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Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy)

--Manuscript Draft--

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Abstract:	Bone retouchers are present in the human toolkit throughout the Lower and Middle Palaeolithic and appear in several contexts across Europe, sometimes in association with heavily retouched stone tools. Here we present the complete assemblage of bone retouchers recovered in De Nadale Cave, a Mousterian Quina site in northern Italy dated to the onset of MIS 4. The results show that this assemblage is consistent – both in morphological and technological features - with bone retouchers recovered in the rest of Europe. The predominance of cervids and bovids' limb bones is observed , and the study of the retouch-induced stigmata reveals intense modification of the lithic industry carried out on-site. This analysis contributes to our understanding of Neanderthal cultural and economic choices in the Quina complex in Europe.
Suggested Reviewers:	Camille Daujeard, PhD Researcher, Institut de Paléontologie Humaine camille.daujeard@mnhn.fr C.Daujeard is one of the most experienced investigators of bone retouchers in Mousterian assemblages
	Jarod Hutson, PhD Professor, MONREPOS hutson@rgzm.de J.Hutson is an experienced investigator of bone retouchers
	Emanuela Cristiani, PhD Professor, Università di Roma La Sapienza emanuela.cristiani@uniroma1.it E.Cristiani is one of the most experienced investigators of bone tools in Palaeolithic assemblages
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Opposed Reviewers:	
Response to Reviewers:	Dear Editor, We reworked and modified our manuscript in accordance with the reviewers' comments. We agree with most of their remarks, and we thoroughly revised the text and the figures, with a major effort to improving the discussion and conclusion sections. Appended below is our point-to-point rebuttal list.

Editor: Reviewer #1 seems to be asking you to do a great deal more work. This isn't appropriate, but perhaps you could address some of these points through literature comparisons?

Reviewer #1: This article by Martellotta et al. describes in detail 335 bone retouchers from the Mousterian Quina site of De Nadale Cave. I commend the authors for their diligent study of these artifacts. Their work build on the previous analysis of 204 bone retouchers from De Nadale reported by Jéquier et al. in 2018. Unfortunately, the authors fail to provide little new information apart from additional measurements and stigmata counts on the De Nadale retouchers. Furthermore, this work does little to advance "our understanding of Neanderthal cultural and economic choices in the Quina complex of Europe" as claimed in the abstract, other than increasing the sample size of bone retouchers attributed to Quina Neanderthals. Repeatedly throughout the manuscript the authors provide suggestions for future work to describe the pattern shown in the De Nadale and other Quina assemblages, yet they make no attempt to undertake this work. Perhaps this work is being conducted as part of a broader study of the De Nadale retoucher assemblage, but the authors should make a better attempt in their discussion of these artifacts, beyond recommendations for future work. Because the authors have a rough outline of the work that still needs to be done, I recommend the article be accepted with major revisions. These major revisions must include some of their own recommendations for further investigations. These additional efforts should seek to address the specific uses of retouchers as a constituent of Quina technology, whether retoucher use is consistent across Quina sites (important because De Nadale is the sole Quina site in Italy), and how retouchers at Quina sites are different or the same as retouchers from other sites in Italy. These are just a few directions that the authors could take to expand on the importance of bone retouchers to Quina technology. At the very least, the authors must describe how their study builds on the previous work of Jéquier et al. and how their study improves our knowledge of bone retouchers at De Nadale, beyond just increasing the sample size. Without these additional details, this article merely adds 335 additional bone retouchers to the thousands and thousands of bone retouchers already known throughout Europe.
All the bone retouchers studied by C. Jéquier and belonging to the sample here analysed, have already been published albeit at preliminar level, in different contributions, which have been explicitly cited within the manuscript (Jéquier et al., 2015, 2018). Nonetheless, a very large part of the sample here analysed is composed by unpublished retouchers (NR=131). Moreover, the present work has different aims than the two papers from Jéquier et al., as we explain in the Introduction: “In this small cavity, large numbers of retouchers have been found, some of which have already been presented in preliminary publications (Jéquier et al., 2015, 2018). Recent excavations at De Nadale Cave extended to almost the entire deposits yielding more than one hundred new retouchers made of giant deer, red deer, and bovid bones. Here we present the complete assemblage of retouchers recovered until the last field campaign conducted in 2017. They are analysed from a morphological and a technological perspective. The aim is to provide a complete description of their techno-morphological features in order to contribute to their contextualisation in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data”. Indeed, for this work, we re-analysed the whole set of retouchers, and we focused on some issues which were not considered in the works from Jéquier et al: (1) a wider consideration of the relationship between the retouchers’ morphology and the stigmata, (2) our suggestion that specific skeletal elements (i.e., radius) were selected for making double retouchers, (3) the comparison between the species whose bones are used as retouchers and the NISP relative to the sites’ faunal spectrum, (4) a reviewed proportion between the amount of linear and punctiform impressions, (5) a comparison with other Quina sites, and finally, because of the reviewers’ comments, (6) more precise information regarding the sizes of use areas and the thickness of the compact bone in correspondence of the use areas.
Regarding the recurrent references to future studies, our intention was to highlight the diversity of possible analysis applicable to this sample. However, we do agree with the reviewer when they notice this redundancy and therefore, we deleted most of them within the manuscript. As the analysis of bone retouchers is indeed part of a broader on-going study of the human groups living at De Nadale Cave, we have now more information available compared to the time of our first submission – over one year ago.

	We added this information in different parts of the text (see comments below). Moreover, we added three new figures (Fig.3, Fig. 13 and Fig. 14) and a table in Supplementary Materials (SM1) for supporting this new additional information. Regarding the suggestion of comparing retouchers' features with other sites in Italy – as we wrote in the introduction, this work strives to analyse the whole assemblage of retouchers from De Nadale Cave, and to contextualise this assemblage "in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data". Finally, we believe that adding "335 additional bone retouchers to the thousands and thousands of bone retouchers already known throughout Europe" still deserves relevance, especially when considering that 131 of them lasted unpublished. These numbers are consistent with the general trend of samples published in the field of bone retouchers. Furthermore, the role that these tools play in the understanding of human evolution and behaviour is becoming more and more established in the field. We suggest referring to some of the most valuable contributions in the study of bone retouchers, for example the volume on retouching of Hutson et al. 2018, the work of Daujeard et al. 2014, the more recent contributions of Alonso-Garcia et al. 2020, Martellotta et al., 2020 and Turner et al. 2020, and references therein. These papers, and many others, suggest and demonstrate that the study of bone retouchers is linked to different strategies in the exploitation of animal raw material, to the relationship between food waste and tool making, to a broader concept of "retouch", which goes beyond the study of retouched lithic tools by including the tools actually used for retouching. Nevertheless, in order to enrich the discussion about our case study, we added more information within the manuscript regarding the relationship between bone retouchers and retouched lithic tools at De Nadale Cave – even though the detailed study of our site's lithic industry is still ongoing. Highlights l.1-3: We modified as follows: •Retouching is a widely shared behaviour among Middle Palaeolithic humans •De Nadale Cave was occupied only by Quina Neanderthals in Italy •More than 300 bone retouchers were obtained from cervid and bovid limb bones •Double retouchers were made using ungulates' radii •Intense retouching activity relates to the lithic tool kits at De Nadale l.4: we corrected as suggested: "More than 300 bone retouchers were obtained from cervid and bovid limb bones". l.5: we corrected as follows: "Neanderthal used ungulates' radii for making double retouchers" p.1 l.2: we believe that specifying the regional area is necessary and important, because Berici Hills, as well as the north-eastern region of Italy, are rich of archaeological evidence, and it would not be appropriate to classify it only as "Italy". l.20: we corrected as suggested. l.24: we corrected as suggested. l.26-27: we added more information and references within the text to support our conclusions. Such information concerns: the relationship between retouchers and retouched lithic tools, and how this relationship is relevant to human behaviour; more detailed information about the reduction sequences observed in the lithic assemblage of De Nadale Cave; how the retouched industry associated with retouching tools is frameable in the Quina techno-complex and, therefore, the role of bone retouchers in the definition of Neanderthal behaviour. See specific comments below, and general comments above, for more details. p.2 l.12: all the sites cited here include bone retouchers. As stated in the previous sentences, we are here talking about evidence of bone retouchers in Middle Palaeolithic contexts, specifically in northern Italy, the focus of this study. In order to clarify, we rephased as follows: "In the north of Italy, which is the focus region of this paper, Tagliente Shelter and Ghiacciaia Cave (Bertola et al., 1999; Thun et al., 2018), Rio Secco Cave (Peresani et al., 2014; Romandini et al., 2018), Fumane Cave (Jéquier et al., 2012, 2013, 2018; Martellotta et al. 2020) and San Bernardino Cave (Giacobini and Malerba, 1998) are among the most representative contexts whose assemblages

contain bone retouchers".
l.28: we corrected as suggested.

p.3
l.8: in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The most diagnostic evidence of this techno-complex is the high rates of retouched tools, mainly scrapers, and core-reduction aimed at the production of thick, wide and often asymmetric flakes. These show further reduction, part of the so-called "ramification cycle", having the double objective of tool-retouching and obtaining of small, usable flakes (Bourguignon, 1996, 1997; Turq, 2000). One of the consequences of this technical behaviour is the Quina retouch, that consists of the removal of scaled invasive flakes, from the dorsal face, using soft-hammer percussion with bone or antler (Bourguignon, 1997, 2001; Turq, 2000; Bourguignon et al., 2013)".
l.17: we corrected as suggested: "animal resource exploitation, both for food and technological purposes, […]".
l.16: we rephrased as follows: "In the definition of Quina complex, the exploitation of animal resources, for food and/or technological purposes, is strictly related to human mobility and subsistence strategies".
l.24-26: in the discussions, we compared De Nadale Cave with other Quina sites – such as Les Pradelles, Axlor, La Quina – through the analysis of bone retouchers. Moreover, we added new information in the discussions for underlining the relationship between bone retouchers and retouched lithic tools at De Nadale.
l.34: for 'technological perspective' we intend an analysis that goes beyond the typological description of the retouchers' morphology and stigmata, and that puts these features in relation with the human groups which used the retouchers themselves.

p.4
l.1: as suggested, we deleted the word "ordinary".
l.1-2: we do not agree with the reviewer's editing suggestion for this sentence, because it unnecessarily diminish the value of our study. Contrary to the reviewer's belief, we do believe that our work, integrated with some of the reviewers' recommendations, contributes to contextualise bone retouchers in the Middle Palaeolithic scenario.
l.9: we modified as suggested.

p.5
l.6: in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The reduction sequences include polyhedral and multi-faceted cores with secant surfaces, alternated cores (Bourguignon sensu) and the minor presence of centripetal schemes such as recurrent centripetal Levallois. Moreover, the predominance in the assemblage of retouched implements or retouch by-products is evident, proven by more than 300 among tools and retouch flakes. The retouched assemblage includes several scrapers with stepped-scaled invasive retouches, and it is therefore comparable to Quina assemblages in Italy and in south-western France (Bourguignon, 1997; Palma di Cesnola, 2001)". All this information has been achieved only recently after completion of the analysis of the lithic industry. Given that Davide Delpiano has provided these data, he has been integrated in the authorship of our paper.
l.21: we modified as follows: "Carnivores are rare: bear (Ursus spelaeus and Ursus sp.), wolf (Canis lupus), fox (Vulpes vulpes), and badger (Meles meles) have been identified, though none show human modification".
l.31: we corrected as suggested.

p.6
l.4-7: our sample includes not only the retouchers collected in Unit 7 (anthropic layer) but also the reworked sediments and the infill of the badger dens (units 6, 8, 12, 13, 14, 15, 16). We made this choice for having a greater sample of retouchers, without however losing any methodological consistency. Indeed, the conservation status of the bones coming from all the stratigraphic units is comparable with the osseous remains of unit 7, and this unit is the only anthropic layer identified in the site. In order to clarify, we rephrased as follows: "By including bone fragments collected in other units besides Unit 7, the number of analysable retouchers increases considerably, and despite their

stratigraphic unreliability, their attribution to a Mousterian assemblage is undeniable".
l.30: we corrected as suggested.

p.7
l.2: we replaced "sockets" with "notches".
l.12-15: we disagree with the reviewer's editing suggestion. We specified that data related to the weight are reported only for the sake of completeness. Indeed, this is the only part of the manuscript where these data are cited, and we do not use them in the Discussion/Conclusion sections.
l.28: we corrected the typing mistake.

p.8
l.8: although we agree with the reviewer in following the already existent nomenclatures, we think that 'superimposed' is a self-explanatory term that suggests an overlapping of concentrated areas. We do not intend to replace the existent nomenclature, but to shorten it for the sake of a more flowing reading.
l.31: The non-identified specimen listed as "carnivora" has a size comparable to a slightly small bear. The authors are aware that the bear is not a carnivore strictu sensu, but they decided to place the fragment in the "carnivora" category to have a better characterization of it.
l.33: the rows in Table 3 are arranged by species.

p.9
l.1: we corrected as suggested.
l.4-5: There are several fragmented epiphyses in the faunal sample, but this is the only one that could have been recognised without any doubt.
l.7: we deleted the sentence as suggested.
l.13: we added the information: "Several shafts bear slight weathering traces (36.6%), mostly referable to the Behrensmeyer stages 1 or 2,"
l.17: we corrected as suggested.
l.31: we corrected as suggested.

p.10
l.2: we corrected as suggested.
l.12: we corrected as suggested.
l.20: we corrected as suggested.
l.22: as suggested, we deleted this sentence.
l.22: we disagree with the suggestion of moving the paragraph up in the text. We think it is more consistent to describe the stigmata first, and then move to the analysis of the relationship between stigmata and skeletal elements.
l.22-23: it is well established that the single/double retouchers ratio is a relevant parameter to consider in the analysis of retouching tools. First, is part of an accurate description of the analysed sample. Furthermore, abundance/scarcity of double retouchers might be related to the availability of osseous raw material, to the retouch technique, to the ergonomic of the retoucher itself and, as we suggest in this paper, it could be indicative of a selection of more suitable morphologies for making retouchers. See our reply to the general comments for references in literature.

p.11
l.22-34: exploring correlations between the faunal spectrum and the species used as retouchers is a way to assess the exploitation strategies of animal raw materials. We do it for our assemblage, and then we compare such correlations with other Quina contexts. See the cited works of Daujeard et al. 2014 and Costamagno et al. 2018 (among others) for further discussions.

p.12
l.11: we corrected as suggested.
l.23: we deleted this sentence. See our reply to reviewer's general comments regarding references to future studies.
l.24: in order to avoid confusion, we modified as follows: "Focusing on the skeletal elements selected for retouching is important for several reasons".
l.26: we corrected as suggested.
l. 26-28: on the contrary, here we are suggesting that the use of some skeletal elements as retouchers should not be taken for granted. Although the representation of

	skeletal elements solely depends, apparently, on the butchering and bone exploitation processes, we indeed highlight in our assemblage a correlation between the morphology of the skeletal elements and double retouchers. We suggest the possibility of a selection of the most suitable bone blank as driven by technological purposes – not exclusively for double retouchers. We also state it in the manuscript (section 5) "although the selection of the animal species for manufacturing the retouchers seems to be driven by the availability of resources, a pattern is equally observed with regard to the selection of specific morphologies suitable for double retouchers, supporting the notion of technological control and predetermination". p.13 l.1-2: we deleted the last sentence. For more details, see comment above. p.13 l.3: we considered this possibility during the analysis, however in our assemblage double retouchers are actually slightly smaller than single retouchers – of about 3 cm on average. This might be related with the skeletal element: single retouchers are mostly made from tibias, whereas double retouchers are mostly made from radii; since tibias are longer than radii, it is assumable that single retouchers are longer than double retouchers due to different breakage patterns. However, this is in contrast with the reviewer's suggestion about double retouchers being related to longer bone fragments, and therefore we stand by our statement. l.20: in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The selection of specific morphologies for making retouchers assumes importance when considering the relevance of the retouch activity from a techno-economic perspective in Quina contexts". l. 26: these other works take into consideration only bone retouchers which are not interested by post-depositional fractures – and they could therefore fall in our definition of "complete retouchers". However, such definition has be considered carefully, as we state in the introduction: "Retouchers defined as complete were isolated. Such identification was carried out on the basis of the observation of the fresh bone fractures (Villa and Mahieu, 1991; Grunwald, 2016; Coil et al., 2017) and therefore observing the angle of the fracture, its general morphology, and the texture of the edge (smooth or rough). We are aware that the application of these parameters might lead to an underestimation of the sample of the complete retouchers, since it takes into consideration only tools obtained by bones fractured in a fresh state and excludes other ways of support procurement. We think that more focused studies on the microscopic features of fractures based on different states of freshness of the bone could be useful for a better definition of such a parameter. However, in this context it was needed to distinguish the complete retouchers in order to carry out a preliminary morphometric analysis, in which we observed the relationship among the length, width and thickness values of the tools looking for any morphometric pattern". l.32: we believe that thickness is a valuable parameter in the analysis of bone retouchers because it gives us more information about the relationship between the carcass processing and the potential selection of bone blanks for making retouchers. For a detail discussion of the topic, see Costamagno et al. 2018, and references therein. p.14 l.4: because it goes beyond the aims of this work. The study of the intimate relationship between the morphology of the bones and their use as retouchers – hence, an expression of conscious selection – deserves a more detailed and focused study, which involves more specific methodologies, such as 3D visual technology. However, we decided to delete this sentence, according to our statement in general comments regarding references on future studies, and we added more detailed information on the morphologies of the analysed bone retouchers by means of Figure 3. l.8-10: a study is ongoing for better investigate the fracture patterns of bone retouchers of De Nadale, and it will be accompanied by an experimental program. l.28-30: we integrated the text as follows: "the morphology of the stigmata varies in relation to the retouch intensity and the retouching angle, but experimental studies revealed an association between the physical properties of the lithic tool and the stigmata morphology (Mallye et al., 2012; Tartar, 2012)". l.34: we corrected as suggested.

