z eksperimentalnimi kamenimi koničastimi orodji je na njih prišlo do makroskopskih poškodb ter do zlomov terminalnih delov konic. Takšne poškodbe so prisotne na srednjepaleolitskih koničastih orodjih iz Divjih bab I, kar lahko skupaj z najdenimi terminalnimi odlomki konic štejemo za posreden dokaz, da so neandertalci z njimi luknjali tudi kosti (Turk *et al*. 2001, t. 3–7).

Do novih pomembnih ugotovitev glede umetne izdelave lukenj je prišel F. Z. Horusitzky (Horusitzky 2003; Turk *et al*. 2003), saj mu je uspelo izdelati luknje, ki do potankosti ustrezajo tistim na piščali. Horusitzky je najprej s koničastim kamenim orodjem in lesenim tolkačem izklesal v recentno kost plitvo vdolbinico, ne da bi kost do konca preluknjal. Na mestu vdolbinice je nato s koščenim prebijačem in lesenim tolkačem prebil kostno kompakto. Koničasto ošiljene kosti, ki so jih našli v Divjih babah I, so tako dobile nov pomen (*sl. 5*). Tudi na teh atipičnih domnevnih koščenih izdelkih ni ohranjenih nobenih sledov izdelave, vendar so lahko služili kot prebijači pri izdelavi lukenj. Koščen prebijač in zob delujeta na kost kot klin, zato lahko kost ob luknji vzdolžno poči. Pri luknjanju s koščenim prebijačem lahko poči samo na strani, ki jo luknjamo, pri poskusnem luknjanju z odlitki zverskih zobovij pa je počila na obeh straneh. Neprekinjena, komaj vidna vzdolžna razpoka je na piščali prisotna na ploski

Sl. 4: Giuliano Bastiani in Ivan Turk med izdelavo lukenj v svežo stegnenico rjavega medveda.
Sl. 4: Giuliano Bastiani and Ivan Turk piercing holes in a fresh brown bear femur.

Piercing holes with experimental pointed stone tools created, on the latter, macroscopic damage and fractures of the terminal parts. Such damage was observed on Middle Palaeolithic pointed tools from Divje babe I, which could be considered, together with the uncovered terminal fragments of points, as indirect evidence of Neanderthals also piercing bones with them (Turk *et al*. 2001, T. 3-7).

New important findings concerning the artificial origin of holes were provided by Horusitzky (Horusitzky 2003; Turk *et al*. 2003). He was able to make holes that match those on the flute in detail. He began by carving a shallow indentation into the recent bone using a pointed stone tool and a wooden mallet. He proceeded by piercing through the compact bone on the spot of the indentation using a bone piercing tool and a wooden mallet. The bones sharpened into a point, found at Divje babe I, have thus taken on a new meaning (*Fig. 5*). These atypical and supposed bone products have also not revealed any tool marks, but could have served as piercing tools in making holes. Both a bone piercing tool and a tooth act on the bone as a wedge, whereby the bone around the hole can break. If piercing by using a bone piercing tool, the bone can break on the perforated side only, while it broke on both sides by test piercing with casts of carnivore teeth. The flute bears an uninterrupted, hardly

Sl. 5: Orodje s katerim so bile lahko izdelane luknje na piščali: koničasto kameno orodje in koščen prebijač iz Divjih bab I. Foto: Fototeka Inštituta za arheologijo ZRC SAZU.
Sl. 5: Tools used to pierce holes of the flute: bone piercing tool and pointed stone tool from Divje babe I. Photo: Archive of the Institute of Archaeology, Slovene Academy of Sciences and Arts.

posteriorni strani, kjer sta ohranjeni dve popolni luknji in ena delna. Razpoka je lahko nastala med izdelavo ali uporabo, lahko pa tudi postsedimentno.

Po iskanju praktičnih možnosti za nastanek lukenj v luči obeh hipotez je bila piščal analizirana še z večrezinsko računalniško tomografijo (Turk *et al*. 2005). Na podlagi 228 CT-rezin, posnetih vzdolž diafize, je bilo ugotovljeno, da debelina kostne kompakte ni vplivala na položaj lukenj. Zver, ki pri grizenju preizkuša kost in išče njene šibke točke, bi kost preluknjala na mestih, kjer je kostna kompakta najtanjša. Vendar sta obe v celoti ohranjeni luknji na posteriorni strani nastali na mestu, kjer je kompakta najdebelejša, čeprav se v bližini obeh lukenj občutno stanjša. Za človeka in njegova orodja debelina kompakte ni bila ovira, saj jo je lahko stanjšal z brušenjem. V območju ene izmed obeh v celoti ohranjenih lukenj je dejansko opazno rahlo postmortalno stanjšanje kostne kompakte, ki ga ne moremo pripisati delovanju zveri. S predhodnim stanjšanjem (brušenjem) kompakte si je neandertalec olajšal izdelavo luknje. Temeljna ugotovitev večrezinske računalniške tomografije je, da luknje in zverske poškodbe niso istočasne. Najprej so nastale štiri luknje in šele nato večina poškodb, ki bi jih lahko pripisali zverem.

S pomočjo praktičnih poskusov, eksperimentalne arheologije in večrezinske računalniške tomografije je

visible crack along the flat posterior side of the bone, where two complete and one partial holes are preserved. The said crack could have occurred either in production or in use, but also during post-sedimentation.

After looking for practical possibilities for the origin of the holes in light of the two proposed hypotheses, the flute was also analyzed with multi-slice computer tomography (Turk *et al*. 2005). The 228 CT slices, taken along the diaphysis, revealed that the thickness of the compact bone did not have a bearing on the position of the holes. An animal that gnaws the bone testing it for its weak spots, would pierce where the compact bone was thinnest. On the flute, however, both completely preserved holes on the posterior side were made on the spot where the compact bone is thickest despite the fact that the bone thins out considerably in their vicinity. The thickness of the compact bone thus did not represent an obstacle for man and his tools, since he could thin the bone out by grinding. The surrounding area of one of the completely preserved holes actually shows a slight post-mortal thinning of the compact bone that cannot be attributed to carnivore activity. By thinning (grinding) the compact bone, Neanderthals facilitated the perforation of the bone. The basic finding of the multi-slice computer tomography, however, was that the holes and carnivore damage are not contemporary;

I. Turku in sodelavcem uspelo pojasniti izvor lukenj, ki so nastale umetno. Šele po opravljeni računalniški tomografiji se je I. Turk končno odločil, da predmet proglasi za artefakt, interpretiran kot neandertalsko piščal.

NOVA MUZIKOLOŠKA SPOZNANJA

Medtem ko je arheologija potrebovala skoraj deset let, da je prišla do ključne ugotovitve, da je preluknjana kost iz Divjih bab I artefakt, je bila med etnomuzikologi, ki so prvi preučevali njene glasbene zmogljivosti, precej hitro sprejeta kot paleolitska piščal (Omerzel-Terlep 1996; 1997; Kunej 1997; Kunej, Turk 2000). Študija glasbenih zmogljivosti piščali je pritegnila tudi širši krog strokovnjakov (Fink 1997; Horusitzky 2003; Atema 2004). Nova spoznanja glede glasbene zmogljivosti piščali nam prinašajo raziskave akademskega glasbenika Ljubena Dimkaroskega. V nadaljevanju podajamo njegovo besedilo s ključnimi ugotovitvami. V širšo muzikološko razpravo, ki bo del nekega drugega članka na to temo, se na tem mestu ne bomo spuščali.

Svetovno znana najdba iz Divjih bab I je danes po zaslugi slovenskih in nekaterih tujih strokovnjakov arheološko dobro opredeljena, zato sem želel preizkusiti njeno glasbeno funkcionalnost. Naredil in preizkusil sem več kot 30 rekonstruiranih lesenih in koščenih kopij piščali v želji, da najdem pravi zvok piščali. Vse kopije so bile narejene na podlagi rekonstrukcije piščali, ki so jo podali I. Turk et al. *(2005, sl. 14). Raziskave sem izvajal na stegnenicah mladih rjavih medvedov, ki mi jih je priskrbela Lovska zveza Slovenije, ter na telečjih, kozjih, svinjskih, srninih in jelenovih kosteh. Naposled sem raziskavo usmeril predvsem v igranje na kopijo, narejeno iz stegnenice mladega jamskega medveda iz Divjih bab I. Fosilno kost sem izbral z namenom, da se čim bolj približam dimenzijam originalne piščali (*sl. 2*). Kopiji sem dodal še dele, ki so bili na originalu očitno odlomljeni (glej Turk* et al. *2005).*

Na glasbilo[1] *igram z obema rokama v naravni, neprisiljeni drži, tako da se dolžina (113,6 mm) in oblika glasbila (torzijska zavitost kosti okoli 20°) anatomsko prilegata dlani in prstom rok. Glasbilo je netemperirano, z njim v zvočnem zaporedju dvanajsttonske lestvice dosegam dve oktavi in pol. V prepihavanju njegov obseg znaša več kot tri oktave. Je aerofono glasbilo, pihalo. V glasbenem jeziku lahko na njem izvajam: legato, stakato, dvojni in trojni jezik, frulato, glisando, kromatiko, razložene akorde, intervalske skoke ter melodična zaporedja od najnižjega do najvišjega tona. Dinamične zmožnosti segajo od piano do forte kot pri sodobnih inštrumentih. Intervalski skoki so možni v celotnem obsegu glasbila. V*

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[1] Medtem ko se v dosedanjih arheoloških objavah uporablja beseda piščal (v angleščini flute, francoščini flûte, nemščini Flöte), bom odslej sam uporabljal ustreznejši izraz: glasbilo. Zakaj sem se tako odločil, je razvidno iz nadaljevanja.

first the four holes were made, followed by most of the damage attributable to carnivores.

