Nove analize "piščali" iz Divjih bab I (Slovenija)

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Izvleček

Avtorji prispevka so ponovno analizirali sporno najdbo domnevne piščali iz musterjenske plasti v Divjih babah I (Slovenija) in prišli do nekaterih novih ugotovitev. Eksperimentalno so preverili obe najverjetnejši hipotezi o nastanku lukenj. Pravilnejša se jim zdi hipoteza o umetnem izvoru lukenj. Če bi obveljala nasprotna hipoteza, da so luknje narejene z zobmi, bi šlo lahko kvečjemu za več nenormalnih ugrizov jamske hijene s kanini. Vendar jamska hijena v najdišču ni bila ugotovljena.

Abstract

The paper re-analyses the disputed find of a suspected flute from the Mousterian layer in Divje babe I (Slovenia). The two most probable hypotheses of the creation of the holes were checked experimentally. The hypothesis that they are of artificial origin seems more probable. The alternative, that the holes were made by teeth, would have required abnormal biting or chewing behaviour by cave hyena using their canine teeth. The presence of cave hyena has not been established at the site.

1. **UVOD**

Nenavadna, piščali podobna najdba iz musterjenske plasti v Divjih babah I je do dobra razburkala stroko in javnost. Najdbo je mogoče različno razlagati in tega smo se najditelji zavedali od vsega začetka. Vendar so nekateri mediji najdbo brez nadaljnjega razglasili za najstarejšo piščal. Sami smo vedno in povsod poudarjali, da gre pri takšni razlagi le za domnevo (Turk et al. 1995; 1997; Kunej, Turk 2000). Domneva ima za podlago veliko podobnost najdbe z dejanskimi paleolitskimi in kasnejšimi koščenimi piščalmi. Vendar podobnost v tem primeru ni dokaz, ker manjkajo elementi za zanesljivo artefaktno opredelitev najdbe.

Na začetku burne razprave o piščali (odslej bo to le delovna oznaka najdbe, ki jo vnaprej ne opredeljuje kot tako) smo bili premalo izkušeni, da bi se reševanja samosvojega problema lotili na čim ustreznejši način. Žal se je nekaj podobnega zgodilo tudi drugim strokovnjakom, ki jih je pritegnilo to zanimivo vprašanje (Albrecht et al. 1998; Chase, Nowell 1998a, 1998b; D'Errico et al. 1998a).

Mednarodno srečanje v Spodnji Idriji leta 1998 na temo piščali je predvsem pokazalo, da uporabljanje enih in istih dokazov enkrat za drugič proti različnim domnevam ne pelje nikamor. Zato smo, oboroženi z novimi izkušnjami, ponovno proučili obe najverjetnejši domnevi o nastanku piščali, ki smo jih predvideli že v svojem prvem poročilu o najdbi, in jih ponavljali v vseh ostalih prispevkih. Raziskavo smo tudi tokrat podprli z ustreznimi poskusi, ki pa smo jih razširili na obe domnevi (prim. Kunej, Turk 2000). Medtem smo odkopali in proučili tudi vso plast 8 v osrednjem predelu jame, kjer je bila najdena piščal, in v raziskavo vključili tudi te podatke.

Naj na tem mestu še enkrat poudarimo, da so luknje in vse poškodbe na piščali skoraj izključno mehanskega izvora (lomljenje, abrazija). Znakov izrazitejših kemičnih poškodb (korozija), ki jih v najdišču dobro poznamo na podlagi številnih primerkov, predvsem večjih kostnih odlomkov kot tudi celih kosti, ni. Ugotavljanje izvora mehanskih poškodb je ključnega pomena za razlago najdbe. In prav v tem so mnenja deljena. Nekateri zagovarjajo umetni drugi naravni nastanek lukenj. V igri sta človek s svojimi tehničnimi pripomočki in zveri s svojimi zobmi. Druge možnosti ne pridejo v poštev.

Kot med vso razpravo o piščali tudi tokrat nimamo namena nikomur vsiljevati svojega mnenja. Zato ne bomo odgovarjali zagovornikom domneve o naravnem izvoru lukenj oz. piščali v običajnem polemičnem tonu.Trudili se bomo podati samo kar se da objektivne razloge za eno in drugo domnevo. Na njihovi podlagi se lahko potem vsak sam odloči za eno ali nobeno od obeh obravnavanih hipotez. Lahko tudi za sestavljenko obeh domnev. Vendar je v tem primeru treba ločiti, kaj je prispeval človek in kaj zver.

2. **TAFONOMIJA**

Preden si podrobneje ogledamo luknje in odtiske na fosilnih kosteh, se moramo seznaniti z nekaterimi tafonomskimi izsledki na najdišču Divje babe I, ki nam bodo v pomoč pri razlagi dejavnosti zveri na kosteh jamskega medveda. Ta dejavnost ni neposredno povezana z nastankom piščali kot celote. Zato tu predstavljeni tafonomski izsledki v nobenem primeru ne morejo biti dokaz za to, da je piščal oblikovala izključno kaka zver.

Splošno tafonomsko sliko najdišča smo dobili na podlagi analize različnih kategorij (mladi in odrasli, celi in fragmentirani primerki) dolgih cevastih kosti in kosti šap jamskega medveda.

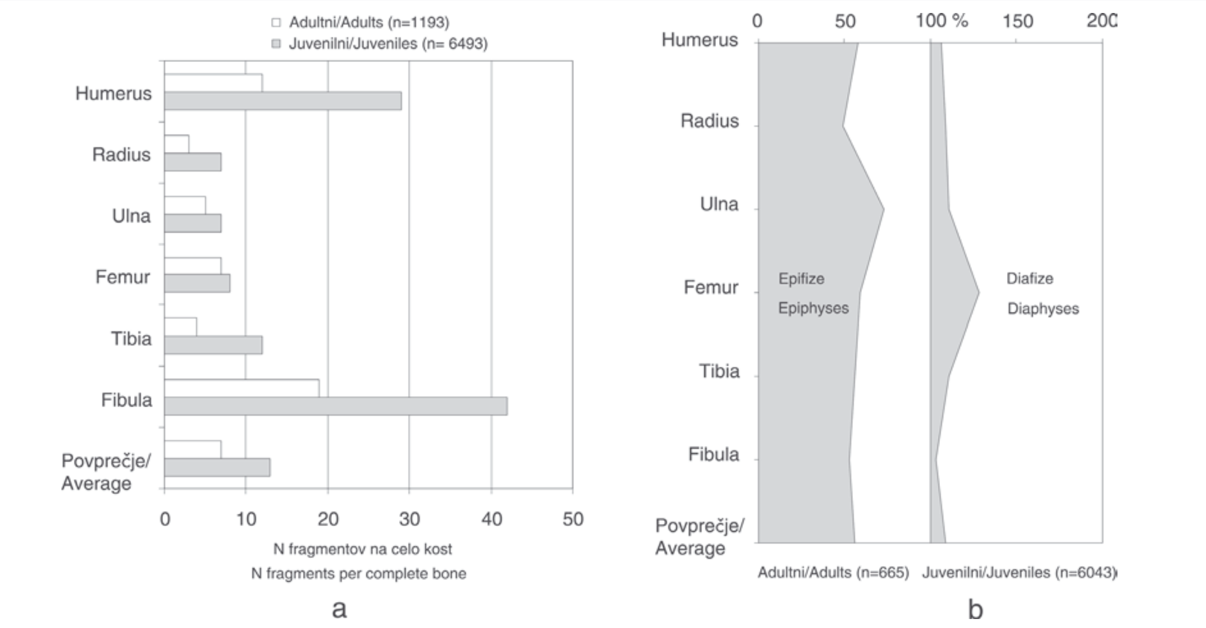
Diafize dolgih cevstih kosti (humerus, radius, ulna, femur in tibija) odraslih primerkov so tako trdne, da jih ni mogla zdrobiti nobena zver, vključno z jamsko hijeno. Na podlagi izmerjene povprečne sile (4550 N), ki je potrebna za luknjanje sveže kortikalne lupine diafize femurja večjega, skoraj odraslega osebka recentnega rjavega medveda, sklepamo, da je bila za luknjanje femurja odraslega jamskega medveda potrebna sila od 6000 N navzgor (glej *tab. 4*), in to pri popolnoma odprti čeljusti, ko so žvekalne mišice iztegnjene in je njihov delovni učinek najmanjši.

Zveri so bile sposobne zdrobiti vse kosti mladih primerkov in kosti šap odraslih primerkov. Nekater od teh kosti so po potrebi lahko razbili tudi ljudje. Ti so s kamnom zlahka razbili tudi tiste kosti, ki jih zveri niso mogle zdrobiti.

Posebno pozornost zaslužijo vse kategorije kosti šap (prim. Marean 1991). Te kosti so zaradi svoje majhnosti in oblike še najbolj odporne na preperevanje. So lahko prepoznavne tudi kot fragment. Zanimive so predvsem za zveri. Zaradi vseh navedenih lastnosti so najboljše merilo za oceno delovanja zveri na kosteh jamskega medveda.

Da bi lahko ovrednotili tafonomsko sliko kostnega gradiva zgornjega dela plasti 8 v osrednjem predelu jame, kjer je bila najdena piščal, smo za primerjavo izbrali povprečno sliko kostnega gradiva iz vseh do vključno leta 1998 raziskanih plasti (2-8) v tem delu jame (*sl. 1*). Na njeni podlagi smo lahko naredili naslednje splošne sklepe:

Pri dolgih cevastih kosteh obstaja velika razlika v fragmentarnosti mladih in odraslih primerkov. Mladi primerki so zastopani skoraj izključno s fragmentiranimi diafizami, medtem ko pri odraslih primerkih rahlo prevladujejo fragmentirane epifize. Mladi primerki imajo tudi več fragmentiranih kosti za celo kost kot odrasli primerki. Pri mladih primerkih od



Sl. 1: Povprečna tafonomska slika dolgih cevastih kosti jamskega medveda v združenih plasteh 2-8 v osrednjem predelu jame. a) Število fragmentiranih kosti brez iveri na celo kost. b) Deleži diafiznih in epifiznih fragmentov. Pri adultnih primerkih so zajete epifize z metafizo ali brez nje. Pri juvenilnih primerkih so zajete diafize z metafizo ali brez metafiz.

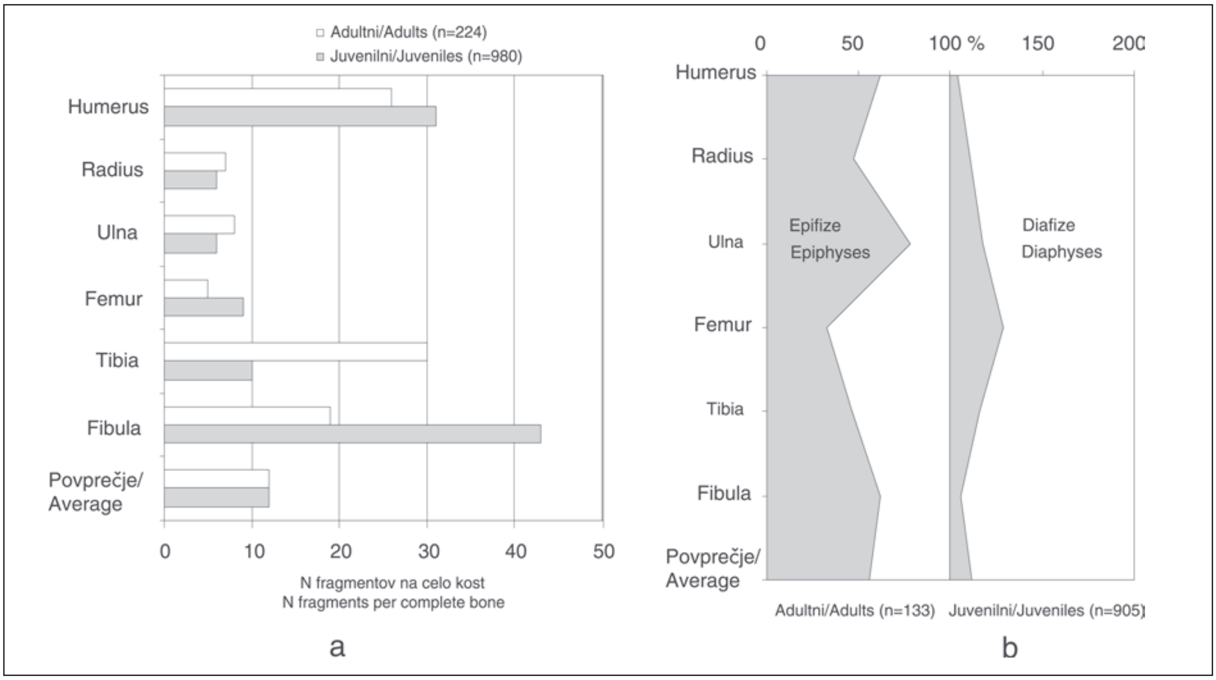
Fig 1: Avarage taphonomic picture of long bones of cave bear in combined layers 2-8 in the central part of the cave. a) Number of fragmented bones without splinters per whole bone. b) Proportions of diaphyseal and epyphiseal fragments. In adult specimens complete epiphyses with and without metaphyses are considered. In juvenile specimens complete diaphyses with and without metaphyses are considered.

Tab. 1: Struktura ostankov femurjev juvenilnih primerkov iz združenih plasti 2-10.
Table 1: Structure of remains of femurs of juvenile specimens from combined layers 2-10.

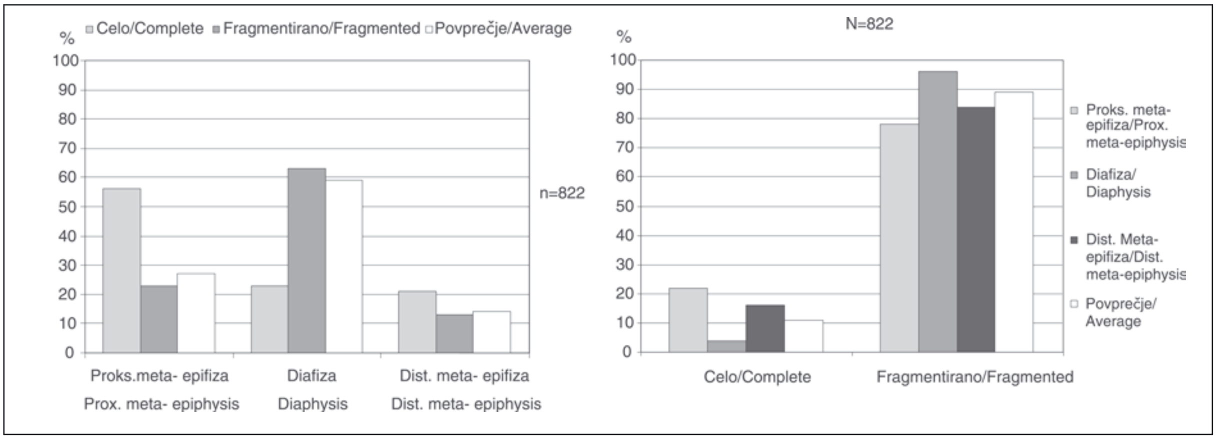
(n)	Proksimalna meta-, epifiza *Proximal meta-, epiphysis*	Diafiza *Diaphysis*	Distalna meta-, epifiza *Distal meta-, epiphysis*	Skupaj *Total*
Celo *Complete*	49 epifiz	20	19 epifiz	88
Fragmentirano *Fragmented*	170	466	98	734
Skupaj *Total*	219	486	117	822

povprečja izbranih dolgih kosti najbolj odstopa femur skupaj z ulno in radiusom.

Struktura najdenih ostankov femurjev mladih primerkov je takšna, da so povprečno najslabše zastopane cele in najbolje fragmentirane diafize (*tab. 1; sl. 3*). Diafiza je del, ki ima največ hranljivih snovi. Ker so v analizi zajeti samo cilindrični odlomki, lahko trdimo, da so najdene diafize poškodovale predvsem majhne do srednje velike zveri, potem ko so odstranile epi- in metafize. Te so slabše zastopane, najslabše pa distalne epi- in metafize femurja. Delovanje zveri je dokazano tudi z redkimi sledovi grizenja (vdol-



Sl. 2: Tafonomska slika dolgih cevastih kosti v zgornjem delu plasti 8 v osrednjem predelu jame. a) Število fragmentiranih kosti brez iveri na celo kost. b) Deleži diafiznih in epifiznih fragmentov. Pri adultnih primerkih so zajete epifize z ali brez metafize. Pri juvenilnih primerkih so zajete diafize z ali brez metafiz.
Fig. 2: Taphonomic picture of long bones in the upper part of layer 8 in central part of the cave. a) Number of fragmented bones without splinters per whole bone. b) Proportions of diaphyseal and epyphiseal fragments. In adult specimens complete epiphyses with and without metaphyses are considered. In juvenile specimens complete diaphyses with and without metaphyses are considered.



Sl. 3: Povprečna struktura ostankov femurjev juvenilnih primerkov iz združenih plasti 2-10 v osrednjem predelu jame.
Fig. 3: Average structure of the remains of femurs of juvenile specimens from combined layers 2-10 in the central part of the cave.

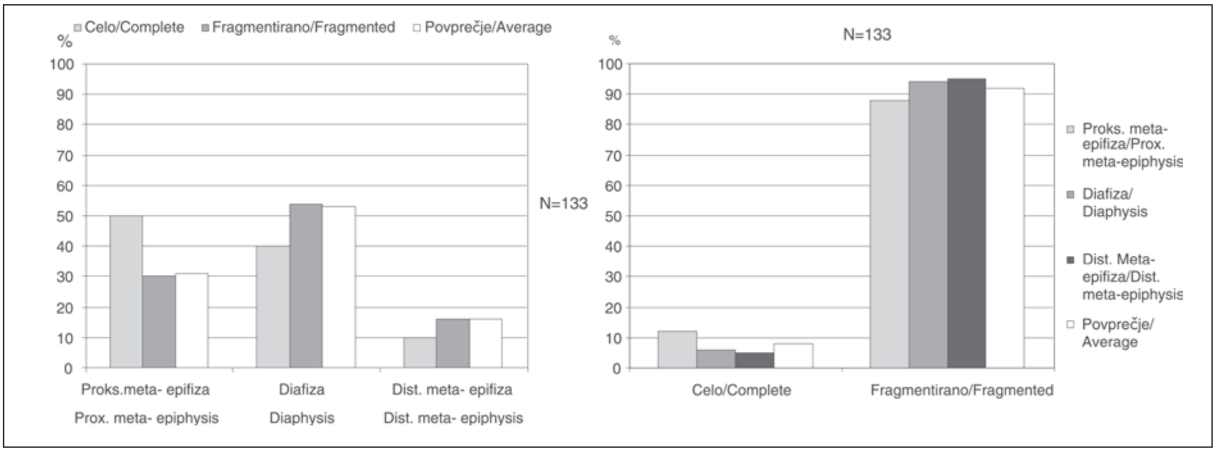
binice, odtiski, raze ipd.) na vseh dolgih kosteh, predvsem mladih primerkov.

Pri kosteh šap obstajajo, podobno kot pri dolgih kosteh, velike razlike med mladimi in odraslimi primerki. Na *sl. 5* je prikazano poenostavljeno najmanjše število združenih celih in fragmentiranih skeletnih delov. Dobili smo ga tako, da smo za vsako kost delili (utežili) število njenih najdb s številom levih in desnih kosti v skeletu. Najbolj zastopan skeletni del lahko tako predstavlja tudi število oseb-kov, določenih na podlagi kosti šap. Za grobo oceno tafonomskih izgub kosti šap navajamo še (najmanjše) število osebkov na podlagi izoliranih zob, ki so bili najdeni skupaj s kostmi šap. Pri odraslih osebkih je bolj verjetno število osebkov zunaj oklepajev. Navajamo tudi število najdenih sezamoidnih koščic v velikosti graha kot merilo za natančnost pobiranja kosti šap.

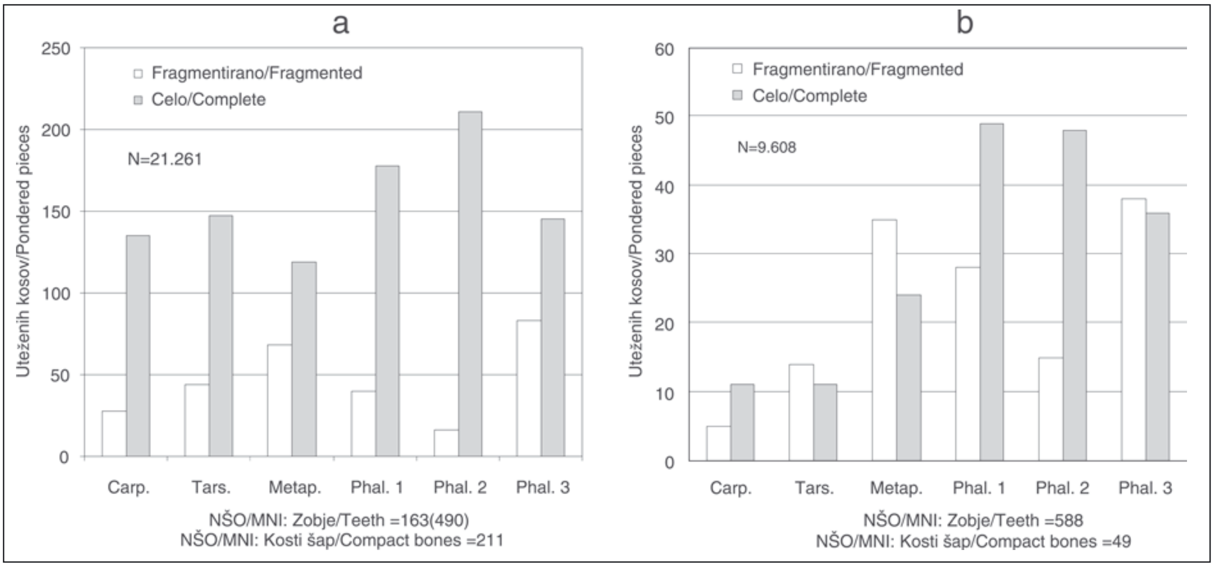
Analiza kosti šap ponuja, kot rečeno, najboljši možni vpogled v dogajanje s kostmi v najdišču, ki obsega predvsem preperevanje in destruktivno delovanje zveri.

Kosti mladih primerkov so bistveno bolj fragmentirane (več fragmentov na celo kost) in zdesetkane (manj celih kosti po osebku) kot kosti odraslih primerkov. Najbolj ohranjeni del šap (največ celih in najmanj fragmentiranih kosti) pri mladih in starih primerkih je drugi prstni členek (*sl. 5*).

Splošna slika najdenih kosti šap, ki je posledica raznih bolj ali manj vplivnih dejavnikov, je očitno



Sl. 4: Struktura ostankov femurjev juvenilnih primerkov iz zgornjega dela plasti 8 v osrednjem predelu jame.
Fig. 4: Structure of remains of femurs of juvenile specimens from the upper part of layer 8 in the central part of the cave.



Sl. 5: Povprečna tafonomska slika kosti šap v združenih plasteh 2-10 v osrednjem predelu jame. a) Adultni primerki. b) Juvenilni primerki. NŠO = (najmanjše) število osebkov na podlagi največjega števila uteženih kosti šap brez 11.686 sezamoidnih kosti in na podlagi pridruženih izoliranih zob.
Fig. 5: Average taphonomic picture of compact bones in combined layers 2-10 in the central part of the cave. a) Adults. b) Juveniles. MNI = (minimum) number of individuals on the basis of the maximum number of loaded compact bones without 11.686 sesamoid bones and on the basis of associated isolated teeth.

povezana z različno trdnostjo obeh starostnih kategorij kosti. Med dejavniki sta nedvomno najpomembnejša preperevanje in delovanje zveri. Zanima nas, kaj je bilo močnejše. Odgovor je mogoč na podlagi izsledkov analize notranje strukture (odnos celo nasproti fragmentiranemu) obeh starostnih kategorij.

Preperevanje bi prizadelo predvsem najbolj krhke kosti: tretji in drugi prstni členek, večino karpalno-tarzalnih kosti in predvsem sezamoidne kosti. Večina teh kosti je zlasti pri odraslih primerkih med bolje zastopanimi skeletnimi deli.

Zveri bi načele šape pri sklepih (karpalne in tarzalne kosti) ali pri prstih in napredovale proti sredini (kosti metapodija). Najskladnejša s takšno dejavnostjo je slika kosti šap mladih primerkov. Najmanj je karpalno-tarzalnih kosti, ki jih lahko dovolj velike zveri večinoma pogoltnejo cele. Petnicam pogosto manjka velik del *tuber calcanei.* Največ je kosti prstov, ki zverem zaradi krempljev domnevno niso bili preveč zanimivi. Metapodiji, ki so se jih zveri domnevno lotile potem, ko so odstranile prstne členke ali zapestno-nartne kosti, so med najbolj fragmentiranimi deli in po zastopanosti na srednjem mestu. Običajno jim manjka velik del distalne metafize, redkeje proksimalne epifize. Kosti šap odraslih primerkov kažejo bistveno drugačno podobo, ki je verjetno posledica *in situ* preperevanja in omejenega delovanja zveri (manjkajoča distalna epifiza pri metapodijih).

Neposredne dokaze za delovanje zveri imamo v odtiskih zob na vseh kosteh šap, razen na tretjem prstnem členku.

Če z opisano povprečno tafonomsko sliko osrednjega dela jame primerjamo kostne ostanke iz zgornjega dela plasti 8, kjer je bila najdena piščal, ne bomo našli večjih razlik (prim. *sl. 1; 3; 5* in *2; 4; 6*). To še posebej velja za mlade primerke.

Manjša odstopanja so samo v strukturi najdenih ostankov femurjev mladih primerkov. V zgornjem delu plasti 8 je več celih diafiz kot v vzorcu, ki predstavlja povprečje osrednjega dela jame. Manjše so tudi razlike v ohranjenosti različnih delov femurja. Vse to bi govorilo prej za zmanjšano kot povečano dejavnost zveri. Da je bilo morda res tako, kaže tudi relativno bolj izenačena ohranjenost kosti šap odraslih primerkov.

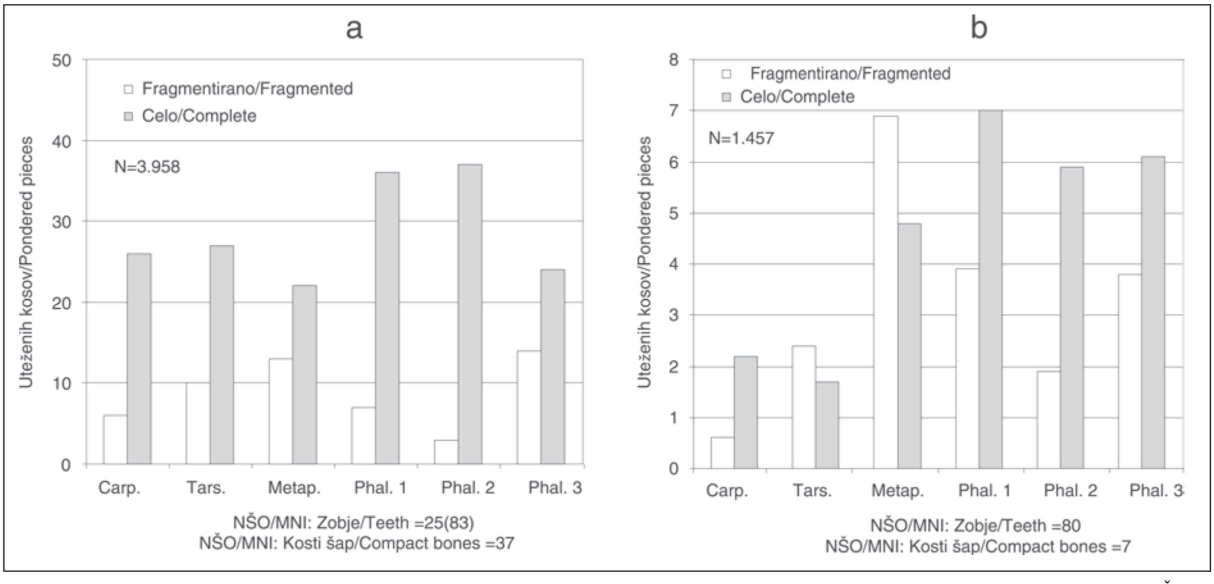
Podobno sliko kot plast 8 zgoraj daje tudi plast 8 v celoti. Nekoliko bolj odstopajo plasti 2-7 (Turk, Dirjec 1997a, sl. 8.6).

Na splošno lahko trdimo, da so na kosti delovali vedno bolj ali manj isti dejavniki. Kot rečeno, ti dejavniki niso nujno izoblikovali piščal, so jo pa zanesljivo preoblikovali.

3. **PRVA HIPOTEZA: LUKNJE NAREJENE Z ZOBMI**

Luknje na fosilnih kosteh, predvsem jamskega medveda, ki naj bi jih naredile zveri, so že dolgo znane (Kos 1931; M. Brodar 1985). Mnenja o tem, katere zveri in s katerimi zobmi so kosti luknjale, pa so bila vedno deljena ali nedorečena.

Pri luknjah na piščali manjka kronski dokaz za



Sl. 6: Tafonomska slika kosti šap v zgornjem delu plasti 8 v osrednjem predelu jame. a) Adultni primerki. b) Juvenilni primerki. NŠO = (najmanjše) število osebkov na podlagi največjega števila uteženih kosti šap brez 1.694 sezamoidnih kosti in na podlagi pridruženih izoliranih zob.

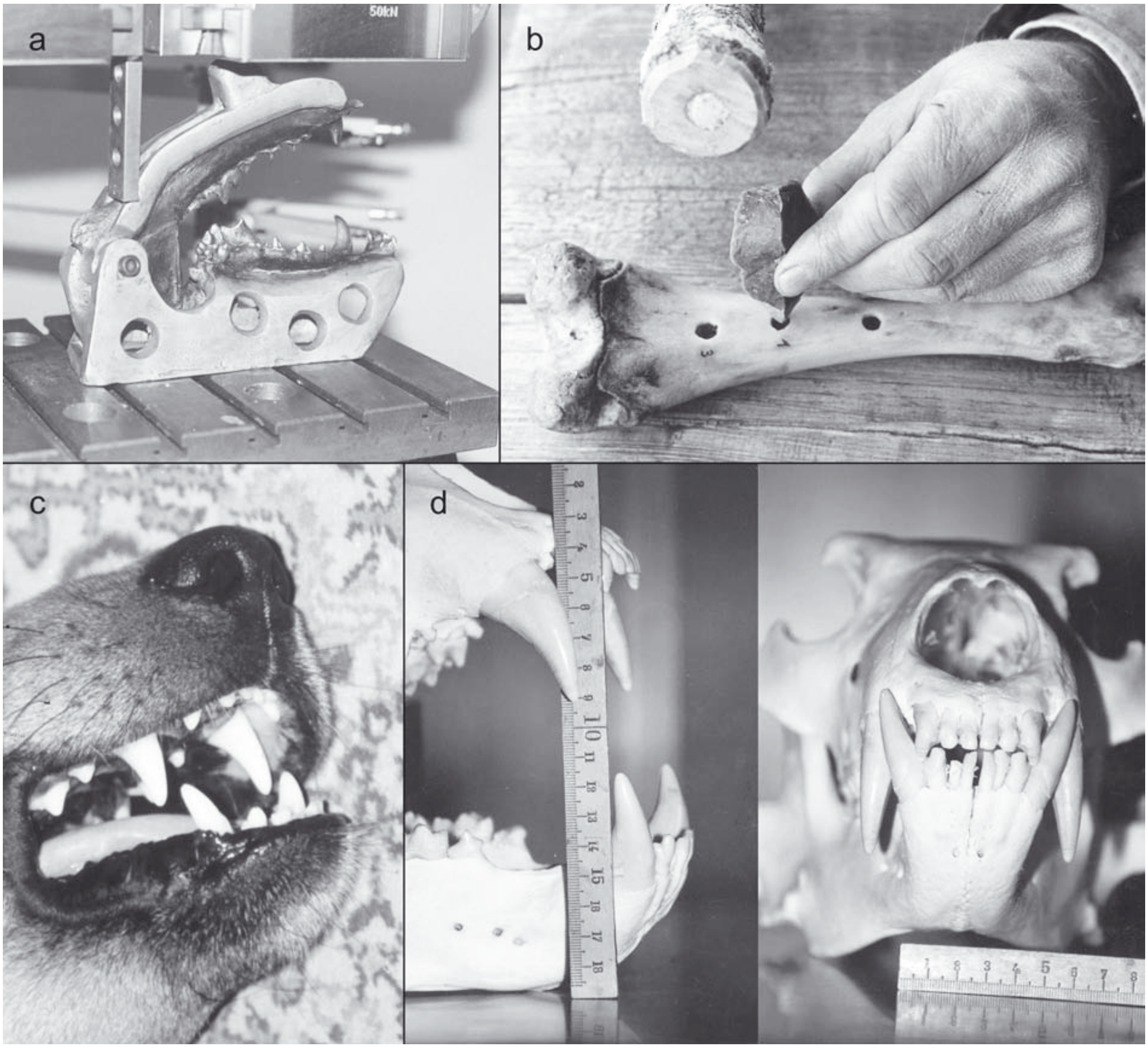
Fig. 6: Taphonomic picture of compact bones in the upper part of layer 8 in the central part of the cave. a) Adults. b) Juveniles. MNI = (minimum) number of individuals on the basis of the maximum number of loaded compact bones without 1.694 sesamoid bones and on the

njihov naravni oz. zverski izvor, to je (so) makroskopski ostanek ali ostanki udrte kortikalne lupine na robu lukenj ali v medularni votlini. Na večini ugrizenih kosti iz najdišča so se ti ostanki kljub tanki kortikalni lupini ali prav zato odlično ohranili in nam takoj razpršijo vse dvome o izvoru takšnih poškodb (prim. *sl. 19, 11* in *16* ter M. Brodar 1985). Robovi lukenj piščali takšnih zalomljenih ostankov nimajo.

V trenutku odkritja piščali žal nismo bili posebej pozorni na morebitne delčke udrte kortikalne lupine, ki bi lahko ostali v medularni votlini, zlasti pri prediranju lupine z otopelim (zbrušenim) zobom. Piščal je bila izluščena iz sredine večjega kosa zelo kompaktne breče, ki smo ga odkrhnili od debele, cementirane površine plasti 8. Medularna votlina, proti pričakovanju, ni bila zapolnjena z usedlinami niti ni breča segala vanjo na obeh odlomljenih koncih piščali. Zato je neverjetno, da bi v njej ostali drobci kortikalne lupine, ki bi se vdrla pod zobmi.

V zvezi z okoliščinami in sedimentnim okoljem najdbe se lahko vprašamo:

Zakaj sediment, kljub številnim odprtinam na piščali, ni prodrl v medularno votlino in se tam cementiral, kot se je to zgodilo pri vseh cevastih kosteh s *post mortem* dostopno medularno votlino v plasti s piščaljo. Zakaj se je inkrustirala in oblepila s sedimentom samo površina kosti? Zakaj se ni podobno zgodilo tudi z notranjostjo? Kaj pomenijo ostanki fosiliziranih dlak na oblepljeni površini kosti?



basis of associated isolated teeth.

Sl. 7: a) Bronasta maketa čeljusti volka in trgalni stroj ZWICK/Z 050 Fakultete za strojništvo v Ljubljani, s katerim smo naredili večino poskusov spomladi leta 1998. b) Predlagana mogoča uporaba koničastega orodja za izdelavo lukenj. c-d) Sprednji zobje psa in rjavega medveda. Vidna je močna paraksialna okluzija kaninov, ki je značilna za vse zveri.

Fig. 7: a) Bronze model of the jaws of a wolf and ZWICK/Z 050 universal testing machine at the Faculty of Engineering in Ljubljana, with which we carried out most of experiments in april, 1998. b) Proposed possible use of pointed tool for making holes. c-d) Front teeth of dog and brown bear. Note the strong paraxial occlusion of the canine teeth, which is typical of all carnivores.

3.1. **Izhodišče hipoteze**

Pri preučevanju možnosti, da je luknje na piščali naredila neka zver, moramo upoštevati tako splošne kot posebne pogoje, ki jih imajo zveri pri grizenju nasploh, in vse možne posledice, ki nastanejo pri grizenju kosti. Zadnje lahko predvidimo samo na podlagi poskusov. Ker z zvermi, četudi udomačenimi, nismo mogli izvesti zahtevnih eksperimentalnih ugrizov na svežih stegnenicah mladih rjavih medvedov, smo vse potrebne poskuse naredili z realističnimi maketami zverskega zobovja iz brona in železa (*sl. 7:* a). Tako smo se kar se da približali naravnim okoliščinam, v katerih bi lahko nastala piščal. Nismo pa mogli simulirati trdnosti pravih zob, refleksno deaktiviranje žvekalnih mišic pri preobremenitvi, neenakomerno krčenje žvekalnih mišic in narediti lukenj točno na istih mestih, kot so na piščali. Za vse pomanjkljivosti je kriv material, iz katerega smo izdelali umetna zobovja, delovanje trgalnega stroja, s katerim smo stiskali umetne čeljusti, in ne nazadnje stegnenica nedoraslega rjavega medveda, ki ima pri enaki starosti bistveno daljšo diafizo kot stegnenica nedoraslega jamskega medveda.

V zvezi z domnevo o takšnem izvoru lukenj na piščali ugotavljamo naslednje:

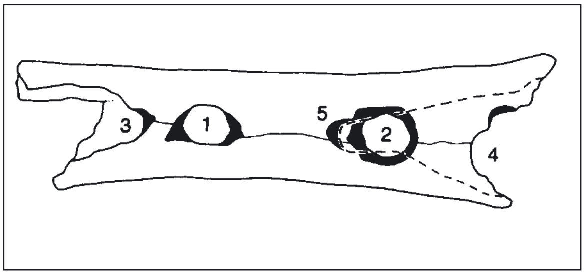
3-4 mm debelo kortikalno lupino na naluknjani stegnenici bi lahko predrli samo koničasti stalni zobje (kanini in nekateri ličniki) večjih odraslih zveri, kot so volk, jamska hijena, rjavi in jamski medved, leopard in jamski lev. Mlade zveri zaradi votlih in slabo ukoreninjenih stalnih zob ne pridejo v poštev (toda glej Sutcliffe 1970, 1112; d'Errico et al. 1998a, 14).