p.15
l.2: at the time of the first submission of the manuscript, there were no relevant data regarding the lithic industry. Even though the study is still ongoing, we added the following information: “In De Nadale cave, more than 250 retouched tools have been recovered so far, equal to 21.6% of the whole lithic assemblage. Among these, more than half are represented by scrapers and limaces characterized by supra-elevated, scaled removals on one or several edges. If we suppose that one single retoucher was used every time a tool was manufactured or resharpened, the extremely high amount of bone retouchers (and their use intensity) can be explained with the curation of such lithic tools, requiring several retouch phases. Moreover, we can assert that the human group that occupied De Nadale cave used exogenous raw materials and, again, extremely reduced lithic blanks. More tools could have been produced, then exported and used in kill-butchering sites or other sites. All this information has been achieved only recently after completion of the analysis of the lithic industry. Given that Davide Delpiano has provided these data, he has been integrated in the authorship of our paper.
l.12: we corrected as suggested.
l.20: we sustain this hypothesis as well, but it is worth pointing out references regarding other theories.

p.16
l.12-14: as we stated in the comments above, we do not believe length plays an important role in the analysis of double retouchers as morphology does. We never stated that the longest fragments available were selected; this was a reviewer’s supposition, and we ask to refer to the comments above for a reply regarding the difference in length between single and double retouchers. If we suppose that there is a selection – of the most morphologically suitable bone blanks, not the longest – intentionality is a possibility that should not be excluded. See Figure 3 for more details. Finally, regarding the relevance of double retouchers, see comments above.
l.18: we corrected as suggested.
l.19 in order to address the reviewer’s concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: “The Quina débitage results in wide and thick flakes, and most of them are retouched into scrapers. These features are shared by De Nadale lithic assemblage, even if the over-exploitation of cores and tools results in small and reduced blanks”.
l.21: in order to address the reviewer’s concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: “The features of the Quina flakes facilitate their re-sharpening, by means of several sequences of retouch with steps in the modification of the morphology and the delineation of the edges. At the same time, the flakes could be subjected to recycling, obtaining smaller products, in accordance to a behaviour known as "Quina ramification cycle" (Bourguignon et al., 2006). Even though not all the flakes produced by the Quina method are retouched, the retouch activity surely plays a key-role in this lithic techno-complex. Moreover, a high presence of lips has been observed, which could suggest the use of bone retouchers as soft hammer, rather than retouchers per se. That should be confirmed by the numerous and intensively used bone retouchers found in association with Quina industries. These modalities of exploitation of both lithic and animal raw material could be linked to high mobility and specific subsistence strategies”. We updated the reference list accordingly.

p.17
l.2: we deleted the references to future studies - see our reply to general comments above. Instead, we added in the previous sentences information for underlining the role of bone retouchers in the definition of human behaviour in the context of Quina techo-complex (see comment above).

p.30
l.3: we corrected as suggested.

p.31
l.12: we corrected as suggested.

l.15: we corrected as suggested.
l.21: we corrected as suggested.
l.22: we corrected as suggested.
l.28: we corrected as suggested.
l.30-31: we corrected as suggested.
l.32: we corrected as suggested.

p.32
l.3: we corrected as suggested.
l.12: we corrected as suggested.
l.15: we corrected as suggested.
l. 17: we corrected as suggested.

Figures
Fig.2: the number of retouchers for each taxon are already reported in Table 3.
(ex) Fig. 4: we deleted the figure as suggested.
(ex) Fig. 5: we deleted the figure as suggested.
Fig. 9 (now Fig. 8): we decided to keep this plot as it is, because we think it is necessary to show the variance of these data, rather than giving simple percentages.
Fig. 11 (now Fig. 10): we believe that some data should be presented through visualisation as well, even if the percentages are already present in the text. We think that this will optimize the communication of our output, and for this reason, we decided to not to delete this figure.
Fig. 12 (now Fig. 11): a table is a good suggestion, but it will make the article unnecessarily heavy to read, as it will be a table of more than 300 rows. However, we decided to supply this information in the Supplementary Materials (SM1).
Fig. 13 (now Fig. 12): see comment for figure 11 (now figure 10).

Reviewer #2: In their manuscript entitled "Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy).", Martellotta et al. give a detailed analysis of the whole series of bone retouchers coming from the Middle Palaeolithic site of De Nadale cave in Italy.

First of all, I would like to underline that I provided a previous review on this manuscript for another journal (Palevol) in 2019. For that reason, my apologies if certain of my remarks below and on the manuscript are similar with that first review. I would also like to precise that the journal never sent me the response of the authors to my comments. Anyway, I could see that, in general, the authors have followed my main previous remarks. However, some points remain to be clarified. Most of them have been notified on the PDF, and some few others will be listed below.
The reviewer should know that we decided to withdraw the manuscript from the journal Comptes Rendu Paevol because of severe delays in the publication of the revised and accepted manuscript. We are grateful to the reviewer for their comments, in both versions of the manuscript, and we would like them to know that we did indeed produced a rebuttal letter in the reviewing process for Palevol, which was addressing every comment, and openly stating that such comments contributed to ameliorate the original manuscript.
About the previous studies of the bone retouchers of De Nadale cave, authors did not give enough precision here. Indeed, many of the bone retouchers (n=204) have already been the subject of articles published by Jéquier et al. (2015, 2018) and thus some explanations are needed to clarify the part of the studied material presented here, and the different methodological approaches used in the two studies. Those clarifications are required for publication.
All the bone retouchers studied by C. Jéquier and belonging to the sample here analysed, have already been published in different contributions, which have been explicitly cited within the manuscript (Jéquier et al., 2015, 2018). Nonetheless, a very large part of the sample here analysed is composed by unpublished retouchers (NR=131). In addition, we inserted a new figure (Fig. 3) containing more detailed information regarding the morphology of the bone blanks used as retouchers.
Moreover, the present work has different aims than the two papers from Jéquier et al., and we explain it in the Introduction: “In this small cavity, large numbers of retouchers have been found, some of which have already been presented in preliminary publications (Jéquier et al., 2015, 2018). Recent excavations at De Nadale Cave

extended to almost the entire deposits yielding more than one hundred new retouchers made of giant deer, red deer, and bovid bones. Here we present the complete assemblage of retouchers recovered until the last field campaign conducted in 2017. They are analysed from a morphological and a technological perspective. The aim is to provide a complete description of their techno-morphological features in order to contribute to their contextualisation in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data".
In the state of art, and somewhere else in the manuscript, authors give too much emphasis on Quina sites, ignoring the numerous sites with bone retouchers associated to different lithic technology. They may be more cautious about it.
We decided to emphasize the Quina sites rather than the others because the aim of this paper is to give a contribution about the use of bone retouchers and exploitation of animal resources in Quina contexts.
In the results, the Figure 1 may classify differently the ungulates, divided them into the different size-classes defined in the Methods.
About Fig. 1 (now Fig. 2): we decided to maintain the figure as it is, adding in the caption that the computations have been made based on the NR of bone retouchers. We also refer to table 3 for a more detailed illustration of the sample divided into species and size-classes.

R. 2: Please, refer to the PDF to see the other recommendations to the authors.

p.3
l.1-2: our intention here is to specify that, from this point on, the term "retoucher" in our text always stands for "bone retoucher". We did it in order to avoid confusion with tools made from inorganic raw materials.
l.19-23: we deleted any references to retouchers coming from non-Quina contexts in the manuscript. As suggested, we added the reference to Daujeard et al., 2018.

p.6
l.1-2: we replaced the term "selected" with "collected".
l.2-4: De Nadale Cave presents a single anthropogenic layer (Unit 7). Other units don't show an anthropic origin, even if few archaeological remains were yielded by them. These remains (mostly coming from Units 6 and 8), that constitute an extremely ephemeral evidence, show the same features of those from Unit 7 and they have been recognized as dispersed material from Unit 7 itself.
l.8: as we stated above, the aims of the present work are different from the papers from Jéquier et al. Indeed, for this work, we re-analysed the whole set of retouchers, and we focused on some issues which were not considered in the works from Jéquier et al. These include but are not limited to: (1) a wider consideration of the relationship between the retouchers' morphology and the stigmata, (2) our suggestion that specific skeletal elements (i.e., radius) were selected for making double retouchers, (3) the comparison between the species whose bones are used as retouchers and the NISP relative to the sites' faunal spectrum, (4) a reviewed proportion between the amount of linear and punctiform impressions, (5) a comparison with other Quina sites, and finally, because of the reviewers' comments, (6) more precise information regarding the sizes of use areas and the thickness of the compact bone in correspondence of the use areas. We accepted the suggestion of specifying the number of retouchers already studied by Jéquier et al.; however, we decided to add this information in the introduction rather than in Materials and Methods, because these 204 retouchers have been re-analysed in the present work, in order to address a greater number of issues (see general comments).
l.8: De Nadale Cave presents a single anthropogenic layer (Unit 7). See comment above.
l.31: We accepted the suggestion.

p.7
l.1: we accepted the suggestion
l.33: we think that adding different synonymises for the description of the marks could only be confusing. It has been already established, in the literature, that there is more than one nomenclature for stigmata, but no significant differences can be envisaged among them. In our opinion, the morphological description of stigmata should be as

	simple as possible to avoid confusion and repetitions. Therefore, we maintain the nomenclature specifying that we followed Mallye et al. (2012) and Mozota Holgueras (2012), adding however the following specification: "The analysis of the technological stigmata on the surface of the retouchers was carried out following Mallye et al. (2012) and Mozota Holgueras (2012), although more nomenclatures are present in literature (e.g., Daujeard et al., 2014, 2018). p.8 l.28: We agree with the Reviewer. The use of a carnivore's bone as a retouchers is rare in the Palaeolithic context and, unfortunately, the fragment is not taxonomically identifiable at a specific level. The idea of making a protein analysis in the future is absolutely to take into consideration for further studies. p.9 l.7: we deleted the sentence as suggested. l.15: there are 33 retouchers bearing carnivores' toot-marks, which correspond to 9.8% of the analysed bone tools. In the study of the total faunal assemblage, the percentage of carnivores' marks is lower; for this reason, we think that this datum does not enrich the study of bone retouchers, and for this reason we did not analysed it more in depth. l.19: we correct "percussion cones" into "impact flakes", following the common terminology (Vettese et al., 2017, 2020). l.19: as suggested, we deleted the reference to the differentiation between combustion and calcination p.10 l.1: we have 335 retouchers in total. Of these, 287 are single retouchers (= 287 areas), 46 are double retouchers (=92 areas) and 2 are triple retouchers (=6 areas). Therefore: 287+92+6=385. In order to clarify, we rephrased as follows: "Of the 335 analysed tools, 46 (14%) were used as double retouchers, and two as triple retouchers; therefore, a total of 385 use areas has been identified". l.4: we accepted the suggestion of adding a table containing more specific data about the sizes of the use areas. However, a table of 385 rows is not suitable for a paper, therefore we added it in supplementary materials (SM1); this table contains also specific data about thickness.

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Ferrara li, 01/02/2021

Dr. Chris O. Hunt
Editor, *Journal of Archaeological Science: Reports*

Ref.: Submission for review of the revised manuscript "Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy)".

Dear Dr Hunt,

This letter is aimed at the submission of the aforementioned manuscript to Journal of Archaeological Science Reports.

Our revised version includes the manuscript with almost all accepted advices raised by the reviewers, 4 tables and 14 figures. We replaced some figures but added other ones containing pictures of a selection of lithic artefacts.

I remain available for providing further details.

Sincerely,
Prof. Marco Peresani

Manuscript Number: JASREP-D-20-00693

Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy)

Rebuttal list

Dear Editor,

We reworked and modified our manuscript in accordance with the reviewers' comments. We agree with most of their remarks, and we thoroughly revised the text and the figures, with a major effort to improving the discussion and conclusion sections. Appended below is our point-to-point rebuttal list.

Editor: Reviewer #1 seems to be asking you to do a great deal more work. This isn't appropriate, but perhaps you could address some of these points through literature comparisons?

Reviewer #1: This article by Martellotta et al. describes in detail 335 bone retouchers from the Mousterian Quina site of De Nadale Cave. I commend the authors for their diligent study of these artifacts. Their work build on the previous analysis of 204 bone retouchers from De Nadale reported by Jéquier et al. in 2018. Unfortunately, the authors fail to provide little new information apart from additional measurements and stigmata counts on the De Nadale retouchers. Furthermore, this work does little to advance "our understanding of Neanderthal cultural and economic choices in the Quina complex of Europe" as claimed in the abstract, other than increasing the sample size of bone retouchers attributed to Quina Neanderthals. Repeatedly throughout the manuscript the authors provide suggestions for future work to describe the pattern shown in the De Nadale and other Quina assemblages, yet they make no attempt to undertake this work. Perhaps this work is being conducted as part of a broader study of the De Nadale retoucher assemblage, but the authors should make a better attempt in their discussion of these artifacts, beyond recommendations for future work. Because the authors have a rough outline of the work that still needs to be done, I recommend the article be accepted with major revisions. These major revisions must include some of their own recommendations for further investigations. These additional efforts should seek to address the specific uses of retouchers as a constituent of Quina technology, whether retoucher use is consistent across Quina sites (important because De Nadale is the sole Quina site in Italy), and how retouchers at Quina sites are different or the same as retouchers from other sites in Italy. These are just a few directions that the authors could take to expand on the importance of bone retouchers to Quina technology. At the very least, the authors must describe how their study builds on the previous work of Jéquier et al. and how their study improves our knowledge of bone retouchers at De Nadale, beyond just increasing the sample size. Without these additional details, this article merely adds 335 additional bone retouchers to the thousands and thousands of bone retouchers already known throughout Europe.

All the bone retouchers studied by C. Jéquier and belonging to the sample here analysed, have already been published albeit at preliminar level, in different contributions, which have been explicitly cited within the manuscript (Jéquier et al., 2015, 2018). Nonetheless, a very large part of the sample here analysed is composed by unpublished retouchers (NR=131). Moreover, the present work has different aims than the two papers from Jéquier et al., as we explain in the Introduction: "In this small cavity, large numbers of retouchers have been found, some of which have already been presented in preliminary publications (Jéquier et al., 2015, 2018). Recent excavations at De Nadale Cave extended to almost the entire deposits yielding more than one hundred new retouchers made of giant deer, red deer, and bovid bones. Here we present the complete assemblage of retouchers recovered until the last field campaign conducted in 2017. They are analysed from a morphological and a technological perspective. The aim is to provide a complete description of their techno-morphological features in order to contribute to their contextualisation in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data". Indeed, for this work, we re-analysed the whole set of retouchers, and we focused on some issues which were not considered in the works from Jéquier et al: (1) a wider consideration of the relationship between the retouchers' morphology and the stigmata, (2) our suggestion that specific skeletal elements (i.e., radius) were selected for making double retouchers, (3) the comparison between the species whose bones are used as retouchers and the NISP relative to the sites' faunal spectrum, (4) a reviewed proportion between the amount of linear and punctiform impressions, (5) a comparison with other Quina sites, and finally, because of the reviewers' comments, (6) more precise information regarding the sizes of use areas and the thickness of the compact bone in correspondence of the use areas.

Regarding the recurrent references to future studies, our intention was to highlight the diversity of possible analysis applicable to this sample. However, we do agree with the reviewer when they notice this redundancy and therefore, we deleted most of them within the manuscript. As the analysis of bone retouchers is indeed part of a broader on-going study of the human groups living at De Nadale Cave, we have now more information available compared to the time of our first submission – over one year ago. We added this information in different parts of the text (see comments below). Moreover, we added three new figures (Fig.3, Fig. 13 and Fig. 14) and a table in Supplementary Materials (SM1) for supporting this new additional information.

Regarding the suggestion of comparing retouchers' features with other sites in Italy – as we wrote in the introduction, this work strives to analyse the whole assemblage of retouchers from De Nadale Cave, and to contextualise this assemblage "in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina

Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data".

Finally, we believe that adding "335 additional bone retouchers to the thousands and thousands of bone retouchers already known throughout Europe" still deserves relevance, especially when considering that 131 of them lasted unpublished. These numbers are consistent with the general trend of samples published in the field of bone retouchers. Furthermore, the role that these tools play in the understanding of human evolution and behaviour is becoming more and more established in the field. We suggest referring to some of the most valuable contributions in the study of bone retouchers, for example the volume on retouching of Hutson et al. 2018, the work of Daujeard et al. 2014, the more recent contributions of Alonso-Garcia et al. 2020, Martellotta et al., 2020 and Turner et al. 2020, and references therein. These papers, and many others, suggest and demonstrate that the study of bone retouchers is linked to different strategies in the exploitation of animal raw material, to the relationship between food waste and tool making, to a broader concept of "retouch", which goes beyond the study of retouched lithic tools by including the tools actually used for retouching. Nevertheless, in order to enrich the discussion about our case study, we added more information within the manuscript regarding the relationship between bone retouchers and retouched lithic tools at De Nadale Cave – even though the detailed study of our site's lithic industry is still ongoing.