Practical tests, experimental archaeology and multi-slice computer tomography enabled I. Turk and his collaborators to explain the origin of the holes, which were made artificially. After the computer tomography results, I. Turk finally decided to proclaim the object as an artefact, interpreted as a Neanderthal flute.

NEW MUSICOLOGICAL FINDINGS

Contrary to archaeologists, who took almost a decade to conclude that the perforated bone from Divje babe I was an artefact, the ethnomusicologists who were the first to study its musical capabilities accepted it quite rapidly as a Palaeolithic flute (Omerzel-Terlep 1996; 1997; Kunej 1997; Kunej, Turk 2000). The study of the flute's musical capabilities attracted an even wider circle of experts (Fink 1997; Horusitzky 2003; Atema 2004). New findings on the subject have been provided by the research of Ljuben Dimkaroski, academic musician, whose paper with key findings is presented below. A wider musicological discussion will be part of another paper and will therefore not be discussed here.

The world renowned find from Divje babe I is today, through the work of Slovene and certain foreign scientists, archaeologically well determined. I have therefore wished to test its musical functionality. In order to do so, I created over 30 wooden and bone replicas of the flute and experimented with them. All replicas were based on the reconstruction of the flute put forward by I. Turk et al. *(2005, sl. 14). Replicas were made on femurs of juvenile brown bears provided by Hunters Association of Slovenia, but also calf, goat, pig, roe and red deer bones. In the end, I concentrated the research on playing a replica made on a femur of a juvenile cave bear from Divje babe I. I chose the fossil bone so as to come as close as possible to the dimensions of the original flute (*Fig. 2*). The replica was added parts obviously broken off on the original (see Turk* et al. *2005).*

I played the instrument[1] *with both hands in a natural, relaxed posture so that the length (113.6 mm) and form of the instrument (torsion of the bone is around 20°) anatomically fit the palm and fingers. The instrument encompasses range of two and a half octaves, which can be extended to three octaves by over-blowing. It is an aerophone, a woodwind instrument. In musical terms it allows the playing of non-tempered or tempered steps and leaps, broken chords, as well as any melodic sequences between the lowest and the highest tone. It enables legato and staccato playing, double*

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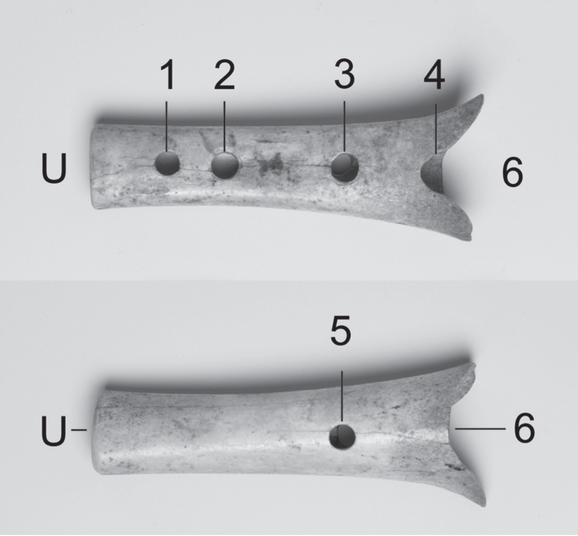
[1] While archaeological publications thus far use the word flute (piščal in Slovene, flûte in French, Flöte in German), I shall henceforth use a more appropriate word, namely instrument. This choice will be explained below.



Sl. 6: Replika piščali iz Divjih bab I. Oštevilčenje odprtin in oznake posameznih delov tu sledijo drži glasbila pri igranju in njihovi funkciji, za razliko od številk in oznak, ki so jih uporabljali I. Turk *et al.* (2005, sl. 1). Foto: Tomaž Lauko, Narodni muzej Slovenije.
Sl. 6: Replica of the flute from Divje babe I. Hole numbers and markings of individual parts follow here the positions of fingers on the instrument during playing and, consequentially, their function. These differ from the numbering and marking used by I. Turk *et al.* (2005, Fig. 1). Photo: Tomaž Lauko, National Museum of Slovenia.

naravi slišnost glasbila dosega več 100 metrov premera, odvisno od vremenskih razmer, v zaprtih prostorih pa je slišnost podobna sodobnim pihalom.

Pradavni izdelovalec glasbila je v zvočnem pomenu dodobra izkoristil zmožnosti stegnenice mladega jamskega medveda, saj mu je širši, distalni del kosti služil kot ***odmevnik****, ožji, proksimalni pa kot* ***ustnik****. Zrak v glasbilu poteka v isti smeri, kot je potekala življenjska energija živali v žilah mladega jamskega medveda od srca proti udom, tako kot pri rastlinah od korenin proti vejam in listom.*

Umetno preoblikovana stegnenica, ki nam jo je zapustil neandertalec, jasno kaže namen zvočnega izražanja, saj razporeditev luknjic in ohranjena dolžina najdbe tvorita ***sistem****, ki omogoča široko paleto zvočnosti in melodijskega gibanja in kaže, da gre za glasbilo v pravem pomenu besede. Poleg tega glasbilo s svojo bogato zvočnostjo omogoča glasbeno sporočanje tudi v jeziku današnjega časa. Menim, da glede na tehnične in izrazne zmogljivosti bistveno presega preprosto signalno funkcijo, zato je mogoče, da so ga uporabljali v obredne in druge namene. Pri določenih tonih glasbilo omogoča pomožne prijeme predvsem v visokem registru. Pri raziskovanju zvočnosti glasbila nisem uporabljal pomagal, kot so čepi, jezički in razna polnila.*

Preseneča tudi zmogljivost zvenenja dvoglasja in troglasja. Njegove tehnične zmogljivosti v smislu izraznosti

and triple tonguing, frulatto, and glissando. The dynamic capabilities range from piano to forte, as with modern instruments. Interval leaps are possible within the entire melodic range of the instrument. In nature, the audibility of the instrument reaches over 100 m in diameter depending on weather conditions, while in the interior it is similar to that of modern woodwind instruments.

The prehistoric instrument maker has thoroughly put to use the musical possibilities offered by the femur of a juvenile cave bear. The wider, distal part of the bone, served as ***the bell*** *and the narrower, proximal part, as* ***the mouthpiece****. The air in the instrument flew in the same direction as the life force in the veins of the animal, from the heart towards the limbs, same as in plants, from the roots to the branches and leaves.*

The artificially altered femur, as left to us by Neanderthals, clearly shows the intent of musical expression, since the disposition of the holes and the preserved length of the find constitute ***a system****, which enables a wide range of sonorities and melodic motions and reveals the object as an instrument. Apart from that, the instrument with its rich sonority enables musical communication also in today's musical languages. Considering its technical and expressional capabilities, I am of the opinion that it substantially surpasses a simple signalling function and was therefore possibly used for ritual or other purposes. The research of the instrument's sonority was conducted without the aids such as plugs, reeds and various fillings.*

Also surprising is the possibility to produce two or three simultaneously sounding pitches. The instrument's technical capabilities in terms of expression refute the supposition of the holes' accidental origin and distribution on the instrument. The functional representation of the instrument is illustrated on figure 6.

The size of the instrument's mouthpiece corresponds to the size of human lips. The sound is created by directed blowing against the sharp edge. Careful observation of the original revealed that the left edge in the interior of the mouthpiece is lightly bevelled in the direction of blowing, which opens up the possibility of artificial intervention (Fig. 7).

Hole 1, which is not completely preserved on the original and is closest to mouthpiece U, is smaller than other holes with a reason: the wavelengths of harmonics are shorter at higher notes and a smaller hole thus enables more precise intoning. Holes 2 and 3 fall into the middle register of the instrument. They are of the same size and they enable the most balanced sounds with rich coloration. The notch on the upper side of the bell can be transformed into Hole 4 by holding it with the right hand[2]*. Hole 5, which is not completely preserved on the original and which I call* ***palm*** *hole, is situated on the lower part*

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[2] If the left hand were used for holding, the instrument would have to be made of the right femur instead of the left. Most publications up to now show that researchers used the notch on the upper part of the bell (Hole 4) as the mouthpiece.

ne dopuščajo domneve o naključnosti nastanka luknjic in njihove razporeditve na inštrumentu. Funkcionalni prikaz rekonstruiranega glasbila je razviden na sliki 6.

Velikost ustnika glasbila ustreza velikosti človeških ustnic. Zvok ustvarjam z usmerjenim pihanjem na rezilni rob. Pri pozornem opazovanju originala sem opazil, da je levi rob ustnika v smeri pihanja na zunanji strani rahlo posnet, kar dopušča možnost človekovega posega (sl. 7).