Zveri bi lahko naredile na piščali istočasno dve ali največ štiri luknje predvsem s kanini, s katerimi zgrabijo in držijo plen. S posebej oblikovanimi ličniki grizejo skoraj vedno samo z eno stranjo zobovja in to izključno med hranjenjem. Zaradi debelega mišičnega tkiva, ki pokriva zadnjo stran stegnenice, na kateri sta luknji 1 in 2 (zaradi praktičnih razlogov smo luknje in izjede na piščali oštevilčili kot je razvidno iz *sl. 8*), luknjanje s kanini *in vivo* ni bilo mogoče. Razen tega bi luknji v vsakem primeru nastali z dvema zaporednima ugrizoma, ekrat više drugič niže na stegnu (prim. Chase, Nowell 1998a, 551 s). Razdalja med luknjo 1 in 2 namreč ne ustreza medčeljustni razdalji nobene od naštetih odraslih zveri.

Medčeljustni razdalji kaninov (ali ličnikov) ustreza samo kombinacija luknje 2 in izjede 3 ter 5. V tem primeru moramo upoštevati tudi različne velikosti luknje in obeh izjed kot ostankov lukenj, ki naj bi jih naredili zobje. Te velikosti ne ustrezajo velikostim lukenj na rekonstruiranemu ugrizu, pri katerem bi eden od zob prvi predrl kortikalno lupino in se zato najgloblje zaril vanjo ter naredil največjo luknjo. Luknji (danes samo še izjedi 3 in 5) bi naredila tudi zob v okluziji in eden od zob v drugi čeljusti. Četrti zob kosti niti ne bi predrl niti jo ne bi bistveno poškodoval. To seveda ni mogoče (*sl. 9*).

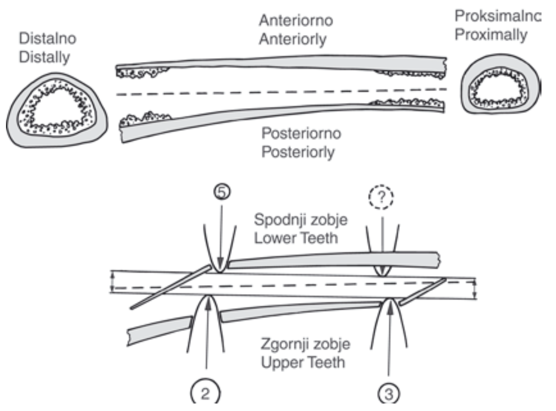
Ugriz s takšnimi posledicami bi na piščali teoretično lahko naredila jamska hijena. Pri uporabi šti-rih ličnikov (levi, desni, zgornji, spodnji) bi ugriz zahteval 2-krat večjo moč žvekalnih mišic kot pri običajnem grizenju samo z eno stranjo ličnikov. Pri uporabi vseh kaninov pa bi morale mišice sprostiti kar 3 do 4-krat večjo silo kot pri običajnem grizenju (izračunano in preverjeno na podlagi meritev na Fakulteti za strojništvo v Ljubljani). Četudi bi hijeni to uspelo, bi bile luknje popolnoma drugačnih velikosti, kot so luknja 2 in izjedi 3, 5 na piščali, luknja 2 in izjeda 5 pa bi bili bolj razmaknjeni (*sl. 9* in *10*).

Iz navedenega jasno sledi, da bi luknji in vse izjede na piščali lahko nastale samo ločeno kot posledica več ugrizov pri hranjenju ali treniranju zobovja in žvekalnih mišic.



Sl. 8: Oštevilčenje lukenj (1, 2) in izjed (3-5) na domnevni piščali. Črno je označena odkrušena medularna stran kortikalne kosti pri luknjah in izjedah (po rentgenskem posnetku).

Fig. 8: Numbered holes (1, 2) and notches (3-5) on suspected flute. In black is indicated crumbled medular side of the cortical bone with holes and notches (after x-ray picture).



Sl. 9: Idealna debelina kortikalne lupine diafize juvenilnega femurja jamskega medveda in rekonstrukcija ugriza z obema stranema zobovja.

Fig. 9: Ideal thickness of cortical bone of the diaphysis of the femur of a juvenile cave bear and reconstruction of the bite with both sides of dentition.

3.2. **Izsledki poskusov**

Tabele 2-4 kažejo povzetek grobih izsledkov naših poskusov luknjanja svežih femurjev še nedoraslih rjavih medvedov na trgalnem stroju ZWICK/Z 050 z realističnimi kovinskimi maketami zobovja hijene, volka in medveda.

Od uspelih eksperimentalnih lukenj, t. j. takih, pri katerih smo v celoti predrli kortikalno lupino, ne da bi kost pri tem po dolgem počila, so skoraj vse na metafizi ali v bližini metafiz. Tu tanka kortikalna lupina obdaja trabekularno kost (spongiozo), kar daje kosti viskoelastične lastnosti (Linde 1994). Zato se kost na teh mestih najlaže predre, ne da bi pri tem vzdolžno počila.

Skoraj vse značilne luknje in odtiski zob, ki so jih naredile zveri na dolgih kosteh, so dejansko na obeh metafizah oziroma epifizah. Ostali relativno pogosti odtisi in luknje od zob so na kratkih in ploskih kosteh, ki imajo podobno zgradbo kot meta- in epifize. To velja tako za recentno kot fosilno gradivo.

Poskusi so pokazali, da običajno udre ali predre kortikalno lupino samo en zob. Zob antagonist pri tem lahko ne pusti nobene sledi. Primeri, ko udreta ali predreta kortikalno lupino oba zoba (zgornji in spodnji) ali eden od njiju udre, drugi pa predre kost, niso ravno pogosti (*tab. 2*). Pri t. i. dvojnih luknjah in

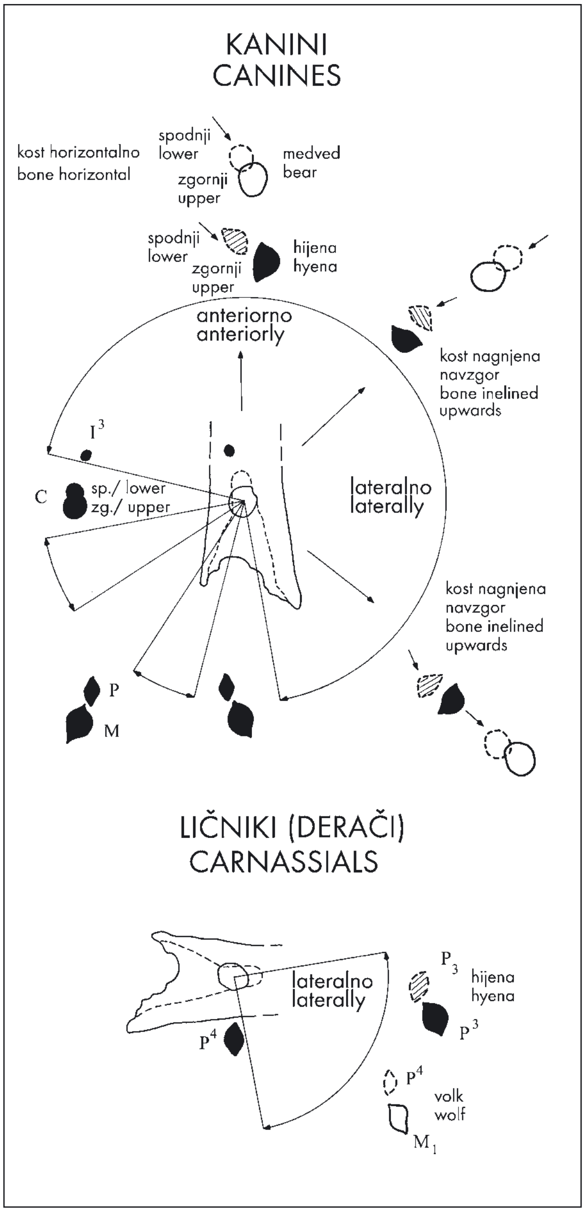
Tab. 2a: Posledice 33 luknjanj svežih femurjev rjavega medveda (29-krat juv. in 4-krat adult.).
Table 2a: Effects of 33 piercings of fresh femurs of brown bear (29 times on juvenile and 4 times on adult).

(n)	Enojni/e *Single*	Dvojni/e* *Double**	Skupaj *Total*
Odtiski *Depressions*	10	5	15
Luknje *Holes*	19	4	23
Skupaj *Total*	29	9	38

* Odtiska ali luknji, ki jih naredita oba zoba, zgornji in spodnji. *Depressions or holes made by both teeth, superior and inferior.*

Tab. 2b: Posledice 33 luknjanj svežih femurjev rjavega medveda (29-krat juv. in 4-krat adult.).
Table 2b: Effects of 33 piercings of fresh femurs of brown bear (29 times on juvenile and 4 times on adult).

(n)	Odtiski *Depressions*	Luknje *Holes*	Skupaj *Total*
Anteriorno *Anterior*	7	18	25
Posteriorno *Posterior*	13	9	22
Skupaj *Total*	20	27	47



Sl. 10: Delovno območje kaninov in tretjega zgornjega sekalca na domnevni piščali. Rezultati ugriza s kanini pri različni usmeritvi in naklonu domnevne piščali. Glej razporeditev odtiskov zob glede na okluzijo zob, smer in naklon predmeta grizenja. Delovno območje ličnikov na domnevni piščali in razporeditev odtiskov zob glede na okluzijo zob.
Fig. 10: Working area of canine teeth and upper third incisor on the suspected flute. Results of bite with canine teeth by various orientation and inclination of the suspected flute. Note disposition of tooth punctures according to teeth occlusion and orientation and inclination of chewed object. Working area of cheek teeth on the suspected flute and disposition of tooth punctures according to teeth occlusion.

→

Sl. 11: Eksperimentalne luknje na svežih femurjih juvenilnih rjavih medvedov (številke na diagramih: 1 predrtje lupine, 2 širjenje luknje. 3 pokanje lupine. Ordinata: sila v N. Abcisa: globina (v mm) do katere je prodrl vrh konice): a) Luknja, narejena z ostrim spodnjim kaninom medveda v izbočeni anteriorni steni osrednjega dela diafize. Premer luknje je 7,5 mm. b) Luknja, narejena s trnom premera 12 mm, 83 mm od stika med distalno metafizo in epifizo na ravni posteriorni steni diafize. Premer luknje je 8 mm. c) Luknja, narejena z ostrim spodnjim kaninom medveda v izbočeni anteriorni steni diafize 105 mm od stika med distalno metafizo in epifizo. Premer luknje je 7,5 mm. d) Luknja, narejena z ostrim zgornjim kaninom medveda v izbočeni anteriorni steni diafize 121 mm od stika med distalno metafizo in epifizo. Premer luknje je 7,7 mm.

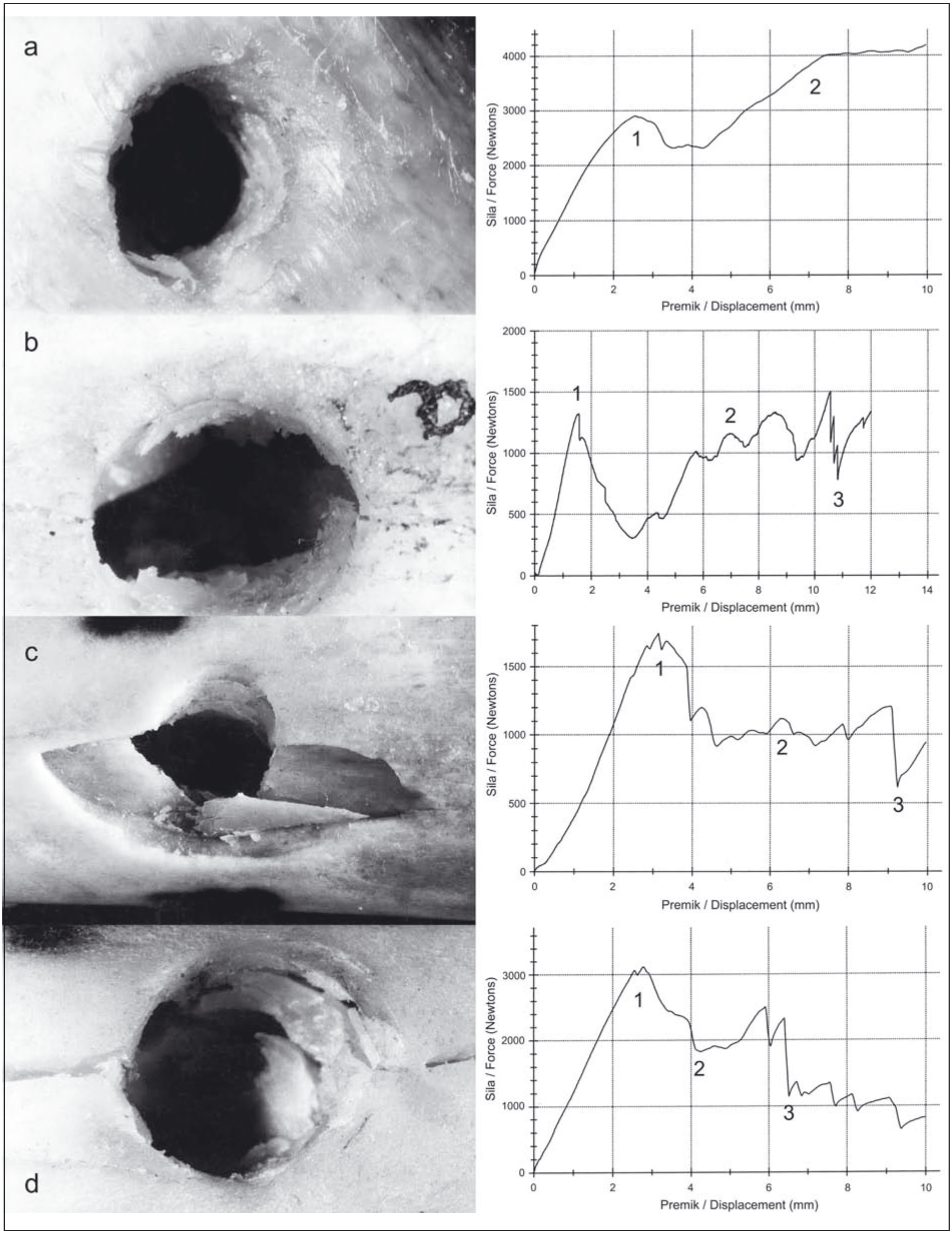


Fig. 11: Experimental holes in fresh juvenile femurs of brown bear (numbers of the diagrams: 1 pierced hole, 2 widening of the hole, 3 cracking of the cortical bone. Ordinate: force in Newtons Abscissa: depth (in mm) to which the tip of the point advanced): a) Hole made in the convex anterior shell of the central part of diaphysis with sharp lower canine tooth of a bear. The diameter of the hole is 7.5 mm. b) Hole made with a thorn diameter of 12 mm, 83 mm from the contact between the distal meta- and epiphysis in the flat posterior shhell of diaphysis. The diameter of the hole is 8 mm. c) Hole made with sharp lower canine tooth of a bear 105 mm from the contact between the distal meta- and epiphysis in the convex anterior shell of diaphysis.The diameter of the hole is 7.5 mm. d) Hole made with sharp upper canine tooth of a bear 121 mm from the contact between the distal meta- and epiphysis in the convex anterior shell of diaphysis. The diameter of the hole is 7.7 mm.

odtiskih smo jih polovico (53 %) dobili na anteriorni strani femurja (*tab. 2b*). Na piščali imamo na tej strani ostanek ene same luknje (*sl. 8:* 5; *12:* f). V najbolj številni zbirki naluknjanih femurjev juvenilnih jamskih medvedov iz Mokriške jame (orinjasjen) imamo 7 lukenj na posteriorni in 6 na anteriorni strani (M. Brodar 1985). Od lukenj na anteriorni strani jih je polovica na femurjih s sledovi grizenja. Od lukenj na posteriorni strani je samo ena na femurju s sledovi grizenja.

Nastanek skoraj polovice (40 %) poskusnih lukenj, ki smo jih naredili na diafizi, je povezan z vzdolžnim pokanjem kortikalne lupine po domala celotni dolžini diafize. Kot vemo, je diafiza zgrajena skoraj izključno iz najdebelejše in manj elastične, plastovite kortikalne lupine, ki obdaja medularni kanal (Klevezal 1996, 16 ss). Zato je kost tu najtežje predreti. Vzdolžne razpoke nastanejo še posebej rade pri luknjah na osrednjem delu diafize in pri širjenju lukenj do premera, ki je večji od 5 mm. Potrebno je poudariti, da kost ne poči samo na strani, na kateri nastane luknja, temveč tudi na nasprotni strani pod zobom v okluziji, ne glede na to ali nasprotni zob kost predre, udre ali pusti komaj vidno sled. Predhodna odstranitev epifiz nedvomno poveča pogostnost razpok.

Na recentnem in fosilnem gradivu so luknje na diafizah skrajno redke v primerjavi z luknjami na meta- in epfizah ter na kratkih kosteh (M. Brodar 1985; Gargett 1996; Albrecht et al. 1998; toda glej d'Errico et al. 1998b: 9, tab. 1). Na podlagi morfologije ne moremo trditi, da so značilne izključno za zveri. Razporeditev lukenj živalskega izvora na cevastih kosteh je nedvomno obratno sorazmerna s silo, potrebno za luknjanje kortikalne lupine (glej *tab. 4*). Sila je premo sorazmerna z ontogenetsko starostjo kosti. Zato so skoraj vse nam znane luknje na epi- in metafizah juvenilnih primerkov (glej M. Brodar 1985, t. 3-5; Albrecht et al. 1998, 11).

Vprašanje je, kakšen bi bil motiv zveri, ki bi naluknjala diafizo, potem ko bi predhodno odstranila epifizi in poškodovala metafizi (prim. Chase, Nowell 1998a, 550). Ko zob enkrat predre kortikalno lupino, deluje kot zagozda, ki kost razkolje. Razklati kost je namen zveri (volkov, hijen), ki se občasno hranijo s kostmi in s kostnim mozgom. Naše meritve so pokazale, da je največja sila potrebna za preluknjanje kortikalne lupine diafize in za nadaljnje prodiranje zoba v lupino, kar je povezano s širjenjem luknje (*sl. 11*). Med širjenjem luknje kortikalna lupina slej ko prej poči. Počeno kost je mogoče razcepiti na dva dela že s polovico prvotne sile. Novo vprašanje, ki ga moramo pojasniti, če zagovarjamo zverski nastanek lukenj in poškodb na piščali, je, zakaj bi zver odnehala, potem ko bi po vsaj dveh poskusih že skoraj dosegla svoj namen.

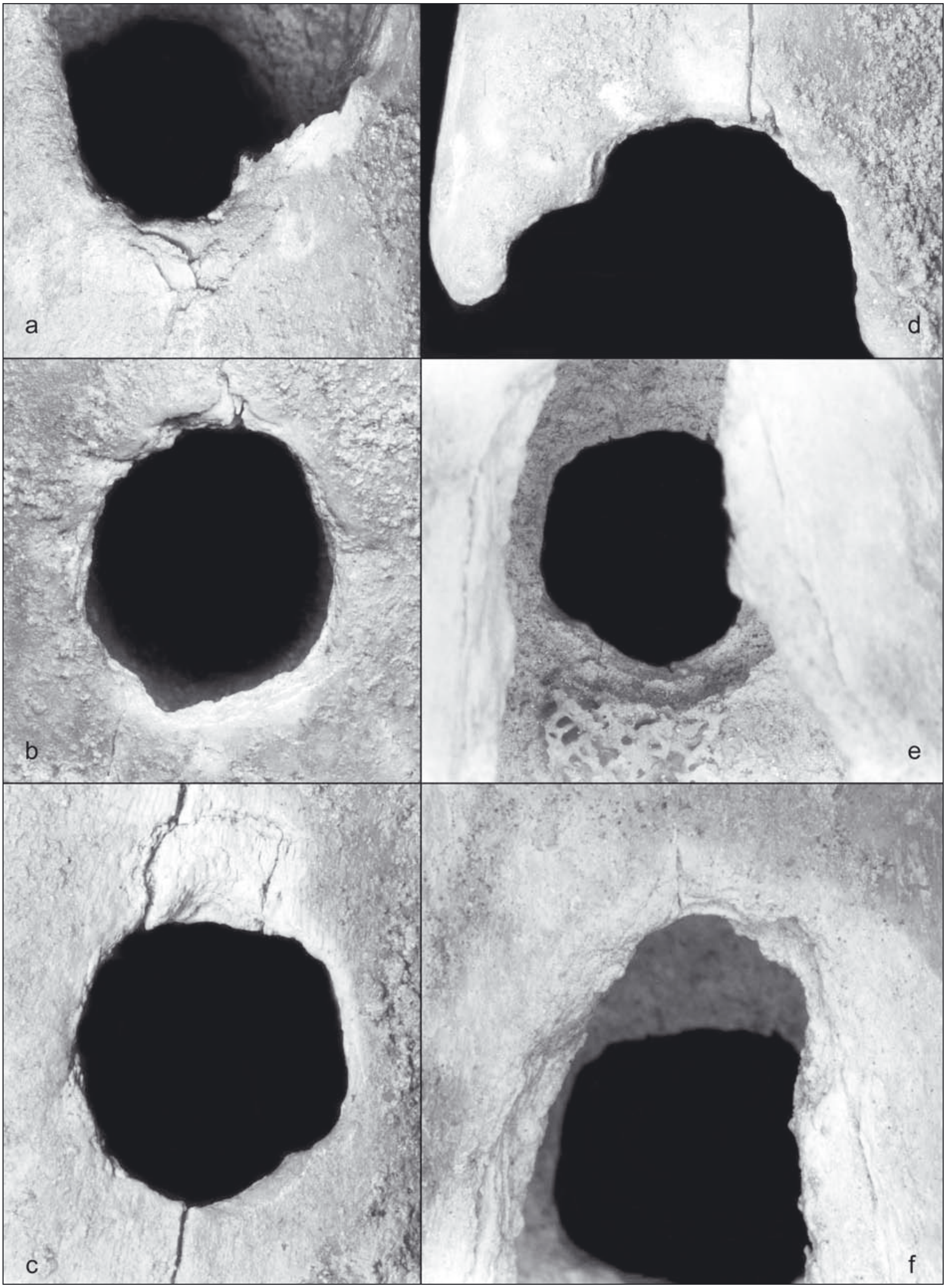
Iz navedenaga sklepamo, da so možnosti, da bi dve ali celo tri, štiri luknje na piščali naredila katerakoli zver s katerimkoli od koničastih zob, in da pri tem ne bi razklala diafize, skrajno omejene.

Luknji na piščali sta tako veliki (9,7 x 8,2 in 9,0 x 8,7mm) in na takem mestu, da bi zob, ki bi se najmanj dvakrat zaril tako globoko, kost skoraj zanesljivo razklal. To bi se glede na naše poskuse zgodilo, neglede na to ali bi bil zob oster ali top. Na mestih, kjer razpoka, po kateri se kost razkolje, izhaja iz luk-nje, ki jo je naredil zob, se pogosto odkrhne ena ali več lamel površinske plasti kortikalne lupine (*sl. 11:* d). Na piščali so tako vzdolžne razpoke kot neizraziti negativi lamelnih odkruškov površinske plasti kortikalne lupine ponekod ob luknjah in izjedah (*sl. 12:* b). Ni pa nobene razpoke, ki bi jo lahko pripisali večkratnemu stisku zoba antagonista. Takšna razpoka bi morala potekati v obeh smereh, proksimalno in distalno od prijemališča zoba. Da bi po dveh ali več zelo močnih ugrizih nastala takšna razpoka samo na eni, naluknjani strani, se nam zdi, glede na naše poskuse, malo verjetno. Možnosti, da so razpoke na piščali po nastanku sekundarne, ni mogoče izključiti. Tako kot je počena piščal, je počenih tudi veliko nedotaknjenih celih cevastih kosti v najdišču. Na *sl. 13:* h je prikazan šolski primer vzdolžnega cepljenja močno preperele kortikalne lupine diafize v sedimentu.

V najdišču Divje babe I, kjer smo sistematično pobrali in analizirali vse kostne ostanke večje od 1 cm, in v drugih nam znanih najdiščih, kjer so selektivno zbirali kosti z luknjami, nam ni znan noben primerek, ki bi imel luknjo na počeni diafizi, tako da bi bilo očitno, da sta luknja in razpoka nastali istočasno. Pač pa imamo vsaj v našem najdišču nekaj redkih nesestavljivih vzdolžnih odlomkov diafiz, ki imajo ob vzdolžnem prelomu polkrožno izjedo (*sl. 13:* a-f).

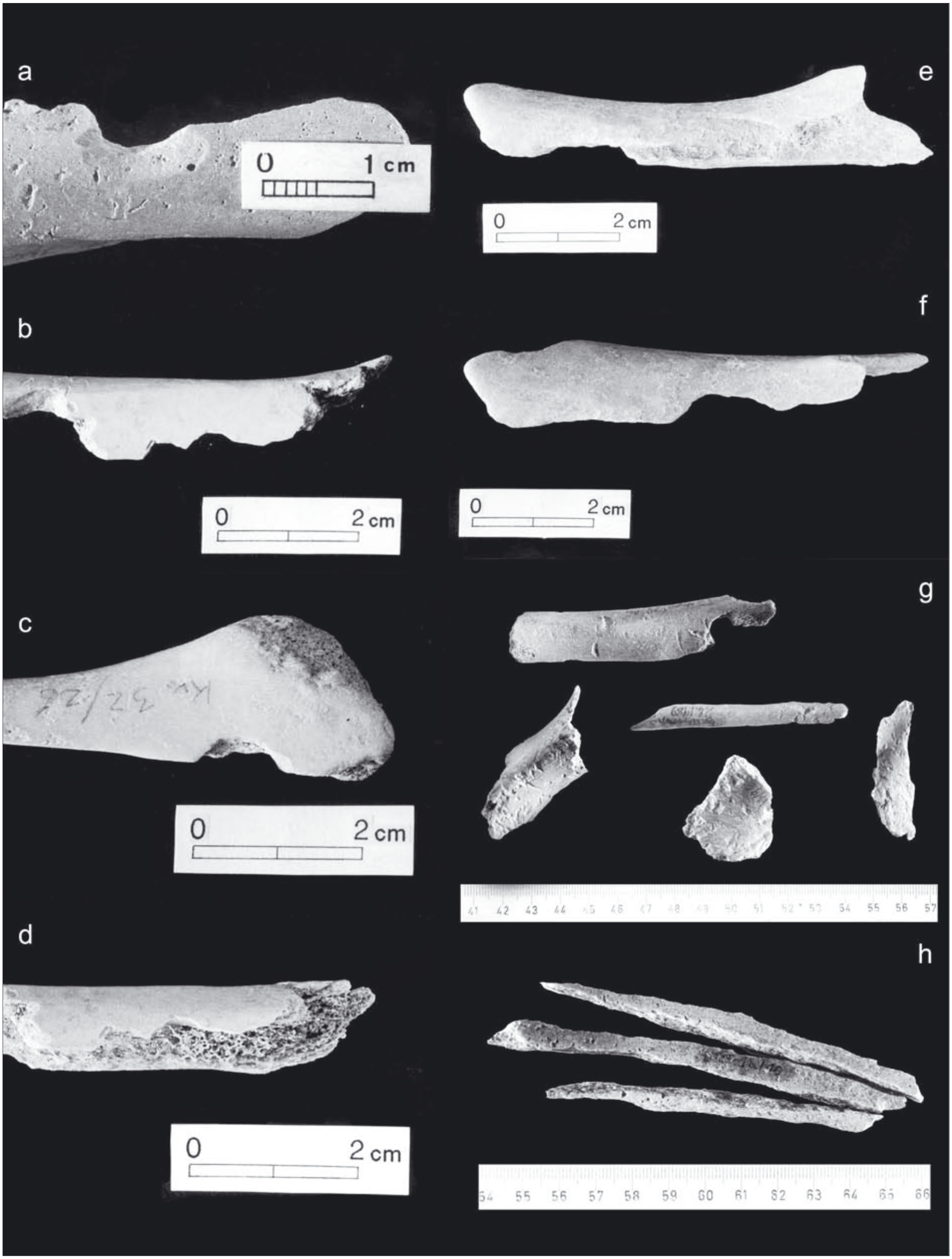
Mislimo, da so zveri v Divjih babah I zelo redko naluknjale cevaste kosti, kar lahko dokažemo tudi s statistiko pojavnosti lukenj v plasteh 2-7 in posebej v plasti 8, kjer je bila najdena piščal. Vseh naluknjanih kosti je približno 8 na 100.000 vseh določljivih kosti v plasteh 2-7 in približno 11 na 50.000 določljivih kosti v plasti 8. Vseh kosti s polkrožno izjedo je pri-bližno 9 na 100.000 vseh določljivih kosti v plasteh 2-7 in približno 12 na 50.000 določljivih kosti v plasti 8.

Če so zveri naluknjale cevaste kosti bolj pogosto, kot smo predvideli na podlagi najdb, so diafize razklale in razklane dele požrle. Vzdolžni odlomki diafiz z značilnimi zverskimi poškodbami so v najdišču namreč prav tako redki: manj kot 4 primerki na 100.000 vseh določljivih kosti ali na 3000 adultnih in juvenilnih diafiz brez diafiz fibul in metapodijev v plasteh 2-7 in 3 primerki na 50.000 vseh določljivih kost ali na 1860 podobnih diafiz v plasti 8 (*sl. 13:* g).



Sl. 12: Makroskopski posnetki lukenj in izjed na domnevni piščali: a) izjeda 3, b) luknja 1, c) luknja 2, d) izjeda 4, e) izjeda 5 in luknja 2, f) izjeda 5. Za številke lukenj in izjed glej *sl. 8*.

Fig. 12: Macroscopic pictures of holes and notches on suspected flute: a) notch 3, b) hole 1, c) hole 2, d) notch 4, e) notch 5 and hole 2, f) notch 5. For numbers of holes and notches see on *Fig. 8*.



Sl. 13: Iveri dolgih kosti s poškodbami, pri katerih je mogoče identificirati povzročitelja poškodb: a-f) Iveri diafiz z izjedo, ki jo je lahko naredil zob, preden se je diafiza razklala na dvoje ali potem. g) Obgrizene iveri. h) Postsedimentno razklana iver kortikalne kosti. Vse Divje babe I, različne plasti. Merilo v cm.

Fig. 13: Splinters of long bones with possible identification of origin of damage on them: a-f) Splinters of diaphyses with notches that could have been made by teeth before or after the diaphysis split in two. g) Chewed splinters. h) Post-sedimentary splinters of cortical bone. All Divje babe I, various layers. Scale in cm.

V nasprotju z zgoraj navedenim pa je v Divjih babah I več odtiskov na metafizah, epifizah in kosteh s tanko kortikalno lupino (približno 3 na 10.000 vseh določljivih kosti v plasteh 2-7 in približno 5 na 5200 vseh določljivih kosti v plasti 8). Skoraj vsi odtiski so na kosteh juvenilnih primerkov.

Odtiskov je bistveno več kot lukenj, ker zverem vedno ne uspe predreti kortikalne lupine (glej tudi Gargett 1996, 132, tab. 6.2). Takšno stanje je lahko tudi posledica tega, da so bile na delu zveri, katerih osnovno zanimanje so bila mehka tkiva in ne kosti. Mednje vsekakor spadata rjavi in jamski medved (glej podpoglavje 3.3.).

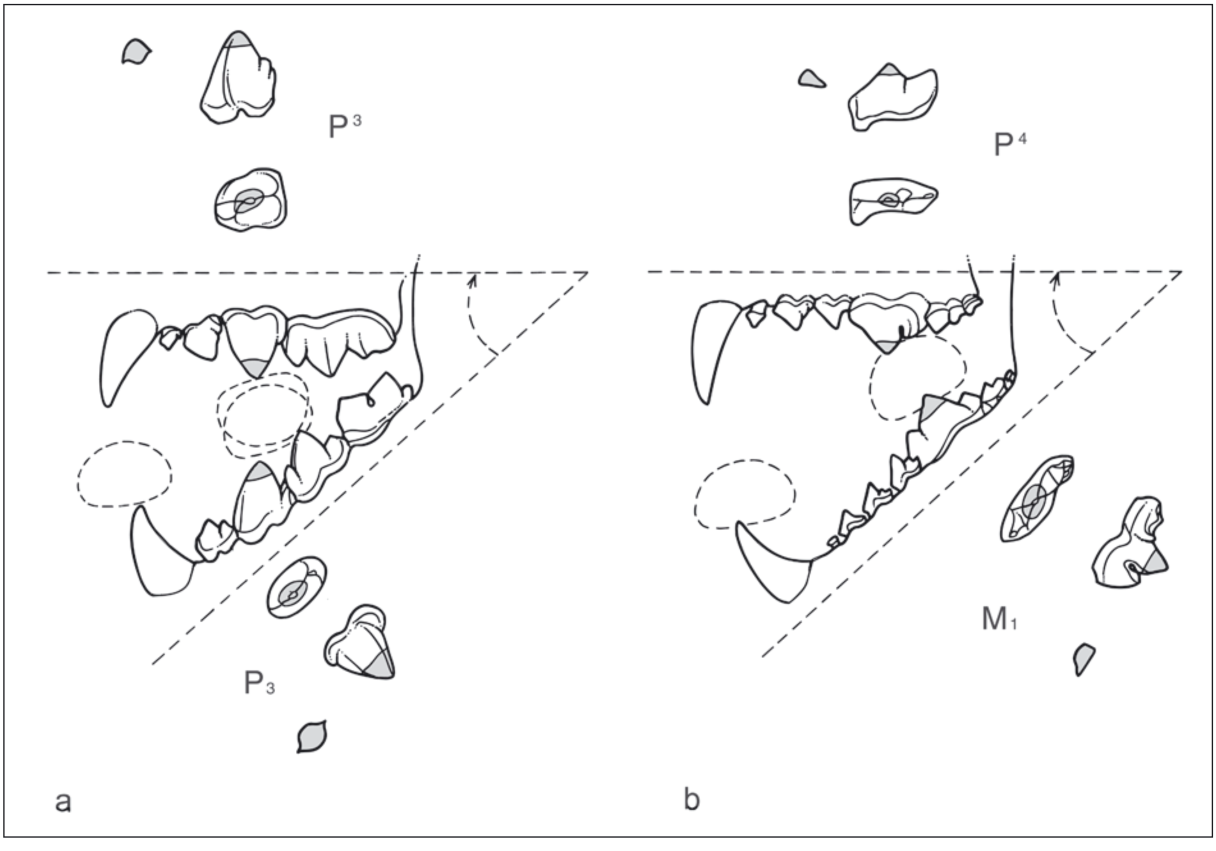
Med plastjo 8 in plastmi 1-7 obstajajo precejšne kvantitativne razlike, kar zadeva luknje in odtiske na kosteh. Te razlike so nesporno posledica povečane dejavnosti nekaterih zveri v času odlaganja plasti 8 in/ali zmanjšane dejavnosti teh istih zveri v času odlaganja plasti 2-7. To pa ne velja za zverske poškodbe na splošno, ki se pojavljajo na večini skeletnih delov, predvsem mladih primerkov, in dajejo drugačno sliko (*tab. 5*). Predvsem ni opazna povečana dejavnost zveri v zgornjem delu plasti 8, kjer je bila najdena piščal in v plasti 7. Na podlagi fargmentarnosti femurjev pa bi lahko trdili prej nasprotno (prim. *sl. 3, 4*).

3.3. **Oblika in razporeditve lukenj ter vrsta poškodb na piščali v luči prve hipoteze**

Lega odtiskov in lukenj skoraj izključno na konceh dolgih fosilnih kosti je posreden dokaz za to, da so zveri z normalnimi grizalnimi navadami delovale predvsem z ličniki (premolarji in molarji). Zveri s temi zobmi ne morejo doseči diafize brez predhodne odstranitve epi- in metafiz(e). Brez te predhodne operacije jo lahko dosežejo samo s kanini. Da so nekatere zveri grizle tudi s kanini, dokazujejo predvsem redki odtiski zob na težko dosegljivih in ne-običajnih mestih na vretencih (*sl. 15:* e-f). Ti so verjetno nastali pri oddvanju delov hrbtenice in/ali glave. Odtiski, narajeni s kanini, so tudi značilne okrogle oblike.

Glede na velikost lukenj na piščali in silo, ki je potrebna za preluknjanje diafize femurja nedoraščenega rjavega medveda (glej *tab. 4*), pridejo v našem primeru v poštev zveri od velikosti volka naprej. Te so, poleg volka, še: jamska hijena, jamski in rjavi medved, leopard in jamski lev. Ostanke vseh, razen hijene, smo doslej našli v različnih plasteh našega najdišča, vključno s plastjo, v kateri je bila piščal.