Highlights

l.1-3: We modified as follows:

- Retouching is a widely shared behaviour among Middle Palaeolithic humans
- De Nadale Cave was occupied only by Quina Neanderthals in Italy
- More than 300 bone retouchers were obtained from cervid and bovid limb bones
- Double retouchers were made using ungulates' radii
- Intense retouching activity relates to the lithic tool kits at De Nadale

l.4: we corrected as suggested: "More than 300 bone retouchers were obtained from cervid and bovid limb bones".

l.5: we corrected as follows: "Neanderthal used ungulates' radii for making double retouchers"

p.1

l.2: we believe that specifying the regional area is necessary and important, because Berici Hills, as well as the north-eastern region of Italy, are rich of archaeological evidence, and it would not be appropriate to classify it only as "Italy".

l.20: we corrected as suggested.

l.24: we corrected as suggested.

l.26-27: we added more information and references within the text to support our conclusions. Such information concerns: the relationship between retouchers and retouched lithic tools, and how this relationship is relevant to human behaviour; more detailed information about the reduction sequences observed in the lithic assemblage of De Nadale Cave; how the retouched industry associated with retouching tools is frameable in the Quina techno-complex and, therefore, the role of bone retouchers in the definition of Neanderthal behaviour. See specific comments below, and general comments above, for more details.

p.2

l.12: all the sites cited here include bone retouchers. As stated in the previous sentences, we are here talking about evidence of bone retouchers in Middle Palaeolithic contexts, specifically in northern Italy, the focus of this study. In order to clarify, we rephased as follows: “In the north of Italy, which is the focus region of this paper, Tagliente Shelter and Ghiacciaia Cave (Bertola et al., 1999; Thun et al., 2018), Rio Secco Cave (Peresani et al., 2014; Romandini et al., 2018), Fumane Cave (Jéquier et al., 2012, 2013, 2018; Martellotta et al. 2020) and San Bernardino Cave (Giacobini and Malerba, 1998) are among the most representative contexts whose assemblages contain bone retouchers”.

l.28: we corrected as suggested.

p.3

l.8: in order to address the reviewer’s concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: “The most diagnostic evidence of this techno-complex is the high rates of retouched tools, mainly scrapers, and core-reduction aimed at the production of thick, wide and often asymmetric flakes. These show further reduction, part of the so-called "ramification cycle", having the double objective of tool-retouching and obtaining of small, usable flakes (Bourguignon, 1996, 1997; Turq, 2000). One of the consequences of this technical behaviour is the Quina retouch, that consists of the removal of scaled invasive flakes, from the dorsal face, using soft-hammer percussion with bone or antler (Bourguignon, 1997, 2001; Turq, 2000; Bourguignon et al., 2013)”.

l.17: we corrected as suggested: “animal resource exploitation, both for food and technological purposes, […]”.

l.16: we rephrased as follows: “In the definition of Quina complex, the exploitation of animal resources, for food and/or technological purposes, is strictly related to human mobility and subsistence strategies”.

l.24-26: in the discussions, we compared De Nadale Cave with other Quina sites – such as Les Pradelles, Axlor, La Quina – through the analysis of bone retouchers.

Moreover, we added new information in the discussions for underlining the relationship between bone retouchers and retouched lithic tools at De Nadale.

l.34: for 'technological perspective' we intend an analysis that goes beyond the typological description of the retouchers' morphology and stigmata, and that puts these features in relation with the human groups which used the retouchers themselves.

p.4

l.1: as suggested, we deleted the word "ordinary".

l.1-2: we do not agree with the reviewer's editing suggestion for this sentence, because it unnecessarily diminish the value of our study. Contrary to the reviewer's belief, we do believe that our work, integrated with some of the reviewers' recommendations, contributes to contextualise bone retouchers in the Middle Palaeolithic scenario.

l.9: we modified as suggested.

p.5

l.6: in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The reduction sequences include polyhedral and multi-faceted cores with secant surfaces, alternated cores (Bourguignon *sensu*) and the minor presence of centripetal schemes such as recurrent centripetal Levallois. Moreover, the predominance in the assemblage of retouched implements or retouch by-products is evident, proven by more than 300 among tools and retouch flakes. The retouched assemblage includes several scrapers with stepped-scaled invasive retouches, and it is therefore comparable to Quina assemblages in Italy and in south-western France (Bourguignon, 1997; Palma di Cesnola, 2001)". All this information has been achieved only recently after completion of the analysis of the lithic industry. Given that Davide Delpiano has provided these data, he has been integrated in the authorship of our paper.

l.21: we modified as follows: "Carnivores are rare: bear (*Ursus spelaeus* and *Ursus* sp.), wolf (*Canis lupus*), fox (*Vulpes vulpes*), and badger (*Meles meles*) have been identified, though none show human modification".

l.31: we corrected as suggested.

p.6

l.4-7: our sample includes not only the retouchers collected in Unit 7 (anthropic layer) but also the reworked sediments and the infill of the badger dens (units 6, 8, 12, 13, 14, 15, 16). We made this choice for having a greater sample of retouchers, without however losing any methodological consistency. Indeed, the conservation status of the bones coming from all the stratigraphic units is comparable with the osseous remains of unit 7, and this unit is the only anthropic layer identified in the site. In order to clarify, we rephrased as follows: “By including bone fragments collected in other units besides Unit 7, the number of analysable retouchers increases considerably, and despite their stratigraphic unreliability, their attribution to a Mousterian assemblage is undeniable”.

l.30: we corrected as suggested.

p.7

l.2: we replaced “sockets” with “notches”.

l.12-15: we disagree with the reviewer’s editing suggestion. We specified that data related to the weight are reported only for the sake of completeness. Indeed, this is the only part of the manuscript where these data are cited, and we do not use them in the Discussion/Conclusion sections.

l.28: we corrected the typing mistake.

p.8

l.8: although we agree with the reviewer in following the already existent nomenclatures, we think that ‘superimposed’ is a self-explanatory term that suggests an overlapping of concentrated areas. We do not intend to replace the existent nomenclature, but to shorten it for the sake of a more flowing reading.

l.31: The non-identified specimen listed as “carnivora” has a size comparable to a slightly small bear. The authors are aware that the bear is not a carnivore *strictu sensu*, but they decided to place the fragment in the “carnivora” category to have a better characterization of it.

l.33: the rows in Table 3 are arranged by species.

p.9

l.1: we corrected as suggested.

l.4-5: There are several fragmented epiphyses in the faunal sample, but this is the only one that could have been recognised without any doubt.

l.7: we deleted the sentence as suggested.

l.13: we added the information: “Several shafts bear slight weathering traces (36.6%), mostly referable to the Behrensmeyer stages 1 or 2,”

l.17: we corrected as suggested.

l.31: we corrected as suggested.

p.10

l.2: we corrected as suggested.

l.12: we corrected as suggested.

l.20: we corrected as suggested.

l.22: as suggested, we deleted this sentence.

l.22: we disagree with the suggestion of moving the paragraph up in the text. We think it is more consistent to describe the stigmata first, and then move to the analysis of the relationship between stigmata and skeletal elements.

l.22-23: it is well established that the single/double retouchers ratio is a relevant parameter to consider in the analysis of retouching tools. First, is part of an accurate description of the analysed sample. Furthermore, abundance/scarcity of double retouchers might be related to the availability of osseous raw material, to the retouch technique, to the ergonomic of the retoucher itself and, as we suggest in this paper, it could be indicative of a selection of more suitable morphologies for making retouchers. See our reply to the general comments for references in literature.

p.11

l.22-34: exploring correlations between the faunal spectrum and the species used as retouchers is a way to assess the exploitation strategies of animal raw materials. We do it for our assemblage, and then we compare such correlations with other Quina contexts. See the cited works of Daujeard et al. 2014 and Costamagno et al. 2018 (among others) for further discussions.

p.12

l.11: we corrected as suggested.

l.23: we deleted this sentence. See our reply to reviewer's general comments regarding references to future studies.

l.24: in order to avoid confusion, we modified as follows: "Focusing on the skeletal elements selected for retouching is important for several reasons".

l.26: we corrected as suggested.

l. 26-28: on the contrary, here we are suggesting that the use of some skeletal elements as retouchers should not be taken for granted. Although the representation of skeletal elements solely depends, *apparently*, on the butchering and bone exploitation processes, we indeed highlight in our assemblage a correlation between the morphology of the skeletal elements and double retouchers. We suggest the possibility of a selection of the most suitable bone blank as driven by technological purposes – not exclusively for double retouchers. We also state it in the manuscript (section 5) “although the selection of the animal species for manufacturing the retouchers seems to be driven by the availability of resources, a pattern is equally observed with regard to the selection of specific morphologies suitable for double retouchers, supporting the notion of technological control and predetermination”.

p.13

l.1-2: we deleted the last sentence. For more details, see comment above.

p.13

l.3: we considered this possibility during the analysis, however in our assemblage double retouchers are actually slightly smaller than single retouchers – of about 3 cm on average. This might be related with the skeletal element: single retouchers are mostly made from tibias, whereas double retouchers are mostly made from radii; since tibias are longer than radii, it is assumable that *single* retouchers are longer than *double* retouchers due to different breakage patterns. However, this is in contrast with the reviewer’s suggestion about double retouchers being related to longer bone fragments, and therefore we stand by our statement.

l.20: in order to address the reviewer’s concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: “The selection of specific morphologies for making retouchers assumes importance when considering the relevance of the retouch activity from a techno-economic perspective in Quina contexts”.

l. 26: these other works take into consideration only bone retouchers which are not interested by post-depositional fractures – and they could therefore fall in our definition of “complete retouchers”. However, such definition has be considered carefully, as we state in the introduction: “Retouchers defined as complete were isolated. Such identification was carried out on the basis of the observation of the fresh bone fractures (Villa and Mahieu, 1991; Grunwald, 2016; Coil et al., 2017) and therefore observing the angle of the fracture, its general morphology, and the texture of the edge (smooth or rough). We are aware that the application of these parameters might lead to an underestimation of the sample of the complete retouchers, since it takes into consideration only tools obtained by bones fractured in a fresh state and excludes other ways of support procurement. We think that more focused studies on the microscopic features of fractures based on different states of freshness of the bone could be useful for a better definition of such a parameter. However, in this context it was needed to distinguish the complete retouchers in order to carry out a preliminary morphometric analysis, in which we observed the relationship among the length, width and thickness values of the tools looking for any morphometric pattern”.

l.32: we believe that thickness is a valuable parameter in the analysis of bone retouchers because it gives us more information about the relationship between the carcass processing and the potential selection of bone blanks for making retouchers.

For a detail discussion of the topic, see Costamagno et al. 2018, and references therein.

p.14

l.4: because it goes beyond the aims of this work. The study of the intimate relationship between the morphology of the bones and their use as retouchers – hence, an expression of conscious selection – deserves a more detailed and focused study, which involves more specific methodologies, such as 3D visual technology. However, we decided to delete this sentence, according to our statement in general comments regarding references on future studies, and we added more detailed information on the morphologies of the analysed bone retouchers by means of Figure 3.

l.8-10: a study is ongoing for better investigate the fracture patterns of bone retouchers of De Nadale, and it will be accompanied by an experimental program.

l.28-30: we integrated the text as follows: "the morphology of the stigmata varies in relation to the retouch intensity and the retouching angle, but experimental studies revealed an association between the physical properties of the lithic tool and the stigmata morphology (Mallye et al., 2012; Tartar, 2012)".

l.34: we corrected as suggested.

p.15

l.2: at the time of the first submission of the manuscript, there were no relevant data regarding the lithic industry. Even though the study is still ongoing, we added the following information: "In De Nadale cave, more than 250 retouched tools have been recovered so far, equal to 21.6% of the whole lithic assemblage. Among these, more than half are represented by scrapers and limaces characterized by supra-elevated, scaled removals on one or several edges. If we suppose that one single retoucher was used every time a tool was manufactured or resharpened, the extremely high amount of bone retouchers (and their use intensity) can be explained with the curation of such lithic tools, requiring several retouch phases. Moreover, we can assert that the human group that occupied De Nadale cave used exogenous raw materials and, again, extremely reduced lithic blanks. More tools could have been produced, then exported and used in kill-butchering sites or other sites. All this information has been achieved only recently after completion of the analysis of the lithic industry. Given that Davide Delpiano has provided these data, he has been integrated in the authorship of our paper.

l.12: we corrected as suggested.

l.20: we sustain this hypothesis as well, but it is worth pointing out references regarding other theories.

p.16

l.12-14: as we stated in the comments above, we do not believe length plays an important role in the analysis of double retouchers as morphology does. We never stated that the longest fragments available were selected; this was a reviewer's supposition, and we ask to refer to the comments above for a reply regarding the difference in length between single and double retouchers. If we suppose that there is a selection – of the most morphologically suitable bone blanks, *not* the longest – intentionality is a possibility that should not be excluded. See Figure 3 for more details. Finally, regarding the relevance of double retouchers, see comments above.

l.18: we corrected as suggested.

l.19 in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The Quina débitage results in wide and thick flakes, and most of them are retouched into scrapers. These features are shared by De Nadale lithic assemblage, even if the over-exploitation of cores and tools results in small and reduced blanks".

l.21: in order to address the reviewer's concerns regarding the relevance of bone retouchers in the study of human behaviour associated with the Quina techno-complex, we integrated our text as follows: "The features of the Quina flakes facilitate their re-sharpening, by means of several sequences of retouch with steps in the modification of the morphology and the delineation of the edges. At the same time, the flakes could be subjected to recycling, obtaining smaller products, in accordance to a behaviour known as "Quina ramification cycle" (Bourguignon et al., 2006). Even though not all the flakes produced by the Quina method are retouched, the retouch activity surely plays a key-role in this lithic techno-complex. Moreover, a high presence of lips has been observed, which could suggest the use of bone retouchers as soft hammer, rather than retouchers *per se*. That should be confirmed by the numerous and intensively used bone retouchers found in association with Quina industries. These modalities of exploitation of both lithic and animal raw material could be linked to high mobility and specific subsistence strategies". We updated the reference list accordingly.

p.17

l.2: we deleted the references to future studies - see our reply to general comments above. Instead, we added in the previous sentences information for underlining the role of bone retouchers in the definition of human behaviour in the context of Quina techo-complex (see comment above).

p.30

l.3: we corrected as suggested.

p.31

l.12: we corrected as suggested.

l.15: we corrected as suggested.

l.21: we corrected as suggested.

l.22: we corrected as suggested.

l.28: we corrected as suggested.

l.30-31: we corrected as suggested.

l.32: we corrected as suggested.

p.32

l.3: we corrected as suggested.

l.12: we corrected as suggested.

l.15: we corrected as suggested.

l. 17: we corrected as suggested.

Figures

Fig.2: the number of retouchers for each taxon are already reported in Table 3.

(ex) Fig. 4: we deleted the figure as suggested.

(ex) Fig. 5: we deleted the figure as suggested.

Fig. 9 (now Fig. 8): we decided to keep this plot as it is, because we think it is necessary to show the variance of these data, rather than giving simple percentages.

Fig. 11 (now Fig. 10): we believe that some data should be presented through visualisation as well, even if the percentages are already present in the text. We think that this will optimize the communication of our output, and for this reason, we decided to not to delete this figure.

Fig. 12 (now Fig. 11): a table is a good suggestion, but it will make the article unnecessarily heavy to read, as it will be a table of more than 300 rows. However, we decided to supply this information in the Supplementary Materials (SM1).

Fig. 13 (now Fig. 12): see comment for figure 11 (now figure 10).

Reviewer #2: In their manuscript entitled "Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy).", Martellotta et al. give a detailed analysis of the whole series of bone retouchers coming from the Middle Palaeolithic site of De Nadale cave in Italy.

First of all, I would like to underline that I provided a previous review on this manuscript for another journal (Palevol) in 2019. For that reason, my apologies if certain of my remarks below and on the manuscript are similar with that first review. I would also like to precise that the journal never sent me the response of the authors to my comments. Anyway, I could see that, in general, the authors have followed my main previous remarks. However, some points remain to be clarified. Most of them have been notified on the PDF, and some few others will be listed below.

The reviewer should know that we decided to withdraw the manuscript from the journal *Comptes Rendu Paevol* because of severe delays in the publication of the revised and accepted manuscript. We are grateful to the reviewer for their comments, in both versions of the manuscript, and we would like them to know that we did indeed produced a rebuttal letter in the reviewing process for *Palevol*, which was addressing every comment, and openly stating that such comments contributed to ameliorate the original manuscript.

About the previous studies of the bone retouchers of De Nadale cave, authors did not give enough precision here. Indeed, many of the bone retouchers (n=204) have already been the subject of articles published by Jéquier et al. (2015, 2018) and thus some explanations are needed to clarify the part of the studied material presented here, and the different methodological approaches used in the two studies. Those clarifications are required for publication.

All the bone retouchers studied by C. Jéquier and belonging to the sample here analysed, have already been published in different contributions, which have been explicitly cited within the manuscript (Jéquier et al., 2015, 2018). Nonetheless, a very large part of the sample here analysed is composed by unpublished retouchers (NR=131). In addition, we inserted a new figure (Fig. 3) containing more detailed information regarding the morphology of the bone blanks used as retouchers. Moreover, the present work has different aims than the two papers from Jéquier et al., and we explain it in the Introduction: “In this small cavity, large numbers of retouchers have been found, some of which have already been presented in preliminary publications (Jéquier et al., 2015, 2018). Recent excavations at De Nadale Cave extended to almost the entire deposits yielding more than one hundred new retouchers made of giant deer, red deer, and bovid bones. Here we present the complete assemblage of retouchers recovered until the last field campaign conducted in 2017. They are analysed from a morphological and a technological perspective. The aim is to provide a complete description of their techno-morphological features in order to contribute to their contextualisation in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe, taking into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data”.