Luknjica 1, ki na originalu ni v celoti ohranjena in je najbližja ustniku U, je manjša kot ostale z razlogom: valovne dolžine alikvotov so v višinah krajše, zato manjša luknjica omogoča točnejše intoniranje. Luknjici 2 in 3 spadata v srednji register inštrumenta, sta zvočno najbolj dorečeni in enako veliki, z bogato barvitostjo. V tem registru zveni glasbilo zelo jasno. Izjeda na zgornji strani odmevnika se s prijemom desne roke preoblikuje v luknjico 4[2]*. Luknjica 5, ki na originalu ni v celoti ohranjena in jo imenujem* ***dlančna****, leži na spodnjem delu inštrumenta, rahlo ekscentrično od luknjice 3*[3]*. Je največja skrivnost in* ***duša*** *glasbila. Podaljša dolžino zračnega stebra in valovanje zraka v inštrumentu. Pripomore k večjemu obsegu glasbila in oblikuje del nizkega registra, ki dopolnjuje njegov značaj. Odprtina inštrumenta nasproti ustnika U, luknja 6, je nastala po odstranitvi kostnega tkiva, kompakte in spongioze distalne metafize. Ima vlogo* ***odmevnika*** *in* ***zapiralnika****. Omogoča igranje v spodnjem registru.*

Zvočni zapisi, ki sem jih opravil do sedaj, potrjujejo zgoraj omenjeno vsebino in so glasbeni artefakti, ki jih bom v prihodnosti nadgrajeval. Cilj mojega raziskovanja ni bil zgolj eksperimentiranje, temveč odkrivanje optimalnih tehničnih zmogljivosti glasbila in osebno izpovedna kreativnost. Način igranja je zato v veliki meri odvisen od instrumentalista. Raziskovanja glasbila sem se lotil brez vsakršnega vedenja o predhodnih raziskavah, torej popolnoma neobremenjen. Ko sem naposled pregledal objave, sem pri skoraj vseh, ki so preučevali najdbo z glasbenega vidika, opazil, da pri uporabni rekonstrukciji niso upoštevali luknjice na anteriorni strani femurja. Za ustnik je vsem služil razširjeni distalni del kosti. Tehnika njihovega igranja je bila v podrobnostih zelo različna od moje. V danem primeru pa so prav podrobnosti bistvene. Temu primerni so bili rezultati zvočnega preizkušanja najdbe.

Najnovejša rekonstrukcija, podprta z izsledki računalniške tomografije (Turk et al. *2005), je najdbo s pomočjo glasbenega eksperimentiranja opredelila kot izvirno oblikovano glasbilo z vsemi lastnostmi modernih glasbenih inštrumentov. Zato menim, da poimenovanje*

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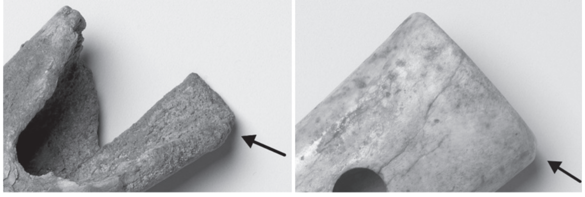
[2] Če bi za prijem uporabili levo roko, bi moralo biti glasbilo namesto iz leve stegnenične kosti izdelano iz desne. Večina dosedanjih objav kaže, da so raziskovalci izjedo na zgornjem delu odmevnika (luknjica 4) uporabljali kot ustnik za vzbujanje zvoka v glasbilu.

[3] To luknjico oz. njen ostanek so nekateri napačno povezovali s t. i. palčno luknjico (glej Omrzel-Terlep 1996; Atema 2004).



Sl. 7: Možni rezilni rob na originalu in rezilni rob na repliki. Foto Tomaž Lauko, Narodni muzej Slovenije.
Sl. 7: Possible sharp edge on the original and sharp edge on the replica. Photo Tomaž Lauko, National Museum of Slovenia.

of the instrument, slightly eccentrically to Hole 3[3]*. It is the biggest mystery and the* ***soul*** *of the instrument. It extends the length of the air column and vibration of air within the instrument. It widens the range of the instrument and forms part of the lower register that enhances its character. The opening of the instrument opposite to mouthpiece U, namely Hole 6, appeared after the removal of bone tissue, both the compact bone and the spongiosis of the distal metaphysis. Its role is that of a* ***bell*** *and* ***closure****. It enables playing in the lower register.*

The sound records that I have done so far confirm the above mentioned observations and are musical artefacts that I will be upgrading in the future. The aim of my research is not merely experimenting on, but also exploring the optimal technical capabilities of the instrument and a personally expressive creativity. The manner of playing therefore largely depends on the instrumentalist. I began researching the instrument without any knowledge of the previous research on the topic and thus completely unbiased. When I finally did peruse the publications, I noticed that almost none of the researchers of the instrument from a musical standpoint considered the hole on the anterior side of the femur in their reconstruction of use. All considered the widened distal part of the bone as the mouthpiece. Their playing techniques were, in detail, very different from the one I employed. However, in this case it is the details that make all the difference. Consequentially, the results of the find's sound tests were also very different.

The latest reconstruction, supported by the findings of computer tomography (Turk et al. *2005) and musical experiments, recognized the find as an original instrument with all the characteristics of modern musical instruments. I am therefore of the opinion that the name flute is not appropriate, since it is actually an instrument. Tests show that the find acts as a complete instrument only in the form that was reconstructed. Any change in the number and disposition of holes would cause its system to fail.*

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[3] This hole or what is left of it has been wrongfully tied to the so-called thumb hole (see Omrzel-Terlep 1996; Atema 2004).

piščal ni ustrezno, ker gre dejansko za glasbilo. Poskusi kažejo, da najdba deluje kot popolno glasbilo samo v obliki, kot jo poznamo oz. smo jo rekonstruirali. Vsaka sprememba v številu in razporeditvi luknjic ima za posledico rušenje sistema."

SKLEP

Preluknjana kost iz Divjih bab I, ki je danes na ogled v stalni razstavi Narodnega muzeja Slovenije, je v marsičem edinstvena. Ne le da gre za najstarejšo piščal, kot kaže, gre za pravo glasbilo, ki so ga izdelali naši predhodniki, neandertalci. Nobena arheološka najdba iz Slovenije ni bila podvržena tako vsestranskim analizam kot glasbilo iz Divjih bab I. Nobena arheološka najdba iz naše dežele ni v svetu povzročila toliko laičnega in znanstvenega zanimanja. Zavzeto delo I. Turka in njegova odprtost in pripravljenost za sodelovanje z ljudmi različnih strok in poklicev so v veliki meri pripomogli, da se naše védenje o neandertalcih korenito spreminja.

Glede na vse ugotovitve menimo, da lahko neandertalca sprejmemo kot bitje, sposobno tako prefinjenega umetniškega izražanja, kot je glasba. Njegove kognitivne sposobnosti radi podcenjujemo, čeprav so, kot je to razvidno tudi na primeru glasbila iz Divjih bab I, poznali učinkovitejše tehnike za izdelavo lukenj kot njihovi nasledniki. Na način, kot ga je ugotovil Horusitzky (2003), je neandertalec izdelal luknjo v nekaj minutah. Anatomsko moderni človek, ki je luknje vrtal, je za izdelavo porabil neprimerno več časa in energije. Poleg obdelave in uporabe kosti je v srednjem in celo starejšem paleolitiku izpričana uporaba in obdelava lesa (najdbe lesenih osti ali sulic). Ni si težko predstavljati, da je bila večina piščali v paleolitiku izdelana iz votlega lesa, do danes pa so se ohranile le tiste iz kosti (Otte 2000).

Vsi, ki smo sodelovali pri izkopavanjih v Divjih babah I, smo imeli veliko željo, da odkrijemo fosilne kosti neandertalca. I. Turk je za takšno najdbo ponujal celo denarno nagrado. Ali je mislil resno ali ne, nismo imeli priložnost izvedeti. Odkritje neandertalske piščali je bilo nekaj povsem nepričakovanega. Upamo, da bodo za slovenski paleolitik kmalu nastopili boljši časi in da bo želja po odkritju neandertalskih fosilnih ostankov zopet aktualna.

CONCLUSION

The perforated bone from Divje babe I, now on permanent display in the National Museum of Slovenia, is unique in many ways. Not only is it the oldest known flute, it also appears to be a complete instrument made by Neanderthals. No archaeological find from Slovenia has so far been subjected to so varied an array of analyses as this instrument from Divje babe I. Furthermore, no archaeological find from Slovenia has aroused so much general as well as scientific interest across the world. It is the dedicated work of Ivan Turk and his openness and readiness to cooperate with scientists of different professions that have greatly contributed to the radically changing knowledge on Neanderthals.

All the findings lead us to conclude that Neanderthals should be accepted as beings capable of a refined artistic expression such as music. Their cognitive capabilities are readily underestimated despite the fact that they knew, as is evident also from the instrument form Divje babe I, more effective technique of hole making as the people that came after them. Using the method defined by Horusitzky (2003), a Neanderthal could make a hole in a matter of minutes. The anatomically modern man bore holes and thereby used substantially more time and energy. Apart from working and using bone, the use and working of wood is attested through finds of wooden spears, in the Middle and even Lower Palaeolithic. It is therefore not difficult to imagine that most flutes in the Palaeolithic were made of hollow wood, though only those made of bone have been preserved until today (Otte 2000).

All that participated in the excavations at Divje babe I had a great desire to uncover fossil remains of Neanderthals. I. Turk even offered a pecuniary reward for such a find, though we were never able to find out whether this was a serious offer or not. The find of a Neanderthal flute was completely unexpected. It is our hope that Slovene Palaeolithic research will soon see better times and that the desire to uncover fossil remains of Neanderthals will again become topical.

