

Could a cave hyena have made a musical instrument? A reply to Cajus G. Diedrich

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Izvleček

[ALI JE JAMSKA HIJENA RES LAHKO NAREDILA GLASBILO? ODGOVOR CAJUSU G. DIEDRICHU] Prispevek je odgovor na članek Cajusa G. Diedricha, ki je bil v elektronski obliki objavljen na spletni strani *Royal Society Open Science*. Diedrichov članek je poln hudih faktičnih napak. Avtor podcenjuje in ne upošteva arheoloških rezultatov in muzikoloških izsledkov raziskovanja neandertalskega glasbila, zato članek lahko povzroča veliko znanstveno škodo. V odgovoru smo se omejili le na komentiranje najhujših napak.

Ključne besede: neandertalsko glasbilo, Divje babe I, preluknjane kosti, tafonomija

Abstract

The contribution is a reply to the article written by Cajus G. Diedrich and published online on the web site of the *Royal Society Open Science*. Diedrich's article is fraught with factual errors and underestimations of the archaeological and musicological findings. As such, it may cause great scientific damage and should thus not remain uncommented. Only the most prominent errors are addressed.

Keywords: Neanderthal musical instrument, Divje babe I, perforated bones, taphonomy

The article by Cajus G. Diedrich (Diedrich 2015) entitled “‘Neanderthal bone flutes’: simply products of Ice Age spotted hyena scavenging activities on cave bear cubs in European cave bear dens”, published online on the web site of the *Royal Society Open Science*¹, reopens the old question of artificial (Brodar, Bayer 1928) versus natural origin (Kos 1931) of the holes in cave bear bones, which includes the best documented find of this kind identified already in its first publication as a potential Mousterian

or Neanderthal flute (hereinafter musical instrument), from Divje babe I (hereinafter DB) (Turk, Dirjec, Kavur 1995). The article is, alas, fraught with factual errors and underestimations of the archaeological and musicological findings, all of which may cause damage to the two disciplines. We therefore feel obliged to respond, for the sake of both archaeology and musicology.

We originally intended to publish this reply in the same journal, i.e. *Royal Society Open Science*.

The editorial board rejected our contribution twice, however, on the grounds of it initially being

¹ <http://rsos.royalsocietypublishing.org/content/2/4/140022>

too long, not concise and not persuasive enough. Because of the importance of the reply, we decided to seek publication elsewhere. The text below presents the original version of our reply.

Apart from numerous inaccuracies, the article “*Neanderthal bone flutes’: simply products of Ice Age spotted hyena scavenging activities on cave bear cubs in European cave bear dens*” also contains serious factual errors that can be found in the following statements made by Diedrich:

1 – “*The first ‘Neanderthal cave bear bone flute’ from the Middle Palaeolithic was believed to have been discovered in the 1920s from Potočka Zijalka...*” (Diedrich 2015, 1).

The site in question only yielded Aurignacian (Upper Palaeolithic) finds, as has been observed from the very beginning of excavations onwards. The finds include a mandible with holes (Brodar, Bayer 1928, Taf. 2), which has been interpreted as a ‘flute’, but never collocated with the adjective Neanderthal.

2 – “*Another juvenile bear cub femur with holes from Divje Babe I Cave, Slovenia ... was declared twice incorrectly as the ‘oldest instrument’, a 43140 BP old ‘Neanderthal flute’ from layer 8. This was already contradictory to the results of archaeological inventory that is well acceptably declared to be solely of, again, Cro-Magnon human Late Palaeolithic origin, and not of Mousterian (cf. [28] ... Therefore, there is no evidence for a Neanderthal (Mousterian) context ...*” (Diedrich 2015, 3–5). “*There, where [pseudo-bone flutes] are dated absolutely (Divje babe Cave 1), are without archaeological context at all*” (Diedrich 2015, 14).

None of the above is correct. The date of 43140 BP (BP means a ^{14}C date) is not among the roughly one hundred published numerical dates (^{14}C , ESR and $^{230}\text{Th}/^{234}\text{U}$) provided for the site by charcoal, bone and tooth samples (Ku 1997; Nelson 1997; Blackwell et al. 2009). The generally accepted Middle Palaeolithic (Mousterian) age of the instrument and its association with the European Neanderthal population has been confirmed by:

1.) the presence of Levallois cores and flakes in Layer 8 (M. Turk 2014, Pls. 20, 21; Fig. on p. 156) and in the layers above and below it (M. Turk 2014, Pls. 10–19, 22–61) (altogether 13 Middle Palaeolithic levels that yielded a total of 700 artefacts and 21 hearths);