In the state of art, and somewhere else in the manuscript, authors give too much emphasis on Quina sites, ignoring the numerous sites with bone retouchers associated to different lithic technology. They may be more cautious about it.

We decided to emphasize the Quina sites rather than the others because the aim of this paper is to give a contribution about the use of bone retouchers and exploitation of animal resources in Quina contexts.

In the results, the Figure 1 may classify differently the ungulates, divided them into the different size-classes defined in the Methods.

About Fig. 1 (now Fig. 2): we decided to maintain the figure as it is, adding in the caption that the computations have been made based on the NR of bone retouchers. We also refer to table 3 for a more detailed illustration of the sample divided into species and size-classes.

R. 2: Please, refer to the PDF to see the other recommendations to the authors.

p.3

l.1-2: our intention here is to specify that, from this point on, the term “retoucher” in our text always stands for “bone retoucher”. We did it in order to avoid confusion with tools made from inorganic raw materials.

l.19-23: we deleted any references to retouchers coming from non-Quina contexts in the manuscript. As suggested, we added the reference to Daujeard et al., 2018.

p.6

l.1-2: we replaced the term “selected” with “collected”.

l.2-4: De Nadale Cave presents a single anthropogenic layer (Unit 7). Other units don’t show an anthropic origin, even if few archaeological remains were yielded by them. These remains (mostly coming from Units 6 and 8), that constitute an extremely ephemeral evidence, show the same features of those from Unit 7 and they have been recognized as dispersed material from Unit 7 itself.

l.8: as we stated above, the aims of the present work are different from the papers from Jéquier et al. Indeed, for this work, we re-analysed the whole set of retouchers, and we focused on some issues which were not considered in the works from Jéquier et al. These include but are not limited to: (1) a wider consideration of the relationship between the retouchers’ morphology and the stigmata, (2) our suggestion that specific skeletal elements (i.e., radius) were selected for making double retouchers, (3) the comparison between the species whose bones are used as retouchers and the NISP relative to the sites’ faunal spectrum, (4) a reviewed proportion between the amount of linear and punctiform impressions, (5) a comparison with other Quina sites, and finally, because of the reviewers’ comments, (6) more precise information regarding the sizes of use areas and the thickness of the compact bone in correspondence of the use areas. We accepted the suggestion of specifying the number of retouchers already studied by Jéquier et al.; however, we decided to add this information in the introduction rather than in Materials and Methods, because these 204 retouchers have been re-analysed in the present work, in order to address a greater number of issues (see general comments).

l.8: De Nadale Cave presents a single anthropogenic layer (Unit 7). See comment above.

l.31: We accepted the suggestion.

p.7

l.1: we accepted the suggestion

l.33: we think that adding different synonymises for the description of the marks could only be confusing. It has been already established, in the literature, that there is more than one nomenclature for stigmata, but no significant differences can be envisaged among them. In our opinion, the morphological description of stigmata should be as simple as possible to avoid confusion and repetitions. Therefore, we maintain the nomenclature specifying that we followed Mallye et al. (2012) and Mozota Holgueras (2012), adding however the following specification: “The analysis of the technological stigmata on the surface of the retouchers was carried out following Mallye et al. (2012) and Mozota Holgueras (2012), although more nomenclatures are present in literature (e.g., Daujeard et al., 2014, 2018).

p.8

l.28: We agree with the Reviewer. The use of a carnivore’s bone as a retouchers is rare in the Palaeolithic context and, unfortunately, the fragment is not taxonomically identifiable at a specific level. The idea of making a protein analysis in the future is absolutely to take into consideration for further studies.

p.9

l.7: we deleted the sentence as suggested.

l.15: there are 33 retouchers bearing carnivores’ toot-marks, which correspond to 9.8% of the analysed bone tools. In the study of the total faunal assemblage, the percentage of carnivores’ marks is lower; for this reason, we think that this datum does not enrich the study of bone retouchers, and for this reason we did not analysed it more in depth.

l.19: we correct “percussion cones” into “impact flakes”, following the common terminology (Vettese et al., 2017, 2020).

l.19: as suggested, we deleted the reference to the differentiation between combustion and calcination

p.10

l.1: we have 335 retouchers in total. Of these, 287 are single retouchers (= 287 areas), 46 are double retouchers (=92 areas) and 2 are triple retouchers (=6 areas). Therefore: 287+92+6=385. In order to clarify, we rephrased as follows: “Of the 335 analysed tools, 46 (14%) were used as double retouchers, and two as triple retouchers; therefore, a total of 385 use areas has been identified”.

l.4: we accepted the suggestion of adding a table containing more specific data about the sizes of the use areas. However, a table of 385 rows is not suitable for a paper, therefore we added it in supplementary materials (SM1); this table contains also specific data about thickness.

Highlights

- Retouching is a widely shared behaviour among Middle Palaeolithic humans
- De Nadale Cave was occupied only by Quina Neanderthals in Italy
- More than 300 bone retouchers were obtained from cervid and bovid limb bones
- Double retouchers were made using ungulates' radii
- Retouching activity at De Nadale relates to the lithic tool set

Bone retouchers from the Mousterian Quina site of De Nadale Cave (Berici Hills, north-eastern Italy)

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Abstract

Bone retouchers are present in the human toolkit throughout the Lower and Middle Palaeolithic and appear in many contexts across Europe, sometimes in association with heavily retouched stone tools. Here we present the complete assemblage of bone retouchers recovered in the Mousterian Quina site of De Nadale Cave in the north of Italy dated to the onset of MIS 4. The results show that this assemblage is consistent – both in morphological and technological features - with bone retouchers recovered in the rest of Europe. The predominance of cervid and bovid limb bones is observed, and the study of the retouch-induced stigmata reveals intense modification of the lithic industry carried out on-site. This analysis contributes to our understanding of Neanderthal cultural and economic choices in the Quina complex in Europe.

Keywords: bone retouchers; cervids; Mousterian Quina; Neanderthal; Italy.

1. Introduction

Retouchers are among the most ancient bone tools in existence. They have been recovered in several important sites in Europe, starting from the Lower Palaeolithic, at Gran Dolina TD10-1 (Rosell et al., 2011; Rosell et al., 2015), Bolomor Cave and Qesem Cave (Blasco et al., 2013; Rosell et al., 2015, 2018) and Schöningen (Julien et al., 2015) among others. These tools became widespread during the Middle Palaeolithic in Eurasia (Mallye et al., 2012; Mozota Holgueras, 2012; Abrams et al., 2014; Daujeard et al., 2014, 2018; Costamagno et al., 2018; Doyon et al., 2018; Neruda and Lázničková-Galetová, 2018, Turner et al., 2020, among others). In the north of Italy, the focus region of this paper, Tagliente Shelter and Ghiacciaia Cave (Bertola et al., 1999; Thun et al., 2018), Rio Secco Cave (Peresani et al., 2014; Romandini et al., 2018), Fumane Cave (Jéquier et al., 2012, 2013, 2018; Martellotta et al. 2020) and San Bernardino Cave (Giacobini and Malerba, 1998) are among the most representative contexts whose assemblages contain bone retouchers. During the Upper Palaeolithic, these tools continued to be utilized in Europe (Tartar, 2012; Jéquier et al., 2012, 2013) and in China (Zhang et al., 2018), only to disappear with the advent of the metal ages and the disuse of stone for tool production.

The first identifications of bone retouchers date back to the end of the nineteenth century and the early twentieth century (Leguay, 1877; Henri-Martin, 1906, 1907, 1907-1910; Giraux, 1907; Mortillet and Mortillet, 1910), after which many functional studies followed, including even several experimental approaches (Mallye et al., 2012; Mozota Holgueras, 2012, 2013, 2014, 2018; Tartar, 2012; Hutson et al., 2018).

Mostly, retouchers result from the recycle of bones following the butchery of large herbivores and sometimes carnivores (Abrams et al., 2014). Evidence also exists for retouchers having been made with inorganic materials: mainly pebbles (Taute, 1965; Bertola et al., 1999; Bourguignon, 2001; De Lumley et al., 2004; Raynal et al., 2005; Nicoud, 2010, among others), occasionally cores and handaxes (Thiébaut et al. 2010) and rarely flint tools – the so-called "bulb retouchers" (Tixier, 2000; Mathias and Viallet 2018; Centi et al., 2019, among others). Regarding bone retouchers, the majority of them are obtained from long bones shaft fragments belonging to both upper and lower limbs, though there are examples of the employment of different skeletal parts, such as epiphyses, ribs, mandibles, teeth, and phalanxes (Henri-Martin, 1906; Auguste, 2002; Jéquier et al., 2012, 2013, 2018; Daujeard et al., 2014; Costamagno et al., 2018). The faunal species used vary depending on the resources exploited in the site surroundings. Archaeological evidence also attests to the use of human bones in some rare cases at La Quina Cave (Verna and D'Errico, 2011), Krapina (Patou-Mathis, 1997), Les Pradelles (Mussini et al., 2011) and Goyet Cave (Rougier et al., 2016). The term "bone retoucher" will be shortened to "retoucher" hereafter, unless a different raw material was used.

Retouchers appear very frequently in association with Mousterian Quina contexts in several parts of Europe (Henri-Martin, 1906; Chase, 1990, 1994; Valensi, 2002; Mozota Holgueras, 2012; Niven et al., 2012; Castel et al., 2017; Costamagno et al., 2018; Ready and Morin, 2019). Quina Mousterian ascribes to a specific lithic industry (Bordes, 1981) though it has not been clearly demonstrated to be a discrete, unified cultural entity characterized by well-defined technological and behavioural patterns. The most diagnostic evidence of this techno-complex is the high rates of retouched tools, mainly scrapers, and core-reduction aimed at the production of thick, wide and often asymmetric flakes. These show a further reduction, part of the so-called "ramification cycle", having the double objective of tool-retouching and obtaining of small, usable flakes (Bourguignon, 1996, 1997; Turq, 2000). One of the consequences of this technical behaviour is the Quina retouch, that consists of the removal of scaled invasive flakes, from the dorsal face, using soft-hammer percussion with bone or antler (Bourguignon, 1997, 2001; Turq, 2000; Bourguignon et al., 2013). Aside from the Quina scrapers, a correlation between bone retouchers and denticulate tools has also been suggested (Rosell et al., 2011). In the definition of Quina complex, the exploitation of animal resources, for food and/or technological purposes, is strictly related to human mobility and subsistence strategies (Castel et al., 2017; Costamagno et al., 2018). Despite their broad dietary spectrum, the critical component of subsistence was the exploitation of ungulates. In Europe, Quina contexts are dominated by mono-specific assemblages, mainly consisting of remains attributable to large and medium-large sized cervids (above all red deer and reindeer, followed by giant deer), bovids (bison and auroch) and horse (Jéquier et al., 2012, 2013, 2018; Mozota Holgueras, 2012; Costamagno et al., 2018; Discamps and Royer, 2017). Therefore, focusing on the exploitation of osseous material could contribute to a more comprehensive definition of the Neanderthal toolkit and clarify the behavioural hallmarks that identify the Quina human groups.

De Nadale Cave, the only Quina Mousterian context currently being investigated in Italy and in south-central Europe (Jéquier et al., 2015; Livraghi et al., 2019) could give an important contribution. In this small cavity, large numbers of retouchers have been found, some of which (NR = 204) have already been presented in preliminary publications (Jéquier et al., 2015, 2018). Recent excavations at De Nadale Cave extended to almost the entire deposits, adding more than one hundred retouchers made of giant deer, red deer, and bovid bones to the published sample. Here we present the complete assemblage of retouchers recovered until the last field campaign conducted in 2017. They are analysed from a morphological and a technological perspective. The aim is to provide a complete description of their techno-morphological features to contextualise them in a specific technocomplex of the Middle Palaeolithic, through comparison with other Quina Mousterian sites in Europe; this comparison takes into account the used areas, the represented faunal species, and the selected skeletal parts in relation to the morphometric data.

2. Materials and methods

2.1 De Nadale cave context

De Nadale Cave is a small cavity located 130 meters above sea level on the Berici Hills, in province of Vicenza, in north-eastern Italy (Fig. 1). The exploration of this area in recent decades yielded evidence of Palaeolithic human occupation, with the most relevant recorded at Broion Cave and Broion Shelter, and San Bernardino Cave (Leonardi, 1979; Peresani, 2001). Research at De Nadale Cave started in 2013 when a first excavation campaign led to the discovery of a cave entrance (8 m wide) after the removal of reworked sediments (unit 1Rim). Later, six campaigns were carried out between 2014 and 2017 in order to investigate the deposits preserved in the cave entrance (Jéquier et al., 2015; Livraghi et al., 2019) and to recover additional cultural and faunal material from the sediments reworked in badger dens.

The excavations exposed a 2-meter-thick stratigraphic sequence at the entrance, thinning to one meter in the cave-mouth, which includes a single anthropic layer (unit 7) embedded between two almost sterile layers (units 6 and 8). Close to the lower boundary of unit 6 and the upper boundary of unit 8, some bone fragments and lithic implements were recovered and attributed to unit 7 (Jéquier et al., 2015). Unit 8 lays on the carbonate sandstone bedrock. Further ongoing excavations will soon survey the complete planimetry of the site and the depth of the cavity. Unit 7 is disturbed by some badger's dens (defined as units 12, 13, 14, 15, 16), along the cave walls and back of the cave, partially emptied during the excavations. The resulting sediment provided a substantial amount of bone and lithic fragments, mixed with recent bones and organic matter. Besides these disturbances, unit 7 is well preserved and extended within the cavity, and it yielded thousands of osteological material and lithic implements, some small charcoal fragments, and a deciduous tooth of Neanderthal (Arnaud et al., 2016).

A molar of a large-sized ungulate was U/Th dated to 70.2±1/0.9 ka BP as minimum age (Jéquier et al., 2015). These results are consistent with the paleoclimatic and paleoenvironmental reconstruction based on the small mammal association, where the prominence of *Microtus arvalis* identifies a cold climatic phase and correlates to a landscape dominated by open woodlands and meadows. Together, these results provide hints for placing the human occupation at De Nadale Cave to an initial phase of the MIS 4 (López-Garcìa et al., 2018).

The lithic industry from of De Nadale differentiates technologically and typologically from the Mousterian elsewhere in the region, especially with regard to the core reduction methods and the types of flakes and retouched tools (Jéquier et al., 2015). The reduction sequences include polyhedral and multi-faceted cores with secant surfaces, alternated cores (Bourguignon *sensu*) and the minor presence of centripetal schemes such as recurrent centripetal Levallois. Moreover, the predominance in the assemblage of retouched implements or retouch by-products is evident, proven by more than 300 among tools and retouch flakes. The retouched assemblage includes several scrapers with stepped-scaled invasive retouches, and it is therefore comparable to Quina assemblages in Italy and in south-western France (Bourguignon, 1997; Palma di Cesnola, 2001).

2.2 Faunal assemblage

The zooarchaeological assemblage found in units 7 and correlates (6base, 8tetto, interfaces, hereafter unit 7) is largely of an anthropogenic nature (Livraghi et al., 2019) (Tab. 1). At De Nadale cave, Neanderthals hunted and exploited predominately three taxa: the red deer (*Cervus elaphus*), the giant deer (*Megaloceros giganteus*) and bovids (*Bison priscus* and *Bos primigenius*) (Terlato et al., 2019). In smaller quantities, other ungulates such as the roe deer (*Capreolus capreolus*), the chamois (*Rupicapra rupicapra*), and the wild boar (*Sus scrofa*) have also been identified. Carnivores are rare: bear (*Ursus spelaeus* and *Ursus* sp.), wolf (*Canis lupus*), fox (*Vulpes vulpes*), and badger (*Meles meles*) have been identified, though none show human modification. The majority of identifiable remains belong to adult individuals. In regard to the skeletal elemental representation, limb and cranial bones are more abundant than the elements from the axial skeleton. A large amount of anthropic traces is observed, largely attributed to different stages of the butchery process and to the fragmentation of the bones for marrow extraction. Finally, a large amount of bone fragments carries traces of fire exposure, assuming a colour gradient from brown, to black, to white. This evidence coincides with the presence of two charcoal accumulations named structures 7SI and 7SII found in the north-eastern area of the cave interpreted as dumping areas or residual fire-places.

2.3 Retouchers

The retouchers analysed in this study were collected among all the stratigraphic units, including the reworked sediments and the infills of the badger dens. These specimens have been included in the present research considering that their conservation is comparable with the osseous remains of the Unit 7, and because this unit is the only anthropic layer identified in the site. By including bone fragments collected in other units besides Unit 7, the number of analysable retouchers increases considerably, and despite their stratigraphic unreliability, their attribution to a Mousterian assemblage is undeniable. The sample is temporarily stored at the Department of Humanities at the University of Ferrara. In this study, 335 retouchers from units 1Rim, 3, 5, 6, 6tana, 7, 8, 13, 14 were taken into consideration. Among them, 48 yielded stigmata in more than one portion of their surface, for a total of 385 use areas.

All retouchers were identified and registered during the excavation which was carried out with trowels and small wooden digging sticks, or after scrutinization of sediments wet sieved for recovering smaller fragments. Surfaces have been examined with naked eyes and by the aid of a stereomicroscope Leica S6D (magnification 6.3x-40x), when necessary; pictures of the use areas have been taken with camera Leica EC3 (scale in millimetres).