Translation: Andreja Maver

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O OKOSTJU JAMSKEGA MEDVEDA IN LOBANJI DIVJEGA PRAŠIČA IZ MOKRIŠKE JAME

CAVE BEAR SKELETON AND WILD BOAR SKULL FROM THE CAVE OF MOKRIŠKA JAMA

Dragan BOŽIČ

Izvleček

Pisec pokaže v prvem delu članka, da Mokriške jame, ki leži na Mokrici v bližini Kamnika, ni odkril župnik in ljubiteljski naravoslovec Simon Robič v drugi polovici 19. stol. in da on v njej ni izkopal okostja jamskega medveda, ki je razstavljeno v Prirodoslovnem muzeju Slovenije v Ljubljani. V resnici je jamo prvič obiskal že leta 1837 prvi kustos Deželnega muzeja za Kranjsko Henrik Freyer, ki je v njej dve leti pozneje izkopaval. Iz najdenih kosti je lahko sestavil nepopolno okostje jamskega medveda, ki je bilo po prvi svetovni vojni dopolnjeno s kostmi z nekaterih drugih najdišč.

V drugem delu članka se pisec ukvarja z veliko lobanjo, ki jo je našel Robič med svojim obiskom jame leta 1877. Po Robičevem mnenju je pripadala velikemu divjemu prašiču. Glede na širino (24 cm) in druge mere, ki jih je navedel, pa je šlo zanesljivo za lobanjo jamskega medveda. Lobanje divjih prašičev so namreč mnogo ožje. Pravilnost te ugotovitve potrjuje rokopisni dokument iz leta 1877, shranjen v arhivu Narodnega muzeja Slovenije v Ljubljani.

Ključne besede: Slovenija, Mokriška jama, pleistocen, jamski medved, Henrik Freyer, divji prašič, Simon Robič

Abstract

In the first part of the paper the author states that the cave of Mokriška jama, situated on the Mokrica mountain near Kamnik, was not discovered by the parish priest and amateur natural scientist Simon Robič in the second half of the 19th century, nor did he excavate there the cave bear skeleton which is on display in the Natural History Museum of Slovenia in Ljubljana. In fact, the cave was first visited by Henrik Freyer, the first curator of the Regional Museum for Carniola, already in 1837. Two years later, he made excavations there. With the collected cave bear bones he composed an incomplete cave bear skeleton, which was after the World War I completed with bones from other sites.

In the second part of the paper the author deals with a large skull found by Robič during his visit to the cave of Mokriška jama in 1877. In Robič's opinion it belonged to a wild boar. According to its width of 24 cm and to other dimensions, quoted by Robič, it only might have belonged to a cave bear, since the sculls of the wild boars are much narrower. The correctness of this conclusion is confirmed by a handwritten document dating from the year 1877, and preserved in the archives of the National Museum of Slovenia in Ljubljana.

Keywords: Slovenia, Mokriška jama, Pleistocene, cave bear, Henrik Freyer, wild boar, Simon Robič

Med zaposlitvijo na Inštitutu za arheologijo Znanstvenoraziskovalnega centra Slovenske akademije znanosti in umetnosti v Ljubljani se je Ivan Turk ukvarjal zlasti z iskanjem novih starejšekamenodobnih najdišč in z izkopavanjem v jami Divje babe I, jaz pa z raziskovanjem mlajše železne in rimske dobe, kar pomeni, da sta bili najini raziskovalni področji močno vsaksebi. Vendar pa

Working at the Institute of Archaeology of the Scientific Research Centre of the Slovenian Academy of Sciences and Arts in Ljubljana Ivan Turk was mostly engaged in the searching for new sites from the Early Stone Age and the excavations in the Divje babe I cave and I was engaged in the research of the Late Iron and Roman Ages, which means that our research fields were quite different.

sva deset let zelo tesno sodelovala pri urejanju *Arheološkega vestnika,* osrednje slovenske arheološke revije, on kot tehnični in jaz kot glavni urednik. Najin prvi skupni zvezek je bil 34. za leto 1983, zadnji pa 43. za leto 1992.

Zdelo se mi je primerno, da v zborniku, izdanem njemu na čast, sodelujem s kratkim člankom o nekaterih kosteh z enega od najpomembnejših starejšekamenodobnih najdišč na Slovenskem, to je iz Mokriške jame na Mokrici v bližini Kamnika.

OKOSTJE JAMSKEGA MEDVEDA

Na stalni razstavi Prirodoslovnega muzeja Slovenije v Ljubljani je razstavljeno skoraj popolno okostje jamskega medveda, o katerem piše v knjigi, izdani leta 2004 v Cerkljah na Gorenjskem (*vir 17*), da ga je Deželnemu muzeju za Kranjsko poklonil župnik in pomemben naravoslovec Simon Robič, ki ga je bil našel v Mokriški jami. Razen tega trdi pisec knjige Janez Močnik, da je Robič to jamo tudi odkril. Močnik je preprosto prepisal napačne podatke, ki jih je v svoji predstavitvi Robičevega življenja in dela za *Slovenski biografski leksikon* navedla Angela Piskernik (*vir 13*), pred njo pa že Krmelj (*vir 11*). Nihče od njih ni poznal resnične zgodovine odkritja jame in okostja jamskega medveda.

Na srečo pa obstaja precej pisnih virov, ki osvetljujejo odkritje Mokriške jame in okostja jamskega medveda. Jamo je že leta 1837 obiskal Henrik Freyer (*sl. 1*), prvi kustos Deželnega muzeja za Kranjsko v Ljubljani (*viri 4, 5, 12* in *14*). Opazil je, da je v njej zelo veliko dobro ohranjenih kosti jamskega medveda. Nekaj lobanj je ležalo že pred jamskim vhodom (*vira 5* in *14*). V muzejski zbirki je takrat že bilo okostje jamskega medveda, ki ga je bil muzeju poklonil Franc Hohenwart, predsednik muzejskega kuratorija (*vir 3*). Sestavljeno je bilo iz kosti, izkopanih v Postojnski jami. Žal je bilo zelo nepopolno. Freyer je prepoznal v Mokriški jami najdišče, na katerem bi lahko zbral dovolj kosti, da bi mu bilo mogoče sestaviti razmeroma popolno medvedje okostje (*viri 4, 5* in *14*). V letu 1839 je v jami dlje časa izkopaval. Iz najdenega kostnega gradiva je v resnici lahko sestavil medvedje okostje, ki je bilo sicer še vedno nepopolno, vendar mnogo boljše kot tisto, ki ga je bil muzeju podaril Hohenwart (*viri 6, 7* in *9*). Po prvi svetovni vojni je Fran Kos to okostje dopolnil z drugimi kostmi, ki so bile takrat v muzeju (*vir 10*). To pomeni, da je okostje, ki je zdaj razstavljeno v muzeju, sestavljeno večinoma iz kosti jamskega medveda, ki jih je v Mokriški jami izkopal Henrik Freyer, pa tudi iz kosti z drugih najdišč.

LOBANJA DIVJEGA PRAŠIČA

Kot sem pokazal, Simon Robič (*sl. 2*) ni odkril Mokriške jame. Prav tako v njej ni izkopal okostja

For ten years, however, we have been close collaborators in the editing of the *Arheološki vestnik*, the main Slovene archaeological journal. He was the technical and I was the chief editor. Our first joint volume was 34 for the year 1983 and the last 43 for the year 1992.

It seemed to me very appropriate to contribute in the miscellany, edited in his honour, a short paper on some bone finds from one of the most important Early Stone Age sites in Slovenia, the cave of Mokriška jama on the Mokrica mountain near Kamnik.

THE CAVE BEAR SKELETON

The permanent exhibition of the Natural History Museum of Slovenia in Ljubljana displays among others almost a complete cave bear skeleton. In a book published in 2004 in Cerklje in Gorenjska (*source 17*) we can read the statement that this skeleton was given to the Regional Museum for Carniola by Simon Robič, the parish priest and an important natural scientist who had found it in the cave of Mokriška jama. According to Janez Močnik, the author of the book, Robič had also discovered the cave. Močnik simply repeated the wrong data, given by Angela Piskernik in her presentation of Robič's life and work (*source 13*) and before her by Fr. Krmelj too (*source 11*). None of them knew the true history of the discovery of the cave and the cave bear skeleton.

Fortunately, there are many written sources describing the discovery of the cave and of the cave bear skeleton. The cave of Mokriška jama was visited already in 1837 by Henrik Freyer (*Fig. 1*), the first curator of the Regional Museum for Carniola (*sources 4, 5, 12* and *14*). He discovered that the cave was very rich with well preserved cave bear bones. Some skulls were lying even in front of the entrance (*sources 5* and *14*). In the museum's collection of that time there had already been a cave bear skeleton, donated by Franc Hohenwart, the president of the museum's curatorium (*source 3*). It was made out of bones, collected in the cave of Postojnska jama, but unfortunately, it was incomplete. Freyer considered the cave of Mokriška jama as the right site to collect enough bones to compose relatively complete cave bear skeleton, which at that time could be seen only in Paris (*sources 4, 5* and *14*). In 1839 he spent long time excavating in the cave. The gathered bone material was insufficient to reconstruct a complete skeleton, but it was still much better than the first one in the museum (*sources 6, 7* and *9*). After the World War I Fran Kos completed the skeleton with bones of unrecorded provenance (*source 10*). That means that the skeleton on display today is composed not only of the cave bear bones excavated by Henrik Freyer in the cave of Mokriška jama, but also of some bones originating from other sites.