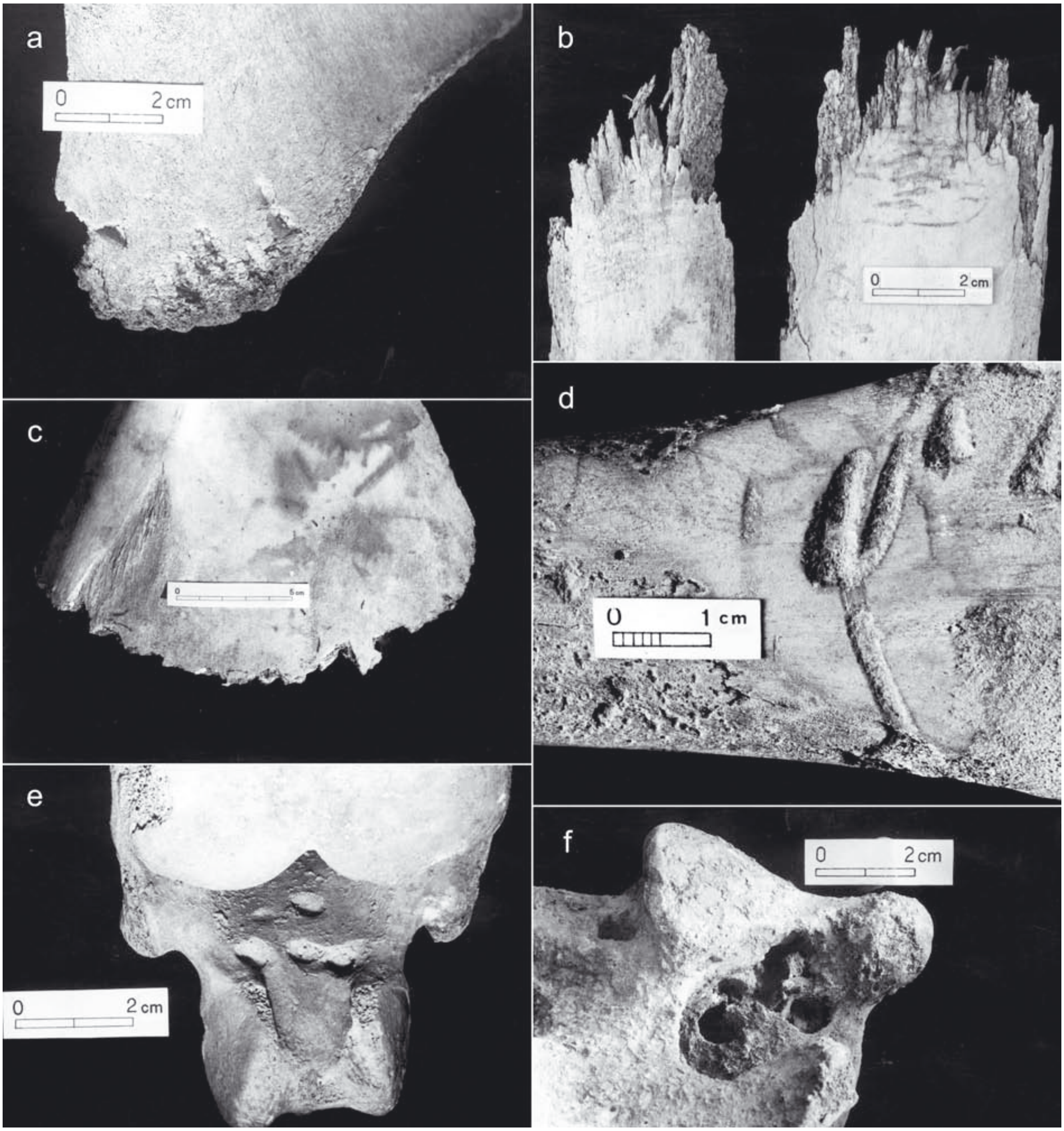
Zveri različno ravnajo s kostmi. Volkovi in hijene se z njimi tudi hranijo, pri čemer jih pogosto poškodujejo. Ostalih zveri kosti posebej ne zanimajo,



Sl. 14: Zobni aparat hijene (a) in volka (b) z označenimi zobmi, ki pridejo v poštev za luknjanje in predvidena oblika lukenj.
Fig. 14: Dentition of a hyena (a) and wolf (b) with teeth marked which enter into consideration for making holes, and the envisaged shape of holes.

vendar jih lahko hote ali nehote poškodujejo med plenjenjem in hranjenjem.

Vse zveri drobijo kosti z ličniki, pri čemer uporabljajo samo eno stran zobovja. Vse mesojede zveri imajo na vsaki strani čeljusti krono enega zgor-njega in spodnjega ličnika posebej prirejeno za zelo učinkovit škarjast ugriz, korenine teh zob pa so prilagojene na velike obremenitve, ki nastanejo pri stiskanju, t. j. premikanju gibljive spodnje čeljusti proti negibljivi zgornji čeljusti (*sl. 14*). To sta zoba derača, ki služita izključno razkosavanju trših in bolj žilavih delov plena (Hillson 1990, 17, sl. 1.5). Vsejede zveri, kamor sodijo tudi medvedi,



Sl. 15: Poškodbe od zob na recentnih in fosilnih kosteh: a) Odtiski deračev volka na robu goveje *os ilium* z mrhovišča v Sloveniji. b) Poškodbe od molarjev divje svinje na distalnih delih govejih in konjskih reber z mrhovišč v Sloveniji. c) Od medveda zgrizen *margo vertebralis* goveje lopatice z mrhovišča v Sloveniji. Poškodbe so bile narejene s sprednjimi zobmi. d) Raze od medvedjih kaninov (glej *sl. 19:* c) v bližini distalne metafize juvenilnega femurja jamskega medveda iz Mokriške jame. e,f) Odtiski kaninov (medveda ali hijene?) v *foramen vertebrae* ledvenega in drugega vratnega vretenca iz Divjih bab I, plast 8.

Fig. 15: Teeth damage on recent and fossil bones: a) Punctures of the carnassial teeth of a wolf on the edge of cattle *os illium* from a feeding site in Slovenia. b) Demage from cheek teeth of wild boar on the distal end of cattle or horse ribs from feeding sites in Slovenia. c) *Margo vertebralis* of cattle shoulder blade from a feeding site in Slovenia chewed by bear. Damage was done by front teeth. d) Furrows from bear canine teeth (see *Fig. 19:* c) in the vicinity of the distal metaphysis of a femur of juvenile cave bear from Mokriška jama, Slovenia. e,f) Punctures of canine teeth (of bear or hyena?) in the *foramen vertebrae* from Divje babe I, layer 8.

takšnih zob nimajo, zato si pri razkosavanju pomagajo izključno s sprednjimi zobmi.

Vse zveri uporabljajo sprednje zobe za ubijanje plena in za to, da si odgriznejo grižljaje hrane. Mesojedim predstavljajo ti zobje, zlasti ukrivljeni kanini z izredno močno korenino, glavno orožje. Zato jih skrbno čuvajo in, če se le da, ne obremnjujejo napačno in do stopnje, ko se lahko odlomijo.

Zgornji in spodnji kanini zaradi svoje dolžine in ukrivljenosti niso nikoli v osi (*sl. 7:* c, d). Zaradi tega pride pri stiskanju z njimi, odvisno od trdnosti stiskanih materialov, hkrati do največjega učinka krivljenja in strižnih napetosti v primerjavi z vsemi ostalimi zobmi. To ima lahko pri zelo trdih materialih različne posledice: Ali spodrsavanje predmeta stiskanja ob konicah kaninov. Ali spodrsavanje ene od konic ob predmetu stisknja, če je predmet imobiliziran z drugim kaninom. Ali v skrajnem primeru poškodbo ali odlom koničastega dela zoba, če je predmet stiskanja primerno trden in nepremičen. Zgradba zobovine (dentina) je namreč takšna, da v nasprotju z osnimi ne prenese večjih stranskih obremenitev (Klevezal 1996; Hilsson 1990, 152 ss).

Tab. 3: Posledice 39 luknjanj svežih femurjev rjavega medveda (32-krat juv., 1-krat subadult. in 6-krat adult.).
Table 3: Effects of making 39 holes on fresh femurs of brown bear (32 juvenile, one sub-adult and 6 adult).

(n)	Brez razpoke *Without fissure*	Z razpoko *With fissure*	Skupaj *Total*
Enojne luknje *Single hole*	13	11	24
Dvojne luknje *Double hole*	4	0	4
Enojni odtiski *Single depression*	15	5*	20
Skupaj *Total*	32	16	48

* Vsi odtisi razen enega, narejenega s trnom, so nastali hkrati z enojno luknjo z razpoko! *All the depressions except one, made with a thorn, were made simultaneously with a single hole with fissure.*

Tab. 4: Izmerjna sila (N) na konicah zob, ki je bila potrebna za odtiskovanje in luknjanje kortikalne lupine svežih femurjev rjavega medveda. Naveden je razpon (od,do), povprecje (krepko) in število meritev (v oklepaju).
Table 4: Measured force (Newtons) at the tips of teeth rquired for depressing and piercing the compact bone of the fresh femurs of brown bear. The range (from, to) is given, the average (bold type) and number of measurements (in brackets).

Juvenilni *Juveniles*	Odtisek *Depression*	Metafiza *Metaphysis*	1050, **1050** (1)
		Diafiza *Diaphysis*	850-2300, **1570** (2)
	Luknja *Hole*	Metafiza *Metaphysis*	850-1320, **1085** (2)
		Diafiza *Diaphysis*	710-4180, **2420** (14)
Sub- in adultni *Sub- and Adults*	Odtisek *Depression*	Epifiza *Epiphysis*	2540-3310, **2910** (3)
		Diafiza *Diaphysis*	1310-2670, **1990** (2)
	Luknja *Hole*	Epifiza *Epiphysis*	2050-3640, **2690** (3)
		Diafiza *Diaphysis*	2320-7980, **4550** (9)

Tab. 5: Zastopanost zverskih poškodb v doslej raziskanih plasteh v predelu jame, kjer je bila najdena piščal.
Table 5: Frequency of carnivore damage on bones in layers near the flute's location.

1	Plast(i) *Layer(s)*	2 - 6	7	8 zgoraj *upper*	8 sredina *middle*	8 spodaj *lower*
2	Vseh obgrizenih kosti *Total of chewed bones* *	237	5	15	31	35
3	Vseh kostnih ostankov *Total of bone remains* **	460 000	42 000	104 000	76 000	92 00
4	ŠDO *NISP* ***	91 000	7 000	21 000	14 000	16 000
5	Razmerje 3/2 *Ratio 3/2*	1940	8400	6933	2451	2681

* V tej kategoriji so tudi nedoločljivi odlomki. *This category includes also unidentified fragments.*
** V tej kategoriji so nedoločljivi ostanki in ŠDO. *This category includes unidentified fragments and NISP.*
*** ŠDO Število določljivih ostankov. *NISP Number of identified specimens.*

Kot vsako zobovje je tudi zobovje zveri simetrično. V zvezi z luknjami na piščali je pomembno dejstvo, da zveri načelno ne morejo premikati spodnje čeljusti v nobeni drugi smeri kot navzgor in navzdol. Zato se odtis zgornjih in spodnjih zob pri ponavljanju ugriza ne premika iz osi, ki jo določa geometrija čeljusti in oblikovanost ter usmeritev (aksialna, paraksialna) posameznih zob. Poškodbe na predmetih grizenja nastanejo izključno zaradi stiskanja z zobmi ali zaradi spodrsavanja predmeta grizenja ob zobeh (*sl. 15:* d). V nobenem primeru ne gre za podrsavanje zob po predmetu grizenja (žvečenje v pravem pomenu besede), ki pušča bistveno drugačne sledove (*sl. 15:* b).

Naštete lastnosti zverskega zobovja, vključno z zgradbo zob, biomehaniko čeljusti in povratnim delovanjem receptorjev, ki preprečujejo preobremenitev vsakega posameznega zoba, moramo zagotovo upoštevati pri analizi lukenj na sporni piščali. Prav tako moramo upoštevati maneversko območje zob, ki pridejo v poštev za luknjanje. To je veliko večje pri kaninih kot pri ličnikih (*sl. 10*).

Oglejmo si zdaj možnosti, ki jih imajo posamezne zveri za luknjanje cevastih kosti, predvsem diafize. Zagovorniki domneve o naravnem izvoru lukenj si niso enotni, katera zver bi naredila luknje in s katerim zobom (Albrecht et al. 1998; Chase, Nowell 1998a,1998b; D'Errico et al. 1998a, 1998b).

Volk, ki ga predlagata P. Chase in A. Nowell (1998a, 550), je brez jamskega medveda najbolje zastopna zver v Divjih babah I. Volku lahko pripišemo tudi največ obgrizenih kosti, med katerimi močno prevladujejo kosti mladih primerkov. Volkovi so lahko povzročili tudi očitno odsotnost nekaterih manj trdnih skeletnih delov (*sl. 5*).

Volk lahko naluknja kost izključno z derači (*sl. 14:* b). Izmerjena sila ugriza z ličniki pri psih velikosti volka (največ 1394 N - Lindner et al. 1995, tab. 1) namreč komaj dosega izmerjeno potrebno silo za predrtje kortikalne lupine juvenilne diafize (prim. Lindner et al. 1995 in *tab. 3*). Pri uporabi kaninov morajo žvekalne mišice zaradi podaljšane ročice sprostiti najmanj 1,6-krat večjo silo (izračunano na podlagi mer čeljusti), da je učinek kaninov enakovreden unčinku deračev (prim. Lindner et al. 1995, 51) . Ne glede na to ali volk to zmore ali ne, so volčji kanini prešibki, da bi prenesli delovanje upogibne in strižne sile, ki nastaneta pri stiskanju s kanini. Pri poskusnem luknjanju diafize se nam je eden od kovinskih kaninov takoj ukrivil. Pravi kanin bi se odlomil, predno bi se zaril do potrebne polovice višine krone v 3-4 mm debelo kortikalno lupino in naredil približno tako veliki luknji kot sta na piščali oziroma bi volk prej odnehal zaradi bolečine v zobeh, ki varuje zobovje pred mehanskimi poškodbami. Kanini se pogosto odlomijo večjim psom, ki imajo to neobičajno navado, da z njimi grizejo trde predmete (Le Brech et al. 1997). Vsekakor je tako grizenje s takimi posledicami nenormalno in pri divjih mesojedih zvereh, če sploh obstaja, težko razložljivo drugače kot bolezensko (steklina?).

Odtiski najvišje štrlečih konic (parakona in protokonida) volčjih deračev (zgornji četrti premolar in spodnji prvi molar) so bistveno različni od oblike lukenj na piščali (prim *sl.* *12* in *15:* a; *16:* a). Zato in zaradi same razporeditve luknje 2 in izjede 5, ki ne ustreza okluziji teh zob (*sl.* *10*), lahko volka upra-vičeno izključimo s seznama kandidatov za luknjanje piščali (toda prim. Chase, Nowell 1998a, 552).

Jamska hijena, ki jo predlaga G. Albrecht s sodelavci (1998, 16), v najdišču ni zastopana niti z neposrednimi osteoodontološkimi ostanki niti s koproliti niti nista posredno potrdila njene prisotnosti tafonomska analiza in podroben pregled poškodb na množičnih kostnih ostankih jamskega medveda.

Tafonomska slika našega gradiva nima prav nič skupnega s tafonomsko sliko, ki je značilna za dejavnost hijene (Zapfe 1942; Sutcliffe 1970; Brain 1981; Marean et al. 1992; Stiner 1995, 250, sl. 9.10; d'Errico, Villa 1997; Arribas, Palmquist 1998). Hijena bi zanesljivo požrla večino kosti šap tako mladih kot odraslih primerkov (Lyman 1994, 215). Slednjih bi bilo v zgor-njem delu plasti 8 bistveno manj kot v drugih plasteh. Vendar temu ni tako (*sl.* *6*). Doslej nismo v nobeni pla-sti našli za hijenino dejavnost značilno oblikovanih kostnih odlomkov, vključno s prebavljenimi kostmi (d'Errico, Villa 1997).

Jamska hijena bi bila tako kot njena današnja sorodnica sposobna narediti luknje v piščal in kost tudi razklati (Zapfe 1942; Sutcliffe 1970). Za luk-njanje prideta v poštev samo oster zgornji ali spodnji tretji premolar - t. i. drobilca (s topimi premolarji luknjanje ni izvedljivo zaradi prekratkih konic!) in oster ali top zgornji ali spodnji kanin (*sl.* *14:* a) (glej Ewer 1954, 191; Brain 1981, 69 ss). Luknjanju in drobljenju kosti so pri hijeni prilagojeni vsi ličniki in ne samo zadnji kot pri drugih zvereh. Hijena lahko tako zdrobi večje kosti kot ostale zveri, ker ji pri prijemu s sprednjimi ličniki ni treba toliko iztegniti žvekalne mišice, da bi pri tem izgubila del moči.

Odtiska konic obeh premolarjev sta drugačne oblike kot luknji 1-2 na piščali (prim. *sl.* *12* in *16:* d). Za luknjo 2 in odlom v obliki črke »V« na sprednji strani stegnenice, ki se konča z manjšo izjedo 5, nekateri trdijo, da sta nastali istočasno pod pritiskom zgornjega in spodnjega zoba v okluziji (Chase, Nowell 1998a, 551; d'Errico et al. 1998a, 77). Naši poskusi, s katerimi smo simulirali takšen ugriz, so pokazali, da odlom in izjeda 5 na piščali nista mogla nastati hkrati. Kost sicer lahko vzdolžno poči zaradi pritiska zoba, vendar nastane na obeh straneh luknje, katere ostanek predstavlja izjeda 5, vedno ena, izjemoma več vzdolžnih razpok (*sl.* *11:* d in Kunej, Turk 2000, sl. 15.2: c). Ker iz izjede 5 izhaja komaj zaznavna razpoka, je bolj verjetno, da je bila izjeda, preden se je kost zalomila, sestavni del manjše luk-nje, ki je zaustavila naknadni »V« odlom dela kortikalne lupine. Obstoj takšne luknje se nam pred poskusi z zobmi ni zdel verjeten, čeprav so nas nekateri nanjo opozarjali (prim. Turk et al. 1997 in Omerzel-Terlep 1996, 281; Otte 2000).

Morfologija robov luknje 2 in izjede 5 je tako različna, da si razlike težko razložimo z ugrizom. Isto velja za luknjo 1 in izjedo 3 (*sl.* *12*). Pemolarji bi morali pustiti bolj poenotene obrise robov lukenj. Razlike je komaj mogoče razložiti s selektivnim mehanskim prepereva-njem robov lukenj 1-2 in izjed 3-5 v različnih mikrookoljih (prim. Chase, Nowell 1998a, 552). Luknje in izjede z različno preperelimi robovi so za kaj takega preveč neenakomerno razporejene po kosti (*sl.* *8*).

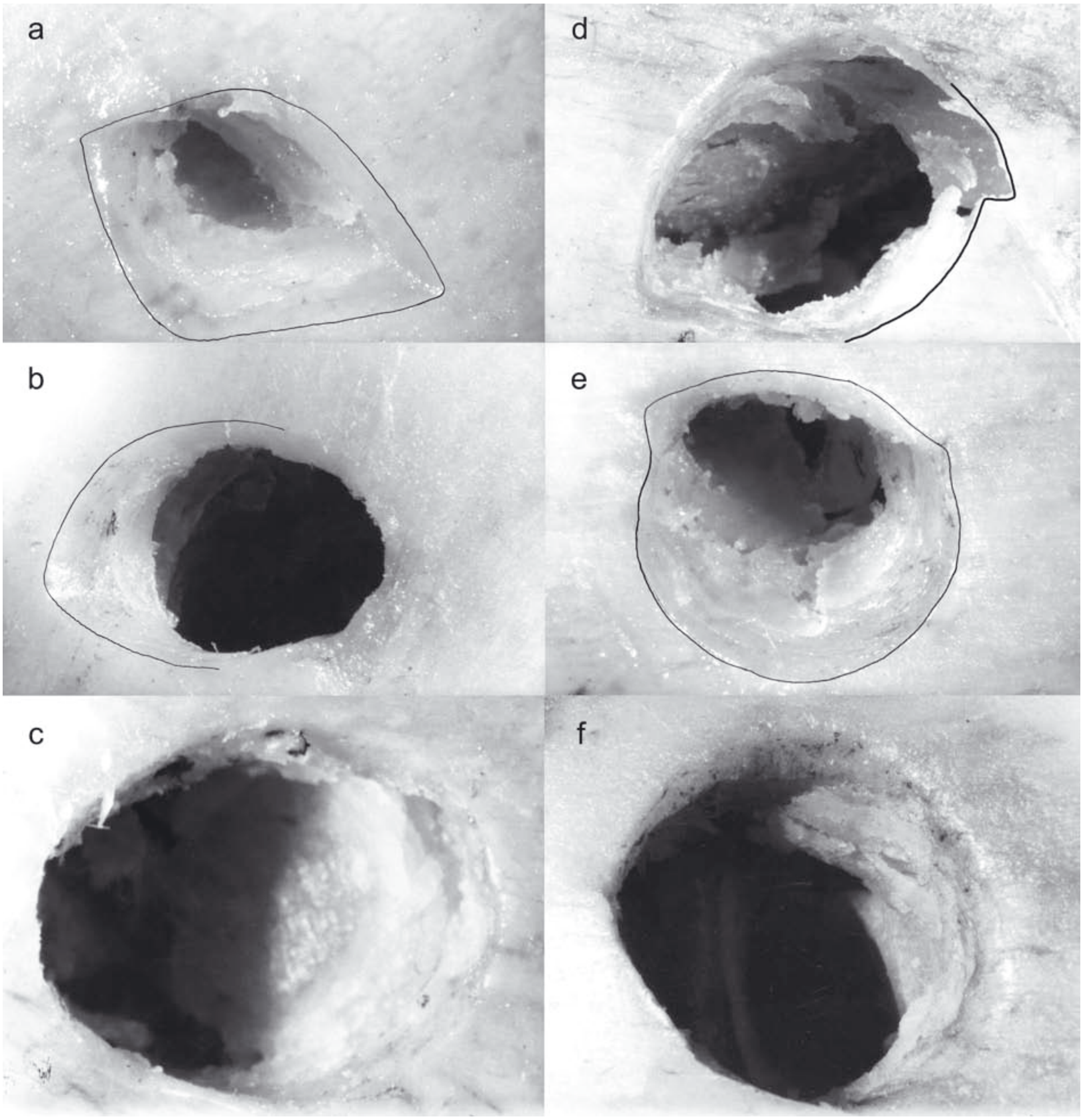
Razporeditev, oblika in velikost odtiskov obeh premolarjev hijene, ki prideta v poštev za luknjanje v položaju kosti, ko je ugriz komaj še mogoč (spodnji zob za luknjo 2, zgornji za izjedo 5), ne ustreza razporeditvi, obliki in velikosti luknje 2 in pod njo ležeče izjede 5 (prim. *sl.* *10* in *12*).

Razporeditev, oblika in velikost luknje 2 ter izjede 5 še najbolj ustrezajo ugrizu jamske hijene s topima kaninoma (prim. Albrecht et al. 1998, 16, sl. 14). Pri topi konici je za preluknjanje kortikalne lupine potrebna večja sila (2610-6490 N na diafizi) kot pri ostri konici. Slednja mora prvotno manjšo luknjo, ki jo sicer naredi z ustrezno manjšo silo kot topa konica, razširiti, za kar je potrebna relativno veliko večja sila kot zgolj za predrtje kortikalne lupine, razen v prime-rih, ko kost poči (prim. *sl.* *11:* a in *11:* d). Zbrušen zgornji kanin bi naredil precej okroglo luknjo, zbrušen spodnji kanin pa bolj ovalno (prim *sl.* *16:* e). Seveda, če se kost ne bi razklala. Razmik med luknjama bi bil v vsakem primeru večji kot na piščali (prim *sl.* *10* in *12:* f).

Pri takšnem teoretskem ugrizu jamske hijene lahko v zvezi s piščaljo postavimo več vprašanj.

Prvič, zakaj jamska hijena, če nimamo nobenega drugega zagotovila, da bi kadarkoli obiskala najdišče, kaj šele da bi imela tam brlog. Drugič, čemu bi se hijena lotila kosti s kanini, če ima za to posebej prilagojene ličnike (Zapfe 1942, 112; Ewer 1954, 188, 191; Sutcliffe 1970, 1112; Brain 1981, 69), s katerimi doseže enak učinek že z uporabo največ polovične sile žvekalnih mišic. Tretjič, zakaj ne bi kost zdrobila, če je imela za to vse možnosti in je bil to tudi njen namen (prim. Sutcliffe 1970, 1112). Četrtič, kako bi ji uspelo s kanini in morda z drugimi zobmi tako virtuozno poravnati obe luknji in izjedi. O tem in drugih težavah, povezanih z uporabo kaninov pri luknjanju diafize, podrobneje pri obeh medvedih (rjavem in jamskem) kot najresnejših kandidatih za luknjanje kosti.

Rjavi in jamski medved, ki ju predlaga F. d'Errico s sodelavci (1998b, 13), sta edina prava vsejeda med zvermi, ki pridejo v poštev pri preizkusu domneve o na-ravnem izvoru lukenj na piščali. Medvedi so tudi edine velike zveri, ki za razkosanje hrane uporabljajo izključno sprednje zobe. To za zveri nenormalno grizenje je stvar razvoja zob ličnikov, ki so se sčasoma popolnoma prilagodili na mešano prehrano. Očitna posledica nenormalne uporabe sprednjih zob je relativno



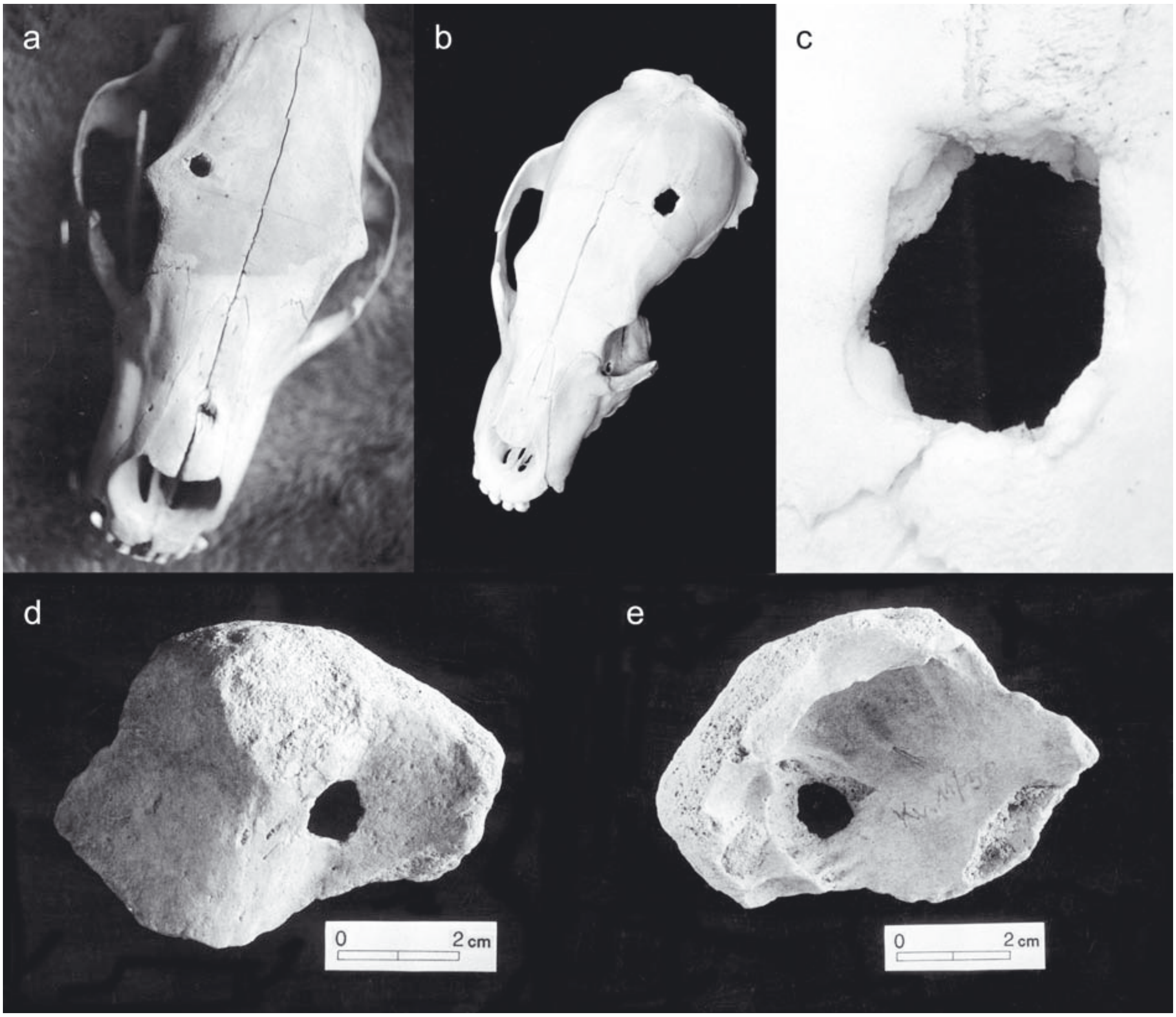
Sl. 16: Eksperimentalne luknje in odtiski, narejeni na svežih juvenilnih femurjih rjavega medveda: a) Na metafizi s spodnjim deračem (M_1) volka. b) Na diafizi s spodnjim kaninom (C_1) volka. c) Na distalnem delu diafize z zgornjim kaninom (C^1) rjavega medveda. d) Na metafizi z zgornjim tretjim premolarjem (P^3) hijene. e) Na metafizi s spodnjim kaninom (C_1) hijene. f)) Na metafizi s spodnjim kaninom (C_1) rjavega medveda.

Fig. 16: Experimental holes and punctures made on the femurs of juvenile brown bear: a) On the metaphysis with lower carnassial tooth (M_1) of wolf. b) On the diaphysis with lower canine tooth (C_1) of wolf. c) On the distal part of diaphysis with upper canine tooth (C^1) of brown bear. d) On the metaphysis with upper third premolar tooth (P^3) of hyena. e) On the metaphysis with lower canine tooth (C_1) of hyena. d) On the metaphysis with lower canine tooth (C_1) of brown bear.

veliko število *in vivo* odlomljenih kaninov in incizivov pri jamskem medvedu in močna obraba sekalcev pri rjavem in jamskem medvedu. Čeprav je medved vsejed, se običajno ne hrani s kostmi (Zapfe 1942, 118). V recentnih medvedjih iztrebkih se le redko najdejo ostanki kosti (Aune et al. 1984, 61 s, tab. 10; Le Franc et al. 1987, 25). Koproliti jamskega medveda, ki bi nam lahko dali stvarne podtake o njegovi prehrani, zaenkrat niso znani (toda glej Battaglia 1922).

Medved lahko pri napadu s kanini poškoduje in tudi preluknja nekatere kosti. Običajno gre za ploske lobanjske kosti, saj medved najraje napade pri glavi (*sl. 17*). Podobno lahko pride do poškodb kosti pri hranjenju z mesom, med drugim tudi z mesom svojih sovrstnikov. Kanibalizem pri živečih rjavih medvedih ni neznan pojav (Le Franc et al. 1987, 40). Zanesljive dokaze zanj imamo tudi pri jamskem medvedu (*sl. 18:* c-f), kljub njegovi izrazito vegeterjanski prehrani (Nelson et al. 1998).

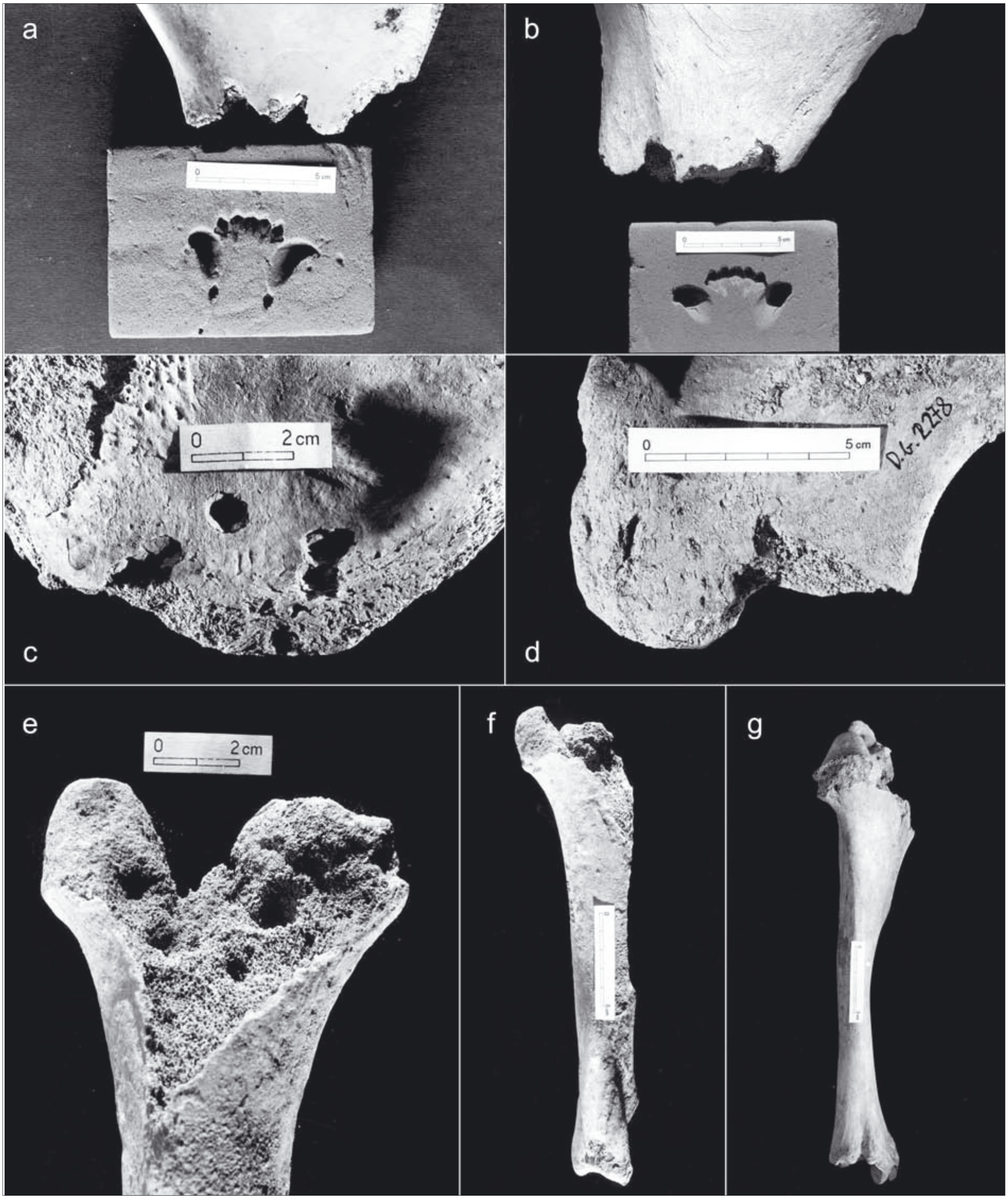
Da bi se prepričali o naravi in pogostnosti poškodb, ki jih medved naredi na kosteh, smo pregledali 11 mrhovišč v jugozahodni Sloveniji. Na njih so kostni ostanki več tisoč konj, govedi, prašičev in drugih domačih ter divjih živali, s katerimi so desetletja hranili večinski del slovenske populacije rjavega medveda, ki šteje kakšnih 450 primerkov (Huber, Adamič 1999). Na kosteh, ki so vse cele, neglede na velikost, smo odkrili izredno malo značilnih poškodb od zob. Gre skoraj izključno za poškodbe, narejene s kanini na robovih ploskih kosti in v bližini sklepov dolgih kosti, ki imajo dobre primerjave v fosilnem gradivu iz Divjih bab I in iz drugih podobnih najdišč (*sl. 18:* a,b,g). Ker se medve-



Sl. 17: Priče agresije pri medvedih: a,b) Novodobna primera poškodb lobanje juvenilnih rjavih medvedov, ubitih od odraslih samcev v Gorskem Kotarju (Hrvaška) in v kočevskih gozdovih (Slovenija). Luknje so bile narejene s kanini. c) Povečava luknje na lobanji b. d,e) Primerek preluknjane *os frontale* juvenilnega jamskega medveda iz Divjih bab I, plast 8-10. Luknja je bila narejena s kaninom v orbitalnem predelu kot na eni recentni lobanji.

Fig. 17: Witnesses of agression by bears: a,b) Examples of damage to the recent skulls of juvenile brown bears killed by adult males in Gorski Kotar (Croatia) and Kočevje forest (Slovenia). The holes were made with canine teeth. c) Close view of hole on skull b. d,e) Example of pierced *os frontale* of juvenile cave bear from Divje babe I, layers 8-10. The hole was made with canine tooth in the orbital area as in recent skull a.

di na mrhovišču počutijo ogrožene, dezartikulirajo večje kose trupel (npr. glavo, sprednjo ali zadnjo nogo) in jih odvlečejo na varnejša mesta, kjer se v miru hranijo. Pri dezartikulaciji in vlačenju dezartikuliranih delov po razgibanem in/ali porašče-nem terenu lahko z zobmi poškodujejo sklepne dele. Poškodbe na robovih



Sl. 18: Poškodbe od medvedjih zob na recentnih in fosilnih kosteh: a,b) Sledovi sprednjih zob rjavega medveda na goveji *os ischii* z mrhovišč v Sloveniji v primerjavi z odtisi sprednjih spodnjih zob. c,d) Odtisi kaninov medveda na *os ischii* (Divje babe I, štev. 2278) adultnega jamskega medveda. e,f) Poškodbe od medvedjih sprednjih zob na proksimalnem delu tibije adultnega jamskega medveda (Divje babe I, štev. 2277). g) Podobna poškodba na goveji tibiji z mrhovišča v Sloveniji.

Fig. 18: Damage of bear's teeth to the recent and fossile bones: a,b) Marks of the front teeth of brown bear on cattle *os ischii* from a feeding site in Slovenia in comparison with the impression of front lower teeth. c,d) Impressions of canine teeth of bear on the *os ischii* (Divje babe I, no 2278) of an adult cave bear. e,f) Damage from bear front teeth on the proximal part of the tibia of an adult cave bear (Divje babe I, no 2277). g) Similar damage to cattle tibia from a feeding site in Slovenia.

ploskih kosti nastanejo pri obžiranju mesa in hrustanca. Najpogostejše so na kosteh ramen in okolčja. Medvedi so pri izkoščevanju pravi mojstri. Že razpadajoče meso oberejo do kosti, ne da bi kosti pri tem poškodovali, razen v izredno redkih primerih. Izrecno poudarjamo, da na mrhoviščih nismo našli niti ene luknje na dolgi kosti.