Every bone blank was anatomically and taxonomically determined using the complete Alpine fauna reference collection of the Section of Prehistory and Anthropological Sciences at Department of Humanities, the University of Ferrara. When the taxonomical identification was not possible, the cortical bone fragments were categorised based on the thickness: I - small (i.e. *Lepus* sp. and other lagomorphs, *Mustelidae, Vulpes vulpes*); II - small-medium (i.e. *Capreolus capreolus*, *Rupicapra rupicapra*, *Canis lupus*); III - medium (i.e. *Capra ibex, Sus scrofa*); IV- medium-large (i.e. *Cervus elaphus, Megaloceros giganteus*, *Ursidae*); V- large (i.e. *Bovinae*).

The degree of preservation of the bone and the bone surfaces is excellent (Livraghi, 2015; Livraghi et al., 2019), making it possible to define the surface alterations and to discern human traces from animal ones (pits, punctures, scores, furrowing, scooping-out, etc.), trampling abrasion, and mechanical modifications due to excavation tools. Reference was made to taphonomic literature for the purpose of identifying and distinguish those post-depositional modifications from anthropogenic ones (see Livraghi et al., 2019 for references). Butchering and percussion marks for dietary purposes have been recognized and distinguished from retouch-induced stigmata by observing their morphology, position and orientation. Cutmarks include incisions and scraping marks.

Anthropic traces linked to bone breakage for marrow extraction, such as cortical percussion notches, impact flakes, peeling, percussion pits, adhering flakes and micro-notches, were also taken into account following the well-established literature (Blumenschine and Selvaggio, 1988; Capaldo and Blumenschine, 1994; White, 1992; Blasco et al., 2013; Vettese et al., 2017). Among them, only two traces were present in the De Nadale faunal record: cortical percussion notches and impact flakes. Percussion marks are described as notches, semi-circular in their morphology, observed in proximity of the fracture edges, and associated to negative flake scars. Impact flakes correspond to positive flakes of the notches resulting from the percussion action due to the breakage of diaphyses. The analysis of the morphology fragmented bone shafts revealed an intentional action of breaking the diaphyses to access marrow (Villa and Mahieu, 1991; Blumenschine, 1995; Fisher, 1995; Outram, 2001; Grunwald, 2016; Coil et al., 2017). Marks ascribable to natural post-depositional degradation and animal chewing, therefore not related to anthropic actions, were identified only on taxonomically determined remains, and on fragments longer than 5 cm.

The maximum length and the maximum width (mm) were registered for every bone fragment. The cortical bone thickness (mm) in the point where the use area is located, was also registered in order to determine if it could be correlated with the selection of anatomical portions and/or species. Finally, the weight (g) was registered only for the sake of completeness. The post-depositional processes lead to the loss of weight of the bones, and therefore the current weight does not correspond to the original weight of the tool.

The analysis of the technological stigmata on the surface of the retouchers was carried out following Mallye et al. (2012) and Mozota Holgueras (2012), although more nomenclatures are present in literature (e.g., Daujeard et al., 2014, 2018). The location of the use areas, the retouch intensity (i.e. the concentration of impact marks), and the number of the areas were recorded; the values of maximum length and width (mm) were registered only of the complete use areas. Regarding the orientation of retouchers and the positioning of the areas, the anatomical identification of the bone fragments was not considered. Each tool was oriented based on the long axis, defined at its largest length, and the use areas are generally located on the surface of one or both the extremities of the retoucher. Retouchers showing more than one use area are reoriented, and the areas are analysed individually.

The stigmata were counted and grouped in four morphological categories:

- pits: triangular or ovoidal depressions of the osseous surface, due to the impact of the bone surface with the dihedral morphologies corresponding to the irregularities of the lithic edge;
- linear impressions: long, narrow and deep depressions, with asymmetrical V-shaped section; they show a generally linear course, sometimes also sinuous, concave or convex; their inner surface could be smooth or rough, and they could be associated to the impact between the retoucher and a sharp lithic edge;
- retouch-induced striae: short, shallow striations, with a linear or slightly curved profile, parallel and close to each other; these could be produced when bone and lithic edge impact with an oblique direction; in this case, the blow is arrested less brutally and the lithic edge almost scratches on the bone surface;

- notches: massive, deeper and wider depressions these could be described as an erosion of the bone surface, caused by a continuous percussion; their morphology depends on their extension and the most common category of stigmata identifiable in the use area.

These categories of stigmata often occur together in the same use area. Moreover, four categories of retouch intensity were distinguished, according to Mallye et al. (2012) (Fig. 1c, p. 1133): (1) isolated, (2) dispersed, (3) concentrated and (4) concentrated and superimposed (hereafter, superimposed).

Retouchers defined as complete were isolated. Such identification was carried out on the basis of the observation of the fresh bone fractures (Villa and Mahieu, 1991; Grunwald, 2016; Coil et al., 2017) and therefore observing the angle of the fracture, its general morphology, and the texture of the edge (smooth or rough). We are aware that the application of these parameters might lead to an underestimation of the sample of the complete retouchers, since it takes into consideration only tools obtained by bones fractured in a fresh state and excludes other ways of support procurement. We think that more focused studies on the microscopic features of fractures based on different states of freshness of the bone could be useful for a better definition of such a parameter. However, in this context it was needed to distinguish the complete retouchers in order to carry out a preliminary morphometric analysis, in which we observed the relationship among the length, width and thickness values of the tools looking for any morphometric pattern.

3. Results

3.1 Raw materials

A total of 335 retouchers from De Nadale Cave were analysed. Of these, 35 retouchers were considered complete on the basis of the observation of the fresh bone fractures (Tab. 2).

Of the taxonomically species-level determinable specimens, the most represented are *Megaloceros giganteus* (NR = 52, 15.5% of the total analysed retouchers), *Cervus elaphus* (NR = 39, 11.6%), and large bovids (*Bos/bison*, NR = 36, 10.7%, and *Bison priscus*, NR = 4, 1.2%), in line with the general faunal spectrum recognised at the site (Livraghi et al., 2019; Tab. 1). A significant proportion (50.3%) of bone fragments could only be identified as ungulates, but it was possible to group them into the large-sized animal category. (Fig. 2, Tab. 3)

49% of the analysed retouchers was identifiable at a skeletal element-level (Tab. 3; SM1). Long bones are the most selected element (91.5%; 13.3% of the total NISP), in particular tibiae (32.3%; 4.7% of the total NISP), followed by radii, femurs, metacarpals and metatarsals. Diaphyses were mainly

selected (97% of the total analysed bone retouchers) (Fig. 3). Only one epiphysis is recognised, belonging to a radius of *Bos/Bison*. That is the only epiphysis identified in the entire faunal assemblage. Peculiar anatomical portions used as retouchers are ribs (7) (Fig. 4a), mandibles (3, among which one bears two teeth), scapulae (2) and one horn core of *Capra ibex* (Fig. 4b).
With regard to the taphonomy, manganese stains represent the most common alteration of the surface (66.4%). Degradation due to root-etching is observed to a lesser but still relevant extent (44.6%). A significant proportion of the analysed retouchers is affected by the presence of carbonate concretions (34.2%), which in some cases (10%) cover part of the use area, making the identification of stigmata difficult. Trampling traces are common (36%), attributable to the elevated content in stones of the deposit. Several shafts bear slight weathering traces (36.6%), mostly referable to the Behrensmeyer stages 1 or 2, while exfoliation (3.6%) and corrosion (3.3%) marks are observed on a smaller scale. Traces due to the action of animals are very few: 9.8% are carnivores' tooth-marks and only 0.6% rodents'.
Anthropic traces due to butchering activities are observed on 82% of retouchers (NR = 274). Among them, cut-marks are the mostly frequent registered (67.5%). Some shafts present impact notches (30.7%) and few of them have been recognized as impact flakes (1.1%). Finally, scraping marks are present on the 21.5%. These traces always locate underneath the retouch stigmata; they are oriented parallel to the long axis of the shaft, covering an area larger than the use area but never the entire shaft fragment.

3.2 Metric data

The average sizes of the complete retouchers are reported in Table 4 and more detailed information can be found in Supplementary Materials (SM1). The maximum lengths range from 54 to 150 mm, and the maximum widths range from 20 to 46 mm. The thickness of the cortical bone ranges from 5 to 19 mm. The average weight of these specimens is 22.1 g. Retouchers are usually elongated, rectangular, and commonly flat. Although some shafts show accentuated convex surfaces in relation to the anatomical element, it seems that the flattest portion of the surface was preferred for use.

3.3 Use areas and stigmata

Of the 335 analysed tools, 46 (14%) were used as double retouchers, and two as triple retouchers. About 62% of the areas are complete, while the others are cut by fractures either from use or post-depositional processes (Fig. 5). It is worth noting that on double retouchers one area always looks more intensively used than the other, suggesting primary and secondary phases. The maximum length of the use areas goes from 3 to 37 mm, while the maximum width ranges from 3 to 25 mm (more detailed information could be found in Supplementary Material – SM1). On single retouchers, use areas are always located on the apical portion of the tool face. The presence of three use areas is registered on two retouchers: a tibia of *Cervus/Megaloceros* (Fig. 6a) and a femur of *Cervus elaphus* (Fig. 6b). In these cases, two areas are adjacent to each other - they are distinguishable due to the different orientation of the stigmata (Fig. 6.1 and 5.3) – while the third area is located either in an adjacent (Fig. 6.2) or opposite (Fig. 6.4) position on the diaphysis in relation to the others. On retouchers with two areas, each area is generally located on the two extremities of the same shaft, although in some cases the two areas could be adjacent (Fig. 7).

All four stigmata categories have been observed (Fig. 8). Linear impressions prevail (58.7%), followed by punctiform impressions (28.7%), retouch-induced striae (7.1%) and notches (5.4%). Linear (Fig. 9.1) and punctiform (Fig. 9.2) impressions are often deep and marked; the striations, when present, are superficial and parallel to each other. Notches are extensive and deep (Fig. 9.3), indicating an intense retouch activity. In terms of distribution (Fig. 10), most of the stigmata are concentrated (48.2%), then dispersed (27.3%), superimposed (13.3%) and isolated (9.6%) stigmata follow. In 2% of the sample it was not possible to evaluate the density of the stigmata because of the small size of the fragment and/or the alteration of the surface.

Although the most used elements are tibias (NR = 54; Fig. 3g-h), there are very few double (3.7%) or triple (1.8%) retouchers among them, made from bones of *Megaloceros giganteus* and *Cervus elaphus*. Radii/ulnas instead, despite being less represented (NR = 21 on diaphysis; Fig. 3c-d) record a very high number of double retouchers (42.8%). Among them, three are made from bones of *Megaloceros giganteus* and four from bones of *Bos/Bison,* while one is made from a bone of *Cervus elaphus* and another one has been only identified as *Cervidae*. A similar situation is recognisable among the metapodials, where three out of five retouchers are double: two of them have been identified as bones of *Bos/Bison*, while the other was not identifiable at a species-level, instead only being identified as large-size *Ungulata* (Fig. 11; see also SM1 for more details on double and triple retouchers).

4. Discussion

4.1 Raw material

4.1.1 Faunal spectrum

The analysis of the species selected to obtain blanks for retouchers is a very significant issue given the use of animal raw material is strictly related to the subsistence strategies and the mobility of Neanderthal groups.

The over 300 retouchers from De Nadale show a predominance of cervids (*Megaloceros giganteus* and *Cervus elaphus*) and large bovids (*Bos/Bison*, *Bison priscus*) bones.

A specific selection of species for making retouchers could be linked to the availability of resources or if it could be based on precise technological criteria. This issue seems to vary from site to site. In some cases, retouchers are obtained from bones belonging to dominant species in the faunal spectrum, suggesting that their manufacture is not subjected to a technological choice of the anatomical element, but rather to the availability of faunal elements produced from the butchering process (Armand and Delagnes, 1998; Auguste, 2002; Daujeard et al., 2014). In other cases, retouchers are not obtained from the dominant species of the faunal assemblage, meaning that Neanderthals did not use indistinctly all the bones produced from butchery, but that they carefully selected some fragments following criteria grounded on morphological, metrical, and technological features (Mallye et al., 2012; Daujeard et al., 2014; Costamagno et al., 2018; Alonso-García et al., 2020; Martellotta et al., 2020).

At De Nadale Cave, the predominant species selected for manufacturing retouchers are consistent with the composition of the faunal assemblage (Livraghi et al., 2019, Tab. 1) (Tab. 3; Fig. 12), where cervids (*Megaloceros giganteus*, NISP = 25.9%, and *Cervus elaphus*, NISP = 23.8%) and *Bos/Bison* (NISP = 16.7%) are the most represented species. Among the taxonomically species-level determinable retouchers (NR = 134), we can observe a similar predominance: the sample is dominated by *Megaloceros giganteus* (NR = 33.8%), followed by *Cervus elaphus* (NR = 25.3%) and *Bos/Bison* (NR = 23.4%) (Fig. 12a). Comparing these three species in relation to the NISP (NR retouchers/NISP for each species) we can see that they are generally equally distributed within the faunal spectrum (*Megaloceros giganteus* = 40.9%, *Cervus elaphus* = 30.7%, *Bos/Bison* = 28.3%) (Fig. 12b). The selection of a particular species has often been associated to the thickness of the compact bone (Daujeard et al., 2014; Costamagno et al., 2018). Therefore, based on the consistency between the species used for making retouchers and the whole faunal assemblage, we could argue that at De Nadale Cave species were selected for making retouchers according to the availability of environmental resources, and that this selection seems to overlook the thickness parameter. This result integrates the framework of the exploitation strategies of animal raw materials during the Quina techno-complex. Such a predominance in cervids and large bovids as sources for retouchers is also observed in other Mousterian sites in Europe: in Spain, at Axlor Cave (Mozota Holgueras, 2012), and in the Swabian Jura (Toniato et al., 2018). On the other hand, in other regions - especially southwestern France – reindeer was the main source for these bone tools (Castel et al., 1998, Costamagno et al., 2018).

4.1.2 Anatomical elements

The selection of limb bones for manufacturing retouchers is an extremely widespread pattern. De Nadale Cave fits in this model in that almost all retouchers are obtained from long bones; among the most selected elements, tibias are the most represented, followed by radii, femurs, metacarpals and metatarsals. Humeri, on the contrary, are extremely rare (Tab. 3; Fig. 3; Fig. 11). These data are consistent with others in Quina sites in Europe, like Les Pradelles (Costamagno et al., 2018). Diaphyses are almost the only bone portions used as retouchers, a fact that is consistent with several Quina contexts; although in some sites (Auguste, 2002; Valensi, 2002) epiphyses also appear to be used. At De Nadale, only one retoucher made from an epiphysis was found, and it represented the only epiphysis in the entire assemblage (Tab. 3). The lack of this skeletal element could be ascribed to several factors: the high fragmentation rate in the deposit (Livraghi et al., 2019), the use of epiphyses as fuel (Costamagno et al., 2005) – since this assemblage contains a high number of burned and calcinated bones – or the fact that epiphyses may possess less of the technological features suitable for retouching as diaphysis do.

Focusing on the skeletal elements selected for retouching is important for several reasons. On one hand, it helps to understand the carcass exploitation strategies adopted by Neanderthals given retouchers normally result from the breakage of bones for subsistence purposes. On the other hand, since precise anatomical elements respond to morphological criteria – mandatory for such retouch activity - it is possible to infer that their selection was driven by a technological purpose (Alonso-García et al., 2020; Martellotta et al., 2020). Most of the analysed bone retouchers bear cut-marks and percussion marks on their surface, meaning that the selected blanks result from butchery. The number of expected elements (NEE) at De Nadale Cave suggests that the treatment of the carcasses was partitioned, with a first phase carried out at the killing site instead (Livraghi et al., 2019). Indeed, the bias between the frequency of appendicular and the axial elements is not due to post-depositional events, rather than to selection carried out by the human groups, who preferably introduced into the site the leg quarters.

The morphology of the anatomical elements seems to acquire greater importance in relation to double retouchers. If the use of more than one portion of the surface of the same retoucher occurred randomly, or was driven by non-technological factors, we would expect that most of the double retouchers were obtained from the most represented anatomical element – in De Nadale case, tibias. The study of the use areas, instead, shows that radius is the element in which double retouchers are observed most frequently, compared to the total amount of radius in the sample (Fig. 11). To a lesser extent, we could infer the same pattern among the metapodials: of a total of five metapodials computed in the assemblage, three were used as double retouchers. Therefore, we can suppose that the choice of using a retoucher in different parts of its surface suggests that only specific anatomical elements are suitable for being used as double retouchers. Moreover, although most of the blanks consist of limb bones, at De Nadale other anatomical elements – such as mandibles, ribs, scapulae, horns – have been used as retouchers. This further supports the fact that the blank was chosen depending on specific technological criteria, probably linked to the surface morphology and its grasping properties. The selection of particular anatomical elements besides long bones is not unusual in Quina sites: ribs at Les Pradelles (Costamagno et al., 2018); mandibles at La Quina (Verna and D'Errico, 2011) and Les Pradelles (Costamagno et al., 2018); phalanxes at La Quina (Valensi, 2002), Abri Lartet (Ready and Morin, 2019) and Les Pradelles (Costamagno et al., 2018); pelvises and scapulae at Les Pradelles (Costamagno et al., 2018). The selection of specific morphologies for making retouchers assumes importance when considering the relevance of the retouch activity from a techno-economic perspective in Quina contexts.