Sl. 1: Portret kustosa Deželnega muzeja za Kranjsko Henrika Freyerja (1802–1866), ki ga je leta 1837 naslikal Matevž Langus. Hrani Narodni muzej Slovenije v Ljubljani. Foto: Tomaž Lauko.
Fig. 1: Portrait of Henrik Freyer (1802–1866), the curator of the Regional Museum for Carniola, painted by Matevž Langus in 1837. Kept by the National Museum of Slovenia in Ljubljana. Photo: Tomaž Lauko.

jamskega medveda, ki je razstavljeno v Prirodoslovnem muzeju Slovenije v Ljubljani. Jamo je obiskal leta 1877, to je natanko 40 let po Freyerju. Izčrpno poročilo o svojem obisku je objavil v tedniku *Novice gospodarske, obrtniške in narodne* (*vir 8*). V jami je opazil še veliko kosti jamskega medveda. Razen dolgih in drugih kosti je v njej našel še dve zelo veliki lobanji. Prva je po njegovem mnenju sodila k jamskemu medvedu, druga pa k divjemu prašiču. Mere druge je navedel v članku: 4 dm dolga, 2 dm in 4 cm široka in 1 dm in 6 cm visoka. Eden od meljakov je bil 4 cm in 5 mm dolg in 2 cm širok.

Robičevo dodelitev druge lobanje divjemu prašiču so brez komentarja omenili ne le jamar Valter Bohinec (*vir 16*), ampak tudi Mitja Brodar, ki je kmalu po drugi svetovni vojni v Mokriški jami izkopaval in pri tem našel tudi kamnito in koščeno orodje (*vir 12*), in paleontolog Ivan Rakovec, ki je opravil natančno raziskavo v jami izkopanih kosti jamskega medveda (*vir 15*).

Če pa primerjamo mere domnevne lobanje divjega prašiča, ki jih je navedel Robič, z merami velikih lobanj te živalske vrste,[1] ugotovimo, da dolžina 40 cm in višina 16 cm kakor tudi velikost meljaka (dolžina

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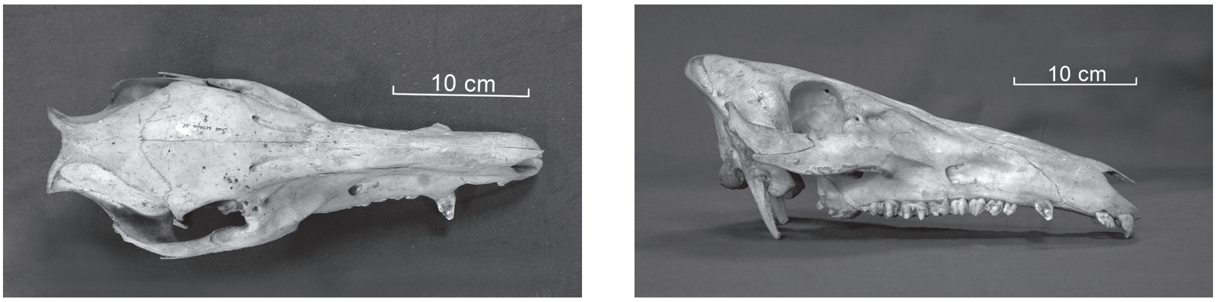
[1] Na *sl. 3* predstavljena lobanja divjega prašiča ni zelo velika, vendar dobro kaže razmerja med dolžino, širino in višino.

Sl. 2: Portret župnika Simona Robiča (1824–1897). Foto: Julius Müller, Ljubljana. Hrani Narodni muzej Slovenije v Ljubljani.
Fig. 2: Portrait of the parish priest Simon Robič (1824–1897). Photo: Julius Müller. Kept by the National Museum of Slovenia in Ljubljana.

THE WILD BOAR SKULL

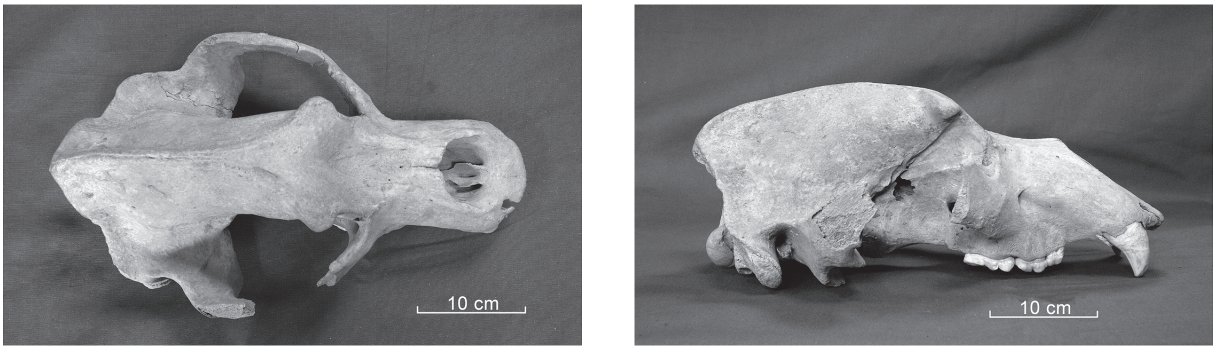
As cited above, Simon Robič (*Fig. 2*) did not discover the cave of Mokriška jama nor did he excavate the cave bear skeleton which is displayed in the Museum of Natural History of Slovenia in Ljubljana. In fact, he visited the cave in 1877, exactly 40 years after Freyer. He published a detailed report on his visit in the Slovene weekly *Novice gospodarske, obrtniške in narodne* (*source 8*). In the cave he could still find many cave bear bones. Beside long and other bones he found also two skulls, both rather large. In his opinion the first one belonged to a cave bear, and the second one to a wild boar. He measured the latter one and quoted its dimensions in the paper: 4 dm long, 2 dm and 4 cm wide and 1 dm and 6 cm high. The molar was 4 cm and 5 mm long and 2 cm wide.

The Robič's attribution of the second skull to a wild boar was cited without any comment not only by the caver Valter Bohinec (*source 16*), but also by Mitja Brodar, who made excavations in the cave after the World War II and found, next to the animal bones, several stone and bone tools (*source 12*), as well as by the palaeontologist Ivan Rakovec, who has thoroughly analyzed the cave bear bones from the cave of Mokriška jama (*source 15*).



Sl. 3: Lobanja divjega prašiča brez spodnje čeljustnice od zgoraj in od strani. Hrani Inštitut za arheologijo ZRC SAZU v Ljubljani. Foto: Igor Lapajne.

Fig. 3: Wild boar skull without lower jawbone from above and from the side. Kept by the Institute of Archaeology, SASA SRC in Ljubljana. Photo:Igor Lapajne.



Sl. 4: Lobanja jamskega medveda brez spodnje čeljustnice, najdena v jami Divje babe I v dolini Idrijce, od zgoraj in od strani. Hrani Inštitut za arheologijo ZRC SAZU v Ljubljani. Foto: Igor Lapajne.

Fig. 4: Cave bear skull without lower jawbone, found in the Divje babe I cave in the Idrijca valley, from above and from the side. Kept by the Institute of Archaeology, SASA SRC in Ljubljana. Photo: Igor Lapajne.

4,5 cm, širina 2 cm) sicer ustrezajo meram velikih lobanj divjega prašiča, nikakor pa ne širina 24 cm, ker so te lobanje mnogo ožje. Po drugi strani pa tako mere druge lobanje kot meljaka povsem ustrezajo meram velikih lobanj jamskega medveda (*sl. 4* in *5*). To pomeni, da jamskemu medvedu ni pripadala samo prva lobanja, ki jo je našel Robič, ampak tudi druga, napačno pripisana divjemu prašiču!

Da je tak sklep pravilen, dokazuje rokopisni dokument, ki sem ga pred mnogimi leti odkril v arhivu Narodnega muzeja Slovenije v Ljubljani. Leta 1877 je bil kustos Deželnega muzeja za Kranjsko Dragotin Dežman, ki je očitno prebral Robičev članek. Ker ga je lobanja, ki jo je Robič pripisal divjemu prašiču, zelo zanimala, ga je zaprosil, naj mu jo pošlje v muzej.

Župnik na Šenturški gori mu je rade volje ustregel. Pošiljko je pospremil s pismom (*vir 1; sl. 6*), v katerem piše: “Tu Vam pošiljam zaželjeno lobajno (sic) predpotopnega divjega prešiča na ogled in prosim, da mi jo boste, ker imam le to edino, o kaki priložnosti zopet nazaj poslali.” Dežman mu jo je po ogledu res vrnil (*vir 2*), na zgornji rob Robičevega pisma pa je pripisal: “Lobanja,

However, if the dimensions of the presumed wild boar skull, quoted by Robič, are compared with the dimensions of large skulls of this animal,[1] it becomes evident that the length of 40 cm and the height of 16 cm, and the dimensions of the molar (length 4.5 cm, width 2 cm) correspond to the dimensions of a large wild boar skull, but the width of 24 cm definitely not, because such skulls are much narrower. On the other hand, the dimensions of the second skull and of the molar correspond very well to the dimensions of a large cave bear skull (*Figs. 4* and *5*). That means that not only the first skull, found by Robič, but also the second one belonged to a cave bear and not to a wild boar!