Oblika konice kanina rjavega in jamskega medveda najbolj ustreza skoraj okrogli obliki lukenj na piščali (prim. *sl. 12* in *16:* c,f). Zaradi masivnih kaninov in izredno močnega ugriza medved načelno naj ne bi imel težav z naluknjanjem diafize sporne piščali. Več težav bi imel z razvrščanjem lukenj in izjed na eni ali drugi strani diafize ali obeh straneh diafize ter s preprečitvijo popolnega razkola diafize.

Pri poskusnem luknjanju diafize z maketo ostrih kanininov današnjega rjavega medveda smo naredili približno enako veliki luknji in na približno istem mestu kot na piščali s silo 1340 in 1816 N. To nam je uspelo samo pri eni od 5 lukenj brez razpoke in pri eni od 3 lukenj z razpoko. Od osmih lukenj jih je kar šest (4 brez razpoke in 2 z razpoko) nastalo na »napačni« anteriorni strani, kjer na piščali ni ohranjena nobena luknja. To se seveda ne ujema z našim prvotnim, izključno teoretičnim razmišljanjem, da je kost trdnejša na izbočeni strani (Turk et al. 1997, 168). Očitno je pri »točkovni« obremenitvi bolj odločilna debelina kot oblika kortikalne lupine. Značilno za debelino in obliko lupine je, da se spreminjata tako vzdolž kosti enega primerka kot med enako kostjo pri različnih primerkih iste starosti. Drug nepričakovan rezultat poskusov, ki smo ga že omenili, je vzdolžno pokanje kosti. Diafiza nam je počila v treh od osmih luknjanj.

Poskusi s topo zbrušenima kaninoma (zbrušeni ploskvi sta bili veliki približno 6 x 5 mm) so pokazali, da je za luknjo, ki v vseh pogledih približno ustreza luknji na piščali, potrebna sila 2609 N. Za luknjanje diafize femurja majhnega odraslega primerka rjavega medveda je bila potrebna sila 6493 N zgolj za razločen odtisek zoba pa 3308 N! Diafizo femurja odraslega primerka rjavega medveda smo naluknjali s silo 7980 N.

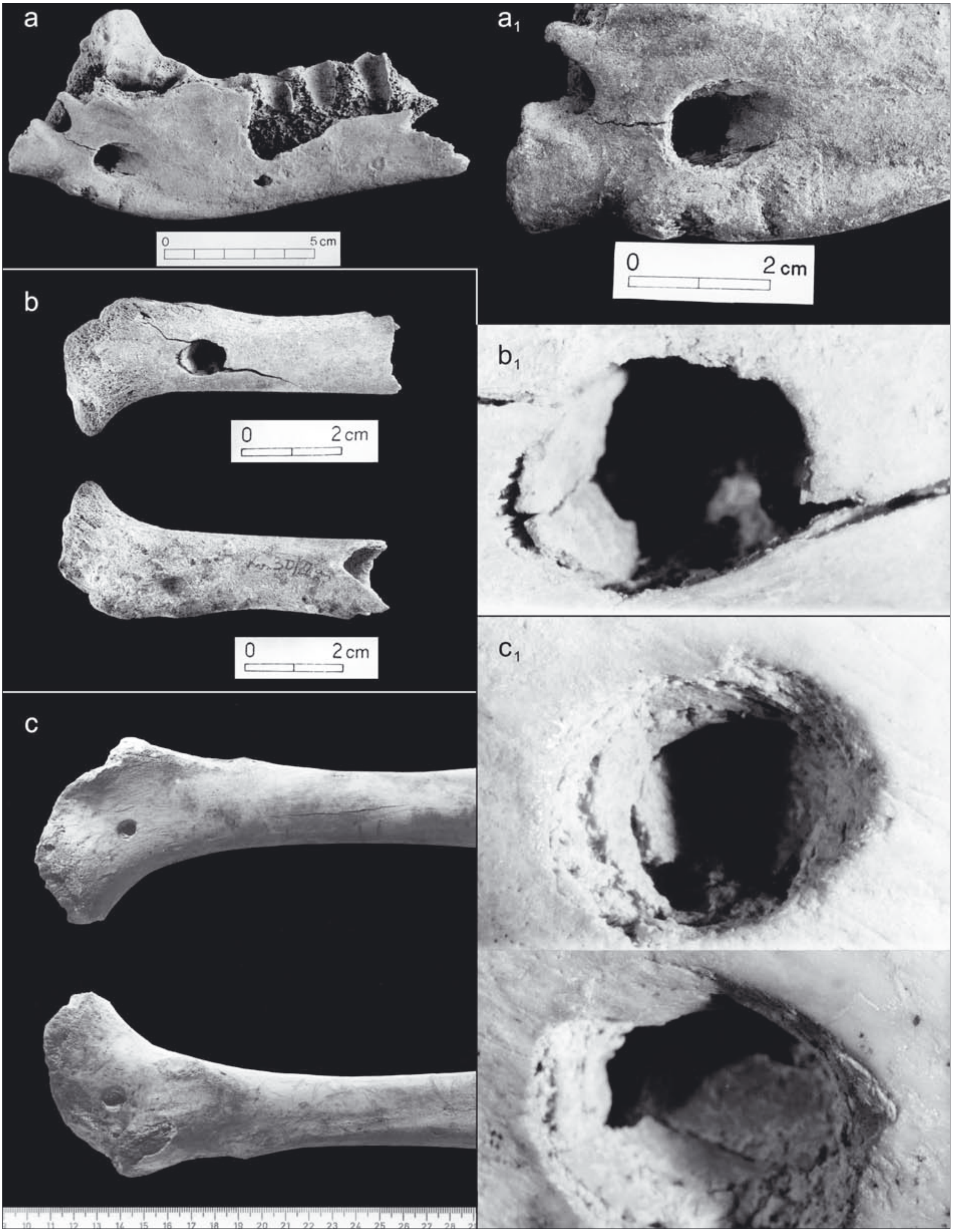
Od skupno treh lukenj, ki smo jih naredili s topima kaninoma na femurjih juvenilnih primerkov, sta bili dve na »napačni« anteriorni strani. V dveh primerih je kost vzdolžno počila. Pri subadultnih primerkih so od skupno štirih lukenj, narejenih s topim kaninom, kar tri prav tako nastale na »napačni« anteriorni strani. V enem primeru je kost počila. Od skupno 18 bolj ali manj uspešnih luknjanj diafize nam je samo v enem primeru uspelo narediti hkrati luknjo tako z zgornjim kot s spodnjim kaninom. Običajno je kost predrl samo eden od obeh zob.

Za uspešno luknjanje je bilo treba kost točno sredinsko nastaviti med konici zob. V nasprotnem primeru je zob odrinil kost in jo preluknjal bliže enemu stranskemu robu namesto v sredini med obema robovoma. Pri takšnem luknjanju nastanejo ob luknji poškodbe (*sl. 11:* c), ki jih poznamo tudi na fosilnih primerkih. Zaradi neizkušenosti smo takšno luknjo v naši prvi študiji lukenj teoretično napačno opredelili za umetno (Turk et al. 1997, 166).

Pri prediranju debele kortikalne lupine s kanini dobimo zaradi njihove ukrivljenosti posebno oblikovan obod luknje, ki je hkrati s skoraj okroglo obliko odprtine, značilen samo za kanine. Lingvalno kanin vleče za sabo kortikalno lupino in jo uvihava (gnete) navznoter, labialno pa jo odriva navznoter in hkrati na površini rahlo vzdiguje navzgor (*sl. 11:* a). Zato je stena luknje na eni strani bolj ali manj navpična na nasprotni strani pa spodrezana od zunaj navznoter. Lingvalno ob kaninu se del površine kosti stisne, kar je običajno dobro vidno. Vse to je najbolj izrazito pri ostrih, manj pri topih zobeh.

Videti je, da obe popolni luknji na piščali nimata teh značilnosti. Krog in krog odkrušen notranji (medularni) del kortikalne lupine pri luknji 2 (*sl. 12:* e) je celo v popolnem neskladju z opisanim delova-njem kanina. Lahko bi nastal samo pri tako topem ka-ninu, ki bi imel površino zbrušene konice skoraj enako površini luknje 2.

Medvedji ugriz s kanini je povezan z vrsto pomislekov splošne in posebne narave. Medved, ki bi naredil luknje na piščali, bi zelo težko vsaj dvakrat tako virtuozno nacentriral spolzko svežo kost med ostri konici kaninov, da bi bile vse luknje in izjede po vsaj dveh uspešnih ugrizih v liniji. Nekoliko laže bi to storil medved z zbrušenimi kanini. Vprašanje, ki se mu ne moremo izogniti je, zakaj so na piščali kar dve luknji (1-2) in ena do dve izjedi (3, 4) na posteriorni strani in nobena luknja ter samo ena izjeda (5) na anteriorni strani. Glede na naše poskuse bi za primer uporabe zob (kaninov) pričakovali prej obratno. Razdalja med luknjo 2 in izjedo 5 je premajhna za paraaksialno okluzijo normalnih medvedjih kaninov, ji je pa ta najbližja med vsemi obravnavanimi ugrizi zveri (prim. *sl. 10* in *12*). Vendar tako majhna razdalja zahteva, da je kost med luknjanjem močno nagnjena navzgor. Takšen nagib kosti pa je manj verjeten od horizontalnega položaja in nagiba navzdol, ki ju zver pri daljših vzvodih nagonsko vzpostavi s šapo. Kako so dejansko razporejene in kako so videti obojestranske luknje na bolj elastični metafizi in ploščati kosti, nam povedo recentne in fosilne najdbe (*sl. 19:* b,c; *18*: a-d). Luknja 2 bi bila lahko narejena samo z zgornjim, izjeda 5 pa s spodnjim kaninom v strogo določeni legi piščali. Poškodbo ob proksimalnem robu luknje 2 v obliki udrte in erodirane kortikalne lupine (*sl. 12:* c) je nemogoče narediti s kaninom. Luknja 1 ima na steni medularne votline dva nepravilna vzdolžna odkruška, enega proksimalno, drugega dis-



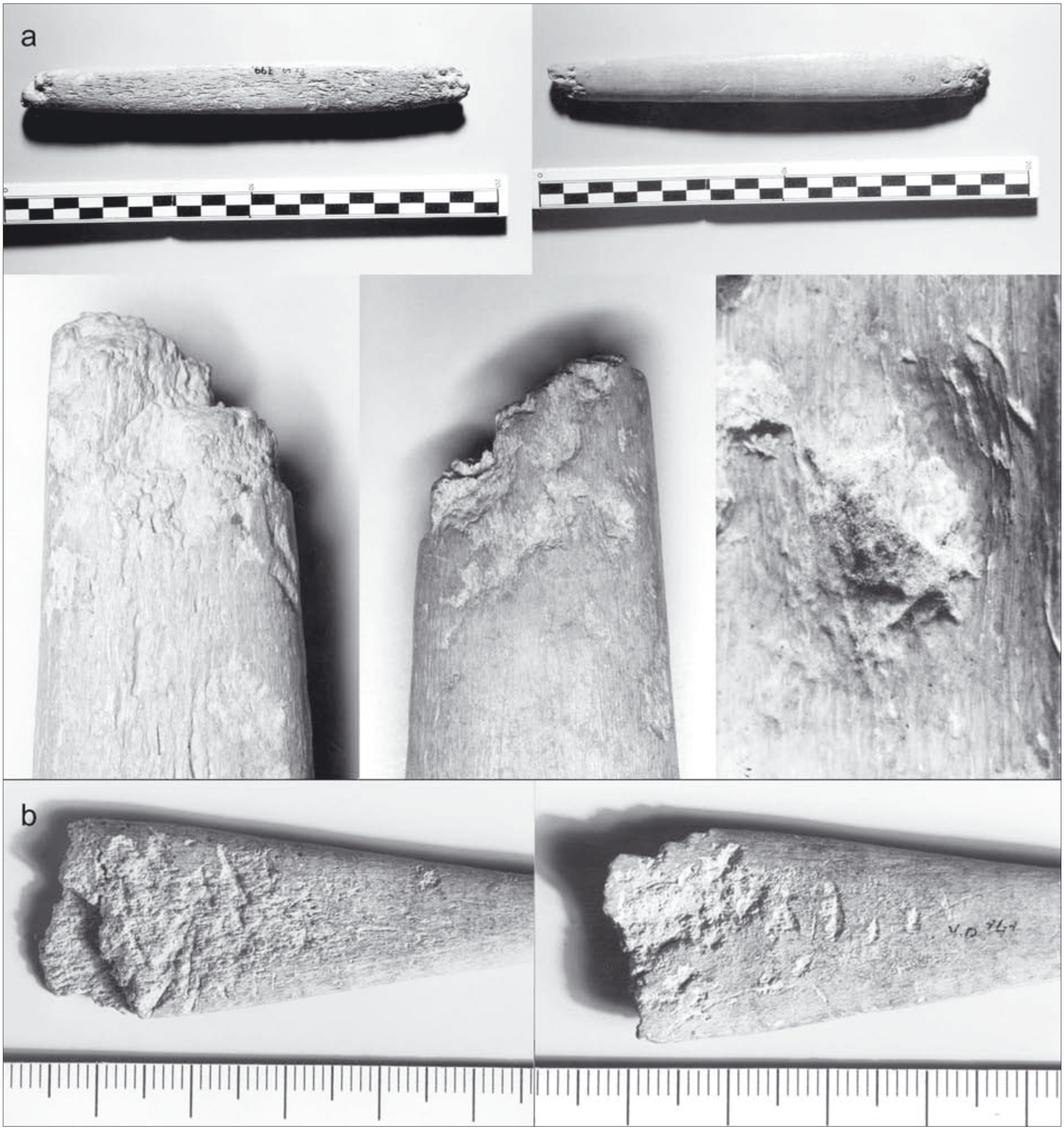
Sl. 19: Šolski primeri lukenj na juvenilni mandibuli in juvenilnih femurjih jamskega medveda iz Divjih bab I (a,b) in Mokriške jame (c), vdrtih z medvedjimi kanini. Zamik zgornje in spodnje luknje oziroma vdrtine (b,c), njihova usmerjenost, nakazana z ostanki vdrte kortikalne lupine, premer in rahlo ovalna oblika (a_1-c_1) se ujema s paraksialno okluzijo, ukrivljenostjo, velikostjo in presekom medvedjih kaninov.
Fig. 19: Textbook example of holes in juvenile mandible and femurs of cave bear from Divje babe I (a,b) and Mokriška jama (c), pierced with bear canine teeth. The displacement of the upper and lower holes or impressions (b,c), their orientation, shown by the remains of depressed shell of cortical bone, diameter and slightly oval shape (a_1-c_1), corresponds with the paraxial occlusion, curvature, size and cross-section of bear canine teeth.

talno (*sl. 8*). Luknja 2 ima krog in krog na široko odkrušeno steno medularne votline (*sl. 12:* e). Od kod tolikšne razlike pri delovanju zoba, ki pritisne vedno enako? Težko je razumeti tudi dejstvo, da medved kljub svoji prislovični moči piščali ni strl. In ne nazadnje, čemu bi se medved toliko ukvarjal s kostjo, ko ga kosti običajno ne zanimajo.

Velike mačke. Leopard in jamski lev bi lahko med hranjenjem naluknjala piščal bodisi s kanini bodisi z ličniki (prim. Brain 1981, 102 s; de Ruiter, Berger. 2000). Pri kaninih nastopijo enake težave kot pri vseh zvereh. Odtisi konic ličnikov so drugačne oblike in drugače razporejeni kot luknje na piščali, zato ne pridejo v poštev.

Kar zadeva druge poškodbe na piščali, ugotavljamo naslednje:

Večina obče priznanih koščenih paleolitskih piščali ima odlomljen en ali oba konca. Vsaj ena od teh piščali



Sl. 20: a) Koščena konica štev. 49 iz Potočke zijalke v Sloveniji (orinjasjen), ki jo je na obeh koncih zgrizla neka zver. Detajli poškodb, ki gredo čez sledove, nastale pri izdelavi konice. b) Koščena konica z razcepljeno bazo štev. 141 iz Velike pećine (Hrvaška) s sledovi grizenja (?). Objavljena z dovoljenjem Zavoda za paleontologiju i geologiju kvartara HAZU.

Fig. 20: a) Bone point no. 49 from Potočka zijalka in Slovenia (Aurignacian) which has been chewed on both ends and sides by some carnivore, probably wolf. Details of damage imposed over traces of stone tools used in manufacturing the point. b) Split base bone point no. 141 from Velika pećina (Croatia) with tooth marks (?). Reproduced with permission of Zavod za paleontologiju i geologiju kvartara HAZU.

je bila najdena v takšnem sedimentnem okolju, da se ni mogla fragmentirati v usedlinah (Einwögerer, Käfer 1998). Zato naknadna intervencija zveri ni izključena. Tudi našo najdbo so lahko na konceh naknadno obdelale zveri. Poznani so primeri pravih koščenih paleolitskih artefaktov, ki so jih zgrizle zveri (*sl. 20* in Malez 1967, t. 5: 1; López Bayón et al. 1997, 257, foto 1). Komaj vidne poškodbe na površini piščali, ki bi jih lahko pripisali zverem (d'Errico, konferenca v Sp. Idriji in *sl. 21*; *22:* a-c) niso tako značilne, da ne bi mogle nastati tudi na kakšen drug način. Posebej moteče je dejstvo, da so površina in robovi piščali močno mehansko zbrušeni. Zato je težko presojati o izvoru mikroskopskih poškodb (prim. Shipman 1988, 316 ss). Oblika velike izjede 4 ima vse značilnosti delovanja zveri (prim. Chase, Nowell 1998a, 550; d'Errico et al. 1998a, 77). Ima samo to napako, da je na ploski posteriorni strani, medtem ko je večina podobnih poškodb na izbočeni anteriorni strani. To smo ugotovili na podlagi pregleda 466 sicer nenaluknjanih (če zanemarimo tistih nekaj zelo redkih primerkov, vključno s piščaljo) diafiz juvenilnih femurjev iz Divjih bab I (*tab. 1*). Stanje se ujema z izsledki naših poskusov, pri katerih je večina lukenj nastala na izbočeni sprednji strani femurja.

Za poškodbe piščali, vključno z izjedo 4, ni razloga, na podlagi katerega bi jih lahko nedvoumno povezali z nastankom lukenj in sklepali, da je piščal naredila neka zver (toda glej d'Errico, konferenca v Sp. Idriji).

4. **DRUGA HIPOTEZA: LUKNJE, NAREJENE S KAMNITIMI ORODJI**

Za nekatere luknje v kosteh jamskega medveda so že davno domnevali, da so narejene z orodji (glej Albrecht et al. 1998, 1-4). Ker ni bilo zadovoljivo pojasnjeno, s kakšnimi orodji in kako so bile luknje izdelane, je ostala senca dvoma o njihovem umetnem izvoru. Razen tega kontekst zgodnjih najdb ni vedno tako jasen, kot je pri najnovejši najdbi iz Divjih bab I (glej M. Brodar 1985; Albrecht et al. 1998; Turk, Bastiani 2000).

Proučevanje druge, alternativne hipoteze je za pri-mer piščali povezano z iskanjem odgovorov na naslednja temeljna vprašanja:

1.) Ali imamo na piščali sledove izdelave?

2.) Ali imamo v srednjem paleolitiku na splošno in posebej v najdišču domnevne piščali zanesljive dokaze o uporabi kosti kot surovine?

3.) Ali poznamo v najdišču domnevne piščali orodja, primerna za izdelovanje lukenj?

4.) Kakšna bi bila lahko tehnologija luknjanja, da bi bile luknje podobne luknjam, ki so bile narejene z zobmi?

4.1. **Sledovi izdelave**

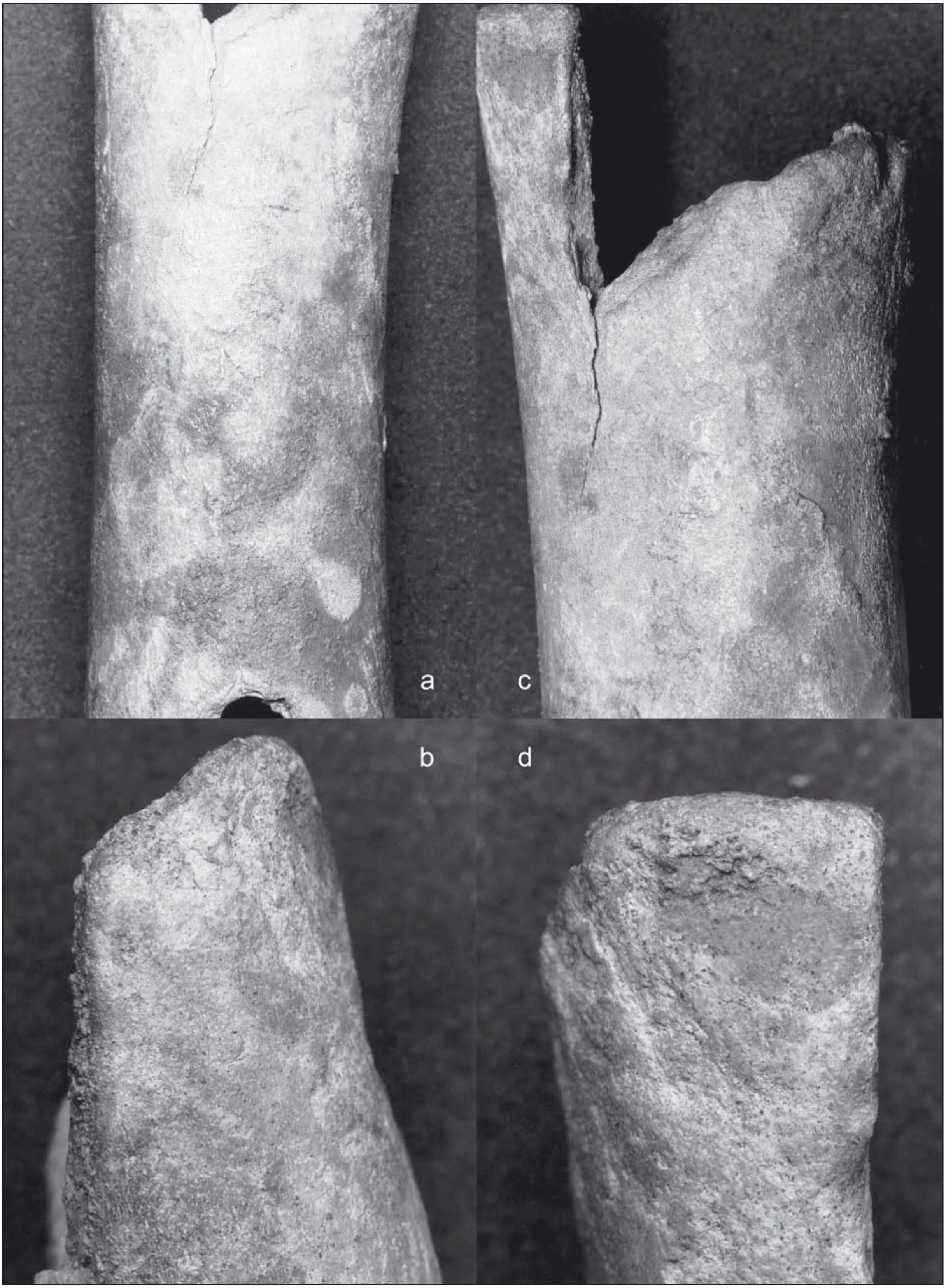
Na luknjah piščali in v njihovi bližini ni niti mikro- niti makroskopskih sledov orodij, ki bi lahko služili kot kronski dokaz domnevi o njihovem umetnem izvoru (*sl. 23:* a-c). Luknje so namreč tisti dodatek, ki omogoča oblikovno primerjavo s pravimi mlajšepaleolitskimi piščalmi (prim. Fages, Mourer-Chauviré 1983; Dauvois 1989; Buisson 1990; Rottländer 1996; Einwögerer, Käfer 1998).

Odsotnost kronskega dokaza še ne pomeni, da je domneva o umetnem izvoru lukenj napačna in nevredna podrobne analize, podprte z ustreznimi poskusi. Našteli bi lahko vrsto pravih koščenih paleo-litskih izdelkov brez kakršnihkoli sledov orodij, uporabljenih pri njihovi izdelavi. Takšne so npr. že nekatere orinjasjenske koščene konice iz Divjih bab I (Turk, Kavur 1997, 122). Zaradi zelo močne abrazije, ki je značilnost našega najdišča, je na mikroskopski ravni težko ločiti npr. globlje umetne ureze od sledov, ki jih pusti spodrsavanje zob (prim. *sl. 22:* a,b,e in Shipman 1988, 320, sl. 9). Plitke ureze, narejene s sileksom, je lahko abrazija tudi povsem izbrisala. Za najdišče kot celoto in tudi za arheološke plasti posebej je značilen zelo majhen promil zanesljivo dia-gnosticiranih umetnih urezov.

Na močno inkrustirani površini piščali je samo nekaj komaj vidnih udolbinic, žlebov in raz (*sl. 22*). Med njimi je samo ena mikroskopska zareza na erodirani površini kortikalne lupine proksimalno ob luknji 2 (*sl. 22:* e). Izvor enih in drugih »sledov« je glede na ohranjenost površin vprašljiv. Vendar vsi niso takšnega mnenja, vsaj kar zadeva nekatere teh sledov (d'Errico, konferenca v Sp. Idriji). Na robovih lukenj, izjed in na konceh piščali ni nobenih makroskopskih raz in odtisov. Vsi robovi so (naravno?) oglajeni.

4.2. **Uporaba kosti v srednjem paleolitiku**

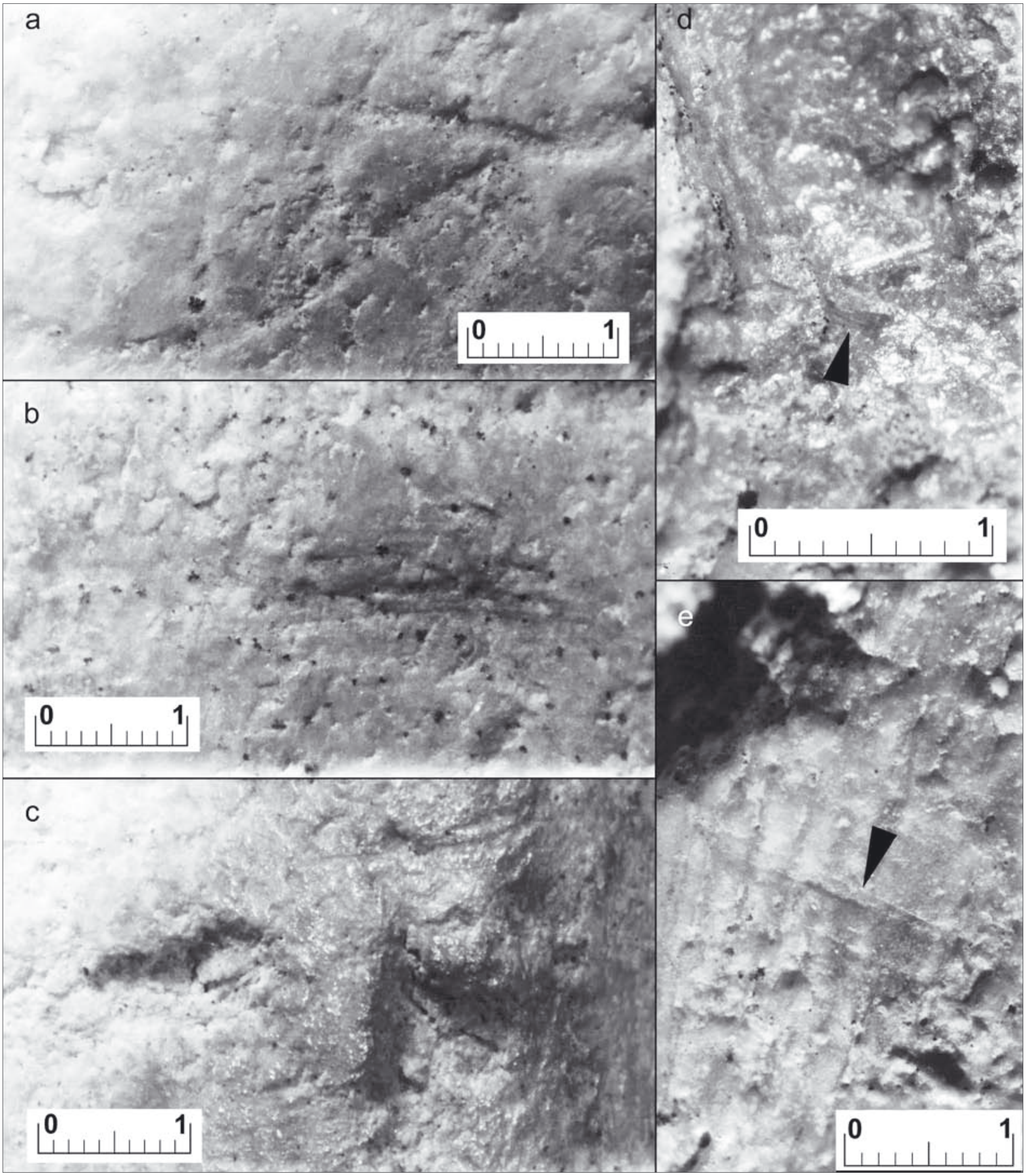
Po zaslugi novejših odkritij danes ni več dvoma, da so kost kot surovino za izdelke mlajšepaleolitskega videza priložnostno uporabljali že v srednjem paleolitiku (Hahn et al. 1973, sl. 24; Baffier, Julien 1990; Taborin 1990; Marks et al. 1996, 282; d'Errico et al. 1998c; Gaudzinski 1999; Fiedler 1999, sl. 5: 4). Nekaj šibkih signalov za to imamo tudi v našem najdišču. Poleg domnevne piščali smo v različnih musterjenskih plasteh odkrili med stotisoči naravnih kostnih odlomkov tudi redke odlomke, ki so močno podobni delom koščenih konic, šil in/ali gladil (*sl. 24:* c,d; *t. 1-2* in M. Brodar 1999, t. 6: 5-7; Turk, Bastiani 2000, sl. 4). Večina teh domnevnih koščenih artefaktov, ki so brez sledov obdelave, je bilo najdenih v plasti 7 in 8. Časovno torej zelo blizu piščali. Povežemo jih lahko z



Sl. 21: Deli diafize domnevne piščali: a) anteriorna, izbočena stran, b) lateralni del proksimalnega odloma, c) anteriorni del proksimalnega odloma, d) ravno odlomljeni medialni del proksimalnega odloma.
Fig. 21: Parts of the diaphysis of the suspected flute: a) anterior convex side, b) lateral part of the proximal break, c) anterior part of the proximal break, d) straight broken medial part of the proximal break

ostanki ognjišč in z drugimi najdbami (Turk, Bastiani 2000). Eden med njimi (*t. 2:* 2) je celo iz neposredne bližine kurišča, ki je bilo od ognjišča s piščaljo oddaljeno le nekaj metrov in je lahko z njim sočasno.

Posebej je potrebno opozoriti na unikatne, poševno odlomljene kose z ostrimi robovi odloma in močno zaobljenimi ostalimi robovi (*t. 1:* 2, 6; *2:* 5). Lahko bi nastali slučajno med ogromno množico oglajenih odlomkov v plasteh z več deset tisoč ostanki jamskega medveda. Vendar. Podoben odlomek smo zadnje leto izkopavanj (1999) našli v praktično sterilni plasti 16 skupaj z edinim artefaktom, masivnim retuširanim



Sl. 22: Primeri mikroskopskih poškodb negotovega izvora na domnevni piščali: a-b) raze na izbočeni, anteriorni proksimalno-lateralni strani, c) vdolbinice na izbočeni, anteriorni strani, lateralno ob proksimalnem odlomu, d) kratke zareze na proksimalnem obodu luknje 1, e) zareze na odrgnjeni kortikalni kosti, proksimalno od luknje 2. Zareze potekajo prečno na vidno kortikalno zgradbo. Merilo v mm.

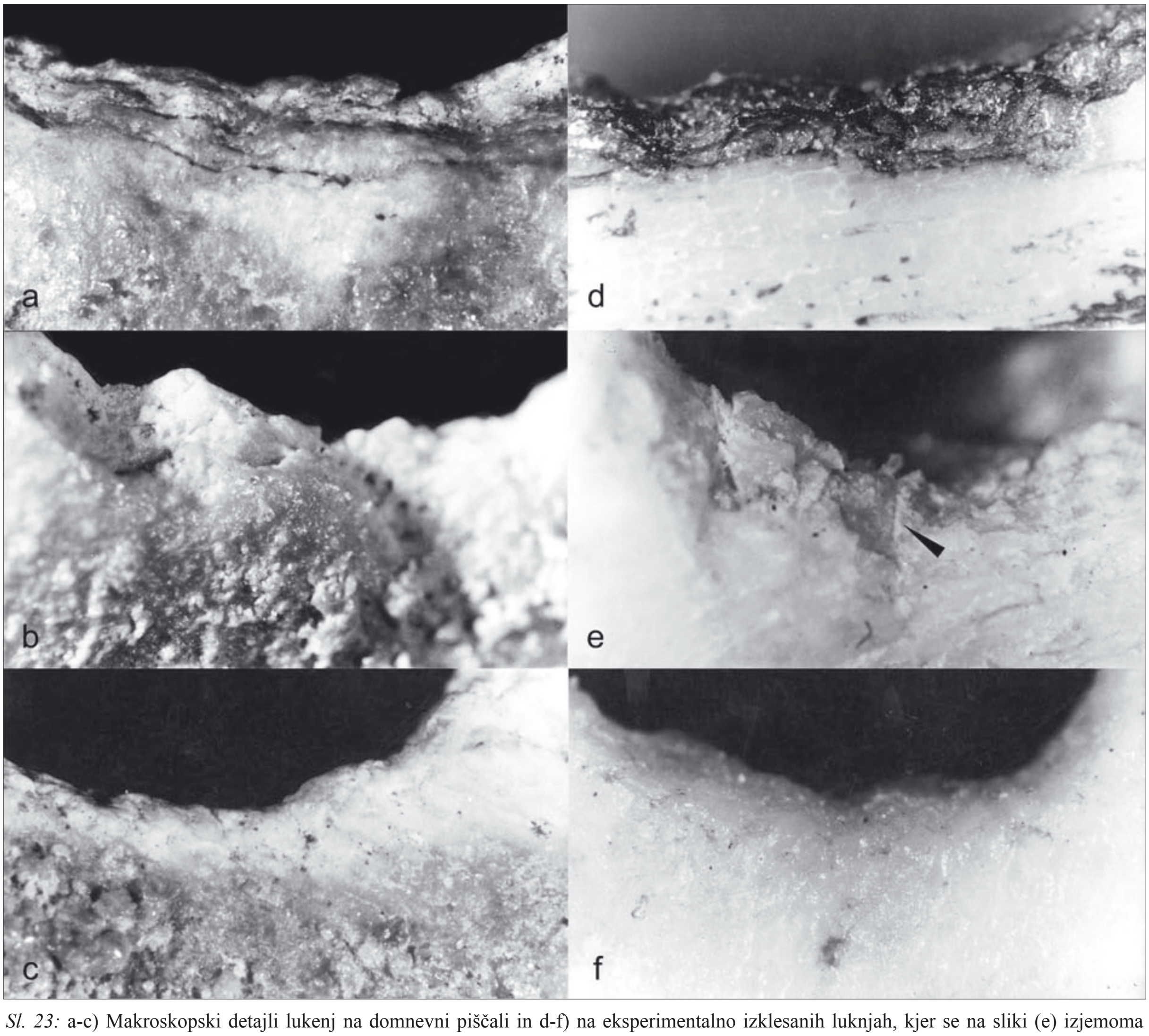
Fig. 22: Examples of microscopic damage of uncertain origin on the suspected flute: a-b) striae on the convex anterior proximal-lateral side, c) pitting on the convex anterior side, laterally close to proximal break, d) short cuts on the proximal edge of the hole 1, e) cuts on eroded cortical bone, proximally from hole 2. The cuts run across the visible cortical structure. Scale in mm.

odbitkom (*t. 2:* 5). Odlomek je bil v kvadratu 38 na globini 4,53-4,65 m, odbitek pa v sosednjem kvadratu največ 12 cm višje. Ker v plasti praktično ni kosti in nobenih drugih sledov človekove prisotnosti, si najdeni unikatni odlomek zelo težko razložimo z delovanjem naravnih sil, kar lahko velja tudi za vse ostale podobne odlomke.