4.2 Metric data

Length and width measurements of complete retouchers from De Nadale are slightly larger than ones in other Quina sites. With regard to the length, De Nadale retouchers are comparable to those at La Quina (Verna and D'Errico, 2011) and Axlor (Mozota Holgueras, 2012), while – at Les Pradelles (Costamagno et al., 2018) – these tools show smaller length ranges (50-120 mm). The same situation is registered regarding the width of De Nadale Cave specimens: while there is similarity with the retouchers from La Quina (Verna and D'Errico, 2011) and Axlor (Mozota Holgueras, 2012), in Les Pradelles (Costamagno et al., 2018) the width ranges 10 to 40 mm. The thickness of the cortical bone could be one of the selection criteria linked to the carcass processing (Costamagno et al., 2018). At De Nadale, the thickness (Tab. 4; SM1) is similar to retouchers at Les Pradelles (Costamagno et al., 2018) and Axlor (Mozota Holgueras, 2012), but they are definitely thicker than those in La Quina (Verna and D'Errico, 2011), where they do not typically exceed 11 mm.
Regarding the specific sizes, the general morphology of De Nadale retouchers is elongated and flat. These morphological features could be associated to a better grasping of the tool (Bourguignon, 2001;

Daujeard et al., 2014). That is consistent with Axlor (Mozota Holgueras, 2012). Among a wide selection of useful bone flakes, Neanderthals tended to choose the longest and thickest ones. Although the choice of the blanks has often been linked to the selection among the food wastes (Armand and Delagnes, 1998; Daujeard et al., 2014), some experimental studies suggest that bone breakage was driven to obtain fragments with specific and predetermined features suitable for retouching (Mozota Holgueras, 2012, 2013).

4.3 Use areas

The use areas identified and analysed on the retouchers from De Nadale fit with the ones observed in several Quina sites, and, in general, in Middle Palaeolithic sites. Most of the De Nadale tools have one area located in apical position. Although double retouchers are common in several assemblages, triple retouchers occur rarely, mostly because the findings are often fragmentary. When two areas are registered, they are both located in apical position, but on opposite sides. In triple retouchers, two areas are adjacent to each other, and are distinguishable due to the different orientation of the stigmata. Stigmata orientation is often taken into consideration during the analyses of the use area, and it could be ascribed to several factors: the bone morphology (Costamagno et al., 2018), the habitual body position of the knapper during the retouching activity (Vincent, 1993), the shape of the lithic edge, the orientation of the retoucher towards the lithic edge (Tartar, 2012), and the knapper's handedness. The most frequently observed stigmata at De Nadale Cave are linear impressions, followed by punctiform marks. Both are often deep, and it is not unusual that an intense retouch activity leads to the detachment of entire bone portions (resulting in notches). Such a pattern is observed at Les Pradelles (Costamagno et al., 2018), La Quina (Valensi, 2002), and Axlor (Mozota Holgueras, 2012). The morphology of the stigmata varies in relation to the retouch intensity and the retouching angle, but experimental studies revealed an association between the physical properties of the lithic tool and the stigmata morphology (Mallye et al., 2012; Tartar, 2012).

With regard to the intensity of retouching activity at De Nadale, stigmata are mostly densely patterned. The intensity of stigmata impressed on the bone surface could depend on several factors. Since this parameter seems to not be dependent on the morphological features of the retoucher, we suppose that it was related to the type of retouch and the lithic raw material. This hypothesis has been proposed by different authors within experimental studies where concentrated and superimposed areas result from a greater number of retouch blows (Mallye et al., 2012; Mozota, 2012). In De Nadale cave, more than 250 retouched tools (Fig. 13) have been recovered so far, equal to 21.6% of the whole lithic assemblage. Among these, more than half are represented by scrapers and limaces characterized by supra-elevated, scaled removals on one or several edges. If we suppose that one single retoucher was used every time a tool was manufactured or resharpened, the extremely high amount of bone retoucher (and their use intensity) can be explained with the curation of such lithic tools, bearing several retouch phases. Moreover, we can assert that the human group that occupied De Nadale cave was characterized by high mobility strategies, confirmed by the use of exogenous raw materials and, again, by extremely reduced lithic blanks. More tools could have been produced, then exported and used in kill-butchering sites or other temporary camp-sites. Anyway, at De Nadale Cave variations of the intensity are only observed between areas located on the same blank (double retouchers); shifts from a primary, more intensively used area, and a secondary, less used area are observed systematically.

At De Nadale, scraping marks are frequently observed on the retouchers' surface, always covered by the retouch-induced stigmata. As 17% of retouchers bear scraping marks, similar proportions are observed in Les Pradelles (18%, Costamagno et al., 2018); in general, scraping marks are observed on the majority of retouchers. A scraping action is carried out either to prepare the bone surface by removing the periosteum (Armand and Delagnes, 1998; Auguste, 2002; Mallye et al., 2012; Daujeard et al., 2014) - even if it is not strictly necessary (Mozota, 2012) - or to prepare the edges of the lithic blank (Jéquier, 2014; Costamagno et al., 2018). Therefore, we could argue that at De Nadale Cave scraping action was not carried out to remove the flesh or the periosteum from a specific anatomical element, but it could be linked to the preparation of the edge of the lithic tool. Regardless of the motivation, the presence of scraping marks should be indicative of the bone tool being used at a fresh state, since, according to Tartar (2009), the absence of scraping marks means that the periosteum was already dry when the retoucher was used – meaning that a considerable amount of time had passed after the death, especially in glacial contexts.

5. Conclusions

De Nadale Cave revealed a remarkable assemblage of bone retouchers that will surely increase the collection of retouch-induced stigmata and the morpho-technological features of these particular tools in the Middle Palaeolithic. This analysis revealed several analogies with the ones recovered in various Middle Palaeolithic cultural complexes. Bone is almost always the preferred choice for the raw material, and its exploitation often focuses on the diaphysis of the limbs of large herbivores, frequently in consistence with the faunal spectrum of each site. Similarities are also highlighted regarding the retouch activity; the general morphology of the tool and the localisation of the retouch-

induced stigmata observed on bone retouchers from De Nadale Cave fit well with the assemblages from other Middle Palaeolithic contexts.
Moreover, De Nadale Cave is an excellent example of how Neanderthals exploited animal resources, both for subsistence and technological purposes, in the cultural frame of the Mousterian Quina complex. The morpho-technological and metric features of the retouchers analysed here provide evidence to compare the De Nadale assemblage with others recovered in other Quina contexts in Europe. This study confirms that Neanderthals had knowledge of the technological properties of these bone tools applied to retouching. In fact, although the selection of the animal species for manufacturing the retouchers seems to be driven by the availability of resources, a pattern is equally observed with regard to the selection of specific morphologies suitable for double retouchers, supporting the notion of technological control and predetermination.
Another aspect to consider is the relation between bone retouchers and lithic techno-complexes for the Quina industries, on one hand, and for the other Palaeolithic industries, on the other. The Quina techno-complex is different among others during the Middle Palaeolithic, based on Levallois, Discoid and blade technologies. Quina *débitage* results in wide and thick flakes, and most of them are retouched into scrapers. These features are shared by De Nadale lithic assemblage, even if the over-exploitation of cores and tools results in small and reduced blanks. Quina retouch is distinguishable due to the presence of invasive and superimposed removals, “fan-shaped” and with transverse hinged edges. The features of the Quina flakes facilitate their re-sharpening, by means of several sequences of retouch with steps in the modification of the morphology and the delineation of the edges. At the same time, the flakes could be subjected to recycling, obtaining smaller products, behaviour known as "Quina ramification cycle" (Bourguignon et al., 2006). Even though not all the flakes produced by the Quina method are retouched, the retouch activity surely plays a key-role in the reduction sequence of this lithic techno-complex. Moreover, a high presence of lips (Fig. 14) has been observed on the lithic edges of primary products derived from core-knapping, which could suggest the use of bone retouchers as soft hammer, rather than retouchers *per se*. That is confirmed by the numerous and intensively used bone retouchers found in association with Quina industries. These modalities of exploitation of both lithic and animal raw material could be linked to a high mobility and specific subsistence strategies. From this perspective, bone retouchers could be an element of interest in the definition of the Neanderthal tool-kit which could help clarify the economic and behavioural characteristics of the human groups living during the Quina techno-complex.
The analysis of De Nadale bone retouchers could expand our knowledge of the equipment of the Quina Neanderthals, seen as a bridge between lithic and bone industries. Finally, a similar study - carried out among many Palaeolithic contexts - could shed light on the technological evolution of

bone retouchers and, since they are present in association to the lithic industries from the Lower to the Upper Palaeolithic, add details on the technological human history from our origins to the dawn of the Metal Ages.

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Captions tables and figures

Tables

Table 1. NISP and %NISP values calculated among the whole faunal assemblage at De Nadale Cave. The calculations have been made through all the stratigraphic units (7 and correlates).

Table 2. Inventory of complete and fragmented bone retouchers at De Nadale Cave.

Table 3. Inventory of the analyzed bone retouchers, divided by species, size, skeletal element and bone portion. "NR" = "number of remains". The percentages are calculated in relation to the total NISP (1129) contained in Table 1.

Table 4. Metric data (in mm) of the bone retouchers identified at De Nadale Cave. Only the complete retouchers were taken into account (NR = 35).

Figures

Figure 1

Localization of De Nadale Cave in the North-east of Italy.

Figure 2. Faunal spectrum of bone retouchers at De Nadale Cave. The calculations have been made taking into consideration the entire sample (NR = 335).

Figure 3. Distribution of retouchers shaft portions: a) humerus of *Cervidae*, b) humerus of *Bos/Bison*, c) radius/ulna of *Cervidae*, d) radius/ulna of *Bos/Bison*, e) femur of *Cervidae*, f) femur of *Bos/Bison*, g) tibia of *Cervidae*, h) tibia of *Bos/Bison*. The illustration takes into consideration only the identifiable species and shaft portions (NR = 93)

Figure 4. (a) Retoucher. n. CN2494: *Cervus elaphus*, rib (fragment) : an extended use area is observed on the mesial portion, mostly composed of linear and punctiform impressions; in the central portion of the use area, the intensity of retouch resulted in some notches, created by the superimposition of several linear stigmata; (b) Retoucher n. 198: *Capra ibex*, horn core (fragment): a small use area is present on the proximal portion; the area is interrupted by the fracture, and it is mostly composed of notches created by the superimposition of linear and punctiform stigmata.

Figure 5. Example of a use area interrupted by post-depositional fragmentation (retoucher n. 3312): the line of fracture superimposes to the stigmata, and it removes part of the use area; the fracture is defined as post-depositional based on the observation of its edges.

Figure 6. (a) Retoucher n. 792: tibia of *Cervus/Megaloceros* bearing three distinct use areas: 1) two of them are adjacent and, even if there are few stigmata, we can observe how they group in two distinct areas of the bone surface and that they are oriented differently in relation to the longitudinal axis of the retoucher; 2) the third area is located on the opposite edge of the retoucher: some linear impressions which have been interrupted by a post-depositional fracture can be observed. (b) Retoucher n. 251: femur of *Cervus elaphus* bearing three distinct use areas: 1) two of them are adjacent, they superimpose but they are distinguishable based on the different orientation of the linear impressions regarding to the longitudinal axis of the retoucher; 2) the third area is located on the opposite apical extremity, and it is composed of both linear and punctiform impressions.

Figure 7. Retoucher n. CN3125 : Stigmata of retouching group into two distinct areas of the bone surface due to the spatial distribution and their different orientation relative to the longitudinal axis of the retoucher

Figure 8. Morphological categories of the observed retouch-induced stigmata. Only the complete use areas (211) were used for the calculations. N.B. Two or three complete use areas might be present on the same retoucher (NR = 179)

Figure 9. Examples of stigmata: (a) Retoucher n. CN344: use area mostly composed of linear impressions; they are long and deep, with a convex or sinusoidal course, and they have similar orientation to each other in relation to the longitudinal axis of the retoucher; some punctiform impressions are also present (1); (b) Retoucher n. CN2051: use area mostly composed of punctiform impressions, both of triangular and ovoidal shape; in the center of the area the stigmata slightly superimpose; some linear impressions and few striations are also present (2); (c) Retoucher n. CN3304: use area mostly composed of notches; they are the results of the superimposition of linear impressions, though some triangular punctiform impressions are recognizable; few isolated linear and punctiform impressions are also present (3).

Figure 10. Intensity of the retouch-induced stigmata. The calculations are made considering the total number of use areas (385) identified on the retouchers (NR = 335).

Figure 11. Relation between the anatomical element and the number of use areas, calculated for each species identified in the sample. The calculations have been made based only on the anatomically and taxonomically species-level identifiable skeletal elements (NR = 132).

Figure 12. (a) Relationship between the percentages of bone retouchers (%NR) and the identified species within the whole faunal assemblage (%NISP). The calculations have been made based on the taxonomically species-level determinable sample of retouchers (NR = 133). Details about the NISP are available in Tab. 1. (b) Detail of the distribution of the most represented species (*Megaloceros giganteus*, *Cervus elaphus*, *Bos/Bison*) in relation to the whole faunal assemblage. The calculation of the percentage corresponds to NR retouchers / NISP for each taxon.

Figure 13. Retouched lithic tools from De Nadale Cave: convergent double-convex scraper (a), transverse rectilinear scraper (b), convergent rectilinear-convex scraper (c), simple convex scraper (d), retouched point (e), bifacial scraper (f). These tools reveal several stages of resharpening, documented by the invasive, stepped or scaled retouching on one or more edges.

Figure 14. Prominent knapping lips in correspondence of the proximal end of core-reduction flakes. These widespread technical stigmata may suggest the use of soft hammers (bone, antler or limestone) during knapping activities.

Supplementary Materials captions

SM1

The reference numbers identify the nature of the recovery of each bone retoucher during the excavation process: numbers preceded by "CN" indicate fragments recovered after sieving, whereas excursively numerical references indicate remains longer than 5 cm which were spatially recorded within the excavation area. Double retouchers have been analysed separately: their reference number is set in italics for the primary area and in bold for the secondary area; the reference number for tertiary areas is set in italics and bold. The remains were categorised based on the cortical bone thickness and the bone surface size (M = medium, M-L = medium-large, L = large). Length and width of uncomplete use areas were not recorded. Duplicates in the numbering of the remains are indicate with the letter “a” after the number. The only identified epiphysis is indicated with the symbol “*”. Refitted bone retouchers are indicated with the symbol “**”.

Figure 1

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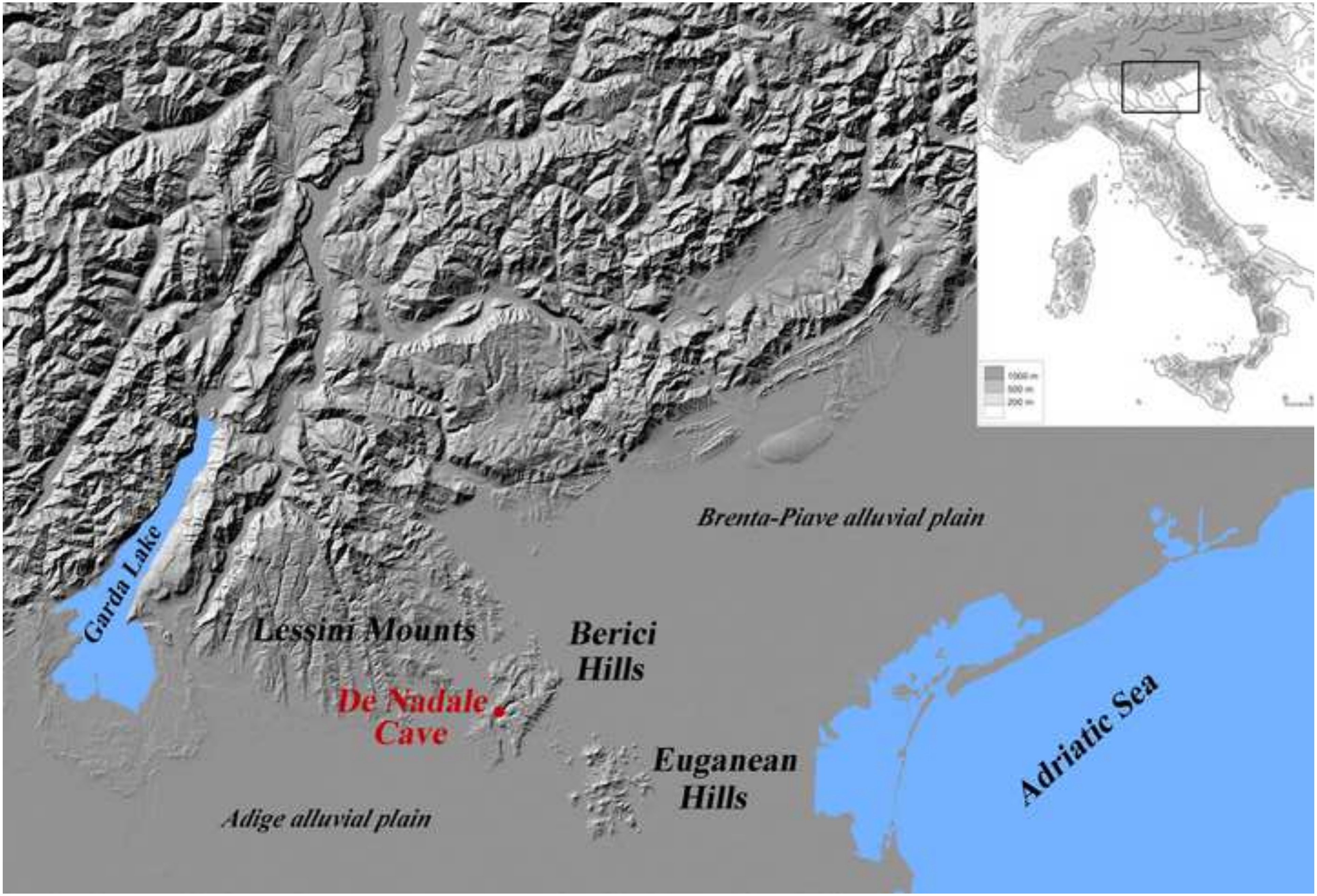