A handwritten document, which I have found many years ago in the archives of the National Museum of Slovenia in Ljubljana, confirms my findings. In 1877 the then curator of the Regional Museum for Carniola in Ljubljana Dragotin Dežman obviously read the Robič’s article. He was very interested in the skull which Robič attributed to a wild boar and asked him to send it to the museum. Robič

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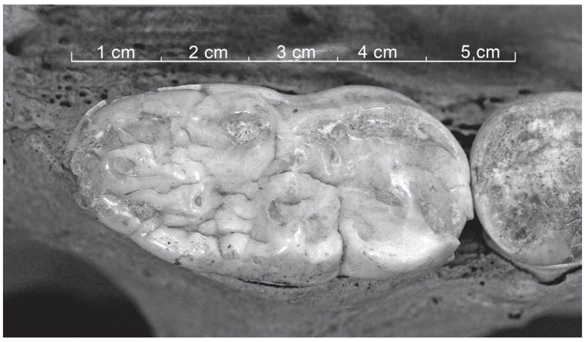
[1] Skull of the wild boar, represented on *figure 3*, is not very large, but it shows well the proportions between the length, width and height.



Sl. 5: Meljak (M_2) v čeljustnici lobanje na *sliki 4*. Foto: Igor Lapajne.
Fig. 5: Molar (M_2) in the jawbone of the skull on *figure 4*. Photo: Igor Lapajne.

ki je pripadala jamskemu medvedu (*Ursus spelaeus*), je bila vrnjena pošiljatelju."[2]

consented and accompanied the parcel by the following letter (*source 1; Fig. 6*): "I am sending you here the desired skull of the antediluvian wild boar to be examined and beg you to send it back on some occasion, because it is the only one that I have." Dežman in fact sent the skull back (*source 2*) and on the upper margin of the letter wrote the following remark: "The skull belonged to a cave bear (*Ursus spelaeus*) and has been returned to sender."[2]

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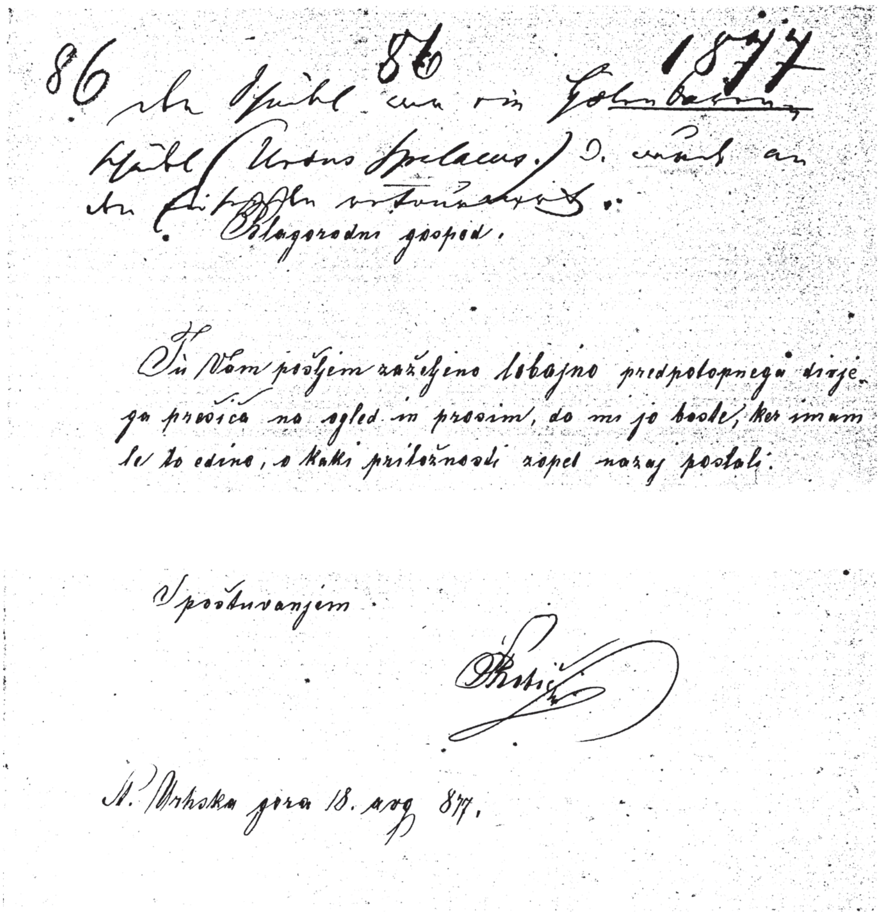
[2] Za pomoč pri pripravi prispevka bi se rad zahvalil naslednjim osebam iz Ljubljane: Mateji Belak, Borutu Toškanu in Dragu Valohu z Inštituta za arheologijo ZRC SAZU, Poloni Bitenc in Blaženki First iz Narodnega muzeja Slovenije, Franciju Cimermanu ter Matiji Križnarju in Cirilu Mlinarju iz Prirodoslovnega muzeja Slovenije. Slovensko besedilo je lektorirala Alenka Božič, angleško pa Darja Pate.

[2] I would like to thank the following colleagues for their kind assistance: Mateja Belak, Borut Toškan and Drago Valoh from the SASA SRC Institute of Archaeology, Franci Cimerman as well as Polona Bitenc and Blaženka First from the National Museum of Slovenia and Matija Križnar and Ciril Mlinar from the Natural History Museum of Slovenia. The Slovene text was corrected by Alenka Božič and the English translation by Darja Pate.



86 Der Schädel war ein Höhlenbären Schädel (Ursus spelaeus.) D. wurde an den Einsender retournirt. 86 1877

Blagorodni gospod.

Tu Vam pošljem zaželjeno lobajno predpotopnega divjega prašiča na ogled in prosim, da mi jo boste, ker imam le to edino, o kaki priložnosti zopet nazaj poslali.

S spoštovanjem.

Robič

Sv. Urhska gora 18. avg 877.

Sl. 6: Zgornji in spodnji del pisma Simona Robiča kustosu Deželnega muzeja za Kranjsko Dragotinu Dežmanu z dne 18. 8. 1877. Hrani knjižnica Narodnega muzeja Slovenije v Ljubljani.
Fig. 6: Upper and lower part of Simon Robič's letter to the curator of the Regional Museum for Carniola Dragotin Dežman dated 18th August 1877. Kept by the library of the National Museum of Slovenia in Ljubljana.

VIRI / SOURCES

ROKOPISNA VIRA / HANDWRITTEN SOURCES

Vir / Source 1

Pismo Simona Robiča Dragotinu Dežmanu z dne 18. avgusta 1877 / The letter of Simon Robič to Dragotin Dežman dated 18th August 1877

Arhiv Narodnega muzeja Slovenije, št. 86/1877 / Archives of the National Museum of Slovenia, No. 86/1877

Blagorodni gospod!

Tu Vam pošljem zaželjeno lobajno (sic) predpotopnega divjega prešiča na ogled in prosim, da mi jo boste, ker imam le to edino, o kaki priložnosti zopet nazaj poslali.

Dežmanov pripis v gotici / Dežman's remark in the Gothic script:

Der Schädel war ein *Hölenbärenschädel* (*Ursus spelaeus*) u. wurde an den Einsender retourniert.

Vir / Source 2

Rechnung über die kurrenten Auslagen des krainischen Landesmuseums vom 24. April bis Ende Dezember 1877 (Laibach 31. Dezember 1877)

Arhiv Narodnega muzeja Slovenije, št. 146/1877 / Archives of the National Museum of Slovenia, No. 146/1877

Post Kr

15. 19/8 Porto der Rücksendung des von Lucas Robitsch zur Einsicht eingesendeten Bärenschädels (*ursus spelaeus*) 13 Kr. Dem Dienstmann für Uebertragung 10 Kr. 23

TISKANI VIRI / PRINTED SOURCES

Vir / Source 3

Hochenwart 1836, 12–13

Stran / Page 12

(…)

Ferner ist in diesem Zimmer ein Skelett eines 6 Schuh hohen Mannes, von Herrn **Faustus Gradischek** gegeben. Dann ein unvollständiges Skelett eines Höhlenbären, von mir gegeben, und vom Herrn Professor der Anatomie, **Melzer** (Vater), zusammengefügt. Da Herr *Freyer* bei den so eben erst beendeten Nachgrabungen abermals Knochen aufgefunden hat, so habe ich gegründete Hoffnung,

Stran / Page 13

daß ein vollständiges Skelett aufgestellt werden wird, welches dann eine Seltenheit mehr seyn wird, da, nach Cuviers Zeugniß, selbst das Museum in Paris nur einzelne Knochen besitzet.

Vir / Source 4

Hochenwart 1839, 115–116

Stran / Page 115

(…)

Herr Custos *Freyer* hat aber noch besonders das Verdienst, einen zweiten Fundort derselben ermittelt zu haben, wie die geneigten Leser aus dem zunächst hier folgenden Berichte ersehen werden. Die von ihm aufgefundenen Knochen

Stran / Page 116

haben ein sehr trockenes Lager, sind daher sehr fest, und unterscheiden sich durch ihre gelbe Farbe und Härte von den in der Adelsberger Grotte aufgefundenen sehr vortheilhaft.

(...)

Der unermüdete Herr *Freyer* hat durch beide Besuche eine beträchtliche Menge von schönen und wohl erhaltenen Knochen gesammelt, und sich vorgenommen, ein vollständigeres Skelet als das von mir dem Museum gegebene, da die Reichhaltigkeit der erhaltenen Knochen ihm dieß gestattet, zusammen zu setzen, und dem Museum zu verehren. Diese Uneigennützigkeit, da die zweimalige Fahrt von Laibach, die Wegweiser, die Gräber, die Träger und ihre Verpflegung auf so weite Strecken nicht unbeträchtlich sind, verdienet alle Anerkennung.