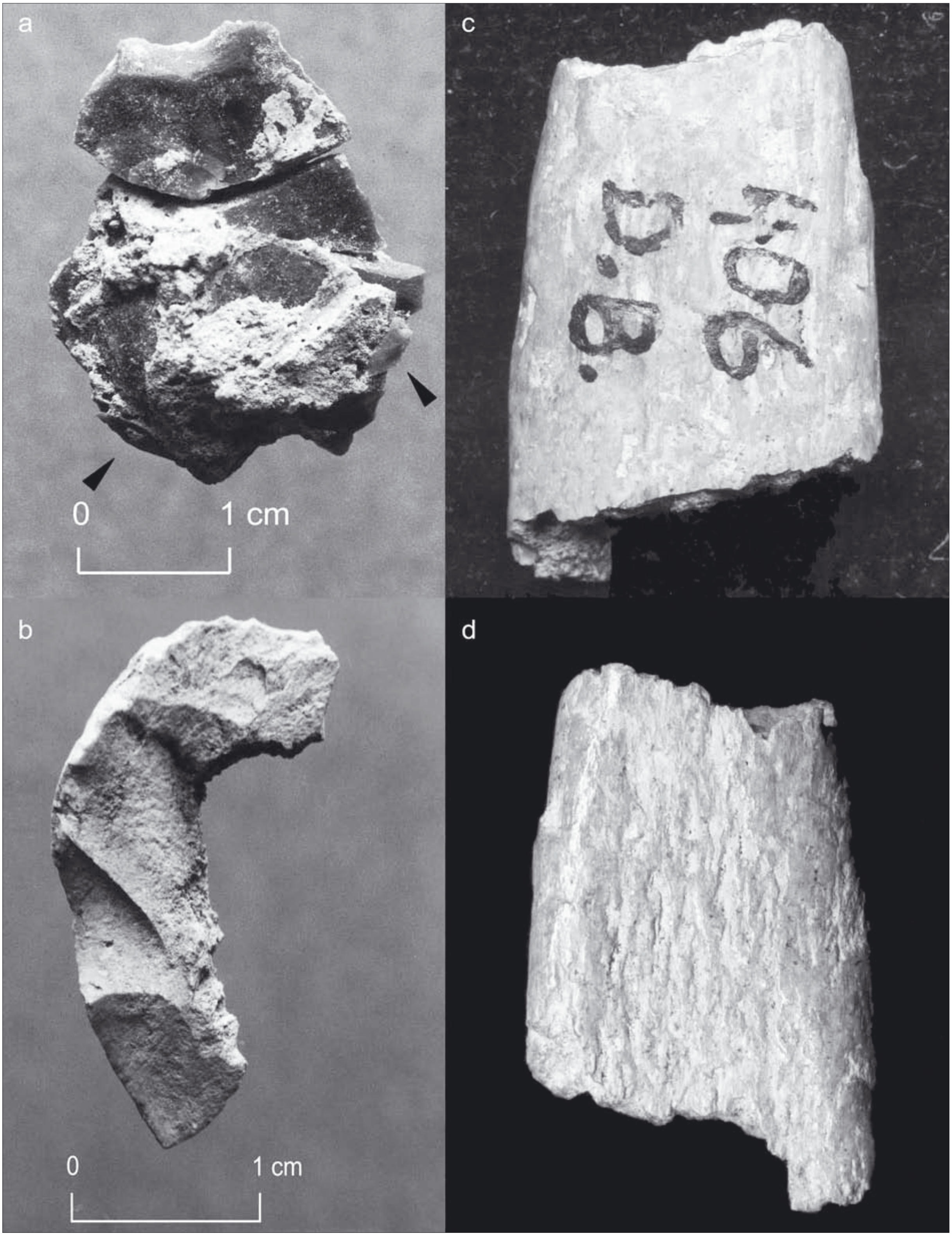
Nenavadno je, da noben artefaktoiden kostni odlomek ni bil najden v plasteh 2-5, ki kronološko ustrezajo zgodnjemu mlajšemu paleolitiku, vključno z orinjasjenom in ki vsebujejo prav tako veliko ostankov jamskega medveda (Turk, Dirjec 1997a). Pač pa imamo v teh plasteh morda en odpaden kos, ki bi lahko nastal pri obdelavi kosti (*sl. 24:* b).

Za neandertalce, ki so obvladali tehnologijo obdelave lesa in kamna, ni obdelava kosti predstavljala večji tehnološki problem (glej Bastiani et al. 2000). Vse skupaj je bilo samo vprašanje prednostne surovine, povezane s tradicijo. V srednjem paleolitiku je bil les tista tradicionalna surovina, ki je popolnoma nadomeščala kost, slonovino in rogovino. To dokazujejo redki ohranjeni izdelki iz lesa in številna orodja s sledovi obdelave lesa (Oakley et al. 1977; Thieme, Veil 1985; Carbonell, Castro-Curel 1992). V Divjih babah I smo v plasti s piščaljo našli fo-silizirane koščke lesa, ki ni bil skurjen. Med ogljem smo v različnih kuriščih našli tudi les tise, ki ne sodi med običajno kurjavo (Culiberg, Šercelj 1997, 79). Te najdbe dajo slutiti, da so paleolitski obiskovalci jame uporabljali les v različne namene: tako za kurjavo kot za druge potrebe. Poleg tega imamo na orodjih veliko makroskopskih poškodb, ki bi lahko nastale pri grobi obdelavi lesa z indirektno perkusijo (Bastiani et al. 2000).

Ker je bil les poleg kamna tradicionalna surovina, od katere so bili neandertalci tudi življensko



Sl. 23: a-c) Makroskopski detajli lukenj na domnevni piščali in d-f) na eksperimentalno izklesanih luknjah, kjer se na sliki (e) izjemoma vidijo rahli sledovi orodja, označeni s puščico.
Fig. 23: a-c) Macroscopic details of holes on suspected flute and d-f) on experimentally chiselled holes in which, in the picture (e) exceptionally are seen slight traces of the tool, marked with an arrow.



Sl. 24: Redke in neobičajne najdbe v Divjih babah I: a) Postsedimentno prelomljen in retuširan odbitek štev. 595 iz breče v plasti 10. Puščice označujejo mesta s cementiranimi retušnimi luskami. b) Odbitek kortikalne kosti z negativi odbitkov, štev. 497, plast 4? c,d) Medialni odlomek domnevne koščene konice štev. 406 iz plasti 20. Konica bi bila narejena iz kortikalne kosti juvenilnega jamskega medveda.

Fig. 24: Very rare and unusual finds from Divje babe I: a) Post-sedimentary broken and retouched flake no. 595 from breccia in layer 10. On the drawing are marked places with cemented retouche chips. b) Flaked cortical bone no. 497 from layer 4? c,d) Medial fragment of presumed bone point no. 406 from layer 20. The point could be made of cortical bone of juvenile cave bear.

odvisni, so le izjemoma posegli po drugih obstojnih surovinah (Granger, Lévęque 1997; Jaubert 1999, 129). Možnosti, da najdemo te zelo redke obstojnejše izdelke, so minimalne. Prehod od ene surovine na drugo, ki naključno ali nenaključno sovpada s prehodom srednjega paleolitika v mlajši paleolitik, je bil postopen in povezan s prilagaja-njem obstoječih tehnologij novim materialom (prim. Christensen 1998, 199). Zamenjava neob-stojnih surovin z obstojnimi in obratno lahko da lažen vtis o nenadnem pojavu ali izginotju celih segmentov neke civilizacije.

V luči takšnih razmišljanj postane arheološko sprejemljivejša tudi izjemna najdba morebitne piščali iz Divjih bab I. Glasba in glasbila so bila v paleolitiku nedvomno bolj razširjena kot lahko sklepamo na podlagi dosedanjih relativno redkih najdb koščenih piščali. Večina piščali je bila zelo verjetno lesenih.

Narava lukenj na piščali iz Divjih bab I, kot tudi nekaterih že dolgo poznanih podobnih lukenj iz drugih najdišč (S. Brodar, M. Brodar 1983, 155 ss; M. Brodar 1985; Dauvois 1989), je takšna, da ne dopušča postaviti učinkovitih morfoloških meril za razlikovanje umetnega od naravnega (prim. M. Brodar 1985). Debela kortikalna lupina cevastih kosti se pri neprekinjenem delovanju sile (konica zoba, ki se ne premika) lahko deformira in lomi na podoben način kot pri delovanju prekinjene, ponavljajoče se sile (konica orodja, ki se premika okoli središča nastajajoče luknje). Če hočemo dobiti podobno luknjo kot pri luknjanju z zobom, moramo uporabiti zobu podobno orodje, po katerem udarjamo.

4.3. **Orodja za luknjanje**

Paleolitski odbitki in delno kline so kot univerzalna orodja uporabnejši v surovem stanju (tehnološko: polizdelek) kot v izdelanem (retuširanem) stanju (tehnološko: izdelek). Le za žaganje, dolbenje in vrtanje moramo polizdelek posebej oblikovati (retuširati) v nazobčano, dletasto in koničasto orodje (prim. Christensen 1998; Bastiani et al. 2000).

V musterjenskih plasteh Divjih bab I je veliko koničastih in jezičastih orodij, primernih za izdelovanje lukenj v kateremkoli materialu (*t. 3; 4*). Takšna orodja se pojavijo že v starejšem paleolitiku in se nadaljujejo v mlajšem paleolitiku. V istih plasteh smo našli tudi relativno veliko odlomkov konic teh specialnih orodij (*sl. 27:* d,e; *t. 5-7* in Turk, Bastiani 2000, sl. 4: 9,10). Nobenega dvoma ni, da so bila koničasta in jezičasta orodja posebej izoblikovana za luknjanje ali da so se izoblikovala, preoblikovala in poškodovala pri samem luknjanju (Bastiani et al. 2000, 45 ss).

Ker nismo poznali vseh mogočih posledic luknjanja v bolj ali manj trde materiale, ki ostaneje vidne ali ne na materialu in orodju, smo izvedli obsežnejše poskuse luknjanja z replikami najdenih paleolitskih orodij (glej tudi ibid.).

4.4. **Izsledki poskusov z replikami paleolitskih artefaktov**

Večino poskusov smo naredili z replikami, narejenimi iz lokalnih surovin (roženec z Oblakovega vrha, katerega izdanek je našel geolog Ivan Mlakar, tufi in roženci iz struge Idrijce), podobnih tistim, ki so jih večinoma uporabljali paleolitski obiskovalci Divjih bab I. Izkazalo se je, da izbor surovine ni pomemben samo za izdelavo orodij, temveč še bolj za uporabo teh na različnih materialih (Turk, Bastiani 2000; Bastiani et al. 2000). Orodja iz surovin »slabše« kakovosti (v smislu klesanja kamna) so veliko bolj trpežna in ne nazadnje bolj učinkovita za obdelavo trših naravnih materialov kot orodja iz surovin »boljše« kakovosti (*sl. 25:* a,b).

Naši poskusi so pokazali, da za izdelavo koščenih konic, šil in gladil iz fosilnih kosti niso potrebna nikakršna specialna orodja (*sl. 25:* c,d). Tako kot pri obdelavi lesa (za podrobnosti glej Bastiani et al. 2000) zadostuje že navaden odbitek (prim. Christensen 1998). Osnovna tehnologija je zelo preprosta. V bistvu gre za kombinacijo metod obdelave lesa in kamna. Polizdelek (primeren odlomek stene cevaste kosti) na grobo oblikujemo z zažagovanjem in klesanjem (direktna perkusija). Tesanje (indirektna perkusija), ki se je izkazalo za tako učinkovito pri grobi obdelavi lesa (Bastiani et al. 2000), ne pride v poštev. Izdelek dokončamo kot pri lesu s struganjem. Težave povzročajo majhne grbine, ki jih lahko odstranimo samo z glajenjem.

Vse naštete metode za obdelavo kosti in podobnih materialov so zanesljivo poznali že na prehodu iz srednjega v mlajši paleolitik (Taborin 1990, 340; Baffier 1999, 73). Pred tem zanje ni tvarnih dokazov. Vendar to še ne pomeni, da ljudje srednjega in starejšega paleolitika teh metod niso poznali in uporabljali pri obdelavi lesa.

Dokaz za prisotnost (sub)fosilnih kosti v najdišču Divje babe I kot potencialnega surovinskega vira že v času srednjega paleolitika smo slučajno odkrili v enem od dvajsetih musterjenskih ognjišč na meji plasti 7 in 8. Med množico običajnih zoglenelih in kalciniranih drobcev kosti je bil tudi eden, ki je bil bistveno drugačen od vseh, kar smo jih kdajkoli videli. Znotraj je bil popolnoma zoglenel (črn), zunaj pa podobne rjave barve kot vse fosilne kosti iz najdišča. Pri sežiganju svežih kosti nikoli ne pride do česa takega (Lyman 1994, 384 ss; Stiner et al. 1995). Ko smo dali v ogenj fosilne kosti, smo dobili odgovor na nenavaden pojav.

Na podoben način kot koščene konice, šila in gladila sta bila lahko v sveži kosti oblikovana oba konca piščali. Večjo izjedo je v kost mogoče narediti tako, da kost najprej naluknjamo. Na vsaki strani luknje naredimo po eno usločeno zarezo in z udarci po kosti po zarezah odstranimo odvečni del kortikalne lupine.

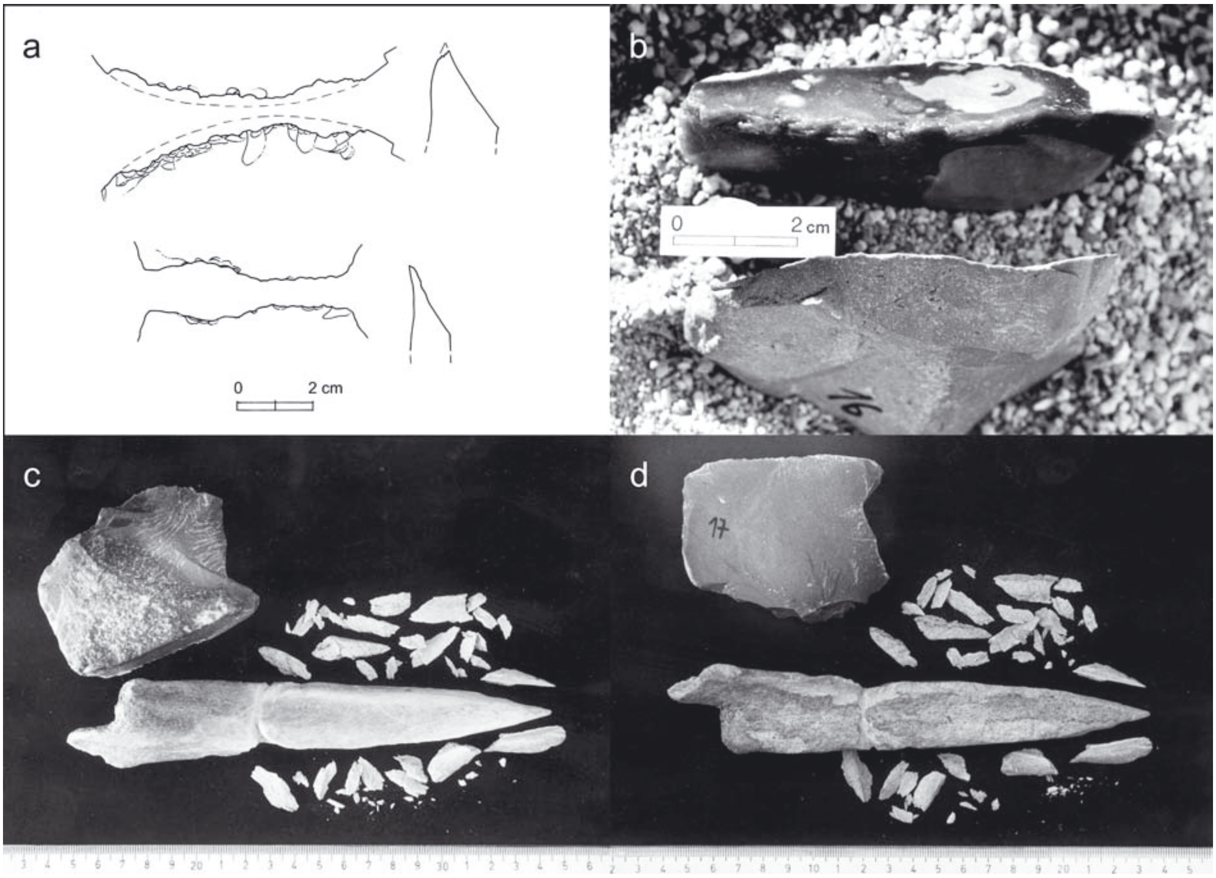
Specialna orodja, ki so zelo koristna, ne pa neobhodno potrebna pri takšnih delih so: jezičasta orodja in orodja, ki imajo en rob izmenično nazobčan.

Če izhajamo iz predpostavke, da je bil les pomembna surovina od starejšega paleolitika dalje (prim. Thieme 1996) in da je bila iz njega vrsta nam neznanih izdelkov, lahko na podlagi številnih starejše- in predvsem srednjepaleolitskih artefaktov, primernih za luknjanje, upravičeno sklepamo, da so ljudje les tudi luknjali. Ker imamo v Divjih babah I izredno veliko koničastih in jezičastih artefaktov, smo naredili več replik teh orodij in z njimi poskusno luknjali les in kost.

Edina razlika med koničastimi in jezičastimi artefakti (oz. med konico in jezičkom) je v obliki potencialnega delovnega dela artefakta. Konice imajo obliko podolžno razpolovljenega stožca, jezički pa podolžno razpolovljenega valja (*t. 4:* 1,3). Ta oblikovna razlika, ki je lahko v skrajnih primerih tudi proizvod uporabe orodja, igra določeno vlogo pri luknjanju materialov različne trdote. Jezičasta orodja so primernejša za luknjanje trdih materialov, koničasta pa so primernejša za luknjanje mehkih materialov.

Luknje v svež les naredimo najlažje, če jih iztešemo. Najučinkovitejša metoda je indirektna perkusija z uporabo jezičastega ali primerno oblikovanega dletastega orodja in lesenega tolkača (Turk, Bastiani 2000; Bastiani et al. 2000). Ta metoda se nam zdi najučinkovitejša tudi za kakršnokoli grobo obdelavo lesa s paleolitskimi kamnitimi orodji. V luči funkcionalne razlage paleolitskih najdb iz Divjih bab I smo jo podrobno obdelali na drugem mestu (Bastiani et al. 2000).

Pri tesanju lukenj v svež les bezga in tise na jezičku jezičastega orodja niso nastale nobene makrosko-



Sl. 25: Eksperimentalna orodja in izdelek: a,b) Uporabne retuše, ki so nastale na ostrem rezilnem robu sileksa iz Francije (zgoraj) in lokalnega tufa (spodaj), s katerim smo enako dolgo tesali eno in isto svežo kortikalno kost juvenilnega rjavega medveda. c,d) Nedokončana koščena konica iz iveri kortikalne fosilne kosti jamskega medveda in za izdelavo uporabljen neretuširan odbitek iz tufa.

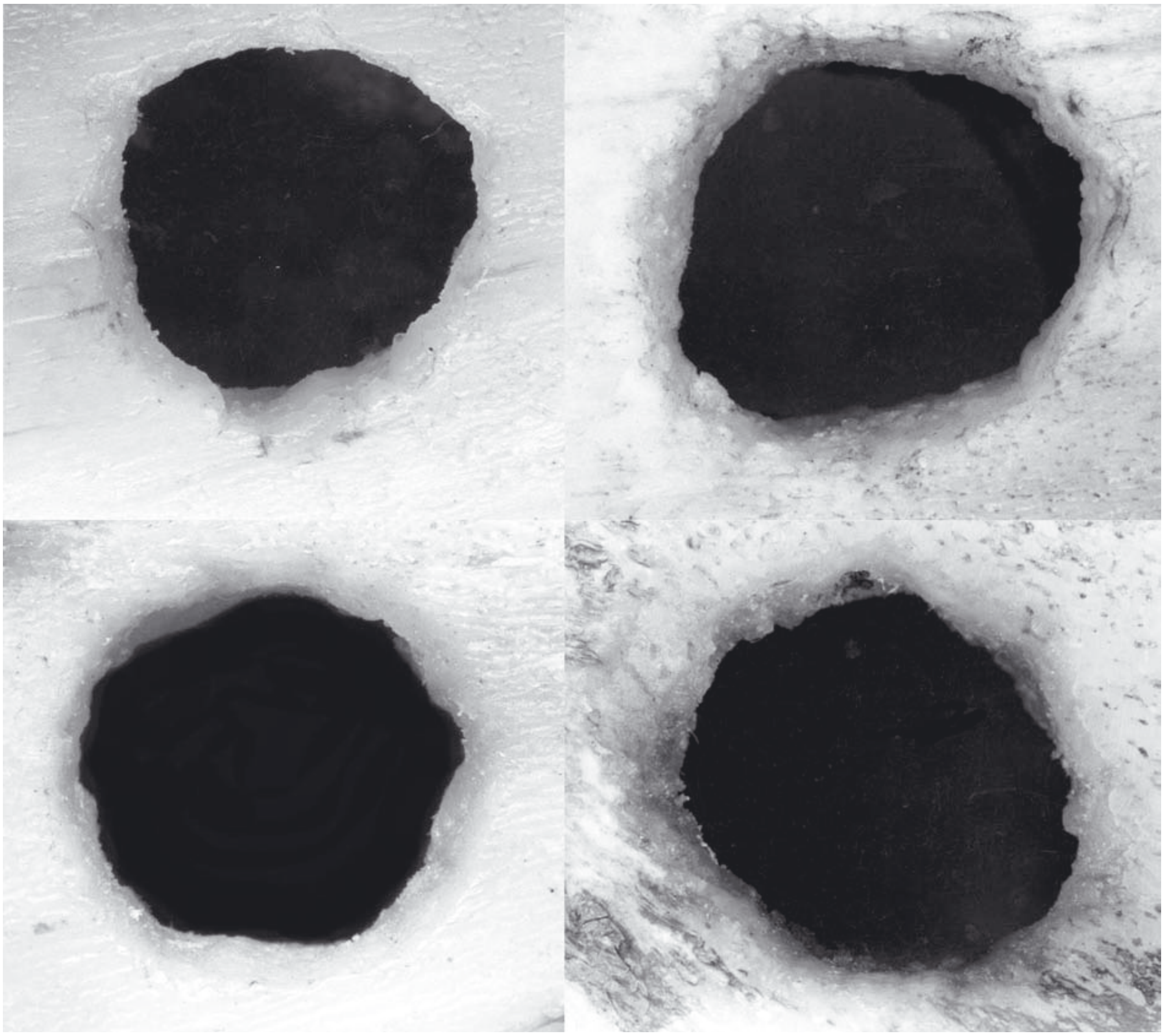
Fig. 25: Experimental stone tools and product: a,b) Retouches from use, created on the sharp cutting edge of silex from France (above) and local tuff (below) with which we worked one and the same fresh cortical bone of juvenile brown bear for the same length of time. c,d) Uncompleted bone point from a splinter of compact fossil bone of cave bear and unretouched flake of tuff used for making it.

pske poškodbe. Edina nevarnost je, da se jeziček odlomi, če hočemo narediti luknjo, ki je globlja od dolžine jezička. Kritična globina lukenj s premerom pod 10 mm je nekako 10 mm. Globlje brez večanja premera luknje ne gre. Vendar pri naravno votlih steblih običajno niso potrebne tako globoke luknje. Značilnejše poškodbe smo dobili na vogalih delovnega roba dletastega orodja ali vbadala (Bastiani et al. 2000, t. 2: 3).

Če si sedaj predstavljamo, da zamenjamo surovino, npr. les s kostjo, je povsem naravno, da bomo na začetku uporabljali enako tehnologijo, tj. enaka orodja in isto metodo kot prej. Do tehnoloških prilagoditev novemu materialu bo prišlo po potrebi in postopoma na podlagi pridobljenih delovnih izkušenj.

Da se da v cevasto kost iztesati luknjo z artefakti, ki so bili najdeni v Divjih babah I na podoben način kot v les, smo že poročali (*sl. 7:* b in Bastiani, Turk 1997). Za nami so to poskušali tudi drugi, vendar z manj uspeha (Albrecht et al. 1998, 13). Variabilnost detajlov izklesanih lukenj je veliko večja od variabilnosti lukenj, narejenih z zobmi (prim. *sl. 11; 16; 19* in *26*). To velja tudi za lijakasto odkrušen rob na notranji, medularni strani. Nekatere poskusno izklesane luknje so v podrobnostih in v splošnem neločljive od lukenj na piščali (prim. *sl. 12* in *23; 26*). Kar je še bolj pomembno, je to, da so lahko brez vsakršnih, tudi mikroskopskih sledov orodja, v našem primeru konice ali jezička (prim. *sl. 23:* d,f in e). Pri tesanju luknje ali lukenj kost nikoli ne poči.

Pri poskusnem luknjanju svežih stegnenic mladega rjavega medveda so na jezičastih in koničastih orodjih nastale značilne makroskopske poškodbe. Raznolikost teh poškodb je veliko večja od raznolikosti, ki jo dobimo na podlagi nekaj poskusov. Gre predvsem za različne retuše na ventralni strani konice ali jezička in za odlomljene dele konic ali jezičkov koničastih in jezičastih orodij. Najprej se retušira sam



Sl. 26: Primeri eksperimentalno narejenih lukenj v svežo diafizo in metafizo juvenilnega rjavega nedveda na način, prikazan v *sl. 7:* b.
Fig. 26: Examples of experimentally made holes in fresh diaphyses and metaphyses of juvenile brown bear in the manner shown in *Fig. 7:* b.

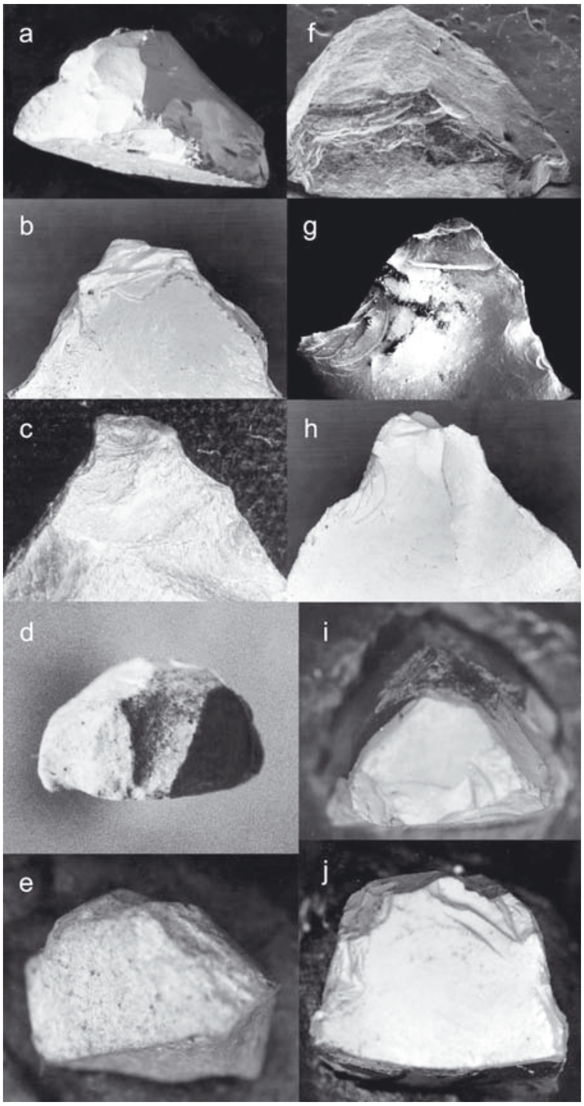
vrh konice ali jezička. Posebej značilen je ventralno zdrobljen vrh (*sl. 27:* g,j). Od vrha se lahko lateralno odkruši vbadalni odbitek ali ventralno eden ali več odbitkov, ki se lahko zaključijo s stopnico ali ne (*sl. 27:* h). Nato se retuširajo boki konice ali jezička. Na konici lahko nastanejo bočne izjede, na jezičku pa posamične stranske retuše z dobro izraženim bulbusom (*sl. 27:* g). Prelomi konic in jezičkov, do katerih je lahko prišlo že po nekaj udarcih ali šele po več tisoč udarcih po orodju, so bili večinoma plani.

Te dragocene eksperimentalne izkušnje so nam omogočile preusmeriti arheološko raziskavo. Preučevanje samih lukenj izključno na arheološkem gradivu je bilo vrtenje v krogu, kjer smo udeleženci razprave uporabljali iste dokaze, in sicer eni za eno in isto stvar, drugi proti eni in isti stvari. V danih okoliščinah je naloga arheologije, da najde posredne argumente za možnost umetnega nastanka lukenj in obdelave kosti nasploh, čeprav v zelo omejenem obsegu. Ozreti se je treba na potencialna luknjalna in druga orodja in na poškodbe na teh orodjih. Ker iz objektivnih razlogov nismo imeli možnosti mikroskopirati, smo se v naši pilotski raziskavi omejili zgolj na makroskopske poškodbe.

4.5. **Makroskopske poškodbe na specialnih orodjih iz Divjih bab I in z njimi povezana vprašanja**

Temeljno vprašanje, ki se postavlja na začetku, je: Ali so ljudje v zgodnjem obdobju obdelovanja kosti in podobnih trdih organskih materialov za določene primere dejansko uporabljali tu predlagano metodo indirektne perkusije?

Dejstvo je, da je ta metoda zelo učinkovita in preprosta in da jo lahko pri luknjanju uporabljamo tako na lesu kot na kosti. Metoda ne izključuje drugih metod, npr. vrtanja, ki je bolj učinkovito na kosti in podobnih materialih kot na svežem lesu. »Svedre« ali perforatorje v tipološkem besednjaku poznamo tako v srednjem paleolitiku (musterjenu) kot v zgodnjem mlajšem paleolitiku (orinjasjenu) (Debénath, Dibble 1994, 99; Bordes 1988, t. 35; Oliva 1987, t. 40). Nekateri so na las podobni enkratnemu jezičastemu orodju iz Divjih bab I (*t. 4:* 3). Izdelki ali luknje so arheološko zanesljivo prepoznavni šele iz šatelperonjena? in orinjasjena. Večina teh lukenj, tudi tistih v zobeh, ni izvrtanih (Taborin 1990, 339, sl.5; 6; Turk et al. 1997, sl. 11.7; Granger, Lévęque 1997, t. A-F). Domnevamo, da so bile nekatere narejene na enak način (se pravi iztesane, čeprav je v primeru kosti boljši izraz izklesane) kot luknje v lesu, torej surovini, ki se je uporabljala pred tem. Tudi na orodjih ne najdemo v tem zgodnjem času nobenih makroskopskih sledov vrtanja. V Divjih babah I nastopa en sam primerek s poškodbami, ki so sicer značilne za vrtanje (*t. 4:* 4).



Sl.. 27: Poškodbe na orodjih iz Divjih bab I (levo) in uporabne retuše na eksperimentalnih orodjih (desno): a,b) Zdrobljena in ventralno retuširana konica koničastega orodja štev. 283 iz plasti 13. c) Negativi odbitkov na ventralni ploskvi pod konico orodja štev. 403 iz plasti 21. d,e) Retuše na čelu odlomljenega jezička jezičastega orodja štev. 624 iz plasti 7, nastale pri uporabi orodja. f) Pri klesanju luknje zdrobljen in ventralno retuširan jeziček eksperimentalnega orodja. g) Plitke bočne izjede, nastale pri eksperimentalnem luknjanju s koničastim orodjem. h) Negativ vbadalnega odbitka pod zdrobljeno konico eksperimentalnega orodja. i, j) Uporabne retuše na čelu in ventralni ploskvi odlomljenega jezička eksperimentalnega jezičastega orodja.

Fig. 27: Damage on tools from Divje babe I (left) and retouches of use on the experimental tools (right): a,b) Crushed and ventrally retouched point of pointed tool no. 283 from layer 13. c) Scars on the ventral surface under the point of tool no. 403 from layer 21. d,e) Retouches of use on front edge of broken tongue of tongued tool no. 624 from layer 7. f) Tongue of experimental tool crushed and ventrally retouched during chiselling a hole. g) Shallow lateral notches created during experimental making of holes with a pointed tool. h) Scar of burin spall below the crushed point of experimental pointed tool. i, j) Retouches of use on front edge and ventral surface of broken tongue of experimental tongued tool.

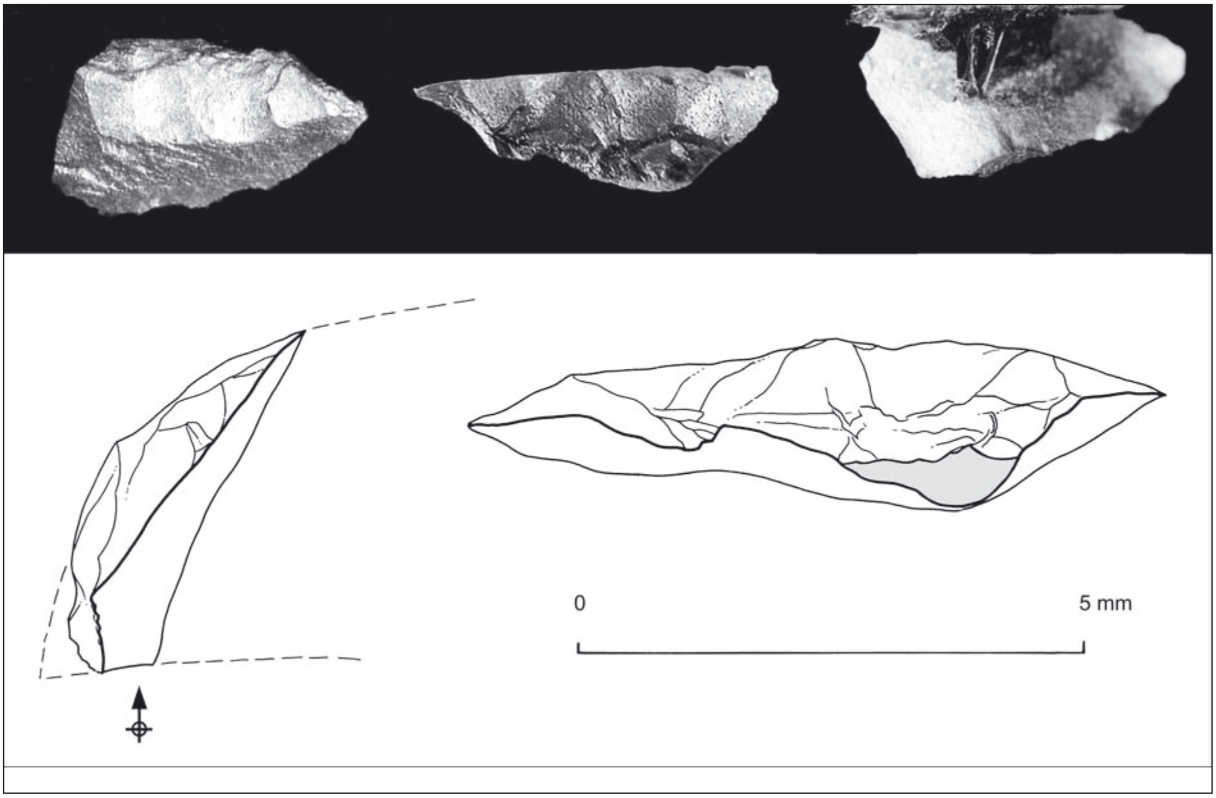
Luknjanje trših materialov, kamor štejemo tudi nekatere trše vrste lesa, ne more biti pridobitev mlajšega paleolitika niti v tehnološkem niti v uporabnem smislu (prim. d'Errico et al. 1998c; Baffier 1999, 94). Da se luknje v večjem številu naenkrat pojavijo prav tam (glej M. Brodar 1985; Holdermann, Serangeli 1998), je lahko zgolj stvar obstojnosti za naluknjanje uporabljenih surovin (Kunej, Turk 2000). Velika podobnost lukenj na piščali z nekaterimi luknjami na t. i. musterjenskih žvižgalkah in z nekaterimi luknjami na cevastih kosteh in mandibulah iz orinjasjenskih najdišč v Sloveniji ne preseneča, ker so bile vse te luknje teoretično lahko narejene z enakimi orodji in z enako metodo (prim. *sl. 12* in Dauvois 1989, 9, sl. 3; Turk et al. sl. 11.12; Turk, Stele 1997, sl. 43). Oboje ni nujno vezano izključno na določeno kulturno tradicijo in na dolečeno vrsto človeka, kot nekateri mislijo (M. Brodar 1999). To dokazuje najdba dveh tipičnih »musterjenskih« žvižgalk iz prvega in drugega prstnega členka navadnega jelena iz časovno odmaknjene mezolitske? plasti v Mali Triglavci (neobjavljeno).

Na samih artefaktih je težko dokazati sledove predlagane metode dela, čeprav nekatere poškodbe lahko kažejo v to smer (*t. 3:* 1; *6:* 1 in Bastiani et al. 2000).

Makroskopski sledovi od obdelovanja kosti so na orodjih težko prepoznavni. V plasti 8 Divjih bab I imamo en trikrat odlomljen »izluščen« kos - *pièce esquillée* (*t. 4:* 2), ki bi lahko nastal pri obdelavi zelo trdega materiala z indirektno perkusijo. Kosov, ki so delno izluščeni (okrcani), je v najdišču še nekaj (Bastiani et al. 2000, t. 4: 2; 6: 8; 13: 3). Vendar je težko reči ali je prišlo do poškodbe pri obdelavi trdega lesa ali kosti. V še starejših plasteh so bila najdena orodja, ki imajo en rob izmenično retuširan (Bastiani et al. 2000, t. 7: 4,5). Poudarek je na izmenično, ker so izmenični zobci sestavni del pravih žag in le v tem primeru lahko govorimo o poznavanju principa delovanja žage. Najbolj značilen primerek takšnega orodja iz Divjih bab I ima poškodovan en zobec (ibid, t. 7: 4). Omembe vredna je tudi možna prisotnost odkruškov retuširanih robov (*sl. 28*; *t. 6:* 1,4). Taki odkruški lahko nastanejo samo pri čezmerni rabi delovnega roba na trdem materialu ali pri popravilu delovnega roba. Včasih jih je težko ločiti od odkruškov, ki nastanejo pri pripravi udarne ploskve na jedru. Vendar mislimo, da to pri naši najdbi ni primer (*sl. 28*).

Za nas so pomembnejše poškodbe, ki so najverjetneje nastale pri luknjanju bodisi lesa bodisi kosti.

Delovni rob z oškrbljenimi vogali enega redkih vbadal je prvi, ki ga omenjamo, čeprav je poškodba lahko nastala samo pri luknjanju lesa (*t. 3:* 3 in prim. Bastiani et al. 2000, t. 2: 3). Ostala omembe vredna orodja so koničasta in jezičasta orodja. V nadaljevanju bomo povzeli nekatere izsledke iz obsežnejše raziskave poškodb na teh orodjih (ibid. 45 ss; Bastiani et al. 2000). Te bi lahko prispevale k reševanju



Sl. 28: Odlomek retuširanega delovnega roba neznanega orodja iz plasti 10 v Divjih babah I in rekonstrukcija nastanka.
Sl. 28: Fragment of retouched working edge of an unknown tool from layer 10 in Divje babe I and reconstruction of original edge.

vprašanja o izvoru lukenj v piščali. Vsi ozsledki se nanašajo na Divje babe I.