2.) the ESR age (50–60 ka) of the cave bear teeth in Layer 8a (Blackwell et al. 2007; 2009), i.e. the cemented upper part of Layer 8, which also revealed the musical instrument in the immediate vicinity of two hearths (I. Turk, Dirjec, M. Turk 2014a, Fig. 14.3; – Turk, Kavur 1997, Figs. 10.10; 10.11) and few artefacts;

3.) the increasing/decreasing numerical ages of most other layers (Turk 2007b, Fig. 7.1; – Turk et al. 2006, Fig. 6);

4.) the analysis of the sediments (Blackwell et al. 2009; – Skaberne, I. Turk, J. Turk 2015) and the associated palaeontological evidence (Turk 2007b) (animal remains, pollen, charcoal), which provided a reliable chrono-climatic span of the whole investigated profile, with four documented hiatuses, from OIS (MIS) 5d to OIS (MIS) 3 (first half) with a clearly definable border between OIS 5 and OIS 4–3 (Turk et al. 2006, Fig. 5); and

5.) the fact that the European sites dating to the period during which Layer 8a formed (OIS 4/OIS 3 boundary) thus far only revealed the bones of Neanderthal individuals, several hundred of them, while the earliest skeleton finds of the anatomically modern newcomers date to the second half of OIS 3.

3 – “*This report of a ‘cave bear femur bone flute’ was not the ‘oldest’, neither historically, nor by stratigraphy*” (Diedrich 2015, 5).

Certainly not true. The last Upper Pleistocene Layer 2 in DB, deposited two metres above the find in question, revealed the only positively identified Aurignacian level with a typical split-base point (Turk 2014b, Fig. 10.1) and fossilized cave bear remains. The numerical age of this level is determined with four different dates (39.7 ± 4.7 ka, 26.2 ± 5.3 ka, 35.3 ± 0.7 BP, 29.7 ± 0.3 BP) (Ku 1997; – Nelson 1997; – Blackwell et al. 2007; – Moreau et al. 2015). These chrono-stratigraphically place the Aurignacian level in Layer 2 side by side with central European Aurignacian sites that revealed famous finds of flutes, such as Hohle Fels and Geissenklösterle. Coupled with other evidence, this proves conclusively that the musical instrument found in the breccia of Layer 8a is both ‘historically’ and stratigraphically earlier than all other Palaeolithic flutes.

4 – “*The bone’s holes on the dorsal side [of the femur-flute] appear not to line up*” (Diedrich 2015, 5).

No? Take another look at Figure 5: 4a on page 6 of Diedrich’s article.

Tab. 1: All the cave bear femora from the 265 m³ of sediments in DB 1989–1999 excavations by Ivan Turk and Janez Dirjec. The finds are kept in the National Museum of Slovenia (Ljubljana) together with other skeletal parts and undeterminable fragments.

	MNI (teeth)	Femur NISP	Femur complete	Femur shaft	Femur joints ^a	Femur shaft with hole(s)
Fetus & new-born	?	441	13 (2.9%)	410 (93%)	18 (4%)	0
Cub & subadult	4814	1009 ^b	15 (1.5%)	535 (53%)	459 (45.5%)	3 (0.56%)
Adult	671	155	15 (9.7%)	38 (24.5%)	102 (66%)	0
SUM	5485	1605	43 (2.7%)	983 (61%)	579 (36%)	3 (0.3%)

^a Both epiphyses and metaphyses of cave bear cubs are taken into consideration.

^b Femur with unfused epiphyses.

5 – “Other authors doubted the ‘flute’ and human origin however (e.g. [32–38]) or were fighting for pro-arguments (e.g. [39, 40])” (Diedrich 2015, 6).

In Endnotes 35 and 40, M. Otte, advocate of the instrument interpretation, is incorrectly cited as the opponent, while the opponents C.-S. Holdermann and J. Serangeli are incorrectly cited as advocates.

6 – “... Slovenian author (cf. [43]), who misidentified: ... (b) the bone, by rotating it upside down (see [44]), the 180° rotation of which is corrected herein (Figure 5a), (c) the general bone taphonomy of cave bear bones ...” (Diedrich 2015, 7).

Diedrich’s rotation of the femur-instrument does not appear to have a sound basis; his proximal-distal orientation is anatomically incorrect and not supported by argumentation. In our publications, we oriented the femur diaphysis anatomically correctly, following these criteria:

1.) The cross section at the border between the diaphysis and the distal metaphysis is markedly different from the cross section at the border between the diaphysis and the proximal metaphysis. The former is pronouncedly convex in the ventral (anterior) side, the latter only slightly. The difference is clearly visible on CT slices of the instrument (Blackwell et al. 2009, Fig. 11.7), less in side views, due to the damage. Together with the shape of the aperture of the *foramen nutricium*, it is a reliable criterion for the proximal-distal orientation of the diaphysis.