Das aufgestellte Skelet wird übrigens eine neue Zierde unseres stets größer werdenden Museums seyn, da bisher noch nirgends, außer Paris ein ähnliches sich vorfindet.

Vir / Source 5

Freyer 1839, 118

(…)

Der Boden ist mit Steingerölle belegt, unter welchem in großer Menge Knochen des *Ursus speleus* auf einander gehäuft liegen, kleine Knochen und Rippen sind minder häufig, schon vor der Grotte trifft man Bärenschädel an, welche aus Muthwillen von den Hirten da- und dorthin geschleudert worden seyn mögen.

Die Jahreszeit war zu weit vorgerückt, um hier übernachten, oder größere Nachforschungen machen zu können, ich mußte die Nacht in der Hirtenhütte sehr unerfreulich zubringen.

Vir / Source 6

Freyer 1842, 3

2. U. spelaeus *Cuv*. Höhlenbär. okamnéno medvédovo hrodje *F*. 16.)

Palaeotherium Volpi non Cuv. predpotópni médved F.

In der Adelsberger Kaiser Ferdinands Grotte in der Gegend des Tanzsaales, und am Calvarienberge; aber größere vollständigere Exemplare sind in der *Mokriza*

Höhle auf der Kreuzer Alpe zu finden, woher ein Scelett im krainischen Landes-Museo aufbewahrt wird.

Vir / Source 7
Deschmann 1856, 39
(...)

Diese Knochenhöhle oder Grotte, *Zjavka,* Feistritzer Seits, *Mokrica* bei Zirklach u. s. w. genannt, woraus der eben so unermüdete als verdienstvolle Landesmuseums-Kustos, Herr Heinrich *Freyer*, im Jahre 1839 mit vieler Mühe und Anstrengung eine bedeutende Menge von Knochen zur vollendeten Zusammenstellung des in dem Laibacher Museum aufgestellten Höhlenbären, *Ursus spelaeus Cuv*., brachte, befindet sich gegenüber der Steineralpe, *velka planina* an der Kreuzer Alpe, am nördlichen Abhange des Mokritzberges, in einer beiläufigen Höhe von 500 Klafter über der Meeresfläche.

Vir / Source 8
Robič 1877, 276
Hoja v Mokriško jamo.
(…)

Po notranjih tleh, zlasti pri stenah leve jame je obilno kostí predpotopnega medveda (ursus spelaeus); še več pa, pravijo, je zasutih v kotu desne jame. (…) Po nalovljenih pajkih sledimo za *kostmi* in kmalu jih najdemo v dveh kotih prav obilno, med njimi črepinjo *predpotopnega medveda* in pa glavo *divjega prešiča* (Sus scrofa ferus), še prav dobro ohranjeno. Posebno velika je, dolga 4 decimetre, široka 2 decimetra in 4 santimetre, visoka pa 1 decimeter in 6 santimetrov. Zob kočnjek je dolg 4 santimetre in 5mm., širok pa 2 santimetra.

Vir / Source 9
Deschmann 1888, 168 in / and 169
Stran / Page 168
Saal X.
Wirbelthiere und Vögel Krains.
Kasten 1. (...)
Stran / Page 169
(…)

3.) Höhlenbären-Skelet aus der Höhle Zijavka an der Mokriza-Alpe bei Stein und Schädel desselben aus der Kreuzberger-Höhle bei Laas und aus der Adelsberger-Grotte.

Vir / Source 10
Kos 1926–1927, 86
Geološke, paleontološke in mineraloške zbirke
(…)

Jamski medved, ki je sedaj nameščen poleg losa, je bil razstavljen prej v zelo nepopolni obliki med mehovi recentnih sesalcev. Iz precej bogatega fosilnega gradiva smo zbrali najboljše ter sestavili to obliko. Manjkajoče falange smo za silo rekonstruirali z žico.

Vir / Source 11
Krmelj 1931, 78
(…)

Kakor znano, je preiskaval tudi votlino na Mokrini (sic), kjer je zasledil popoln okostnjak *medveda brlogarja*, sedaj v ljubljanskem muzeju.

Vir / Source 12
Brodar 1955, 207
Zgodovinski podatki

Mokriška jama ni novo odkritje. Že l. 1837 je slišal o njej H. *Freyer* (1839, str. 117), tedanji kustos muzeja v Ljubljani, in jo še istega leta obiskal. Opisal je svojo pot do nje in v kratkem tudi jamo. (...)

V istem zvezku omenja novo najdišče tudi F. *Hochenwart* (1839, str. 112) v članku o fosilnih kosteh na Kranjskem. (...) Izraža tudi upanje, da bo *Freyerju* uspelo sestaviti za muzejske zbirke zelo popoln medvedji skelet, katerega razen v Parizu še nikjer nimajo.

Znani naš prirodoslovec župnik S. *Robič* (1877, str. 268 in 276) je poročal o svojem obisku “Mokriške jame” v Novicah leta 1877. Tudi on omenja ograjeno lopo in popiše jamo nekoliko obširneje kot *Freyer*. Našel je obilo kosti jamskega medveda, med drugim tudi njegovo lobanjo, razen tega pa še glavo divjega prašiča. Obe sta bili prav dobro ohranjeni.

Vir / Source 13
Piskernik 1960–1971, 114

IV. *Geolog, paleontolog in jamar.* Pri zbiranju okamenin zlasti v Kamniških planinah (1007 kosov, 135 vrst) je R. odkril Mokriško zijalko in tam popoln okostnjak medveda brlogarja (Lj., Prirodoslov. muzej).

Vir / Source 14
Cimerman 1965, 11
(…)

Freyer pa je odkril še eno jamo, ki je v njej našel velike množine kosti jamskih medvedov. Ko je bil že nekaj let kustos v ljubljanskem muzeju, so mu prišle na uho govorice, da vedo za jamo v Kamniških planinah, ki so v njej že dobili živalske kosti. (...) Jamska tla je prekrival grušč, med njim pa so ležale kosti jamskih medvedov. Lobanje je našel že pred vhodom, kamor so jih verjetno iz objestnosti zmetali pastirji. Zaradi pozne jeseni se tedaj Freyer ni dlje zadrževal v jami. Samo premeril jo je, na izkopavanje pa se je odpravil leta 1839 (1, zv. 5, str. 117). Z mnogo truda in prizadevanja je tedaj izkopal toliko kosti jamskih medvedov, da je iz njih lahko sestavil popolno okostje živali (2, str. 39). To okostje je še danes med imenitnejšimi eksponati našega Prirodoslovnega muzeja.

Vir / Source 15

Rakovec 1967, 123

UVOD

(…) Omenim naj še, da je našel *Robič* v njej leta 1877, ko jo je prvič obiskal, poleg lobanje jamskega medveda tudi lobanjo divje svinje, ki je bila dolga 4 dm, široka 2,4 dm ter visoka 1,6 dm (1877, 276).

Vir / Source 16

Bohinec 1971, 13

(…)

Posebno zanimiv je Robičev opis Hoje v Mokriško jamo, prispevek Novicam, ki je datiran s 15. avgustom 1877 s Št. Urhske, to je Šenturške gore. Uvodoma pravi, da je že davno nameraval obiskati to jamo in da ga je skoraj sram povedati, da si jo je "preplazivši že toliko in toliko jam in podmoljev po Notranjskem in Gorenjskem" ogledal šele v začetku julija t. l. (...) Po notranjih tleh je v dveh kotlih našel obilo kosti, "med njimi", tako nadaljuje, "črepinjo *predpotopnega medveda* in pa glavo *divjega prešiča*", še prav dobro ohranjeni. Znano je, da je okostje jamskega medveda, ki ga hrani ljubljanski Prirodoslovni muzej, sestavljen (sic) iz kosti, najdenih v Mokriški zijavki.

Vir / Source 17

Močnik 2004, 13, 210 in / and 211

Stran / Page 13

NAJSTAREJŠA DOBA

Preden so ljudje začeli naseljevati in obvladovati ozemlje cerkljanske občine, so tod v prazgodovinskih dobah gospodarili jamski medvedje. Njihove kosti je v Mokriški jami pod Košutno, ki v ledeni dobi še ni sodila v kamniško občino, našel znameniti šenturški župnik Šimen Robič in eno grozeče okostje poklonil ljubljanskemu Prirodoslovnemu muzeju. Tako piše v njihovi inventarni knjigi.

Stran / Page 210

SIMON ROBIČ

Stran / Page 211

(...)

Bil je tudi geolog, paleontolog in jamar. Preiskal je vrsto podzemnih jam in odkril Mokriško zijalko ter v njej našel okostje medveda brlogarja, katerega skelet je poleg devetnajst (sic) ptičjih razstavljen v Prirodoslovnem muzeju v Ljubljani, ki hrani tudi večino ostalih njegovih bogatih in dragocenih zbirk.