Med najdenimi artefakti je neobičajno veliko različnih koničastih in jezičastih primerkov (*t. 3; 4*). Nekateri so prav nenavadni, kar zadeva izdelavo, obliko (ločno vbadalo, gobčasto praskalo v jeziku tipologije) in uporabo (*t. 4:* 5) (ibid. 23). Menimo, da jih ima veliko odlomljen vrh konice ali jezička (*t. 3:* 1,4-6). Ker ne vemo, kdaj in kako je do takšne poškodbe prišlo, lahko podvomimo v prvotno obliko in namembnost teh artefaktov. Takšen dvom nam pomagajo razpršiti najdbe najmanj dvanajstih odlomljenih konic in jezičkov koničastih in jezičastih artefaktov (*t. 5-7*). Noben odlomek se žal ne prilega na katerega od številnih domnevno odlomljenih koničastih in jezi-častih artefaktov. Naj omenimo, da se nam je med vsemi doslej najdenimi artefakti (471 kosov) posrečilo sestaviti samo tri. Sam vršiček odlomkov je pogosto poškodovan (odlomljen ali retuširan). Noben odlomek nima poškodovane prelomne ploskve. Nasprotno temu imajo skoraj vsi domnevno odlomljeni koničasti in je-zičasti artefakti različno poškodovane prelomne ploskve konic in jezičkov. Poškodbe so zelo verjetno posledica nadaljnje rabe ostrih robov, ki so nastali s prelomom na konici ali jezičku. Močna raba vseh rezilnih robov artefaktov je ena glavnih značilnosti najdišča (Bastiani et al. 2000; Turk, Bastiani 2000). Novo nastali odlomki konic in jezičkov so bili premajhni (povprečna velikost 9,6 mm) in predvsem neprimernih oblik, da bi se jih dalo še uporabljati. In to kljub temu, da so bili novi robovi ob prelomni ploskvi povprečno še vedno daljši (10,9 mm) od domnevno uporabljenih robov (7 mm) odlomljenih koničastih in jezičastih artefaktov ter od robov na pravih mikrolitih (Bastiani et al. 2000, t. 5.2-5). Zanimivo je, da se velikosti odlomljenih konic in jezičkov približujejo skrajni mogoči globini luknjanja s temi orodji, ki je hkrati kritična točka, pri kateri se konica ali jeziček običajno odlomi zaradi prevelikih bočnih obremenitev.

Za prelome odlomljenih koničastih in jezičastih artefaktov ter njihove odlomke sta med drugim značilni predvsem naslednji obliki: prelom z utorom (na obojih) in prelom z zavihkom (samo na odlomljenih artefaktih) (*t. 3:* 1 in Bastiani et al. 2000, 47, sl. 8: b,c,e). Takšnih prelomov sicer ni veliko (5-8 % pri odlomljenih artefaktih in 22 % pri odlomkih), vendar bi jih lahko povezali z uporabo artefaktov (prim. Fischer et al. 1984). Prelomi z utorom ali z zavihkom na jezičastih artefaktih so zelo verjetno nastali pri luknjanju trših materialov. Pomembno je, da je večina takšnih prelomov na odlomljenih artefaktih retuširana.

9-10 % vseh ("inverznih") retuš na ventralni ploskvi artefaktov je na konici ali jezičku, na robu preloma konice ali jezička in na stranskem robu ob prelomu konice ali jezička (Bastiani et al. 2000, tab. 5, 44). Inverzne retuše, povezane s konico ali jezičkom, nastopajo vedno posamič, nikoli v nizu (*t. 4:* 3). Včasih nastopajo skupaj s prelomom z utorom in z nizi retuš na sami prelomni ploskvi. Stopnja retuširanosti pred prelomom in po prelomu je odvisna od uporabe (luknjanje, rezanje).

Med različnimi makroskopskimi poškodbami orodij je tudi 16 % poškodovanih ali odlomljenih konic in jezičkov, ki imajo čelo zdrobljeno namesto retuširano (*sl. 27:* a; *t. 3:* 2; *5:* 1; *7:* 2). Takšne poškodbe smo dobili pogosto pri poskusnem luknjanju kosti (*sl. 27:* f,i). Značilne so tudi za konice projektilov (Shea 1997).

Pogosto so poškodovani tudi sami vršički odlomljenih konic in jezičkov (*t. 7:* 2,4). En tak vršiček smo tudi našli (*t. 7:* 1).

Zelo zelo redke so plitke izjede ob prelomih in na odlomkih konic in jezičkov (*t. 3:* 5; *5:* 4). Plitki izjedi na obeh straneh konice dejansko predstavljata prehod iz koničastega v jezičasto orodje oziroma samooblikovanje orodja med delom (glej Bastiani et al. 2000). Izjedi, ki se nadaljujeta na ventralni strani artefakta, sta lahko nastali samo pri luknjanju kosti. To potrjujejo naši poskusi. Pri luknjanju lesa ali pri uporabi koničastih artefaktov za projektile nikoli ne pride do takšnih poškodb (ibid., Odell, Cowan 1986; Shea 1997).

28 % vseh makroskopskih poškodb predstavljajo nizi retuš (tip gama po Prostu 1993) na prelomnih ploskvah koničastih in jezičastih artefaktov. Zapletene retuše na prelomnih ploskvah bi težko razložili z naravnimi silami. Trije odlomki retuširanega odbitka, najdeni skupaj cementirani v sedimentu potem ko so nastali zaradi pritiska usedlin, takih retuš nimajo. Imajo pa prilepljenih več retušnih lusk, ki jih je pritisk usedlin odluščil s stranskega roba in talona (*sl. 24:* a). Ta enkratna najdba iz plasti 10 v Divjih babah I ne potrebuje nobene dodatne razlage.

V navedenih primerih gre zelo verjetno tudi za poškodbe, ki so nastale pri uporabi koničastih in jezičastih delov artefaktov. Vse opisane poškodbe smo dobili namreč pri poskusnem tesanju lukenj v zelo trde materiale. Pogoste retuše na prelomnih ploskvah skoraj zanesljivo pomenijo, da so se orodja odlomila med uporabo, tj. pri luknjanju. Poškodba orodja ni pomenila tudi njegovega konca, temveč se je to rabilo dalje, tokrat v druge namene. Domnevna nadaljnja raba odlomljenih koničastih in jezičastih orodij je podkrepljena z dejstvom, da se niso nikoli rabili naprej odlomki teh orodij.

Najdena jezičasta in koničasta orodja iz Divjih bab I so se zelo verjetno poškodovala pri izdelovanju lukenj v les. Domnevo, da so luknje tesali, potrjujejo nekatere poškodbe, ki lahko nastanejo samo pri direktni ali indirektni perkusiji. To pomeni, da lahko dobimo podobne poškodbe na artefaktih, ki se enkrat uporabljajo kot orožje (konica projektila) drugič kot orodje (luknjalo). Na najdenih primerkih žal ni izrazitejših makroskopskih poškodb na stranskih ventralnih robovih, ki bi jih lahko uporabili kot kronski dokaz za izdelovanje lukenj v kost. Vendar nekatere poškodbe nedvomno kažejo v to smer (prim. *t. 3:* 5; *5:* 4; *6:* 5*; 7:* 4).

Problem luknjanja je večplasten. Prvič so posledice luknjanja na orodjih odvisne od števila lukenj, ki bi jih obiskovalci jame naredili v kosti. Drugič so poškodbe od orodja do orodja različne, odvisno od orodja in njegove zmogljivosti. Tretjič lahko največ odlomkov konic in jezičkov pričakujemo v svetlem vhodnem predelu jame, kjer smo ugotovili največjo obrabo orodij (Turk, Bastiani 2000; Bastiani et al. 2000, 27 ss). Ker usedlin tam nismo izpirali, smo v vhodnem predelu našli le dobro četrtino vseh tovrstnih odlomkov. Skoraj tri četrtine smo jih našli v temnejšem osrednjem predelu jame, kjer smo vse usedline izpirali in kjer smo ugotovili bistveno zmanjšano obrabo orodij. Različno obrabljenost orodij lahko precej zanesljivo povežemo z različno stopnjo aktivnosti v različno osvetljenima predeloma jame.

Večina jezičastih in koničastih orodij, ki smo jih našli v Divjih babah I, je bila izdelana iz lokalnega tufa in rožence.

Tufi se pri luknjanju kosti bistveno počasneje poškodujejo (retuširajo) kot roženci (*sl. 25*: a). Vzrok je njihova zrnavost. Zato domnevamo, da so se tufi v ta namen pogosteje uporabljali kot roženci in druge kakovostnejše surovine. Posledica tega je lahko to, da je med odlomljenimi jezički in konicami kar 50 % tufov, medtem ko je tufov med drugimi domnevno rabljenimi orodji samo 20 %. Kar zadeva same poškodbe se te bistveno ne razlikujejo med različnimi surovinami, iz katerih so narejena orodja.

5. **SKLEPI**

Naši pionirski poskusi s čeljustmi zveri so nas opozorili predvsem na možnost napačnih razlag izsledkov tafonomskih raziskav, ki preveč enostransko rešujejo vprašanje naravnih in umetnih poškodb kosti. Vprašanje je lahko veliko bolj zapleteno, če se med seboj prepletajo različni dejavniki, tako človeški kot zverski. Zavedati se moramo, da so določene zveri (npr. volkovi) vedno sledile ljudem in se lotevale njihovih kuhinjskih ostankov in drugih odpadkov. Sledovi zverskih zob na človeških artefaktih še ne pomenijo, da so artefakte naredile zveri, oziroma da gre za t. i. psevdoartefakte namesto za prave artefakte, kar je pogosta dilema v paleolitski arheologiji. Prepletanje različnih dejavnikov v paleolitski arheološki praksi ni samo verjetno, temveč lahko celo pogostno. Zato bi morali biti v določenih primerih skrajno pre-vidni pri razlagah sledov, ki jih puščajo na kosteh zveri. Brez natančne analize možnosti, ki jih imajo zveri za svoje početje in ki vključuje tudi eksperiment, so lahko tafonomski sklepi prenagljeni in včasih osnovani celo na napačnem razmišljanju.

Pri določenih luknjah se da po obliki in razporeditvi sklepati ali so bile luknje narejene s kanini ali z ličniki. S kanini luknja kosti predvsem medved. Določen delež lukenj v kosteh je nedvomno povezan z razširjenostjo jamskega medveda in s spremenljivo številčnostjo njegovih ostankov (Albrecht et al. 1998). Zato ne preseneča dejstvo, do so luknje v kosteh prvič opazili ravno v nekaterih paleolitskih najdiščih z množičnimi ostanki jamskega medveda in da so jim posvetili precej več pozornosti kot v paleolitskih najdiščih z malo ali brez ostankov jamskega medveda. Vendar vseh lukenj vseeno ne moremo pripisati nenaravnim ugrizom jamskega medveda in drugih zveri. Videti je, da so paleolitskega človeka naravno naluknjane kosti navdihnile, da je začel po-snemati svoje nevarne tekmece - zveri, in dodajati svoje umetelno izdelane luknje. Namena tega početja v večini primerov ne bi bilo lahko pojasniti. Mislimo, da ni nujno, da bi imele vse umetno naluknjane kosti tudi uporabno vrednost, kot to ni nujno za vse skrbno retuširane, vendar komaj uporabne artefakte. Lahko bi šlo samo za preprosto simbolično izražanje, za opozarjanje nase v smislu kasnejših grafitov, za puščanje sporočil sovrstnikom ... Nekaj tega poznamo v drugačni obliki tudi v živalskem svetu.

Jasni sledovi zverskega udejstvovanja na kosteh, najdenih v vseh plasteh v Divjih babah I, so skrajno redki. Lahko rečemo, da niso pogostejši od značilnih urezov, ki so jih naredili paleolitski obiskovalci jame na kosteh. Na najdišču so bile aktivne predvsem srednje velike zveri, sodeč po poškodbah kosti. Velike zveri, vključno z rjavim in jamskim medvedom, niso naredile skoraj nobene vidne škode.

Zveri bi lahko naredile luknje na piščali samo s kanini med hranjenejem z mesom in/ali kostmi. Luknje niso mogle nastati pri napadu ali obrambi. Teoretično bi bil najverjetnejši kandidat za luknjanje medved, praktično pa je takšno luknjanje komaj verjetno. Druge zveri ne pridejo v poštev predvsem zaradi tako nenormalno močnega ugriza s kanini pri hranjenju. Zavedati se moramo, da je ogromna razlika med luknjanjem kortikalne lupine diafize in luknjanjem kortikalne lupine metafize ter ploskih kosti, kakor tudi med luknjanjem z ličniki in kanini. Zato se poškodb enih in drugih kosti z enimi ali drugimi zobmi ne da vsevprek primerjati (prim. d'Errico 1998a).

Velikost lukenj (premer) je nepomembna za ugotavljanje njihovega izvora, ker so konice zob približno enako velike kot konice paleolitskih orodij (toda glej d'Errico 1998a). Pomembnejša je oblikovanost lukenj, vendar se umetne in naravne luknje v svoji variabilnosti delno prekrivajo. Zato je treba za razlikovanje upoštevati tudi druge kriterije, ki smo jih v glavnem obdelali v tem prispevku.

Luknje, ki se na splošno in v podrobnostih dosti ne razlikujejo od lukenj na piščali, je možno narediti z nekaterimi srednjepaleolitskimi artefakti, ki jih poznamo iz Divjih bab I in drugih najdišč. Metodologija izdelave takšnih lukenj doslej ni bila znana in priznana, čeprav se je najverjetneje zelo učinkovito uporabljala na lesu od starejšega paleolitika dalje. To je metoda indirektne perkusije ali tesanje (Turk, Bastiani 2000; Bastiani et al. 2000).

Pri udarjanju po koničastem ali jezičastem orodju nastanejo pri luknjanju trdih materialov enaki prelomi in poškodbe kot na projektilih in nekatere dodatne oblike poškodb, ki so značilne izključno za tesanje. Te so predvsem retuše in izjede ob robovih. Potrebno je opozoriti, da doslej ni nihče pomislil na takšno možnost za nastanek poškodb na koničastih artefaktih. Da so se ti, vsaj v Divjih babah I, resnično uporabljali kot orodja, dokazujejo številni odlomki konic in jezičkov, ki jih najdemo le izjemoma tudi pri projektilih.

Ljudje srednjega paleolitika so občasno obdelovali tudi kost. To je morda razvidno celo v Divjih babah I, kjer so poleg piščali v isti plasti in v starejših plasteh tudi odlomki drugih domnevnih koščenih artefaktov. Skromna kamnita industrija (471 kosov >1cm in >1g), ki se navezuje na ostanke 20 ognjišč (skoraj polovica ognjišč je bila v plasti s piščaljo), je sestavljena iz močno izrabljenih (poškodovanih) orodij (Bastiani et al. 2000). Poškodbe bi tradicionalno pripisali krioturbaciji, bioturbaciji in podobnim pojavom, čeprav so lahko poškodbe tudi dokaz za še nepojasnene dejavnosti, ki so jih ljudje izvajali v jami, ki ni bila nikoli njihovo stalno bivališče. Kljub nestalni naseljenosti in domnevni kratkotrajnosti obiskov, vloge najdišča, ki se v daljšem časovnem razdobju navidezno ni spreminjala, ne gre podcenjevati.

Nove analize lukenj na piščali, podprte z ustreznimi eksperimenti, so pokazale, da je na eni strani zelo malo razlogov, da bi luknje na piščali naredila katerakoli zver z zobmi in da na drugi strani ni tehtnega razloga, da obeh celih lukenj ne bi naredil človek z razpoložljivim kamnitim orodjem. Kar se tiče zveri je zelo malo tehtnih razlogov, da bi luknje naredila jamska hijena, še manj, da bi jih naredil jamski ali rjavi medved in nobenega razloga, da bi jih naredil volk. Zato je odločitev za domnevo, da je luknje naredil človek zdaj lažja kot pred leti. Vendar pa zaradi odsotnosti direktnih dokazov in podobnih najdb še vedno ni brez tveganja, da smo se, kljub vsemu, zmotili.

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New analyses of the "flute" from Divje babe I (Slovenia)

Translation

1. **INTRODUCTION**

The unusual flute-like find from the Mousterian layer in Divje babe I has thoroughly stirred the profession and public. The find can be explained in two ways, as the finders were aware from the very beginning, although some of the media immediately branded the find the oldest known flute. We ourselves stressed throughout that such an explanation is only tentative (Turk et al. 1995; 1997; Kunej, Turk 2000). The presumption is based on the great similarity to accepted Palaeolithic and later bone flutes. However, similarity in this case is not evidence, because elements for reliable artificial classification of the find are lacking.

At the start of the burning debate about the flute (this term will be used, without it being intended to pre-judge the issue), we had too little experience to approach the solution of this particular problem in the appropriate way. Unfortunately, that has also been the case with other professionals who have been attracted to this interesting question (Albrecht et al. 1998; Chase, Nowell 1998a,b; D'Errico et al. 1998a).

An international meeting in Spodnja Idrija in 1998 to discuss the flute showed above all that using identical evidence for and against various hypotheses leads nowhere. Armed with fresh experience, therefore, we studied again the two most probable hypotheses about the creation of the flute. We supported the investigation with new and more appropriate experiments than at the time of the find to test both hypotheses (see Kunej, Turk 2000). Meanwhile, we also excavated and studied the whole of Layer (Unit) 8 in the central part of the cave where the flute was found, and also included this data in our research.

Let us stress again at this point that the holes and all the damage to the flute are of mechanical origin (breaking, abrasion) almost exclusively. It shows no signs of more explicit chemical damage (corrosion) of which numerous examples exist at the site, mainly on larger fragments as well as whole bones. Establishing the origin of the mechanical damage to the holes is of crucial importance in interpreting the find. It is precisely this that divides opinions. Some advocate an anthropic origin of the holes and others an origin based on carnivore damage.

We will attempt here to give objective reasons for each hypothesis. There could also be a composite of the two. However, in such a case, we need to distinguish what humans contributed and what animals did.

2. **TAPHONOMY**

Before looking in more detail at holes and depressions on fossil bones, it is useful to be familar with some taphonomic results in the Divje babe I site that will assist in explaining the activity of carnivores on the bones of cave bear. This activity is not directly linked with the creation of the flute as a whole. So the taphonomic observations presented here can under no circumstances serve as evidence to support an exclusively carnivore origin of the flute.

We obtained a general taphonomic picture of the site by analysing various categories (young or old, whole or fragmented specimens) of cave bear extremities.

The diaphysis of most long bones of fully-grown individuals are so hard that no carnivore, including cave hyena, could fracture them. By measuring the force required to pierce the fresh cortical bone on the diaphysis of the femur from a recent large subadult brown bear (average 4547 Newtons), we assume that a force of at least 6000 Newtons was required for piercing the femur of an adult cave bear (see *Table 4*). Additionally, it must be done with a completely open mouth, when the muscles of mastication are extended and their effect is minimized.

Carnivores were capable of fragmenting all bones of young individuals and small compact bones (carpals, tarsals, metapodials and phalanges) of adult individuals. Some of these bones could also be smashed by people.

All categories of compact bones deserve particular attention (see Marean 1991). These bones, because of their small size and shape are the most resistant to weathering. They can also be recognised in a fragmentary state. They are of moderate interest only to carnivores. Because of all the properties mentioned, they are the best bones for assessing predatory activity on cave bear bones.

In order to evaluate the taphonomic picture of bone material of the upper part of layer 8 in the central part of the cave, where the flute was found, we selected for comparison an average picture of bone material from all layers investigated to date (Layers 2-8) in this part of the cave (*Fig. 1*). On this basis, we were able to reach the following general conclusions:

In relation to long bones there is a great difference in the fragmentation of young and old specimens. Young specimens are represented almost exclusively by fragmented diaphyses, while in the adult specimens, fragmented epiphyses slightly predominate. Young specimens also have more fragmented bones per whole bone than adult ones. With young specimens, the femur, together with the ulna and radius, most diverges from the average of selected long bones.

Among femurs from young individuals on average, whole bones are least represented and fragmented diaphyses most (*Table 1; Fig. 3*). The diaphysis is the part which has the most stored nutrients. Since mainly cylindrical fragments from the diaphysis remain, the diaphyses found were damaged mainly by small to medium large carnivores when they removed the epi- and metaphyses. These are less well represented, and particularly distal epi- and metaphyses from femurs. The operation of carnivores is also shown by moderate traces of chewing, including gauging, depressions and striae on all long bones, mainly young specimens, with a stress on the femur (*Table 1; Fig. 3*).

With compact bones, as with long bones, great differences exist between young and old specimens. *Figure 5* shows the smallest combined number of whole and fragmented skeletal parts, obtained by dividing (by loading) for each bone the number found by the number of left and right bones in the skeleton. The best represented skeletal part may also thus represent the number of individuals determined from the complete compact bones. To roughly assess the taphonomic losses of compact bones, the (minimum) number of individuals on the basis of the associated finds of isolated teeth is used. With adult individuals, the more probable number of individuals is outside brackets. We also cite the number of sesamoid small bones found the size of a pea, to show the precision in recovering small compact bones.

The compact bones from young specimens are essentially more fragmented with more fragments per whole bone and fewer whole bones per individual than the bones of adult specimens. The best preserved compact bone with the most whole and fewest fragmented bones among both young and adult specimens are medial phalanges (*Fig. 5*).

The degree of preservation of compact bones found is clearly connected with the differing resistance of the two age categories of bones. Among the possible factors responsible for the degree of preservation, weathering and the operation of carnivores are undoubtedly the most important. Which was the strongest may be determined from the ratio of whole to fragmented bones in the two age categories.

Weathering would affect mainly the most fragile bones: distal and medial phalanges, the majority of carpal-tarsal bones and above all sesamoid bones. The majority of these bones, especially among adult specimens, are among the better represented skeletal parts.

Carnivores would start to chew a paw at the joints (carpal and tarsal bones) or at the toes and advance towards the centre (bones of the metapodium). The best evidence for such activity is seen in the bones of young specimens. There are fewest carpal-tarsal bones, which a large enough carnivore could devour whole. Calcanei often lack a large part of the *tuber calcanei*. Finger bones are most numerous presumably because the claws made them less interesting to carnivores. Metapodials, which carnivores would presumably reach when they had removed the phalanges or carpals and tarsals, are among the most fragmented parts and in middle place in terms of representation. They normally lack a large part of the distal metaphysis, and more rarely the proximal epiphysis. Compact bones of adult specimens show an essentially different picture, which results from *in situ* weathering and limited predatory activity demonstrated in chewed-off distal epiphyses of the metapodium.

Direct evidence of predatory activity exists in tooth depressions on all compact bones except on the distal phalanges.

If bone remains from the upper part of Layer 8, where the flute was found, are compared with the described average taphonomic picture of the central part of the cave, there are no major differences (see *Figs 1; 3; 5* and *2; 4; 6*). This is especially true for young specimens.

In the upper part of Layer 8, more complete diaphyses exist than in the whole sample from the central part of the cave. There are also minor differences in the degree of preservation of different parts of the femur. All this suggests a reduced rather than increased activity of carnivores, as was also indicated by the relatively more uniform state of preservation of compact bones from adult specimens.

Layer 8 as a whole gives a similar picture to the upper part of Layer 8. Layers 2-7 deviate rather more (Turk, Dirjec 1997a, Fig. 8.6).

In general, the same agents were more or less always at work. These agents did not necessarily produce the flute, but they certainly transformed it.

3. **FIRST HYPOTHESIS: HOLES MADE BY TEETH**

Holes in fossil bones, mainly cave bear, which are assumed to have been made by carnivores have long been familiar (Kos 1931; M. Brodar 1985). Opinions on which carnivore, and with which teeth they pierced the bones, have always been divided or undetermined.

The holes in the flute provide no conclusive evidence for their origin from carnivores, i.e., macroscopic remain or remains of depressed cortical bone on the edge of the holes or in the medular cavity. In the majority of puctured bones from the site, such remains, despite the thin cortical shell have been excellently preserved and immediately dispel any doubt about the origin of such damage (see *Pl. 5* and *6-8*) (see also M. Brodar 1985). The edges of the holes on the flute do not have any remains of depressed bone.

When the flute was discovered, we were unfortunately not particularly attentive to possible fragments of broken cortical bone which might have remained in the medullary cavity, especially with possible piercing of the shell with blunt (worn) teeth. The flute was extracted from a fairly large piece of very compact breccia which we had broken off the thick cemented surface in Layer 8. The medullary cavity was surprisingly not filled with sediment, nor had the breccia extended into it at the two broken ends of the flute. It is therefore improbable that fragments of cortical bone which may have entered the medullary cavity under the pressure of teeth, would have remained in it.

In connection with the circumstances of the discovery and sedimentary context of the find, the following can be asked:

Why did sediment, despite the numerous openings in the flute, not enter the medullary cavity and cement there, as happened with all long bones with a *post mortem* accessible medullary cavity in the layer with the flute. Why is only the surface of the bone encrusted by sediment? Why did something similar not happen to the interior? What do the remains of fossilised hair on the encrusted bone surface mean?

3.1. **Starting-point**

In studying the first hypothesis, we must consider both general and special conditions which a single carnivore has in biting or chewing, and all the possible effects of chewing a bone. The latter can be established only on the basis of experiments. Since we could not use real carnivores for the required experimental bites in the fresh thigh bone of a young brown bear, we conducted all the necessary experiments with exact replicas of various carnivore dentitions made from bronze and iron (*Fig. 7:* a). We thus approximated as closely as possible the natural conditions in which the flute could have been made. We were unable to simulate the strength of real teeth, the reaction of the pressoreceptors in periodontium connected with reflex deactivation of the muscles of mastication with overburdening, uneven contraction of the masticatory muscle, nor to make a hole in exactly the same places as they are on the flute. The material with which we made the artificial dentition, the operation of the universal testing machine with which we contracted the artificial jaws and, not least, the thigh bone of an immature brown bear which at the same age has an essentially longer diaphysis than the thigh bone of an immature cave bear, are to blame for all the deficencies.

In connection with the hypothesis of a natural origin of the holes in the flute, we ascertained the following:

3-4 mm thick cortical bone on the pierced thigh bone could only have been pierced by the pointed permanent teeth (canine and some cheek teeth) of a largish adult carnivore, such as a wolf, cave hyena, brown or cave bear, leopard or cave lion. Young carnivores, because of hollow and poorly rooted permanent teeth, cannot pierce bone effectively (however, see Sutcliffe 1970, 1112; d'Errico et al. 1998a, 14).

A carnivore could make two or at most four holes in the flute simultaneously, mainly with canine teeth, with which it seizes and holds its prey. Carnivores almost always chew with their specially formed cheek teeth on one side of the dentition. Because of the thick muscle tissue which covers the rear of the thigh bone, where Holes 1 and 2 are (for practical reasons we have numbered the holes and notches in the flute as can be seen on *Fig. 8*), piercing *in vivo* was not possible. Apart from this, the holes would have been made with two successive bites, one higher, one lower on the thigh bone (see Chase, Nowell 1998a, 551 s). The distance between Holes 1 and 2 does not, in fact, correspond to the distance between the teeth in the left and the right side of the dentition of any adult carnivores listed above.

The distance between the two sided canine teeth (or cheek teeth) corresponds only to a combination of Hole 2 and Notches 3 and 5. In this case, we must also consider the different sizes of the hole and the two notches as remains of holes which could have been made by teeth. These sizes do not correspond to the size of holes in the reconstructed bite, in which one of the teeth would first have pierced the cortical bone and then worked itself in and made a very big hole. The holes (today only Notches 3 and 5) could also have been made by teeth in occlusion and one of the teeth in the other jaw. The fourth tooth would neither have pierced nor essentially damaged the bone. This is certainly impossible (*Fig. 9*).

A bite with such effects on the flute could have been made in theory by a cave hyena. Using four cheek teeth (right, left, upper, lower) , a bite would require twice as much force in the muscles of mastication than with normal chewing with only one side of the cheek teeth. With the use of all canine teeth, the muscles would have to release some 3 to 4 times greater force than with normal biting (calculated on the basis of measures of mandibles and the dentition of wolf and hyena). Although this could succeed, the holes would be a completely different size than are Hole 2 and Notches 3 and 5 on the flute (*Figs. 9, 10*).

It follows clearly therefore that the two holes and all the notches on the flute could only have been made separately, as a result of a number of bites in feeding or exercising the dentition and masticatory muscles.

3.2. **Results from experimental tests**

Tables 2-4 show a summary of the rough results of our experiments in piercing fresh femurs of immature brown bear in a ZWICK/Z 050 testing machine, with realistic metal replicas of the dentition of hyena, wolf and bear.

Of successful experimental holes, i.e., those in which we pierced the cortical bone in entirety, without thus cracking the bone lengthwise, almost all were on or close to the metaphyses. Here, the thin cortical shell surrounds the trabecular core which gives the bone a visco-elastic property (Linde 1994). It is therefore easier to pierce the bone in these places without it cracking longitudinally.

In both fossil and fresh long bones, almost all the characteristic depressions or holes recognisable as having been made by carnivores' teeth are, in fact, on the two metaphyses or epiphyses. The other relatively frequent depressions or holes from teeth are on short and flat bones, which have a similar thin cortical shell as the meta- and epiphyses.

The experiments showed that only one tooth normally pierces or depresses the cortical bone (*Table 2a*). The opposing tooth may leave no trace during this. Examples of both teeth (upper and lower) piercing or depressing the cortical bone or one of them piercing and the other depressing, are not alltogether uncommon (*Table 2a*). We obtained half (53%) of the double holes and depressions on the anterior side of the femur (*Table 2b*). On the flute, we have the remains of only one hole on this side (*Figs. 8:* 5; *12:* f). In the largest collection of holed femurs of juvenile cave bears from Mokriška jama in Slovenia (Aurignacian) we have 7 holes on the posterior and 6 on the anterior side (M. Brodar 1985). Of the holes on the anterior side, half are on femurs with traces of chewing. Of the holes on the posterior side, there are traces of chewing on only one femur.

The creation of almost half (40%) of the experimental holes which we made on the diaphysis is connected with longitudinal cracking of the cortical bone over almost the entire length of the diaphysis (*Table 3*). The diaphysis is constructed almost exclusively from the thickest and least elastic stratified cortical bone which surrounds the medullary cavity (Klevezal 1996, 16 ss). The bone is therefore most difficult to pierce here. Longitudinal fissures tend in particular to be created with holes in the central part of the diaphysis and with widening a hole to a diameter greater than 5 mm. It must be stressed that the bone does not crack only at the side on which the hole is created but also on the opposite side under the teeth in occlusion, irrespective of whether this or the opposing tooth pierces the bone, depresses it or hardly leaves any visible trace. Removal of the epiphyses has a strong impact on the resistance of the cortical shell against logitudinal cracking.

Holes on the diaphysis are extremely rare on recent and fossil material in comparison with holes on the meta- and epiphyses and on short bones (M. Brodar 1985; Gargett 1996; Albrecht et al. 1998; however, see d'Errico et al. 1998b: 9, Table 1). On the basis of the morphology, which is often affected by postdepositional processes, we cannot claim that they are characteristic exclusively of carnivores. The disposition of holes resulting from carnivores on long bones is undoubtedly in inverse proportion to the force required for piercing the cortical bone (*Table 4*). This is directly proportional to the ontogenetic stage of the bone, because almost all holes known to us are in juvenile specimens (see M. Brodar 1985, Pl. 3-5; Albrecht et al. 1998,11).

Why would a carnivore pierce the diaphysis when it has previously removed the epiphyses and damaged the metaphyses (see Chase, Nowell 1998a, 550)? When a tooth once pierces the cortical bone, it works as a wedge, which splits the bone. Splitting the bone is the aim of a carnivore, such as wolf and hyena, which occasionally feed on bones and bone marrow. Our measurements showed that the maximum force is required to pierce the cortical bone on the diaphysis and to further advance the tooth into the cortex connected with widening the hole (*Fig. 11*). During hole widening, the cortical bone sooner or later cracks. A cracked bone can be split into two parts with half the original force. The new question which we must answer if we advocate a carnivore origin for the holes and damage to the flute is why a carnivore would stop when, after at least two attempts, it had already almost achieved its aim.

We conclude from the above that the possibility of two and far less three or four holes in the flute being made by any carnivore with any of their pointed teeth, without splitting the diaphysis is extremely limited.

The holes in the flute are so big (9.7 x 8.2 and 9.0 x 8.7mm), and in such a place that a tooth which had dug so deeply at least twice, would almost certainly have split the bone. In view of our experiments, this would have happened irrespective of whether the tooth was sharp or blunt. In the places where a crack along which the bone splits derives from a hole which has been made by a tooth, often one or more lamellas of the surface layer of the cortical bone are splintered (*Fig. 11:* d). We have such longitudinal cracks at the holes and notches on the flute, as unexpressed scars of lamellar flakes in places by them (*Fig. 12:* b). We have no cracks which could be ascribed to the pressure of an opposing tooth applied many times. Such a crack would have to flow in both directions, proximally and distally from the point of grip of the tooth. That two or more very strong bites should have created such a crack only on one, the pierced side, seems to us, in view of our experiments, extremely unlikely. The possibility that the cracks on the flute are of secondary creation cannot be excluded. There are a large number of untouched, whole long bones at the site cracked just like the flute. *Figure 13:* h shows a textbook example of a longitudinally split, strongly weathered, cortical bone on a diaphysis in the sediment.

At the Divje babe I site, where we systematically collected and analysed all the bone remains larger than 1 cm, and in other sites with which we are familiar where they have selectively collected bones with holes, we know of no example which had a hole on a cracked diaphysis such that it was clear that the hole and crack were created simultaneously. However, we have, at least at this site, a few longitudinal fragments of diaphyses (splinters) which have a semi-circular notch by a longitudinal break (*Fig. 13:* a-f).

We think that carnivores in Divje babe I very rarely pierced long bones, as can also be demonstrated with statistics of the frequency of holes in layers 2-7, and especially in layer 8, where the flute was found. Pierced bones account for about 8 per 100,000 of all identifiable bones in layers 2-7 and appoximately 11 per 50,000 in layer 8. Bones with semi-circular notches account for about 9 per 100,000 of all identifiable bones in layers 2-7 and 12 per 50,000 of identifiable bones in layer 8.

In the event of carnivores piercing long bones more often than we established on the basis of the finds, the diaphyses have been split and all the split parts devoured. Splinters of diaphyses with the characteristics of carnivore damage are similarly rare at the site: fewer than 4 examples per 100,000 identifed bones or per 3000 adult and juvenile diaphyses without diaphyses of fibulae and metapodials in layers 2-7 and 3 examples per 50,000 of all identified bones or per 1860 similar diaphyses in layer 8 (*Fig. 13:* g).

In contrast to the above, there are more depressions on metaphyses, epiphyses and bones with thin cortical shell (approximately 3 per 10,000 of all identified bones in layers 2-7 and approximately 5 per 5,200 in layer 8). Almost all depressions occur on bones of juvenile specimens.

There are significantly more depressions than holes, since a carnivore does not always succeed in piercing the cortical bone (see also Gargett 1996, 132, Tab. 6.2). Such a condition could also be because carnivores were at work whose main interest was soft tissue and not the bone. Among them are first of all bears (see subsection 3.3.).

Considerable quantitative differences exist between layer 8 and layers 2-7 in relation to holes and depressions on bones. These differences undoubtedly result from increased activity of some carnivores during the deposition of layer 8, and/or a reduction of activity of these same carnivores during the deposition of layers 2-7. This does not apply to carnivore damage in general, since it appears on the majority of skeletal parts, mainly juvenile specimens, and they provide a different picture (*Table 5*). Above all, there is no noticable increased activity in the upper part of layer 8, where the flute was found and in layer 7. Results in relation to fragmentation of femurs would tend to suggest the opposite (compare also *Figs. 3* and *4*) **.**

3.3. **The shape and disposition of the holes and damage on the flute in perspective of the first hypothesis**

The position of the depressions and holes exclusively at the end of a fossil long bone is indirect evidence that carnivores with normal chewing behaviour worked primarily with cheek teeth (premolars and molars). Carnivores cannot reach the diaphysis with these teeth without the prior removal of the epi- and metaphyses. Without this prior operation, they can only reach it with the canine teeth. That some carnivores bit with canine teeth is also demonstrated by occasional teeth depressions on hard of access and unusual places on vartebrae (*F ig. 15:* e-f). They were probably made while dismembering the head or parts of the spine. Depressions made by canines are typically more or less round in shape.

In view of the size of the holes on the flute and the force required for piercing the diaphysis of an immature brown bear (see *Table 4*), animals of the size of wolf upwards must be considered in the debate. These, in addition to wolf, are cave hyena, cave and brown bear, leopard and cave lion. The remains of all except hyena have so far been found in various layers of this site, including the layer in which the flute was discovered.

Different carnivores deal differently with bones. Only wolves and hyenas feed on bones, thus often damaging them. Bones are of no particular interest to other carnivores, although they may occasionally damage them while killing and feeding (e.g. bears and large cats).

All carnivores fragment bones with their cheek teeth, whereby they use only one side of the dentition. All flesh eating members of the order Carnivora have on each side of the dentition a crown of one of the upper and lower cheek teeth especially arranged for a very effective scissor bite, and the roots of these strong teeth are adapted to the large burden created in pressing, i.e., the lifting of a movable mandible against a fixed upper jaw (*Fig. 14*). These are the carnassial teeth, which serve almost exclusively for dismembering and processing hard and elastic parts of prey (Hillson 1990, 17, Fig. 1.5). Omnivorous carnivores, among which bears are numbered, do not have such teeth, so they use exclusively the front teeth for dismembering flesh.

All carnivores use the front teeth for killing prey and slicing flesh. For pure carnivorous species, these teeth, especially the curved canine teeth with exceptionally strong roots, are the main weapon. So they guard them carefully, and do not burden them unnecessarily and to a degree that could break them.

Because of their length and curvature, the upper and lower canine teeth are never in alignment (*Fig. 7:* c,d). For this reason, in making compression with them, depending on the hardness of the material compressed, at the same time the greatest effect of bend and shear loading is created in comparison with all other teeth. This can have a variety of effects in biting or chewing very hard materials: the object can slip under pressure along the tips of the canine teeth; the one canine tooth can slip along the object under pressure if the object is immobilised by the second canine tooth; and in an extreme case, the crown can be demaged or broken off if the object under pressure is suitably hard and immobile. The structure of the dentine is such that, in contrast with axial loading, it does not withstand major lateral loading (Klevezal 1996; Hilsson 1990, 152 ss).