2.) The medial edge of the diaphysis is, considering the ontogenetic development stage of the femur-instrument from DB, always more or less straight, while the lateral edge is more or less curved (concave), which enables a reliable left-right determination of the diaphysis.

As for the misidentification of the general bone taphonomy of cave bear bones, we believe that Diedrich should, in order to substantiate his claims

on ‘Neanderthal flutes’ in a scientifically correct manner, perform a comparative taphonomic study between the sites he deems of key importance that only functioned as dens, on the one hand, and DB, on the other, all with taking into account the differences and other circumstances. He should also take into account the generally known fact that people in all archaeological periods very successfully used bones as a source of both food and raw material.

The differences that Diedrich observes in the damage of the long marrow bones of cubs, subadult and adult cave bears are, in fact, present throughout time and space, hence also among the fossil finds from DB. For the Palaeolithic sites in South-Eastern Alps, Diedrich sees only hyenas as the main culprit for bone fragmentation. This simple explanation, however, is problematic, all the more by comparing it with the reliable statistical data for the cave bear femora from DB presented here for the first time in *Table 1*. These data in some respects differ significantly from the data for Diedrich’s German cave sites that, it should be emphasized, only served as large carnivore dens, if judged from finds (facts).

The 265 m³ of wet-sieved and examined sediments from the central part of the cave (Layers 2–17a) yielded, alongside numerous artefacts and hearths, 73949 isolated teeth that represent the remains of at least 4155 cave bear individuals with milk teeth (cubs), at least 659 individuals with erupting permanent teeth (cubs and subadults) and at least 671 individuals with fully developed permanent dentition (adults). A single individual can, in a certain phase, have a combined dentition, which lowers the number of individuals, though cubs are still markedly prevalent (cf. Debeljak 2002).

Considering the representation of complete bones, the femora most often chosen to be fragmented were those of cubs and subadult individuals (for

other long marrow bones cf. Turk, Dirjec 2007, 337), not of adult individuals as suggested by Diedrich. More consistent with his hypothesis on the fragmentation of the diaphysis of adult individuals are the data on the representation of diaphyses. They do not, however, offer an unambiguous answer as to the cause. Furthermore, such a picture may be the consequence of a numerical supremacy of cubs over adult individuals. Paradoxically, the highest number of diaphyses belongs to fetuses and newborns. The representation of meta- and epiphyses shows these parts to be least represented for cubs and subadult individuals. The carnivores aiming to break the bone into fragments must first remove the epiphyses with parts of metaphyses by literally chewing them. This is most easily done with the bones of young individuals. In the bones of the adult individuals from DB, the epiphyses are clearly best represented, which suggests femur fragmentation by humans rather than by cave hyenas because of two facts. Firstly, the femora of adult individuals were primarily appreciated for their marrow rather than collagen (as claimed by Diedrich), while the femora of cubs were appreciated for the collagen. And secondly, the main consumers of the marrow throughout archaeological periods were most probably humans, while collagen and spongy bone were sought after by carnivores. The femora of cubs with non-fused epiphyses, which revealed most tooth impressions on metaphyses, were fairly easily split open because of the thinner cortical shell in comparison with the femora of adult individuals (see experiment findings in Turk et al. 2001). The process of crushing diaphyses with the so-called crushing triangle premolars of a cave hyena, which Diedrich does not explain in more detail, involves a hyena or other carnivores first puncturing a diaphysis and then splitting and crushing it. Having said that, compression concentrated in one point can cause the femur or any other long bone to crack longitudinally². The epiphyses in adult bones actually prevent longitudinal splitting, while a diaphysis without the epiphyses splits as the tooth penetrates deeper into the bone and causes increasing tensions in the bone tissue (the 'wedge effect'). Moreover,

² Experiments on fresh brown bear femora have shown this to be true of all age groups, which means that Diedrich's model, of different reaction of the bone belonging to individuals of different ontogenetic phases, from cubs to adults, to crushing with teeth, does not hold water in practice.

in order for the endeavour to be successful with minimal effort, the tooth has to be pointy; it is considerably harder to pierce a bone and split it into splinters with a blunt tooth. Splinters can then be crushed further.