Figure 2

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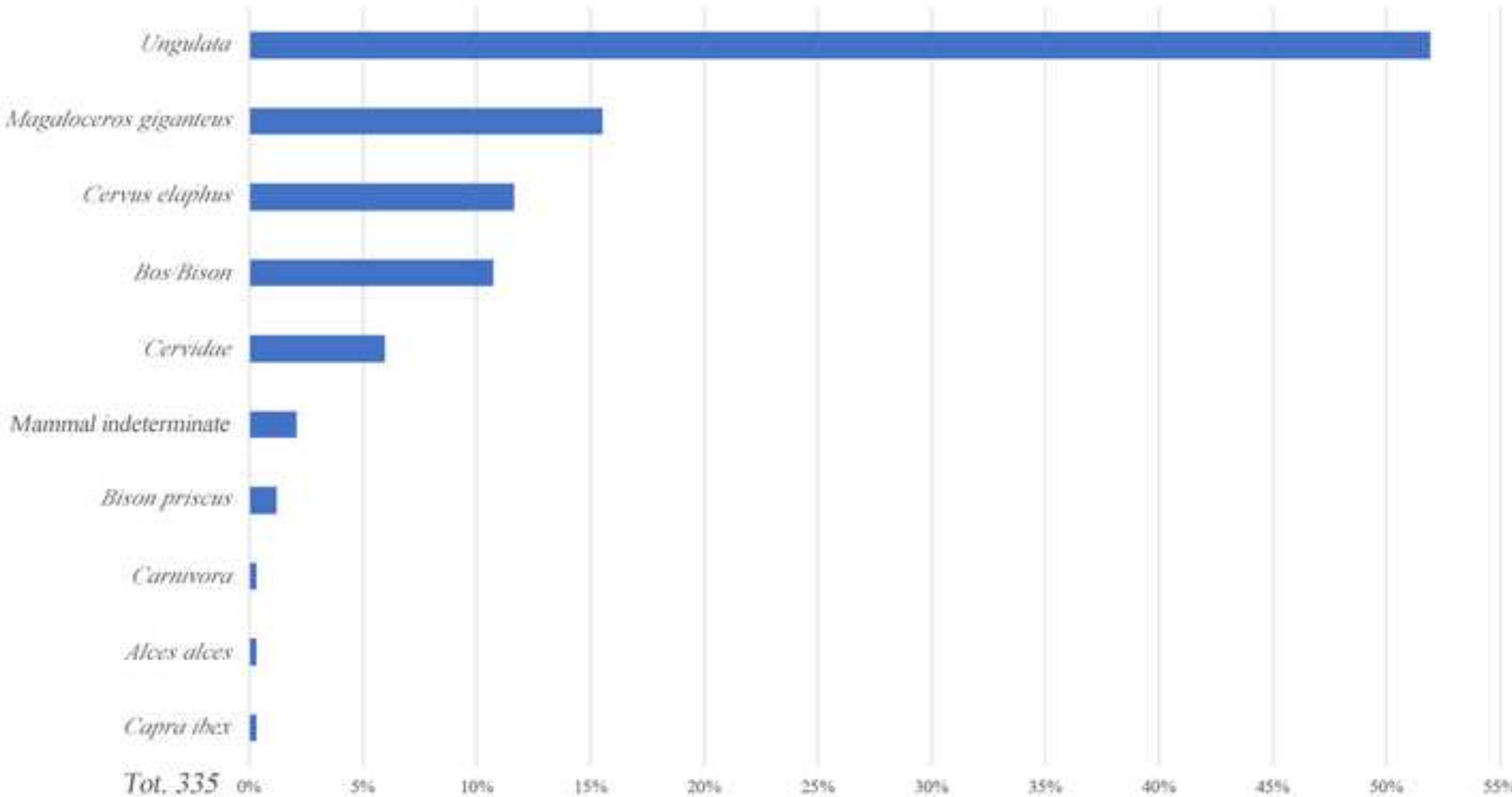

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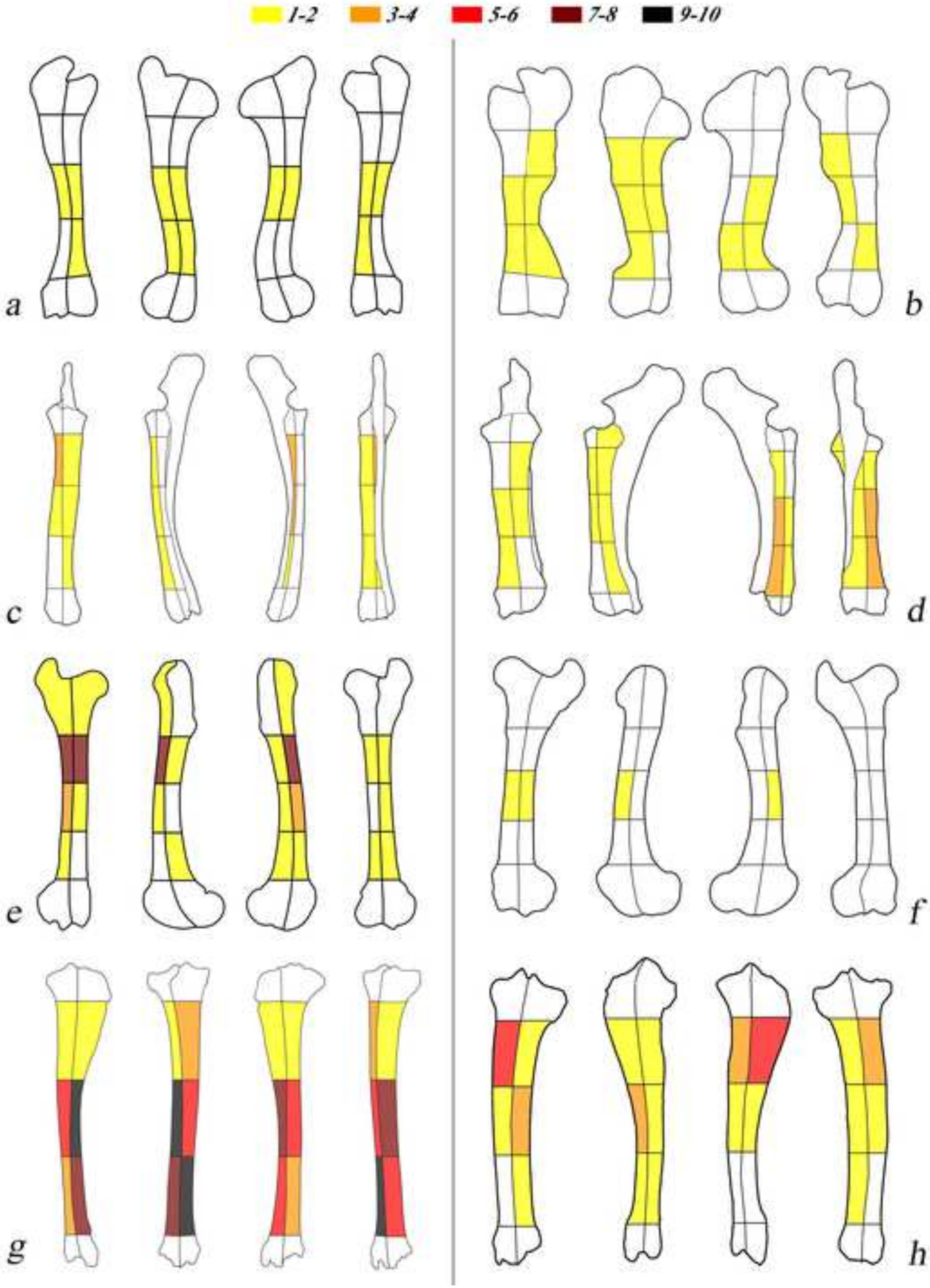

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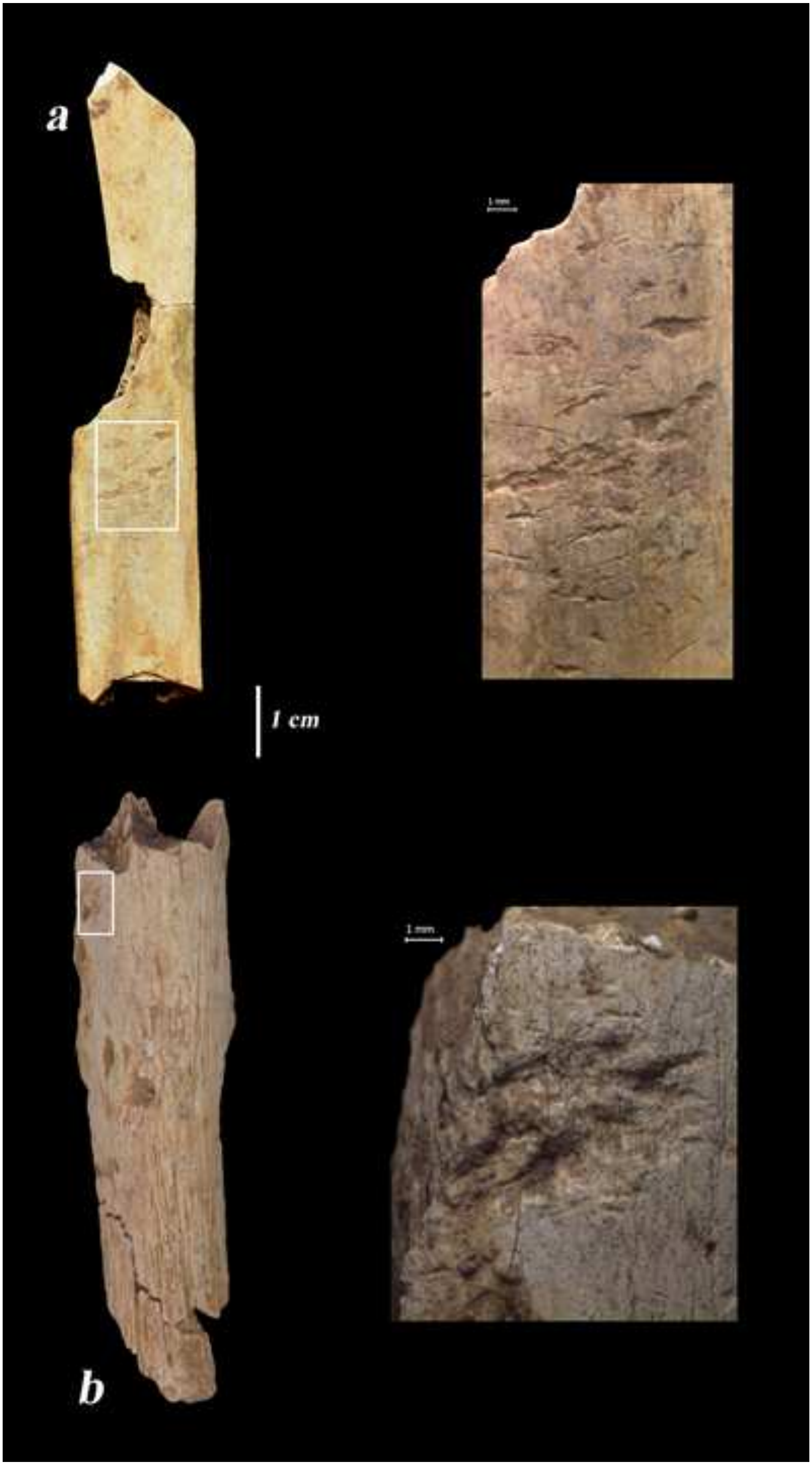

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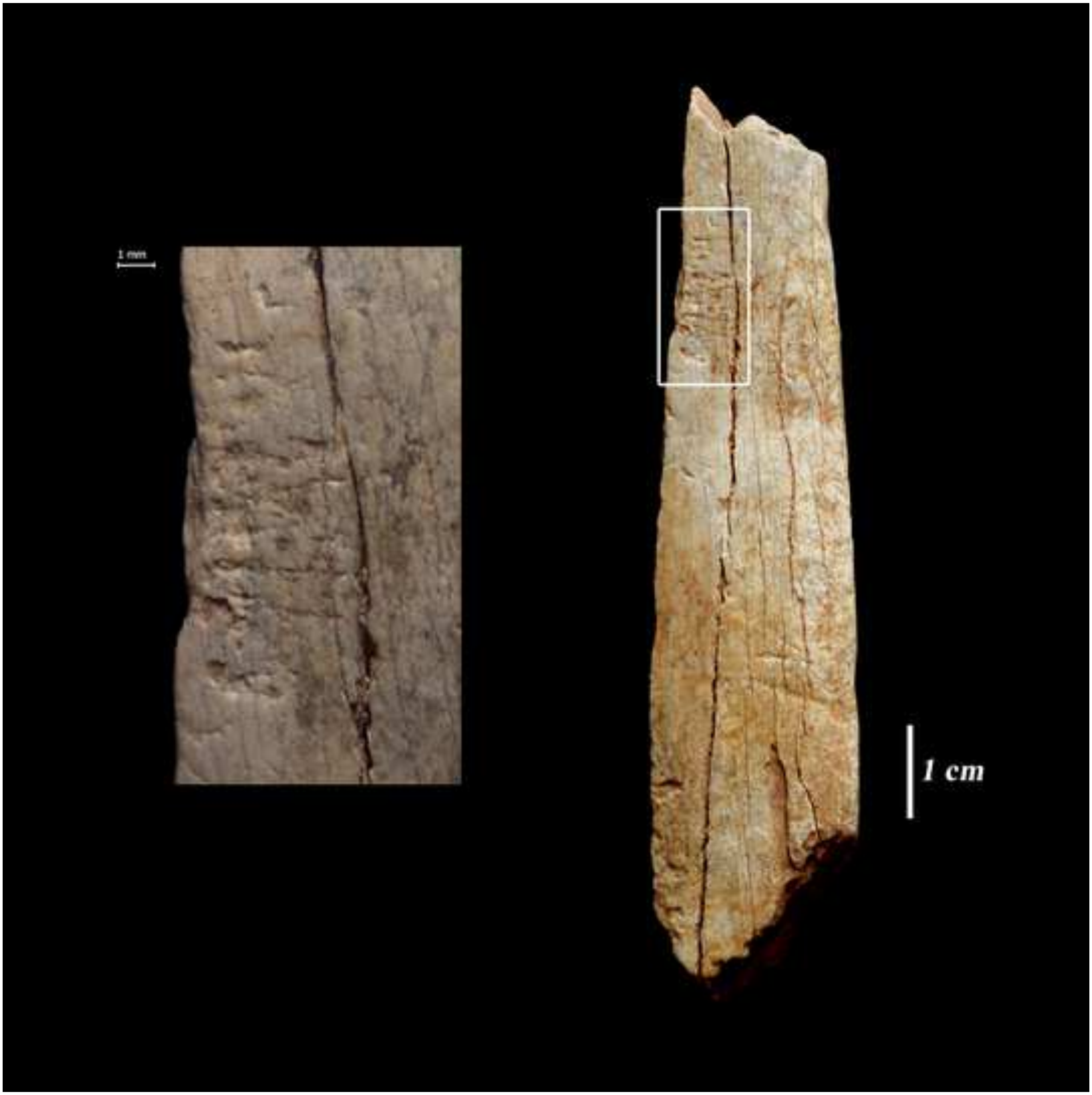