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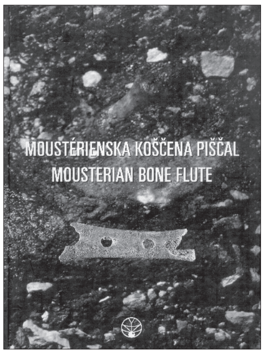


Moustérienska "koščena piščal" in druge najdbe iz Divjih bab I v Sloveniji
Mousterian "bone flute" and other finds from Divje babe I - cave site in Slovenia

V zborniku je celovito predstavljeno in obdelano trenutno najbolj aktualno srednjepaleolitsko najdišče v Sloveniji. Jamsko najdišče Divje babe I je postalo znano zaradi arheološke najdbe, za katero dosedanje raziskave kažejo, da bi lahko bila najstarejša piščal, izdelana iz kosti jamskega medveda. Osrednji del zbornika je posvečen prav tipološki, tehnološki, akustični in muzikološki obdelavi znamenite najdbe. V posameznih poglavjih je predstavljena še stratigrafija, kronologija, favna in flora najdišča ter paleolitske najdbe, vendar le do vključno plasti, v kateri je bila najdena koščena piščal. V knjigi so prvič strnjene in povzete ugotovitve dosedanjih arheoloških izkopavanj, ki pa seveda še niso zaključena. Poleg urednika, ki je tudi avtor in soavtor večine poglavij, sodelujejo v zborniku s prispevki še G. Bastiani, M. Culiberg, J. Dirjec, B. Kavur, B. Kryštufek, T.-L. Ku, D. Kunej, D. E. Nelson, M. Omrzel-Terlep in A. Šercelj.

1997, (Opera Instituti Archaeologici Sloveniae 2), 223 str., 29 barvnih in 75 cb slik, 20 x 29,5 cm, trda vezava, ISBN 961-6182-29-3

* * *

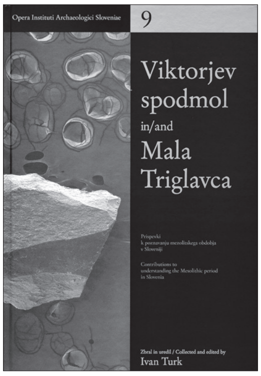
The most topical Middle Paleolithic site in Slovenia is presented in full and discussed in detail in this series. The Divje Babe I cave site became famous for the archaeological discovery of what current investigations indicate could be the oldest flute, made of the bone of a cave bear, yet discovered. The principal part of the compilation is dedicated to a typological, technological, acoustic and musicological discussion of the remarkable find. Individual chapters present the stratigraphy, chronology, fauna and flora from the site, in addition to the Paleolithic material finds (however, only up to the layer including the bone flute).
The book incorporates the first abridged and summarized determinations from the current archaeological excavations, which are not yet concluded. In addition to the editor, who is also the author and coauthor of the majority of chapters, the following individuals also provided contributions to the series: G. Bastiani, M. Culiberg, J. Dirjec, B. Kavur, B. Kryštufek, T.-L. Ku, D. Kunej, D. E. Nelson, M. Omrzel-Terlep and A. Šercelj.

1997, (Opera Instituti Archaeologici Sloveniae 2), 223 pp., 29 coloured photos, 75 b/w photos, 20 exposure tables + 7 tables, 20 x 29.5 cm, hardcover, ISBN 961-6182-29-3.

Ivan Turk (ur. / ed.)

Viktorjev spodmol in / and Mala Triglavca

Prispevki k poznavanju mezolitskega obdobja v Sloveniji
Contributions to understanding the Mesolithic period in Slovenia



V zborniku, prvem s področja mezolitika v Sloveniji, sta obravnavani dve izjemno bogati najdišči na Krasu v zahodni Sloveniji: Viktorjev spodmol in Mala Triglavca. Viktorjev spodmol je novo odkrito najdišče, kjer so se raziskave komaj začele, v Mali Triglavci pa potekajo že dalj časa. Oodrobno je obdelan predvsem Viktorjev spodmol. Pomembna je primerjava rezultatov različnih terenskih in poterenskih metod, uporabljenih v Mali Triglavci in predvsem v Viktorjevem spodmolu.
V posameznih poglavjih so obdelana mikrolitska orodja, ki pripadajo sovterjensko-kastelnovjenskemu (sauveterrien-castelovien) kompleksu, njihova tipologija in odnosi z drugimi najdišči tega kompleksa s posebnim poudarkom na kronologiji in kronoloških povezavah mezolitskih najdišč v severni Italiji, vključno s Tržaškim krasom, in zahodni Sloveniji (I. Turk in M. Turk). V drugih poglavjih so sistematsko prikazani redki rastlinski ostanki (M. Culiberg), izjemno bogate favne mehkužcev (R. Slapnik, V. Mikuž), ektotermnih vretenčarjev (M. Paunović) in malih sesalcev (B. Toškan, B. Kryštufek) ter ostanki velikih sesalcev (B. Toškan). Samo v Viktorjevem spodmolu je bilo na površini dveh kvadratnih metrov v mezolitski plasti najdenih 58.000 ostankov slepca in 6.076 ostankov, ki pripadajo 103 živalskim vrstam. Na isti površini je bilo 72 tipološko opredeljivih mikrolitov, 104 makrolitska orodja in 12.708 kamnoseških odpadkov.

2004, (Opera Instituti Archaeologici Sloveniae 9), 247 str. + 20 tabel, 64 črno-belih risb, fotografij in zemljevidov, 20 x 29,5 cm, trda vezava, ISBN 961-6500-54-6.

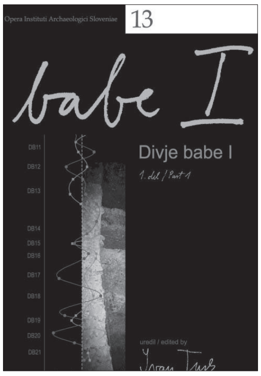
* * *

The monograph, the first regarding the Mesolithic in Slovenia, presents a discussion of two exceptionally rich sites in the Karst in western Slovenia: Viktorjev spodmol and Mala Triglavca. Viktorjev spodmol is a newly discovered site, where only test excavations have been done, while research has been underway at Mala Triglavca for already a while. The compilation primarily presents a detailed review of Viktorjev spodmol. The comparison of results from various field and post-field methods, which were applied at both Mala Triglavca and especially at Viktorijev spodmol, is particularly important.
Individual chapters address the topic of microlithic tools attributed to the Sauveterrien-Castelovien complex, their typology and relations with other sites from this complex, and with a special emphasis on the chronology and chronological correlations between Mesolithic sites in northern Italy, including the Trieste karst, and western Slovenia (I. Turk in M. Turk). The remaining chapters systematically present rare vegetal remains (M. Culiberg), the exceptionally rich collections of mollusc fauna (R. Slapnik, V. Mikuž), ectothermic vertebrates (M. Paunović) and small mammals (B. Toškan, B. Kryštufek) as well as the remains of large mammals (B. Toškan). At Viktorijev spodmol about 58,000 remains of slowworm and 6,076 remains attributed to 103 other animal species were discovered upon a surface of two square metres in the Mesolithic layer. The same surface revealed 72 typologically classifiable microliths, 104 macrolithic tools and 12,708 debris.

2004, (Opera Instituti Archaeologici Sloveniae 9), 247 pp. + 20 plates, 64 b/w photos, drawings and maps, 20 x 29.5 cm, hardcover, ISBN 961-6500-54-6..

Ivan Turk (ur. / ed.)

DIVJE BABE I. Paleolitsko najdišče mlajšega pleistocena v Sloveniji. I. del
DIVJE BABE I. Upper Pleistocene Palaeolithic site in Slovenia. Part I



V prvem delu monografije Divje babe I so podani, analizirani in interpretirani podatki s področja naravoslovja. V prvi vrsti gre za stratigrafsko-sedimentološke-kronološke podatke ter za ostanke flore in favne. Med slednjimi je podrobno obdelano oglje iz številnih ognjišč ter mali in veliki sesalci s poudarkom na jamskem medvedu. Posebej je treba izpostaviti niz absolutnih ESR-datacij in klimatogram najdišča, ki kaže potek temperature in vlage po plasteh v kronoconi zgodnjega in srednjega würma oz. kisikove izotopske stopnje OIS 5 in OIS 3. Zlasti podrobno so obdelani ostanki flore in favne iz izotopske stopnje OIS 3, ki omogočajo nov vpogled v paleookoljske in klimatske razmere tega slabo poznanega kronološkega odseka v Sloveniji in sosednjih pokrajinah. Arheološke najdbe, ki vključujejo tudi musterjenske koščene artefakte, bodo predstavljene v drugem, načrtovanem delu monografije.

2007, (Opera Instituti Archaeologici Sloveniae 13), 480 str., 10 barvnih fotografij, 178 črno-belih risb, fotografij in zemljevidov, 89 tabel in 38 prilog; 20 x 29,5 cm, trda vezava, ISBN 978-961-254-019-7.

* * *

In the first part of the Divje babe I monograph, data from the fields of the natural sciences are presented, analysed and interpreted. This is primarily stratigraphic, sedimentological and chronological data and data about the remains of flora and fauna. The latter includes detailed analysis of charcoal from a number of hearths and the remains of small and large mammals, with an emphasis on cave bear. The series of absolute ESR datings and the climatogram of the site should be highlighted in particular, which shows the course of temperature and humidity by layers in the chronozone of the Early and Middle Würm or oxygen isotope stages OIS 5 and OIS 3. The remains of flora and fauna from OIS 3 in particular are analysed, which enables new insight into palaeo-environmental and climatic conditions of this poorly known chronological segment in Slovenia and neighbouring regions. Archaeological finds, including Mousterian bone artefacts, will be presented in the planned second part of the monograph.

2007, (Opera Instituti Archaeologici Sloveniae 13), 480pp, 10 colour photoogaphs, 178 b-w drawings, photoogaphs and maps, 89 tabels and 38 annexes; 20 x 29.5 cm, hardcover, ISBN 978-961-254-019-7.