The 550 femora of cubs and subadult individuals from DB included, apart from the femur-instrument, only one other femur with one etched hole and another one with two unusually placed and irregularly shaped holes. All other long marrow bones revealed no holes. This is a negligibly low number for carnivores, even if we add to it the few rare bones with tooth impressions. The same is valid for only one musical instrument within the site and the whole of Middle Palaeolithic. However, we should take into account the possibility of such and similar instruments being made of perishable materials. Bone as raw material is very rare in Middle Palaeolithic contexts, which predominantly yielded lithic objects, while wooden objects survived only exceptionally. Contrary to the Middle Palaeolithic, bone often served as raw material in the Upper Palaeolithic, from and including the Aurignacian onwards; the Aurignacian layers in Potočka zijalka, for example, yielded over 130 osseous points mostly made of cave bear bones.

For several German caves-cave bear dens, Diedrich states 20% of adult bones and 80% of cub bones damaged by large carnivores (Diedrich 2015, 9). He does not explain, however, how he arrived at such high shares, which are even inconsistent with his model of cave hyena activity on adult and cub bones. The statistics we can provide for DB on that subject are as follows: the 939723 examined bone pieces recovered from 265 m³ of sediment, weighing ca. 2300 kg and mainly belonging to cave bears, include 396 (0.04%) pieces with characteristic tooth marks, as shown on Figure 5: 6a–6d of Diedrich's article, which includes rare tooth impressions (for over 150 European sites of cave hyena, Diedrich states up to 20% of bone with such damage (Diedrich 2015, 14)), 1655 (0.17%) charred pieces, 15 (0.001%) pieces with cut marks and 881 (0.09%) corroded pieces³. The charred bone fragments in hearths and the rare bones with cut marks are conclusive evidence of humans handling the cave bear remains and not just carnivores. Moreover,

³ Corrosion is the consequence of water activity rather than intestinal juices, because it mainly appears on complete bones and even more frequently on dolomite clasts in correlation with bone corrosion.

the frequency of visits to DB by humans, on the one hand, and cave bears, on the other, estimated on the basis of the number of fossil remains and artefacts, corresponds well, though this can be interpreted in a number of ways (i.e. frequent/occasional use of the cave as a den or a shelter in a cold/temperate climate, systematic exploitation of the remains of perished cave bears, hunting, a combination of the first and second activities). Contrary to this, we have no information as to the frequency of the visits by cave hyenas, which are not attested in the cave by direct evidence. Of the whole assemblage, as many as 95% are fragments smaller than 5 cm. There is an even greater amount of micro-fragments, measuring from 3 to 0.5 mm and less, which were not collected systematically. It is hard to imagine all these fragments being made by hyenas and other large carnivores, without the participation of humans and other factors; in micro-fragments primarily weathering. Another large group of bones are skulls, the expected number of which is roughly estimated between 100 and 600. Only 12 skulls (12%–2%) survive complete. In total, 4541 fragments belong to adult individuals. It is again hard to imagine that all these fragments were made by hyenas so as to get to the brain. Only humans devised an efficient method of extracting the brains quickly (for DB evidence see Turk, Dirjec 2007, 338–339).

7 – “*The position of holes is mostly on the herein studied 19 cub femora, on the ventral side ... This area is thinner in the compacta than the dorsal one*” (Diedrich 2015, 10).

This is not true in the case of the femur-instrument, as confirmed by computer tomography (CT) (Turk et al. 2006, Fig. 9). The experiments in making holes by compression into the fresh femora of the extant brown bear have shown that most holes were made on the convex ventral side rather than the flat dorsal side (Turk et al. 2001, Table 2b), which could be related to the different flexibility of the cortical shell (convexity versus flatness) under antagonistic teeth.

8 – “... all ‘fragmented’ bones [from DB] were simply declared as due to ‘sediment pressure’” (Diedrich 2015, 14).

This is incorrect; we ascribed most fragments to biotic factors. Primarily on the basis of the differences in the typical patterns of the diaphyses of cubs and adults in the levels with and those

without hearths, we argued that the diaphyses of cubs were fragmented by carnivores, primarily wolves, while the diaphyses of adult individuals were mainly broken by humans (Turk, Dirjec 2007, 337–339). Diedrich, to the contrary, believes that the diaphyses of adult individuals were systematically broken by cave hyenas, while the cub diaphyses remained complete because of the more elastic compact bone; this, however, is at odds with the numerous splinters of diaphyses of cubs and subadult individuals from DB, and with his Figures 6 and 7.

9 – “*Finally, also X-rays of the ‘bone flute’ hole margins did not verify any ‘drilling’ nor any stone tool work on the bone*” (Diedrich 2015, 13).