Like any set of teeth, the dentition of a carnivore is symmetrical. In connection with the holes in the flute, the fact is important that carnivores cannot, in principle, move the lower jaw in any other direction than up and down. So the impressions of the opposing teeth in repeat biting do not move from the axis defined by the geometry of the jaw and the shape of individual teeth. Damage to objects bitten is created exclusively because of pressure with the teeth, or because of the slipping of the object bitten along the teeth (*Fig. 15:* d). In no case is there repeating movement of the teeth along the object being chewed (masticating in the real sense of the word), which leaves essentially different traces (*Fig. 15:* b).

The enumerated properties of carnivore dentition, including the structural properties of teeth, the biomechanics of the jaw and the effect of sensory feed-back from the periodontal mechanoreceptors, which prevent overloading of any individual tooth, must certainly be taken into account in the analysis of the holes in the disputed flute. Similarly, the maneuvering space of the teeth which enter into consideration in making holes, has to be considered. This is a great deal larger with the canine teeth than with cheek teeth (*Fig. 10*).

Let us now examine which individual carnivores might have pierced the long bones, above all diaphyses. Advocates for the carnivore hypothesis to explain the holes are not united as to which carnivore and which teeth did the damage (Albrecht et al. 1998; Chase, Nowell 1998a, 1998b; d'Errico et al. 1998a, 1998b).

Wolf, which was suggested by P. Chase and A. Nowell (1998a, 550), apart from cave bear, is the best represented carnivore in Divje babe I. The majority of chewed bones can also be chewed by wolf, and of these, the bones of young cave bears greatly predominate. Wolves could also have caused the clear absence of some less hard skeletal parts (*Fig. 5*).

A wolf can pierce bones exclusively with the carnassial teeth (*Fig. 14:* b).The measured force of a bite with cheek teeth in dogs the size of a wolf at 1394 Newtons (Lindner et al. 1995, tab. 1) barely achieves the measured force required to pierce the cortical shell of a juvenile diaphysis (see Lindner et al. 1995 and *Table 3*). To use the canine teeth, because of the extended lever, the muscles of mastication must release at least 1.6 times greater force (calculated on the basis of measures of the mandible and dentition) in order for the effect of the canine teeth to be the same as that of the carnassial teeth (see Lindner et al. 1995, 51). Irrespective of whether or not a wolf can exert this force, a wolf's canine teeth are too weak to bear the operation of bending and shearing forces which are created in compression with them. In trying to pierce a diaphysis, one of the bronze canine teeth immediately bent. Real wolf canine teeth would break before penetrating to the required half height of the crown, in a 3-4 mm thick cortical bone, needed to make a hole approximately as large as those on the flute, or the animal would stop beforehand due to prevention by the pressoreceptors in the periodontium. On large dogs that bite hard objects, the canine teeth often fracture (Le Brech et al. 1997). Such biting behaviour is abnormal, and among wild carnivorous species, if it exists at all, is hard to explain except as the result of sickness (rabies?).

Depressions from the paracon and protoconid of a wolf's carnassial teeth (upper fourth premolar and lower first molar tooth) are essentially different in shape from the holes in the flute (see *Figs. 12* and 15*:* a*; 16:* a). In addition, the disposition of Hole 2 and Notch 5 does not match the occlusion of those teeth at all (*Fig. 10*). So a wolf would simply not be able to make such holes even with the carnassial teeth and can thus be justifiably excluded from the list of candidates for piercing the flute (however, see Chase, Nowell 1998a).

Cave hyena, which was suggested by G. Albrecht et al. (1998, 16) is represented at the site neither with direct osteoodontological remains nor with coprolites, nor is their presence indirectly confirmed by taphonomic analysis of the cave bear remains. The taphonomic picture of our material bears no resemblance to the taphonomic picture typical of hyena activity (Zapfe 1942; Sutcliffe 1970; Brain 1981; Marean et al. 1992; Stiner 1995, 250, Fig. 9.10; d'Errico, Villa 1997; Arribas, Palmquist 1998). A hyena would certainly devour the majority of compact bones of both young and adult specimens (Lyman 1994, 215). There would be essentially fewer of the latter in the upper part of layer 8 than in other layers. However, this is not the case (*Fig. 6*). We have to date found in no layer bone fragments, including digested bones, characteristically created by hyena feeding activity (d'Errico, Villa 1997).

Cave hyena, like its modern relative, would be able to make the holes in the flute and also to split the bone (Zapfe 1942; Sutcliffe 1970). For piercing, only a sharp upper or lower third premolar tooth (e.g. crusher) and sharp or blunt upper or lower canine teeth come into consideration (*Fig. 14:* a) (see Ewer 1954, 191; Brain 1981, 69 ss). With blunt cheek teeth it would be impossible because of too short points. All the cheek teeth of a hyena are adapted to piercing and fracturing and not just the rear, as with other carnivores. Hyena can thus fracture larger bones than other carnivores because, by gripping with the anterior cheek teeth it is not necessary to extend the muscles of mastication so much that they lose force.

The impressions of the points of both premolar teeth are of a different shape than Holes 1 and 2 on the flute (see *Figs. 12* and *16:* d). For Hole 2 and the fracture in the form of the letter "V" on the anterior side of the thigh bone which ends in the smaller Notch 5, some experts claim that they were created simultaneously under the pressure of the upper and lower teeth in occlusion (Chase, Nowell 1998a, 551; D'Errico et al. 1998a, 77). Our experiments, with which we simulated such a bite, showed that the fracture and notch on the flute could not have been made simultaneously. Although the bone can fracture longitudinally because of the pressure of teeth, always one and exceptionally more longitudinal cracks appear on both sides of the hole, the remnant of which Notch 5 represents (*Fig. 11:* d and Kunej, Turk 2000, Fig. 15.2: c). Since a barely recognisable crack emerges from Notch 5, it is more probable that it was a notch before a piece of cortical bone was broken, the composite part of a smaller hole which halted a subsequent "V" fracture. The existence of such a hole did not seem likely prior to the experiment with teeth, although some experts had drawn our attention to it (see Turk et al. 1997 and Omerzel-Terlep 1996, 281; Otte 2000).

The morphology of the edges of Hole 2 and Notch 5 is so different that it is hard to explain the difference in biting. The same applies to Hole 1 and Notch 3 (*Fig. 12:* b,f). Premolar teeth would have left a more unified outline of the edges of the holes. The difference is hardly possible to explain with the selective mechanical weathering of the edges of Holes 1-2 and Notches 3-5 in different micro-environments (see Chase, Nowell 1998a, 552). The holes and notches with differently weathered edges are too unequally distributed along the bone for anything of the sort (*Fig. 8*).

The disposition, shape and size of the impressions of the two premolar teeth of hyena, which must be considered for piercing in a position on the bone where a bite is barely possible (lower tooth for Hole 2 upper for Notch 5) does not correspond to the disposition, shape and size of Hole 2 and Notch 5 lying below it (see *Figs. 10* and *12*).

The distribution, shape and size of Hole 2 and Notch 5 best match the bite of a cave hyena with blunt canine teeth (see Albrecht et al. 1998, 16, Fig. 14). Blunt points need greater force (2610-6490 Newtons on the diaphysis) for piercing cortical bone than do sharp points. The latter must enlarge an originally smaller hole, which can be made with less force than a blunt point, for which relatively greater force is needed than merely for piercing the cortical bone, except in cases when the bone splits (see *Figs. 11:* a and d) Well worn upper canine tooth would make a fairly round hole, and blunt lower canine tooth a more oval one (*Fig. 16:* e). Of course, if the bone did not split. The distance between Hole 2 and Notch 5 would be in any case greater than it is (see *Figs. 10* and *12:* f).

With such a theoretical bite of a cave hyena, the following questions in connection with the flute can be raised: Firstly, why a cave hyena, if there is no other indication that hyena visited the site, or had a den there. Second, why would a hyena chose to use canine teeth when it has specially adapted cheek teeth (Zapfe 1942, 112; Ewer 1954, 188, 191; Sutcliffe 1970, 1112; Brain 1981, 69) with which it could achieve the same effect with at most half the force of the muscles of mastication? Third, why did it not fracture the diaphysis if it had every opportunity for doing this (see Sutcliffe 1970, 1112)? Fourth, how could it have succeeded with canine teeth, and perhaps with other teeth, to put the two holes and the notches in line in such a virtuoso way? These and other difficulties connected with the use of canine teeth in piercing a diaphysis will be dealt with in more detail in relation to brown and cave bear as the most likely candidates for piercing the bone.

Brown bear and cave bear, which were suggested by F. d'Errico et al. (1998b, 13), are the only real omnivorous carnivores that need be considered in testing the hypothesis of a natural origin for the holes on the flute. Bears are also the only large carnivore which uses exclusively the front teeth in slicing flesh. This unusal biting behaviour for a carnivore is a matter of the development of the molar teeth, which have gradually adapted completely for omnivorous feeding. The obvious result of such unusual use of the front teeth is a relatively large number of *in vivo* broken canine teeth and incisors and strongly worn incisors among bears, including cave bears. Although bears are omnivorous, usually they do not feed on bones (Zapfe 1942, 118). In recent bear excrements, remains of bones of large mammals are rarely found (Aune et al. 1984, 61 s, tab. 10; Le Franc et al. 1987, 25). For cave bear, we have no coprolites which could give us material data on its food (however, see Battaglia 1922).

A bear in attacking with canine teeth can damage and even pierce some bones. Normally the flat and irregular bones of the skull, since a bear tends to attack the head (*Fig. 17*). Damage can similarly occur to bones during feeding on meat, including meat of its own species. Cannibalism is not an unknown phenomenon with living brown bears (Le Franc et al. 1987, 40). We also have reliable evidence of it with cave bears (*Fig. 18:* c-f), despite their pronounced vegetarian diet (Nelson et al. 1998).

In order to be certain about the nature and frequency of damage which a bear does to bones, we examined 11 feeding sites in south-western Slovenia. They contain the bone remains of several thousand horses, cattle, pigs and other domestic and wild animals on which the major part of the Slovene population of brown bear, which numbers some 450 specimens (Huber, Adamič 1999), have fed over the course of decades. We discovered exceptionally few typical toothmarks on the bones, which were all whole, regardless of size. Such damage as there was, was exclusively caused by canine teeth on the edge of flat bones and in the vicinity of the joints of long bones, which compares well with the fossil material from Divje babe I and other similar sites (*Fig. 18:* a,b,g). Since bears feel threatened at a feeding site, they dismember larger pieces of a carcass (e. g., head, front or back legs) and carry them to a safer place where they can feed in peace. In dismembering and dragging the dismembered parts across karstic (rocky) and/or overgrown terrain, they can damage articular parts with their teeth. Damage to the edges of flat bones is created during removal of the meat and cartilage (*Pl. 9:* c). Such damage most frequently occurs on the shoulder blade and pelvis with articulating bones. Bears are real masters in de-boning. They devour decaying meat to the bone, without damaging the bone except in exceptionally rare cases. We stress explicitly that we did not find even a single hole in a long bone at the feeding grounds.

Nevertheless the shape of the tip of the canine of brown bear and cave bear best matches the almost round form of the holes in the flute (see *Figs. 12* and *16:* c,f). Because of the massive canine teeth and exceptionally strong bite of a bear, it would not, in principle, have difficulty in piercing the diaphysis of the suspected flute. It would have more difficulty in distributing the holes and notches on one or the other side of the diaphysis in a straight line and preventing the complete splitting of the diaphysis.

In experimentally piercing a juvenile diaphysis of a modern brown bear with a replica of the sharp canine teeth of an adult modern brown bear, we made roughly the same size holes in approximately the same place as on the flute with a force of 1340 and 1816 Newtons. We were successful in only one of five piercings without a crack and in one of three piercings with a crack. Of eight holes, six (four without a crack and two with a crack) were made on the "wrong" anterior side, where no hole is preserved on the flute. This, of course, does not correspond to our original, exclusively theoretical thinking, that the bone is more resistant on the convex side (Turk et al. 1997, 168). Clearly with loading in one point, the thickness is more decisive than the shape of the cortical bone. It is characteristic of the thickness and shape of the cortical bone that it varies both in the bone of one specimen and in the bone of various specimens of the same ontogenetic age. Another unexpected result of the experiments, which we have already mentioned, is the longitudinal cracking of the bone. The diaphysis cracked in three of eight piercings.

Attempts with worn canine teeth (the worn areas were approximately 6x5 mm large) showed that for a hole which in all aspects approximately corresponds to the holes on the flute, a force of 2609 Newtons is required. For piercing the diaphysis of the femur of a small adult specimen of brown bear, a force of 6493 Newtons was required and for merely a distinct impression of the tooth 3308 Newtons! We pierced the diaphysis of the femur of a large adult specimen of brown bear with a force of 7980 Newtons.

Of a total of three holes which we made with blunt canine teeth on the femur of juvenile specimens, two were on the "wrong" anterior side. In two cases, the bone cracked longitudinally. Of a total of four holes, which we made with blunt canine teeth on subadult specimens, three were on the "wrong" anterior side, too. In one case, the bone cracked. Of a total of 18 more or less successful piercings of the diaphysis, only in one case did we succeed in making holes simultaneously with upper and lower canine teeth. Normally, only one of the two teeth pierced the bone.

To make a successful hole, it was necessary to place and to keep the bone exactly centrally between the points of the teeth. Otherwise, the tooth slid on the bone and pierced it closer to one side instead of centred between the two edges. Such piercing creates damage by the hole (*Fig. 11:* c) which also occurs on fossil specimens. Because of a lack of experience, we theoretically defined such holes as artificial in our first study of holes in bones (Turk et al. 1997, 166).

In piercing the thick cortical bone with canine teeth, because of their curved shape we obtained a specific form of rim to the hole which, at the same time as the almost circular form of the opening, is characteristic only of canine teeth. The lingual side of the canine tooth drags the cortical bone behind it, packs it down while the labial side pushes it away inwards and, at the same time, on the surface it rises slightly upwards (*Fig. 11:* a). So the wall of the hole is more or less vertical on one side and inclined at an acute angle from outside inwards on the other. The part of the bone on the canine's lingual side is compressed by the canine tooth, which is normally clearly visible. All this is most pronounced with sharp and less so with blunt teeth.

Neither complete hole on the flute seems to have these characteristics. The circular crumbling of the inner (medular) part of the cortical bone with Hole 2 (*Fig. 12:* e) is even in complete conflict with the described activity of canine teeth. It could only have been created as it is by worn canine teeth which had an area of worn points almost the same as the area of Hole 2.

A bear bite with canine teeth gives rise to a series of doubts of a general and specific nature. A bear making the holes on the flute would have had great difficulty in centering a slippery fresh bone with such virtuosity, at least twice, between the sharp points of the canine teeth in order for all holes and notches to be in line after at least two successful bites. A bear with worn canine teeth would have been able to do this rather more easily. A question which cannot be avoided is why on the flute there are two holes (nos. 1, 2) and one or two notches (nos. 3, 4) on the posterior side and no hole and only one notch (no. 5) on the anterior side. In view of our experiments, if canine teeth had been used, one would expect more holes and notches on the anterior side. The disposition of Hole 2 and Notch 5 does not best correspond to the bite of bear canine teeth, though it fits the best of all carnivores considered (see *Figs. 10* and *12*). However, it requires upwards inclined bone in the process of piercing, which is less likely than horizontal or downwards inclined bone. Using its front leg a carnivore would normally push the bone downwards. How they are actually distributed and how such holes appear on more elastic metaphyses and flat bones can be seen on recent and fossil bones (*Pl. Figs. 19:* b-c; *18:* a-d). Hole 2 could only have been made with the lower and Notch 5 with the upper canine. The damage by the proximal edge of Hole 2 cannot be made by canine teeth (*Fig. 12:* c). Hole 1 has two irregular, longitudinal crumbled areas in the wall of the medullary cavity, one proximally, the other distally (*Fig. 8*). Hole 2 has all round widely crumbled wall of the medullary cavity (*Fig. 12:* e) Why such differences in the operation of a tooth, which always applies compression the same? It is also difficult to understand the fact that a bear, despite its proverbial strength, did not crush the flute. And not least, why would a bear treat a bone in such a way when bears do not eat bare bones.

Large cats like leopards and cave lions could have pierced the flute either with their canine or with molar teeth (see Brain 1981, 102 s; de Ruiter, Berger 2000). With the canine teeth, the same difficulties appear as with all carnivores. The impressions made by the points of the cheek teeth have a different shape and disposition to the holes on the flute, and so need not be considered.

In relation to other damage to the flute, we established the following:

The majority of generally recognised Palaeolithic bone flutes have one or both ends broken. At least one of these flutes was found in such sediment (loess) that it could not have been fragmented in the post-depositional processes (Einwögerer, Käfer 1998). So the subsequent predepositional intervention of carnivores is not excluded. Carnivores may have subsequently worked on the ends of our find, too. Cases are known of genuine Palaeolithic bone artifacts having been chewed by carnivores (*Fig. 20*) (Malez 1967, Pl. 5: 1; Bayón et al. 1997, 257, foto 1). The barely visible damage on the surface of the flute, which could be ascribed to carnivores (d'Errico, Conference Sp. Idrija and *Figs. 21, 22:* a-c), is not so characteristic that it could not also have been created in some other way. Particularly disturbing is the fact that the surface and edges of the flute are greatly eroded mechanically. It is therefore difficult to judge the origin of microscopic damage (see Shipman 1988, 316 ss). The shape of large Notch 4 has all the characteristics of the activity of carnivores (see Chase, Nowell 1998a, 550; d'Errico et al. 1998a, 77). The only difference is that it is on the flat posterior side, while the majority of similar damage on 466 unpierced (if we ignore very rare examples, including the flute) diaphyses of juvenile femurs from Divje babe I (*Table 1*), is on the convex anterior side. This matches the results of our experiments, in which the majority of holes were made on the convex front of the femur.

For the damage to the flute, including Notch 4 there is no firm basis to conclude that the flute was entirely made by a carnivore (however, see d'Errico, Conference Sp. Idrija).

4. SECOND HYPOTHESIS: HOLES MADE BY STONE TOOLS

Some holes in the bones of cave bear have long been suspected of having been made by tools (see Albrecht et al. 1998, 1-4). Since it has not been sufficiently explained with what tools, and how the holes were made, a shadow of doubt has remained about their anthropic origin. In addition, the context of these earlier finds is not always so clear as it is in the case with the new find from Divje babe I (see M. Brodar 1985; Albrechr et al. 1998; Turk, Bastiani 2000).

Studying the second, alternative hypothesis in the case of the flute is connected with seeking an answer to the following basic questions:

Has the flute traces of working?

Is there reliable evidence on the use of bone as raw material in the Middle Palaeolithic in general and at the site in particular?

Are tools suitable for making the holes in the suspected flute known at the site?

What technology could have been used for making the holes, in order for the holes to be similar to holes made by carnivores?

4.1. Traces of working

There are neither micro nor macro traces of tools on the holes of the flute which could serve as conclusive evidence of their artificial origin (*Fig. 23:* a-c). The holes, however, provide some data with which comparison can be made with accepted Upper Palaeolithic flutes (see Fages, Mourer-Chauviré 1983; Dauvois 1989; Buisson 1990; Rottländer 1996; Einwögerer, Käfer 1998).

The absence of conclusive evidence does not mean that the hypothesis about the artificial origin of the holes is wrong and detailed analysis, supported by suitable experiments, is pointless. A series of genuine Palaeolithic bone artifacts could be enumerated without any kind of trace of the tools used in their manufacture. Such, for example, are some Aurignacian bone points from Divje babe I (Turk, Kavur 1997, 122). Because of the very strong abrasion which is characteristic at this site, it is very difficult to decide on a microscopic level, for example, between deep artificial incisions (cutmarks) and striae (toothmarks) that slipping teeth make (see *Pl. Fig. 22:* a,b,e and Shipman 1988, 320, Fig. 9). Abrasion can also completely erase shallow cutmarks made with a silex. The site as a whole, as well as individual archaeological layers, is characterised by a very low permill of reliably diagnosed cutmarks.

On the strongly encrusted surface of the flute there are only some barely visible pits, grooves and cuts (*Fig. 22*). Among them is only one microscopic cutmark on the erroded surface of cortical shell proximally to hole 2 (*Fig 22:* e). The origin of all these features is problematic (however, see d'Errico, Conference in Sp. Idrija). On the edges of the holes, notches and ends of the flute, there are no cuts or impressions. All edges are (naturally?) rounded.

4.2. **Use of bone in the Middle Palaeolithic**

Thanks to recent discoveries, there is no longer doubt today that bone was already used as opportunistic raw material in the Middle Palaeolithic in making tools of Upper Palaeolithic habitude (Hahn et al. 1973, Fig. 24; Baffier, Julien 1990; Taborin 1990; Marks et al. 1996, 282; d'Errico et al. 1998c; Gaudzinski 1999; Fiedler 1999, Fig. 5: 4). There are also some weak signals of this at the Divje babe I site. In addition to the suspected flute, we discovered in various Mousterian layers, among the hundreds of thousands of natural bone fragments, also fragments which are greatly similar to parts of bone points, awls and/or polishing tools (*Fig. 24:* c,d; *Pl. 1; 2* and M. Brodar 1999, Pl. 6: 5-7; Turk, Bastiani 2000, Fig. 4). The majority of these suspected bone artefacts, which are without traces of working, were found in layers 7 and 8. Chronologically, therefore, very close to the flute. They could be associated with hearths and other finds in these layers (Turk, Bastiani 2000). One of them (*Pl. 2:* 2) is even from the direct vicinity of a hearth which was only a few metres from the flute and could be contemporary with it.

Particular attention must be drawn to unique, obliquely broken basal? pieces with sharp edges of the fossil break and greatly rounded other edges (*Pl. 1:* 2,6; *2:* 5). They may have been created coincidently among the huge mass of abraded fragments in layers with many tens of thousand remains of cave bear. However: we found one such fragment in the last year of excavation (1999) in the practically sterile layer 16a, together with a single artefact, a retouched massive flake (*Pl. 2:* 5). The fragment was found in quadrat 38 at a depth of 4.53-4.65 m, and the flake in the neighbouring quadrat, 12 centimetres at most higher. Since there are practically no bones in the layer, and no other traces of human presence, the unique bone fragment found is very difficult to explain by the action of natural forces, which could also apply to all other similar fragments.

It is unusual that none of these particular bone fragments were found in layers 2-5, which corresponds chronologically to the Early Upper Palaeolithic, including the Aurignacian, and which similarly contains a large number of remains of cave bear (Turk, Dirjec 1997a). Nevertheless a flaked piece of cortical bone was found in these layers (*Fig. 24:* b). It could be explained as a by product of bone working by humans.

The working of bone was not a major technological problem for Neanderthal man, who had mastered the technology to work wood and stone (see Turk, Bastiani 2000). Altogether, it was only a question of the advantages of a given raw material connected with tradition. In the Middle Palaeolithic, wood was the traditional raw material, which easily replaced bone, ivory or antler. This is demonstrated by the occasional preserved products from wood and numerous tools with traces of having been used to work wood (Oakley et al. 1977; Thieme, Veil 1985; Carbonell, Castro-Curel 1992). In Divje babe I, in the layer with the flute, we found fossilised pieces of wood which had not been burnt. Among the charcoal, in various hearths, we also found yew wood, which is not normal fuel (Culiberg, Šercelj 1997, 79). These finds give the impression that Palaeolithic visitors to the cave used wood for various purposes: both for fuel and other needs. In addition, we have a large amount of macroscopic damage on tools, which could have been created during the rough working of wood by indirect percussion (Bastiani et al. 2000).

Since wood, in addition to stone, was a traditional raw material on which Neanderthals were also existentially dependent, only exceptionally did they reach for other, durable raw materials (Granger, Lévęque 1997; Jaubert 1999, 129). The possibilities of finding the few of these durable products still existing are minimal. The transition from one raw material to another, which coincidently or otherwise corresponds to the transition from the Middle to the Upper Palaeolithic, was gradual and connected with the adaptation of existing technolgies to new materials (see Christensen 1998, 199). Replacing less durable raw materials with more durable ones and the reverse gives a false impression of the sudden appearance or disappearance of whole segments of a particular civilization.

In the light of such thinking, even the exceptional find of the putative flute from Divje babe I becomes more acceptable. Music and musical instruments were undoubtedly more widespread in the Palaeolithic than can be concluded on the basis of the relatively few finds of bone flutes to date. The majority of flutes were probably wooden (of hollow stemmed trees such as elder).

The nature of the holes on the flute from Divje babe I, as well as some long familiar similar holes from other sites (S. Brodar, M. Brodar 1983, 155 ss; M. Brodar 1985; Dauvois 1989) is not amenable to effective morphological criteria for distinguishing the anthropic from the natural (see M. Brodar 1985). The thick cortical shell of long bones is deformed by the constant application of force (the point of a tooth which does not move) and may fracture in a similar way as with the application of intermittent, repeated force (the tip of a tool which shifts around the centre of the created hole). If we want to obtain by means of experiment a similar hole as that pierced by teeth, we must use a tool like a tooth, upon which to strike (indirect percussion).

4.3. **Tools for making holes**

Palaeolithic flakes and, partially, blades are more useful in the raw state (technologically: blanks) than in the fully worked (retouched) state (technologically: implements). Only for sawing, hollowing and drilling must a blank be specially shaped (retouched) into a denticulate, burin or pointed tool (see Christensen 1998; Bastiani et al. 2000).

The Mousterian layers of Divje babe I contain a large number of pointed and tongued tools, suitable for making holes in any material (*Pl. 3; 4*). Such a tool already appears in the Lower Palaeolithic and continues into the Upper Palaeolithic. We also found a relatively large number of broken points of these special tools in the same layers (*Fig. 27:* d,e; *Pl. 5-7* and Turk, Bastiani 2000, Fig. 4: 9,10). There is no doubt that some pointed and all tongued tools were specially designed for making holes, or that they were shaped, re-shaped and damaged in the actaul process of making holes (Bastiani et al. 2000, 45 ss).

Since we are not familiar with the possible effects of making holes in more or less hard materials, which may or may not remain visible on the material or the tool, we carried out extensive experiments in making holes with replicas of the Palaeolithic tools found at the site (see also ibid.).

4.4. **Results from experimental tests**

We conducted the majority of experiments with replicas made from local raw materials (chert from Oblakov vrh – an outcrop was discovered by geologist Ivan Mlakar, tuff and chert from alluvial deposits of the river Idrijca), similar to those used for the most part by Palaeolithic visitors to Divje babe I. It appeared that the choice of raw material is important not only for making tools, but even more for the use of these tools on various materials (Turk, Bastiani 2000; Bastiani et al. 2000). Tools from a “poor quality” raw material (in the sense of knapping stone) are a great deal more resilient for working harder natural materials than tools from “better” quality raw materials (*Fig. 25:* a,b).

Our experiments showed that the manufacture of bone points, awls and other objects from fossil bones did not require any kind of special stone tool (*Fig. 25:* c,d). As with working wood (for details see Bastiani et al. 2000), an ordinary flake is sufficient (see also Christensen 1998). The basic technology is very simple. Essentially, it is a combination of methods of working wood and stone. A blank (suitable long bone splinter) is roughly shaped with sawing and chipping (direct percussion). Chiselling (indirect percussion), which appeared effective for such in the rough working of wood (Bastiani et al. 2000), does not enter into respect. The product is completed as with wood with planing/scraping. Small ridges remain a problem, which can only be removed with polishing.

All the enumerated methods of working bone and similar materials are reliably identified at the transition from the Middle to Upper Palaeolithic (Taborin 1990, 340; Baffier 1999, 73). There is no evidence of them before that. However, that does not mean that people of the Lower and Middle Palaeolithic were not familiar with and used them for working wood.

By chance, we discovered evidence of the presence of (sub) fossil bones at the Divje babe I site as a potential source of raw materials in the Middle Palaeolithic, in one of the twenty Mousterian hearths. Among the mass of ordinary burned and calcified fragments of bones there was also one which was essentially different from any we had seen until then. The inside was completely charred (black) while the exterior was a similar brown colour to all the fossil bones at the site. Such an effect is never achieved with experimental burning of fresh bones (Lyman 1994, 384 ss; Stiner et al. 1995). When we put fossil bones in the fire, we obtained the answer to the unusual phenomenon.

Both ends of the flute could be formed in a similar way to bone points, awls and polishers in fresh or (sub)fossile bone. It is possible to make larger notche in a bone by first making hole in it. On each side of the hole, a concave cut is made and the excess parts of the cortical bone removed with blows to the bone by the cuts.

Special tools, which are very useful but not essential in such work, are tongued tools and tools which have one edge denticulated with alternating retouch or cone fractures.

If we accept the premise that wood was an important raw material from the Lower Palaeolithic onwards (see Thieme 1996), and that it was used to make artifacts mostly unknown to us, we can on the basis of numerous Lower and above all Middle Palaeolithic artefacts suitable for making holes, justifiably conclude that people also made holes in wood. Since we have an extremely large number of pointed and tongued artefacts in Divje babe I, we made a number of replicas of these tools and made holes in wood and bone with them.

The major difference between pointed and tongued artefacts (or between a point and a tongue) is in the shape of the potential working part of the artefact. Points have the shape of an oblong half-cone and tongues an oblong half-cylinder (*Pl. 4:* 1,3). This design difference which, in extreme cases, can also result from use of the tool, plays a decisive role in piercing materials of different hardness. Tongued tools are more appropriate for piercing hard materials than pointed tools.

Holes in fresh wood are made most easily if they are chiselled out. The most effective method is indirect percussion with the use of a tongued tool or suitably shaped burin and a wooden ‘hammer’ (Turk, Bastiani 2000; Bastiani et al. 2000). This method seems to us also the most effective for any kind of rough working of wood with Palaeolithic stone tools. In the light of a functional interpretation, Palaeolithic finds from Divje babe I are dealt with in greater detail elsewhere (Bastiani et al. 2000).

In chiselling holes in fresh wood of elder and yew, we caused no macroscopic damage to the tongue of a tongued tool. The only danger is of the tongue breaking if we want to make a hole which is deeper than the length of the tongue. The critical depth of a hole with a diameter under 10 mm is some 10 mm. It cannot go deeper without increasing the diameter of the hole. However, with naturally hollow stems they did not normally need such deep holes. We got more characteristic damage on the corners of the working edge of a burin or burin shaped tool (Bastiani et al. 2000, Pl. 2: 3).

If we now suppose that the raw material is changed, e.g., wood replaced with bone, it is entirely natural that, initially, the same technology will be used, i.e., the same tool and the same method as before. Technological adaption to the new material will come as necessary and gradually, on the basis of working experience obtained.

We have already reported that holes could have been chiselled in long bones with artefacts found at Divje babe I (*Fig. 7:* b and Bastiani, Turk 1997). In contrast to our experimental results, the results of some other authors were negative (Albrecht et al. 1998, 13). The variability of the outlines of the chiselled holes is a great deal greater than the variability of holes made with teeth (see *Figs. 11; 16; 19* and *26*). This also applies for the funnel shaped, eroded edges on the inner, medular side. Some trial chiselled holes are indistinguishable both in details and in general from the holes on the flute (see also *Figs. 12* and *23; 26*). What is even more important is that they can also be without any, even microscopic, traces of the tool, in our case a point or tongue (see *Fig. 23:* d,f and e). In chiselling one hole or more holes in a bone, it never splits.

In attempting to make holes in the fresh thigh bone of young brown bear, typical macroscopic damage occured on the tongued and pointed tools. The variety of such damage is a great deal greater than the variety we obtained on the basis of some experiments. It was primarily various retouches on the ventral side of the point or tongue and broken parts of the point or tongue of pointed or tongued tools. Initially, only the very tip of the point or tongue is retouched. A specific characteristic is a ventrally crushed tip (*Fig. 27:* g,h j). A burin spall can start one or more scars, laterally from the tip, or ventrally, which may or not terminate in a step (*Fig. 27:* h). The flanks of the point or tongue are then retouched. Lateral notches can occur on a point and individual retouches with well-expressed bulbs on both lateral edges on a tongue (*Fig. 27:* g). Fractures of the point or tongue, which could occur after a few blows or only after several thousand blows, were for the most part snap.

These valuable experimental experiences enabled us to change the course of archaeological investigation. In the given circumstances, the task of archaeology is to find indirect arguments, however small, for the possibility of an artifical origin of the holes and the working of bone in general. It is necessary to seek potential hole making and other tools and to seek damage on these tools. Since we were unable, for objective reasons, to use a microscopic approach, in our pilot research we restricted ourselves to macroscopic damage.

4.5. **Macroscopic damage to special tools from Divje babe I and questions in connection with them**

The basic question which we raised at the start is: Whether humans in an early period of working bone and similar hard organic materials in specific cases actually used the method of indirect percussion proposed here?

This method is very effective and simple and can be used for making holes both in wood and in bone. The method does not exclude other methods, e.g., boring, which is more effective on bone and similar material than on fresh wood. “Borers” or perforators in typological vocabulary are known in both the Middle Palaeolithic (Mousterian) and in the early Upper Palaeolithic (Aurignacian) (Debénath, Dibble 1994, 99; Bordes 1988, Pl. 35; Oliva 1987, Pl. 40). Some are almost identical to a unique tongued tool from Divje babe I (*Pl. 4:* 3). Products, or holes, are archaeologically reliably identified only from Chatelperronian and

Aurignacian sites. The majority of these holes, including those in teeth, are not bored (Taborin 1990, 339, Fig. 5; 6; Turk et al. 1997, Fig. 11: 7; Granger, Lévêque 1997, Pl. A-F). We suspect that some of them were made in the same way as holes in wood, the raw material in previous use, i.e., chiselled using the method of indirect percussion. Neither have any macroscopic traces of boring been found on tools in this early period. Only one specimen with damage characteristic of boring occurs at Divje babe I (*Pl. 4:* 4).

Making holes in harder materials, including some harder kinds of wood, cannot be a gain of the Upper Palaeolithic, in either the technological or functional sense (see d'Errico et al. 1998; Baffier 1999, 94). That holes in large numbers all at once occur precisely then can only be a matter of the durability of material usable for piercing. The great similarity of the holes in the flute with some holes in Mousterian whistles and some holes on long bones and mandibles from Aurignacian sites in Slovenia is not surprising, since all these holes could theoretically have been made with the same tools and with the same method (see *Fig. 12* and Dauvois 1989, 9, Fig. 3; Turk et al. Fig. 11.12; Turk, Stele 1997, Fig. 43). It is unnecessary to link them either to a specific cultural tradition and to a specific type of man as some authors think (M. Brodar 1999). This is clearly shown by two finds of typical "Mousterian" whistles from Mesolithic? levels in Mala Triglavca in Slovenia (unpublished).

It is difficult to prove traces of the proposed method of work on the artefacts themselves, although some damage can appear in this direction (*Pl. 3:* 1; *6:* 1 and see also Bastiani et al. 2000).

Macroscopic traces of the working of bone are very difficult to recognize on tools. In layer 8 of Divje babe I, we have a distally, basally and laterally fractured heavy retouched flake - *pièce esquillée* (*Pl. 4:* 2), which could have been created during working some very hard material with indirect percussion. There are a number of other pieces at the site which are partially retouched in the same way (Bastiani et al. 2000, Pl. 4: 2, 6: 8; 13: 3). However, it is difficult to say whether the damage occured during the working of hard wood or bone. Tools have been found in even older layers which have alternating retouch (Bastiani et al. 2000, Pl. 7: 4,5). The stress is on alternating since alternating teeth are an integral part of a real saw and only in such a case can we talk about recognising the principle of the operation of a saw. The most characteristic example of such a tool from Divje babe I has one tooth damaged (*Pl. 7:* 4 and ibid.). This tool could be created especially for sawing hard materials (e.g. bone). It is also worth mentioning the possibe presence of flaked parts of retouched edges (*Fig. 28; Pl. 6:* 1,4). Such flakes can only be created with the excessive use of a working edge on a hard material or in repairing a working edge. They are sometimes difficult to distinguish from flakes which occur in preparing a striking platform on the core. However, we think that this is not the case in the reproduced flaked portion of retouched edge on *Plate 28.*

For our study of the flute, tool damage created in making holes in wood or bone is of more relevance.

The working edge with jagged corners of one of the few burins is the first deserving mention, although the damage could only have been created in holing wood (*Pl. 3:* 3 and Bastiani et al. 2000, Pl. 2: 3). Holing means chiselling a hole, which is a quite different technique from drilling. Other tools worth mentioning are pointed and tongued tools. Below are summarised some of the results of extensive study of damage to such tools (ibid. 45 ss; Bastiani et al. 2000). This could contribute to resolving the question of the origin of the holes in the flute. All results refer to Divje babe I.

Among artefacts found is an unusually large number of different pointed and tongued specimens (*Pl. 3; 4*). Some are unusual in relation to manufacture, shape (burin, *burin busqué*, nosed scraper in the language of typology) and use (*Pl. 4:* 5 and ibid. 23). We believe that there are a large number of fragmented points or tongues (*Pl. 3:* 1,4-6). Since we do not know when and how such damage occured, there remains doubt as to the original shape and purpose of these artefacts. Such doubt is eliminated with the finding of at least twelve broken points and tongues of pointed and tongued artefacts (*Pl. 5-7*). No fragment, unfortunately, matches any of the numerous broken pointed and tongued artefacts. It should be mentioned that of all the artefacts found to date (471 pieces), we have succeeded in refitting only three. The very tip of a fragment is often damaged (broken or retouched). None of the fragments has a damaged fracture surface. In contrast, almost all of the suspected broken pointed and tongued artefacts have variously damaged fracture surfaces to the points and tongues. The damage is very probably the result of continued use of the sharp edges created with the breaking of the point or tongue. Strong use of all the cutting edges of the artefacts is one of the main characteristics of the site (Bastiani et al. 2000; Bastiani et al. 2000). Newly created fragments of points and tongues were too small (average size 9.6 mm) and above all, an unsuitable shape, to be functional; this despite the fact that the new edges along the fracture surface were on average still longer (10.9 mm) than the suspected used edges (7 mm) of the broken pointed and tongued artefacts and the edges on genuine microlytes (Bastiani et al. 2000, Pl. 5: 2-5). It is of interest that the dimensions of broken points and tongues approximate to the extreme possible depth of making holes with these tools, which is simultaneously the critical point at which the point or tongue normally breaks because of too great a side loading.

Primarily the following forms, among others, are characteristic of bending fractures of broken pointed and tongued artefacts and their fragments: hinge fracture on broken artefacts and their fragments and feather fracture only on the broken artefacts (*Pl. 3:* 1) (Bastiani et al. 2000, 47, Fig. 8: b,c,e). There are not many such fractures (5-8% of broken artefacts and 22% of fragments) but they could be connected with the use of the artefact (see Fischer et al. 1984). Hinge or feather fractures on tongued artefacts were probably made in making a hole in hardish material. It is important that the majority of such fractures on broken artefacts are retouched.

9-10% of all ("inverse") retouches on the ventral side of artefacts is on the point or tongue, on the edge of the fracture of a point or tongue and on the side edge along the fracture of a point or tongue (Bastiani et al. 2000, 44, Table 5). Inverse retouches connected with points and tongues always appear individually, never in a series (*Pl. 4:* 3). They sometimes appear together with a hinge fracture and with a series of retouches on the fracture surface itself. The degree of retouch before and after the break depends on use (holing, cutting).

The various macroscopic damage to tools includes also 16% damaged or broken points and tongues which have the frontage crushed instead of retouched (*Fig. 27:* a; *Pl. 3:* 2; *5:* 1; *7:* 2). We frequently obtained such damage in experimental piercing of bone (see *Pl. Fig. 27:* f, i). It is also characteristic of tips of projectiles (Shea 1997).

The very tips of broken points and tongues are often damaged (*Pl. 5:* 1, 2; *6:* 5; *7:* 4). We also found one such tip (*Pl. 7:* 1).

Shallow notches by breaks and on fragments of points and tongues are extremely rare (*Pl. 3:* 5; *5:* 4). Shallow notches on both sides of the point actually represent a transition from a pointed to a tongued tool, or the auto-creation of a tool during work (see Bastiani et al. 2000). Notches which continue on the ventral side of an artefact can only be created during making a hole in bone. This was confirmed by our experiments. In holing wood or with the use of pointed artefacts for projectiles, such damage never occurs (ibid., Odell, Cowan 1986; Shea 1997).

28% of all macroscopic damage represents a string of retouches (type gama according to Prost 1993) on the fracture surface of pointed or tongued artefacts. Complex retouches on the fracture surfaces are hard to explain by natural forces. Three fragments of a retouched flake found together cemented in sediment, created because of the pressure of the sediment, do not have such retouches on snap_fractures. However, they have a number of retouch chips attached which the pressure of the sediment peeled from the side edges and butt (*Fig. 24:* a and Bastiani et al. 2000, Fig. 13: c-f). This unique find with real pseudo- or cryoretouches from layer 10 in Divje babe I needs no additional explanation.

In the cited cases, damage probably occured in the use of pointed and tongued parts of artefacts. All the described damage was, in fact, obtained during experimental chiselling of holes in very hard material. Frequent retouches on the fracture surfaces almost certainly means that the tools were broken during use, i.e., in making holes. Damage to a tool did not signify its end; it would continue to be used, but with a different purpose. Suspected further use of broken pointed or tongued tools is reinforced by the fact that they never reused the fragments from these tools.

Tongued and pointed tools found at Divje babe I were probably damaged when making holes in wood. The suspicion that they chiselled holes is confirmed by some damage which can only be created with direct or indirect percussion. This means that we can get similar damage to artefacts which are used once as a weapon (point of a projectile) and another time as a tool (making holes). In the examples found, there is unfortunately no pronounced macroscopic damage to the side ventral edges, which could serve as convincing evidence of the making of holes in bone. However, some damage points in that direction (see *Pl. 3:* 5; *5:* 4; *6:* 5; *7:* 4).

The problem of making holes is complex. First, the effect on tools from making holes depends on the number of holes which visitors to the cave could make in a bone. Second, damage varies from tool to tool, depending on its capacities. Third, we would expect the most fragments of points and tongues in the light, entrance part of the cave, where we found the greatest wear and tear of tools (Turk, Bastiani 2000; Bastiani et al. 2000, 27 ss). Since we did not sift the sediment there, in the entrance part we found only slightly over a quarter of this kind of fragments. We found almost three quarters in the darker, central part of the cave, where we sifted all sediment and where we established essentially less wear and tear of tools. The variety of wear and tear of tools can almost certainly be connected with differing degrees of activity in the differently lighted parts of the cave.

The majority of tongued and pointed tools that we found in Divje babe I had been made from local tuff and chert.

Edges on tuff are damaged (retouched) essentially more slowly than on chert when making holes. The cause is its granulation. So it could be used for such a purpose more often than chert and other better quality raw materials. The result of this may be that we have some 50% tuff among broken tongues and points, while only 20% of other suspected used tools are from tuff. In relation to the aspect of damage itself, there is no essential difference among the various raw materials from which the tools are made.

5. **Conclusions**

Our first experiments with the jaws of carnivores warned us above all about the possibility of mistake by interpretating the results from taphonomic research that takes too one-sided an approach to resolving questions of natural or anthropic damage to bones. Questions can be very much more complex if various factors, both human and animal, are involved in them. We must be aware that specific carnivores (e.g. wolves) always followed people and tackled their kitchen remains and other waste. Traces of carnivore teeth in potential human artefacts does not necessarily mean that the artefacts have been made by carnivores, that they are preudo-artefacts rather than real ones, which is a common dilemma in Middle Palaeolithic archaeology. The interweaving of different factors in Palaeolithic archaeological practice is not only possible but probable. So in specific cases we must be extremely careful in interpreting traces which animals have left on bones. Without an exact analysis of possibilities which carnivores have for their behaviour, which includes also experiments, taphonomic conclusions can be too rash and sometimes even based on mistaken reasoning.

It is possible to conclude from the shape and distribution of specific holes whether they were made with canine teeth or cheek teeth. Bears primarily pierce bones with canine teeth. A specific proportion of holes in bones is thus undoubtedly connected with the distribution of cave bear and the changeable quantity of their remains (Albrecht et al. 1998). It is not therefore surprising that holes in bones were first noticed precisely in Palaeolithic sites with a mass of remains of cave bear, and considerably greater attention has been paid to such sites than to those with few or without remains of cave bear. Nevertheless, not all holes can be ascribed to unnatural bites of cave bear and other carnivores. It appears that Palaeolithic man was inspired by the natural holes in bones, that he began to copy his dangerous competitors – large carnivores, and to add his own, artificially made holes. The purpose of such behaviour is not easy to explain in most cases. We believe that it is not necessary for all artificial holes also to have had some functional value, just as this is unnecessary for all carefully retouched but barely usable artefacts. It could be simple symbolic expression, drawing attention to themselves in the sense of later graffiti, messages left to fellow members of the species. Something similar is familiar in another form in the animal world.

Clear traces of carnivore activity on bones found in all layers in Divje babe I are extremely rare. It could be said that they are no more frequent than characteristic cutmarks which Palaeolithic visitors to the cave made on bones. Primarily medium large carnivores were active at the site, judging by the damage to bones. Large carnivores, including cave and brown bear, did almost no visible damage.

Carnivores could only have made the holes in the flute with canine teeth during feeding on the meat and/or bones. They could not have made the holes in attack or defence. Theoretically, the most likely candidates for making holes are bears, but in practice, it is hardly credible that they made such holes. Other carnivores do not enter into account mainly because of the improbability of so powerful abnormal bites with canine teeth during feeding. We must be aware that there is a huge difference between piercing the cortical bone of the diaphysis and piercing the cortical bone of the metaphyses and flat bones and between piercing with cheek teeth and with canine teeth. So damage on one or another bone and with one or another tooth, is not altogether comparable (however, see d'Errico 1998a).

The size of the hole (diameter) is not crucial for establishing its origin, since the ends of teeth are roughly the same size as the points of Palaeolithic tools (however, see d'Errico 1998a). The shape of the hole is more important, although anthropic and natural holes, in their variability, partially overlap. It is thus necessary in distinguishing to take account of other criteria, too, which have for the most part been dealt with in this contribution.

Holes which in general and in detail do not differ significantly from the holes in the flute can be made with certain Middle Palaeolithic artefacts that are known at Divje babe I and other sites. The methodology of making such holes has not to date been known or recognised, although it was probably used very effectively on wood from the Lower Palaeolithic onwards. This is the method of indirect percussion, or combination of chiselling and knapping (Turk, Bastiani 2000; Bastiani et al. 2000).

In striking on a pointed or tongued tool, the same fractures and damage are created in the holing of hard materials as with a projectile, together with some additional forms of damage characteristic exclusively of knapping. These are primarily retouches and notches along the edges. It must be made clear that to date no-one has considered such possibilities for the origin of damage on pointed artefacts. That these were really used as tools, at least in Divje babe I, is demonstrated by the numerous fragments of points and tongues of pointed and tongued tools, which we only occasionally find with projectiles.

Middle Palaeolithic people also occasionally worked bones. This is perhaps evident even in Divje babe I, where in addition to the flute, in the same and in older layers, we also have fragments of other presumed bone artefacts. The modest stone industry (471 pieces > 1 cm and > 1 g), which is linked to 20 hearths (almost half the hearths were in the same layer as the flute) consists of greatly worn tools (Bastiani et al. 2000). This phenomenon would be traditionally ascribed to bio- and cryoturbation, though it could be also evidence of still unexplained activities that people carried out in the cave, which was never a permanent residence. Despite the intermittent settlement and presumed short duration of visits, the role of the site, which evidently remained unchanged for an extended period, should not be underestimated.

New analyses of the holes on the flute, supported by suitable experiments, have shown that, on the one hand, there is very little reason for the flute to have been made by any carnivore with teeth, and that, on the other hand, there is no weighty reason for the two holes not to have been made by humans with the available stone tools. In relation to carnivores, there are very few weighty reasons for the holes to have been made by cave hyena, still less for them having been made by cave or brown bear, and no reason for them to have been made by wolf. Because of this, accepting the hypothesis that the holes were made by humans is easier now than years ago. However because of the lack of direct proof and similar finds, it is still possible that, despite everything, we have been wrong.

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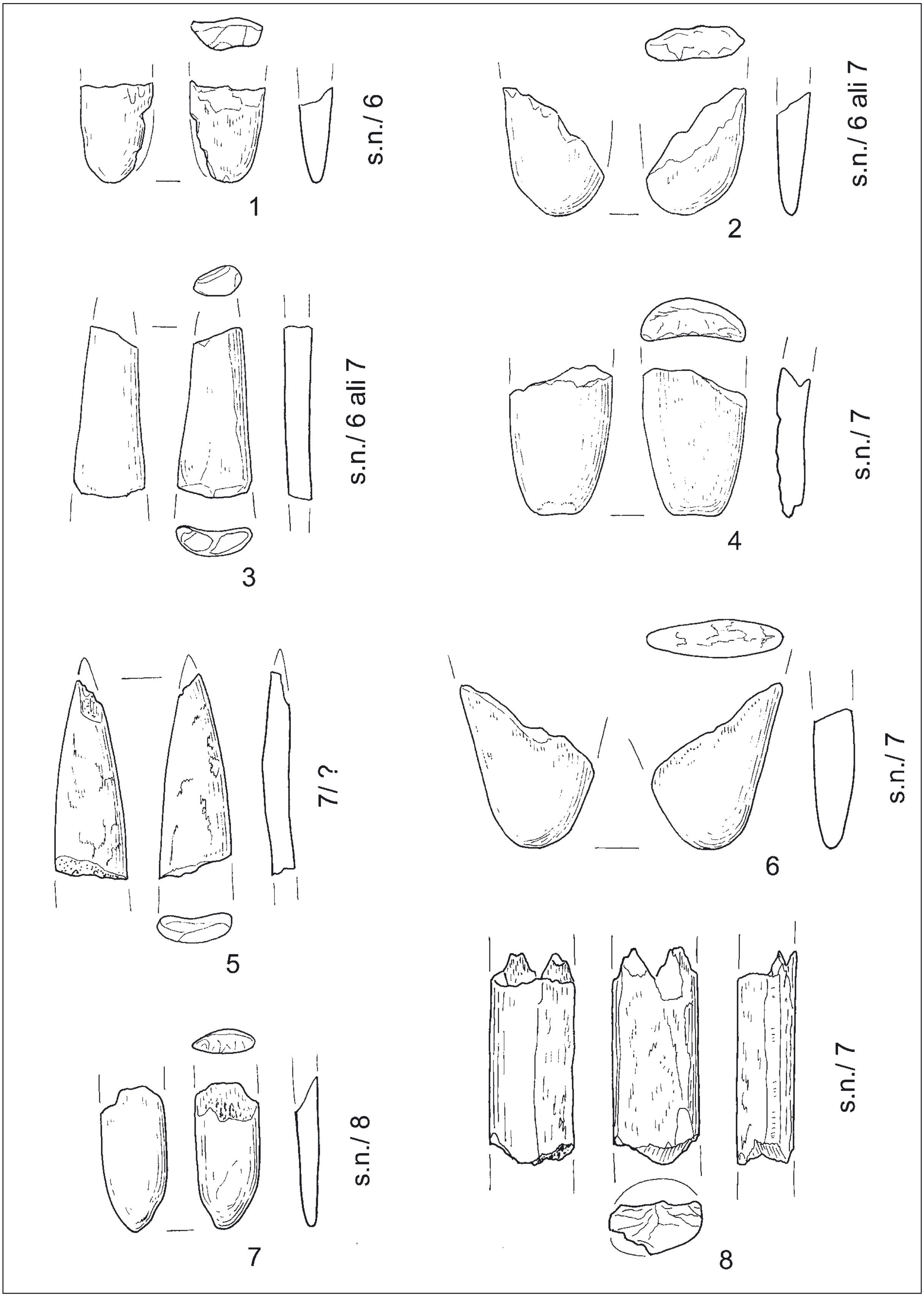
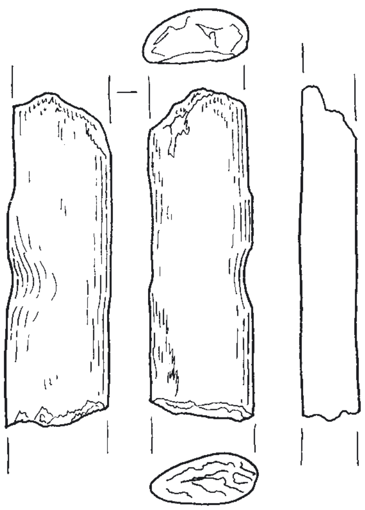
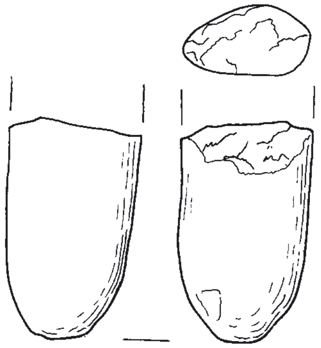


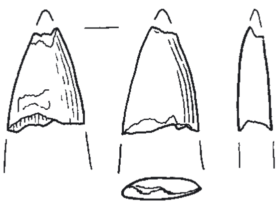
T. 1: Divje babe I: Koščeni artefakti? Vse naravna velikost. Legenda: inv. štev./plast.
Pl. 1: Divje babe I: Bone artefacts? All natural size. Legend: inv. no./layer.


1

s.n./ 7


2

s.n./ 7 ali 8 (ognjišče)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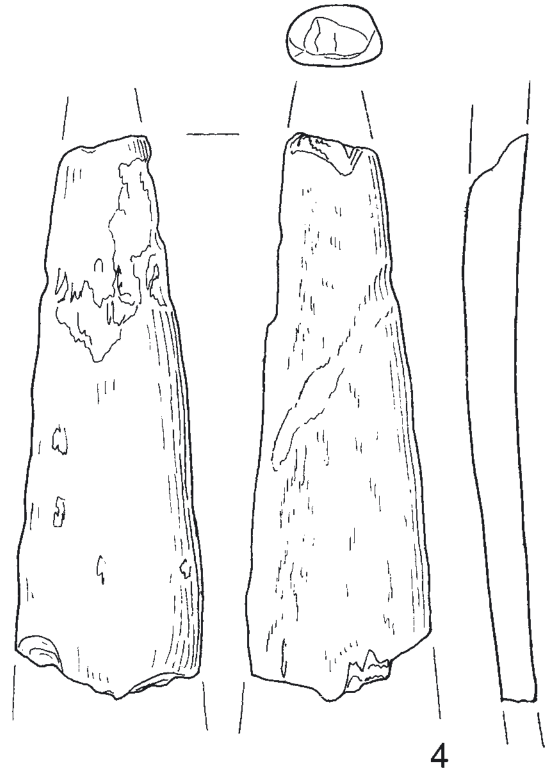
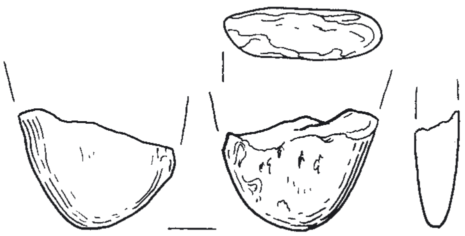

4

3/ 10


5

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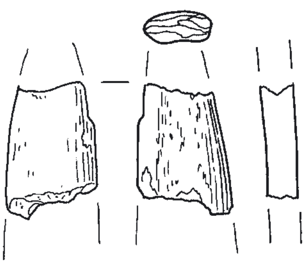
6

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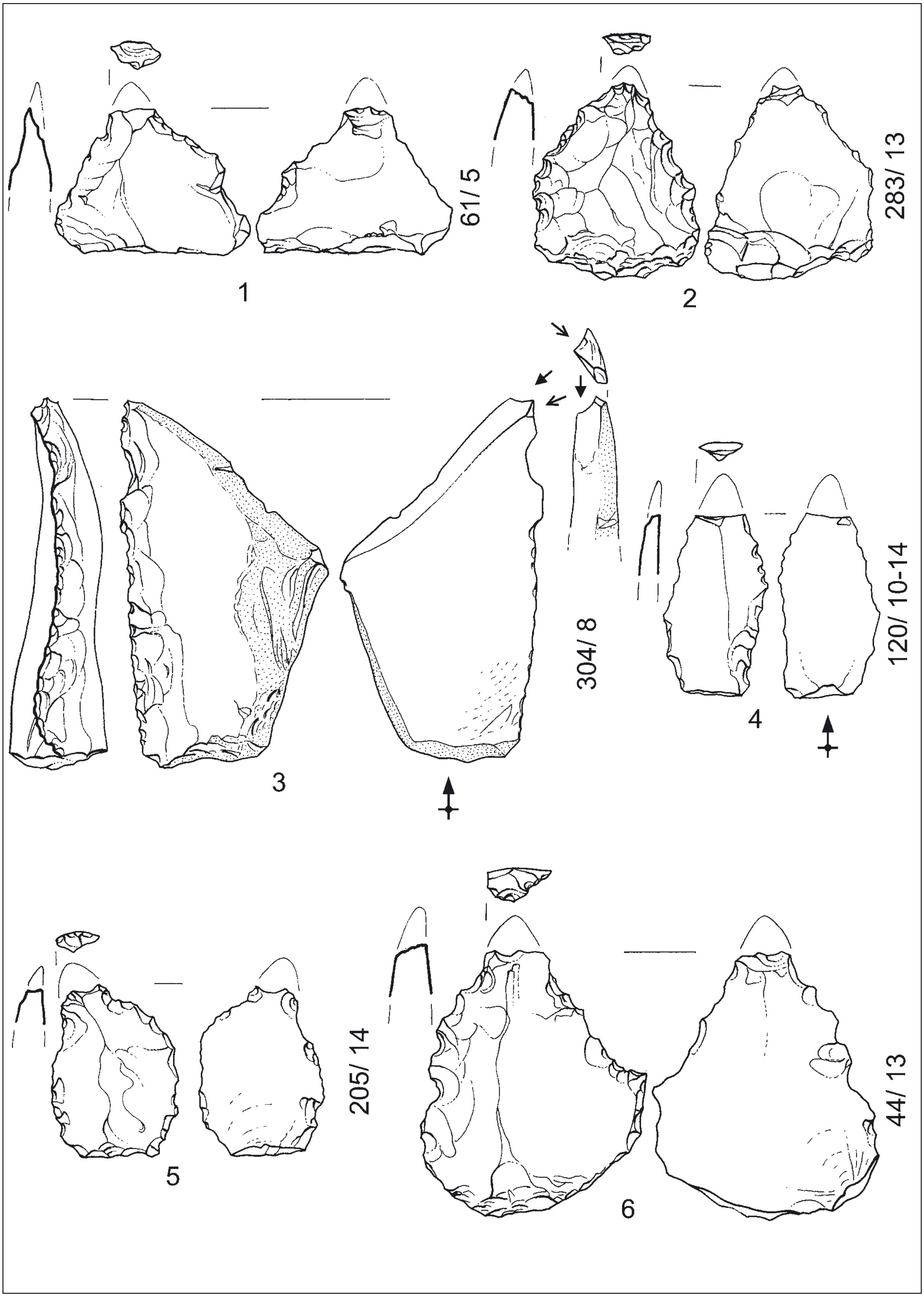
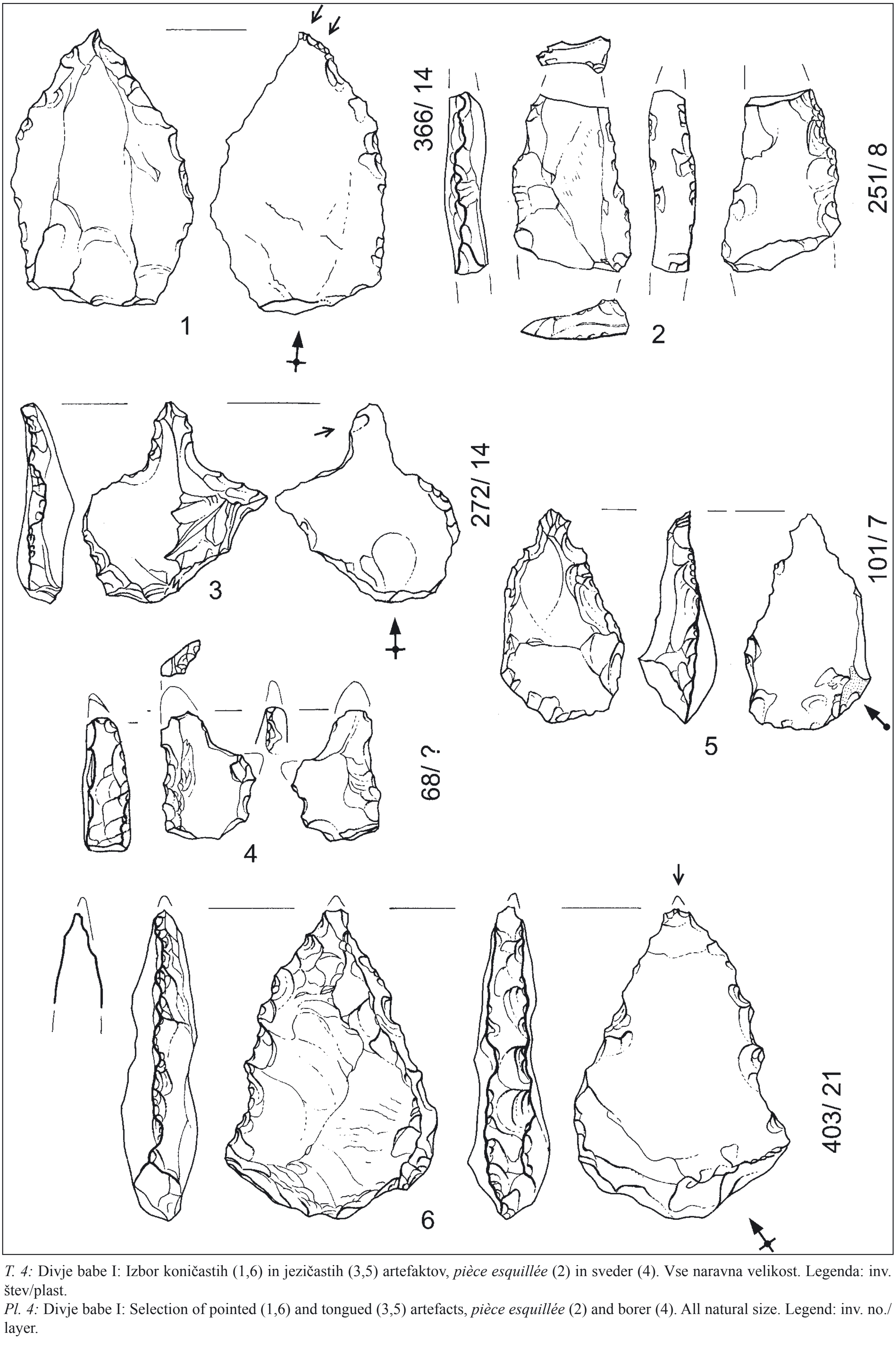
T. 2: Divje babe I: Koščeni artefakti? Vse naravna velikost. Legenda: inv. štev./plast.

Pl. 2: Divje babe I: Bone artefacts? All natural size. Legend: inv. no./layer.

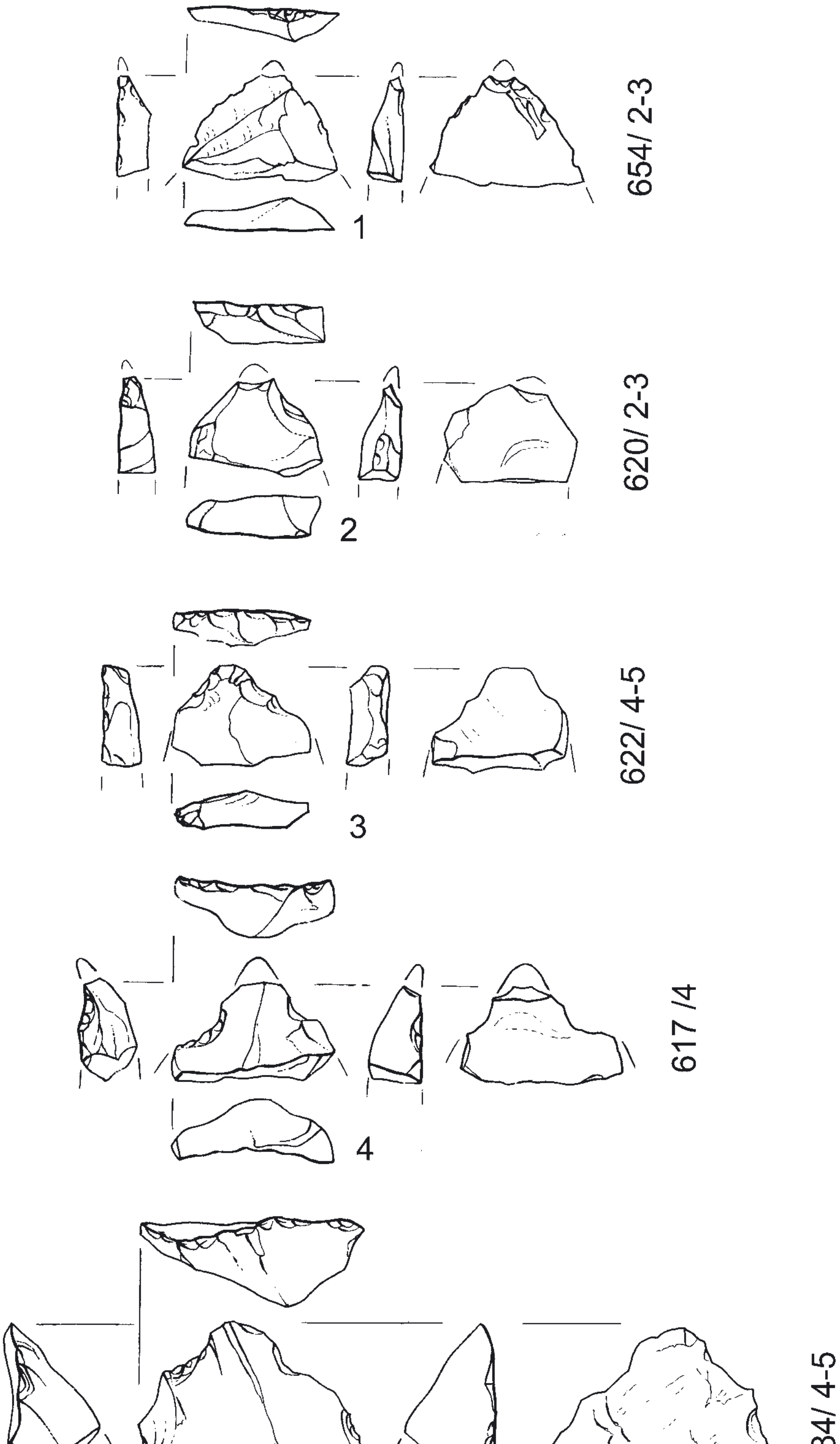


T. 3: Divje babe I: Izbor jezičastih (1,5) in koničastih (2,4 6) artefaktov in dletast artefakt (3). Vse naravna velikost. Legenda: inv. štev/plast.
Pl.3: Divje babe I: Selection of tongued (1,5) and pointed (2,4,6) artefacts and burin like artefact (3). All natural size. Legend: inv. no./layer.



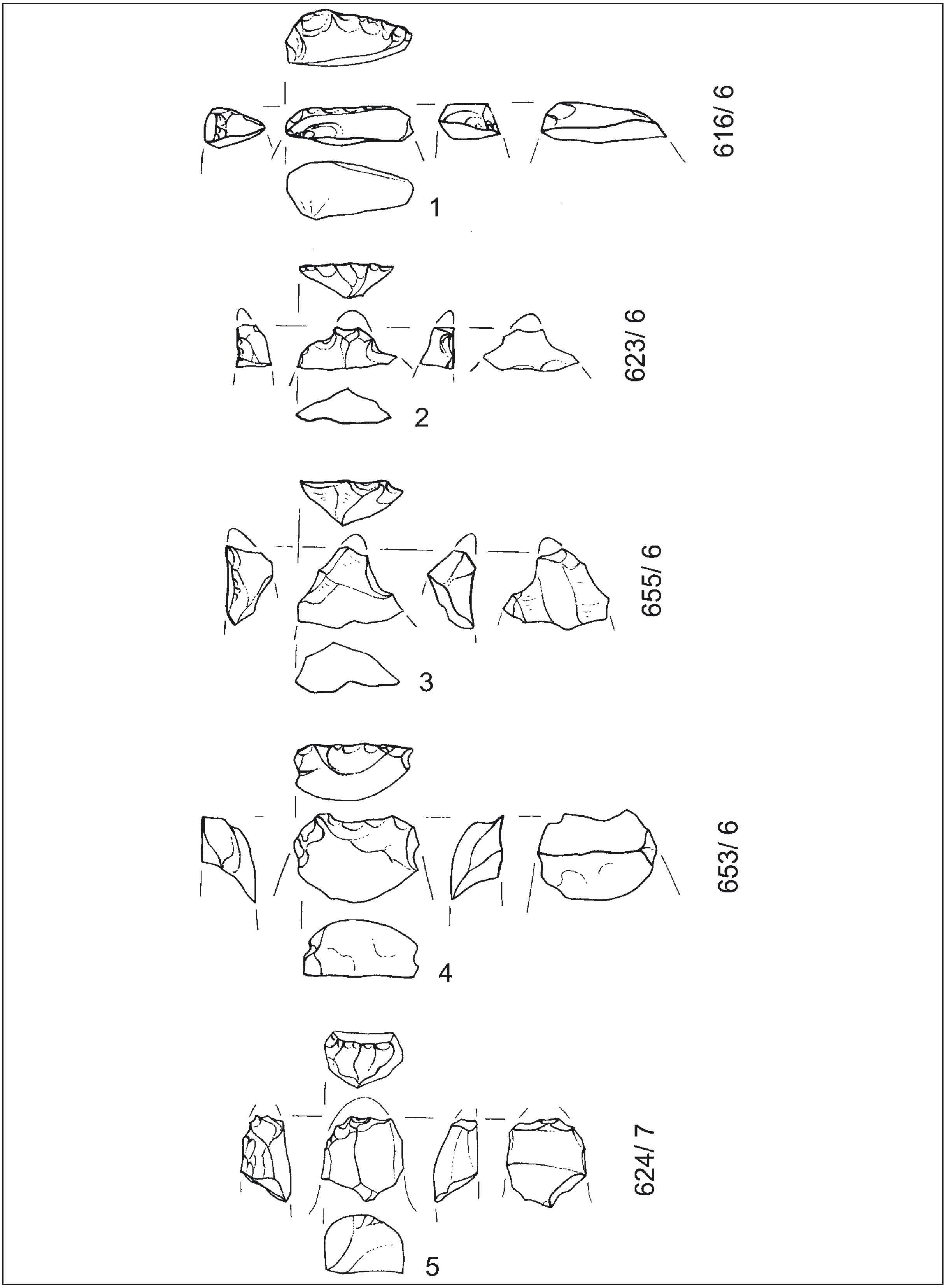
T. 4: Divje babe I: Izbor koničastih (1,6) in jezičastih (3,5) artefaktov, *pièce esquillée* (2) in sveder (4). Vse naravna velikost. Legenda: inv. štev/plast.

Pl. 4: Divje babe I: Selection of pointed (1,6) and tongued (3,5) artefacts, *pièce esquillée* (2) and borer (4). All natural size. Legend: inv. no./ layer.



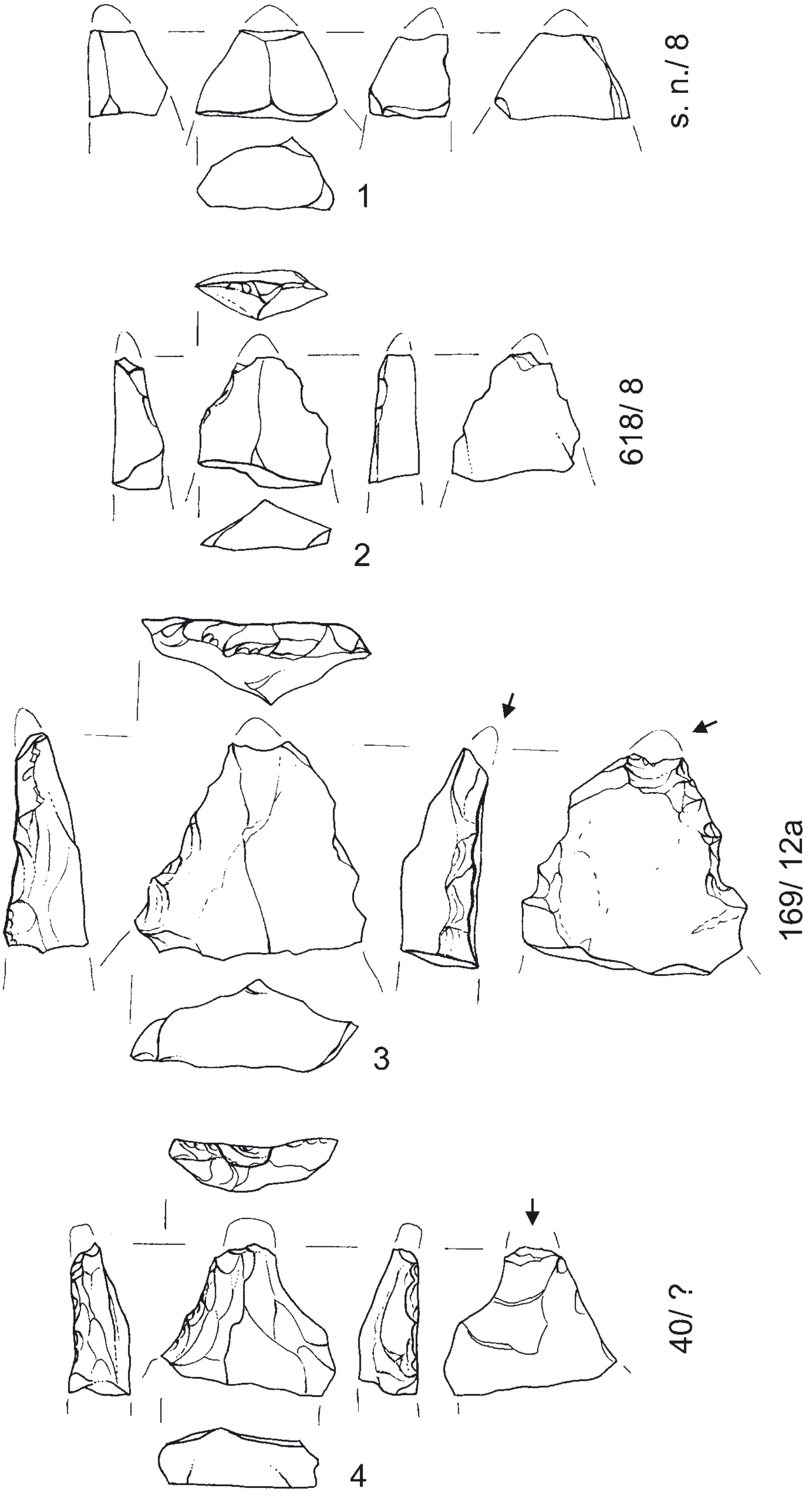
T. 5: Divje babe I: Odlomki konic in jezičkov koničastih in jezičastih artefaktov. Vse povečano 2:1, razen štev. 1 (3:1). Legenda: inv. štev./ plast.

Pl. 5: Divje babe I: Fragments of points and tongues of pointed and tongued artefacts. All 2x magnification except no. 1 (3x).Legend: inv. no./layer.



T. 6: Divje babe I: Odlomki konic in jezičkov koničastih in jezičastih artefaktov ter drugi retuširani odlomki. Vse povečano 2:1. Legenda: inv. štev./plast.

Pl. 6: Divje babe I: Fragments of points and tongues of pointed and tongued artefacts and other retouched fragments. All 2x magnification. Legend: inv. no./layer.



T. 7: Divje babe I: Odlomki konic in jezičkov koničastih in jezičastih artefaktov. Vse povečano 2:1, razen štev. 1 (5:1). Legenda: inv. štev./ plast.

Pl. 7: Divje babe I: Fragments of points and tongues of pointed and tongued artefacts. All 2x magnification except no. 1 (5x). Legend: inv. no./ layer.