It does not make much sense to insist on drilled holes because there are other efficient ways of making holes (Turk et al. 2003; 2006) and tools suitable for such tasks, also from the Middle Palaeolithic levels in DB (Turk et al. 2006, Fig. 12; – Blackwell et al. 2009). The Palaeolithic visitors to DB, like humans in general, drew ideas from nature. Imitating animals, they also could pierce bones in a controlled manner, using simple tools instead of teeth and the dynamic strength of a strike instead of the compression. This would also explain the absence of tool marks around the holes of the femur-instrument and the difficulty in distinguishing these holes from those eventually made by the tip of a tooth of a certain cross section. While a human strove not to break the bone while attempting to pierce it in order to make an instrument, a hyena would strive to do just that. As for other traces of manufacturing (cut marks), they are present either in an indistinct form or masked by corrosion and incrustation on bone surface. The same holds true of the presumed bite marks not necessary directly connected with the holes (cf. arguments in Turk et al. 2001, Fig. 20; – Turk et al. 2006, 313), which could even be mistaken for corrosion and mechanical synsedimentary damage by an unexperienced eye.

10 – “*Another argument comes from the oval holes, if attributed to the bone crushing premolar hyena teeth their elongation axes are in most cases parallel to the bone shaft, but only in holes within the shaft.*” (Diedrich 2015, 12).

The round to sub-oval shape of the holes on the femur-instrument does not correspond with the particular shape of the tip of the lower and upper third premolar of a cave hyena in cross

section and its impressions as shown by Diedrich, for example, on Figure 7: 2b – bottom impression (see also experimental tooth punctures in Turk et al. 2001, Fig. 16d). The sub-oval shape of one of the holes in the longitudinal axis precludes the possibility of a normal bite with carnassials as shown on Diedrich's Figure 8. The holes on the femur-instrument are also without the impression or puncture of the antagonistic tooth that would correspond with the occlusion of hyena premolars (cf. Turk et al. 2001, Figs. 10, 14). Moreover, laws of physics make it impossible to puncture a hole under a hole and to make an impression next to a hole, either with canines or with carnassials (I. Turk, Dirjec, M. Turk 2014b, 260).

We will conclude by briefly reiterating the most important facts supporting an artificial origin of the holes on the femur-instrument.

Experiments have shown that hyenas making several holes (which Diedrich does not adequately explain in connection with bites), particularly if aligned, would certainly split the bone or at least crack it (Turk et al. 2001). None of this can be observed on the femur-instrument. Experiments have also shown how a DB human, with readily available Middle Palaeolithic pointed stone and simple bone tools, could make such holes on specific bones (Turk et al. 2001; 2003), probably also to gain suitable splinters to make early bone points, the use of which peaks in the Aurignacian together with the holes in cave bear bones. In fact, the natural shape of the selected left femur, its size and modifications (disposition of holes, their number, straight cutting edge, bell with a notch) are ergonomically perfect features, adapted to a right-handed musician (Dimkaroski 2011; 2014). In its range (3.5 octave), the femur-instrument surpasses all known Aurignacian flutes made of bird bones (maximum of 1 octave). If the find from

DB is not an instrument, as claimed by Diedrich (...*neither instrument(s) nor human made at all*". – (Diedrich 2015, 14)), is playing the Ode to Joy on it then not music⁴? Are we to believe that a cave hyena could have modified exactly the right bone in such a way that its musical capabilities surpass the uncontested flutes from Hohle Fels and Geisenklösterle, as well as modern flutes? And why should we think that Neanderthals could not have had sufficient knowledge and experience to make such an instrument?

Archaeologists and other experts who advocate the use of the perforated femur as an instrument have adequately explained both the technique of making holes without leaving tool marks and the technique of playing the flute. They were able to reconstruct both half holes and conduct numerous experiments on bear femora and on different versions of the instrument. Contrary to that, Diedrich and others who advocate that the holes were made by carnivores have failed to explain, in a convincing and irrefutable manner, how a carnivore could, with its canines or carnassials, bite the bone so as to create the disposition and shape of holes we observe on the femur-instrument. Moreover, they consistently ignore or underestimate the alternative technique of making holes and of playing the instrument to the benefit of their interpretation. But most counter-productive for the discussion on the earliest known musical instrument is that they willingly misunderstand or misrepresent the facts on both the object and the site, in spite of the exhaustive primary publications on the subject.

Translation: Andreja Maver

⁴ Listen to the reconstructed Neanderthal bone musical instrument on YouTube (www.youtube.com/watch?v=sHy9FOblt7Y).

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