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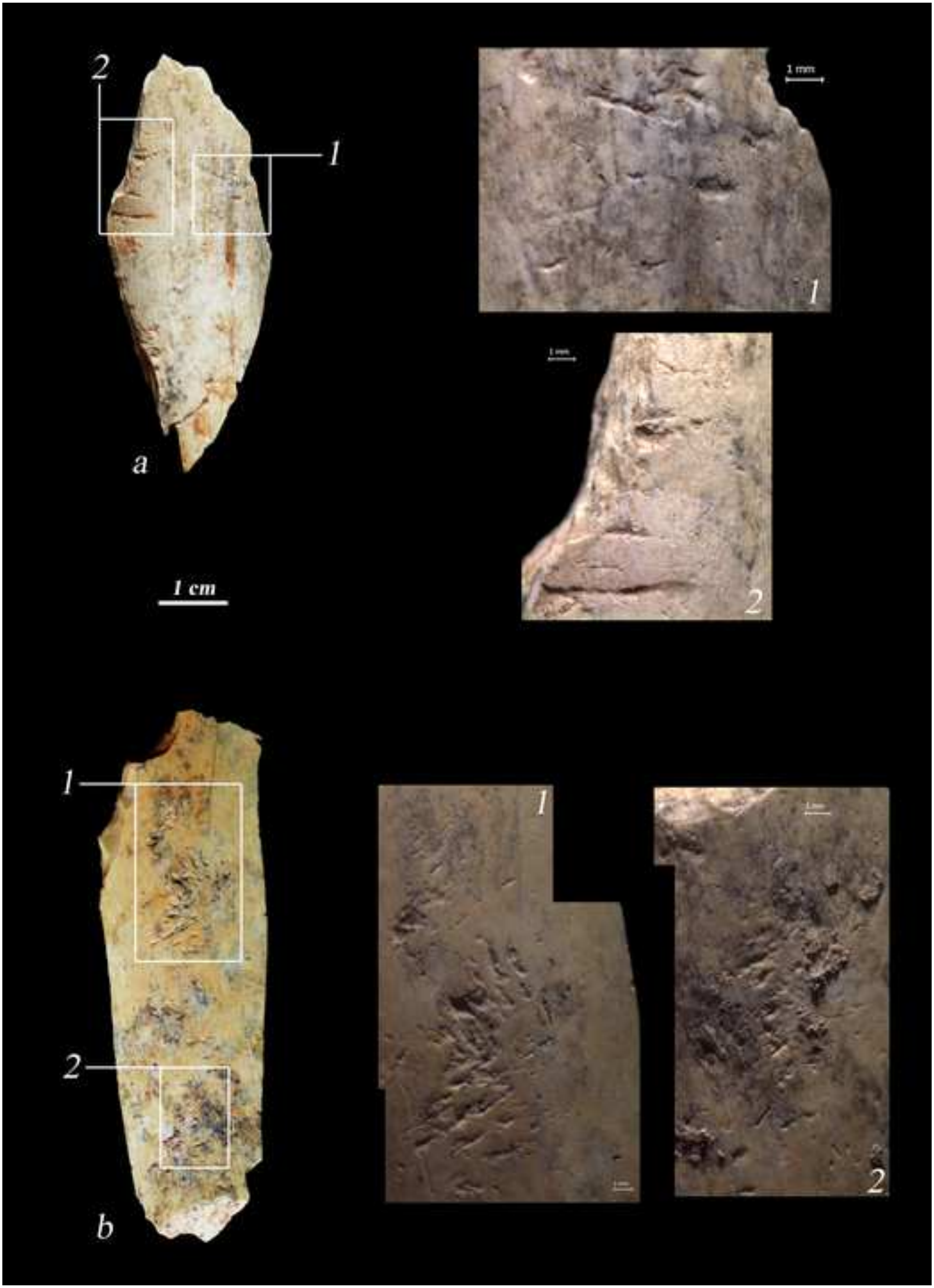

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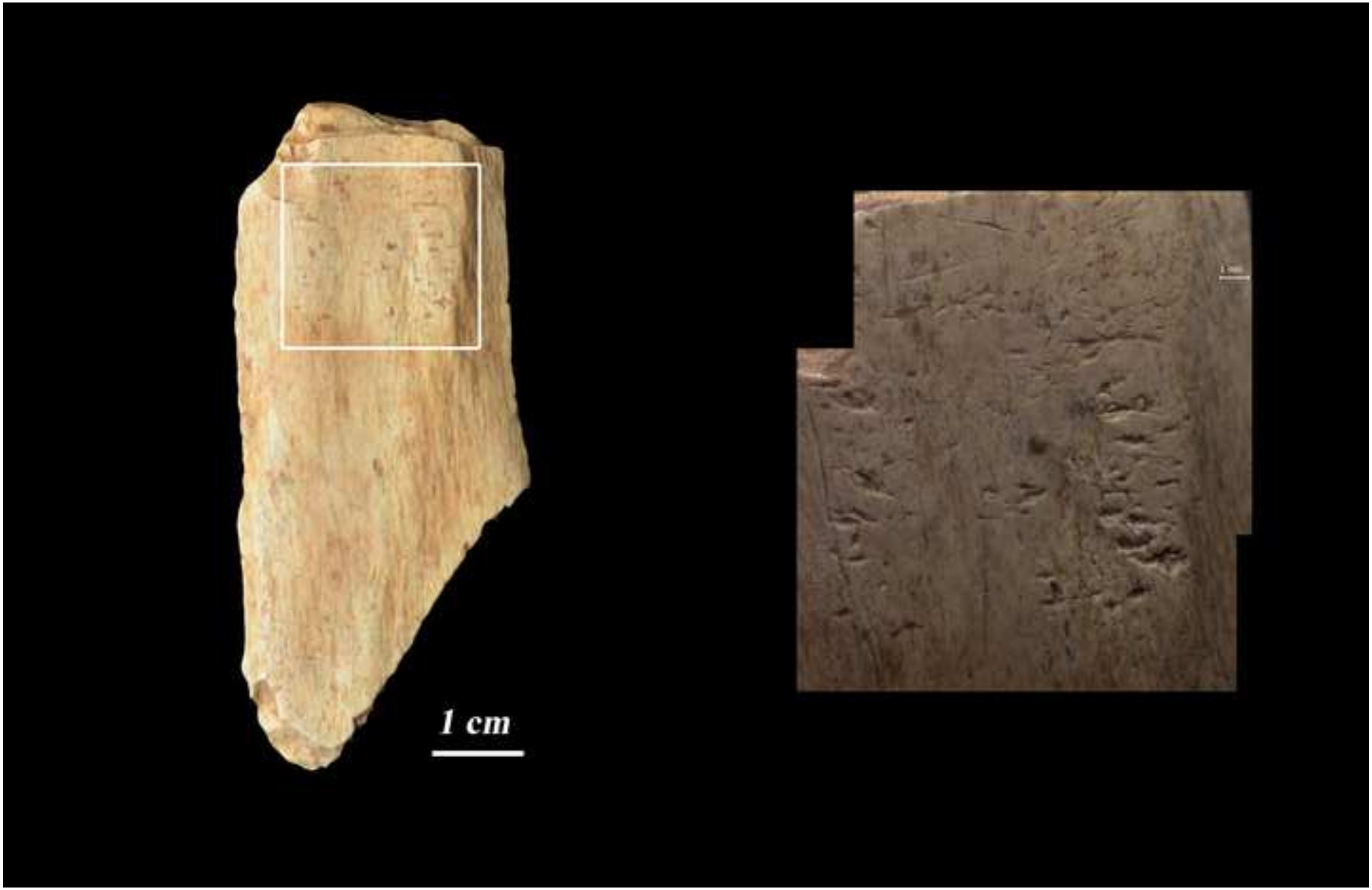
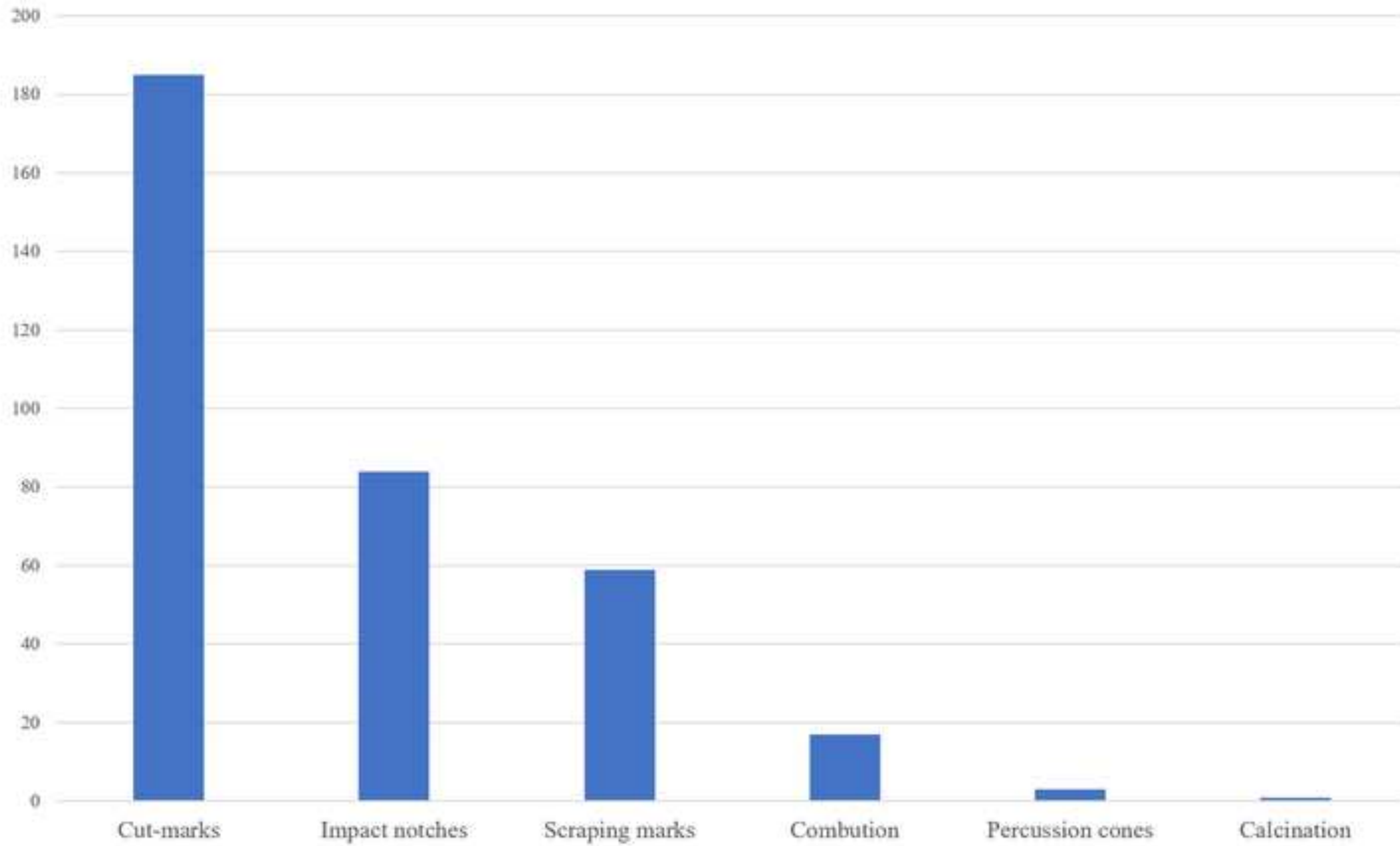


Figure 8


200
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Cut-marks
Impact notches
Scraping marks
Combution
Percussion cones
Calcination

Figure 9 Click here to access/download;Figure;Figure 9.jpg

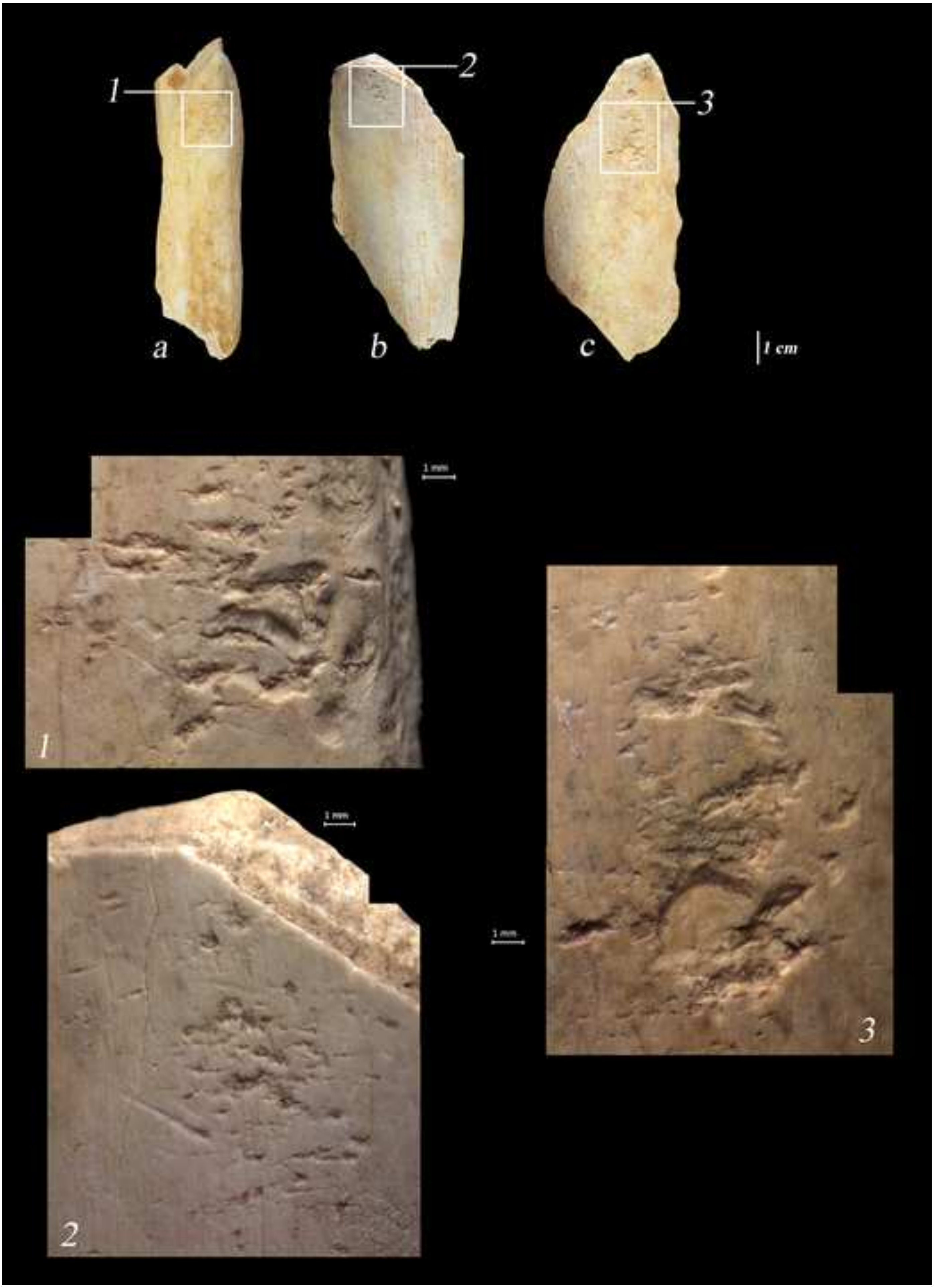

Figure 10

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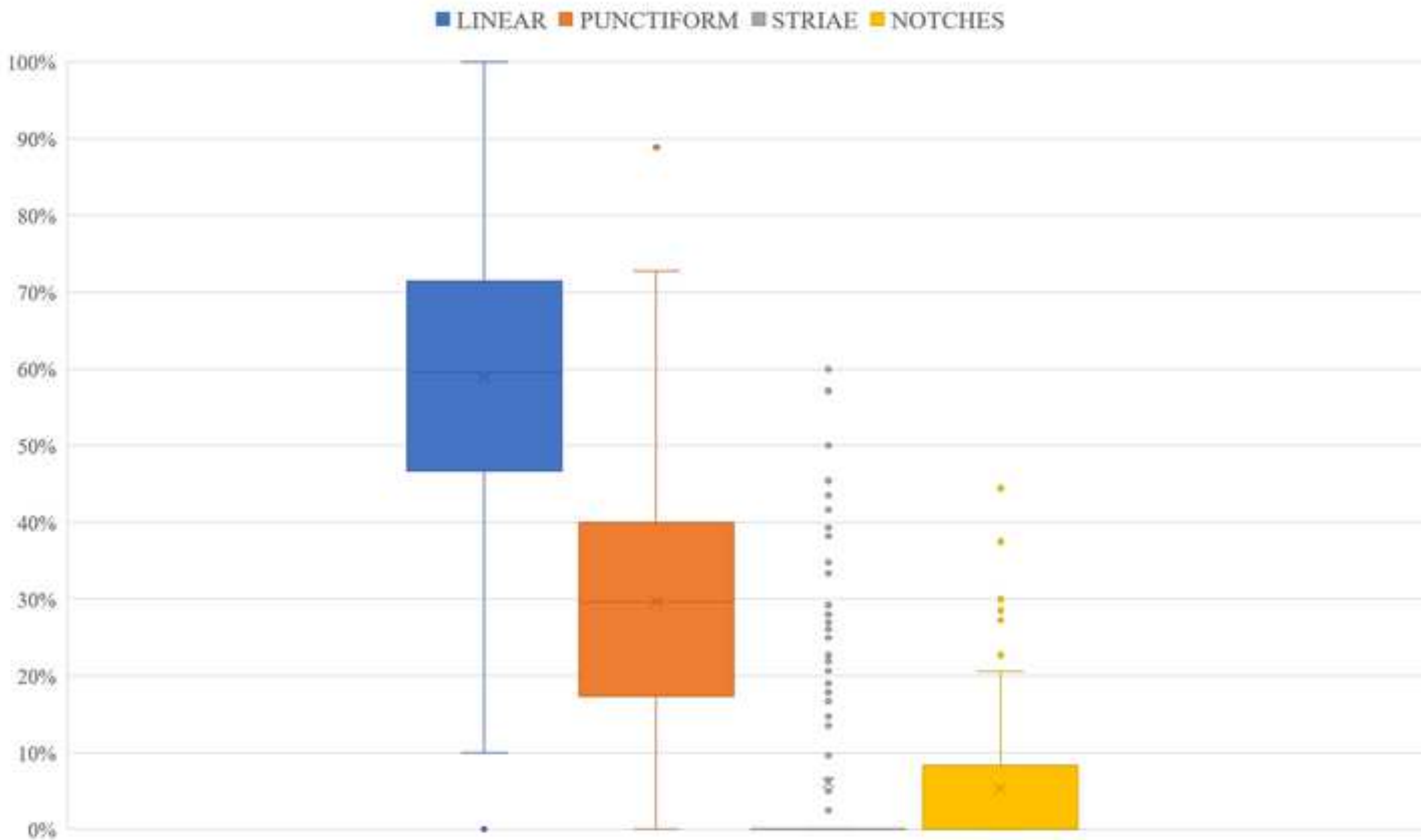
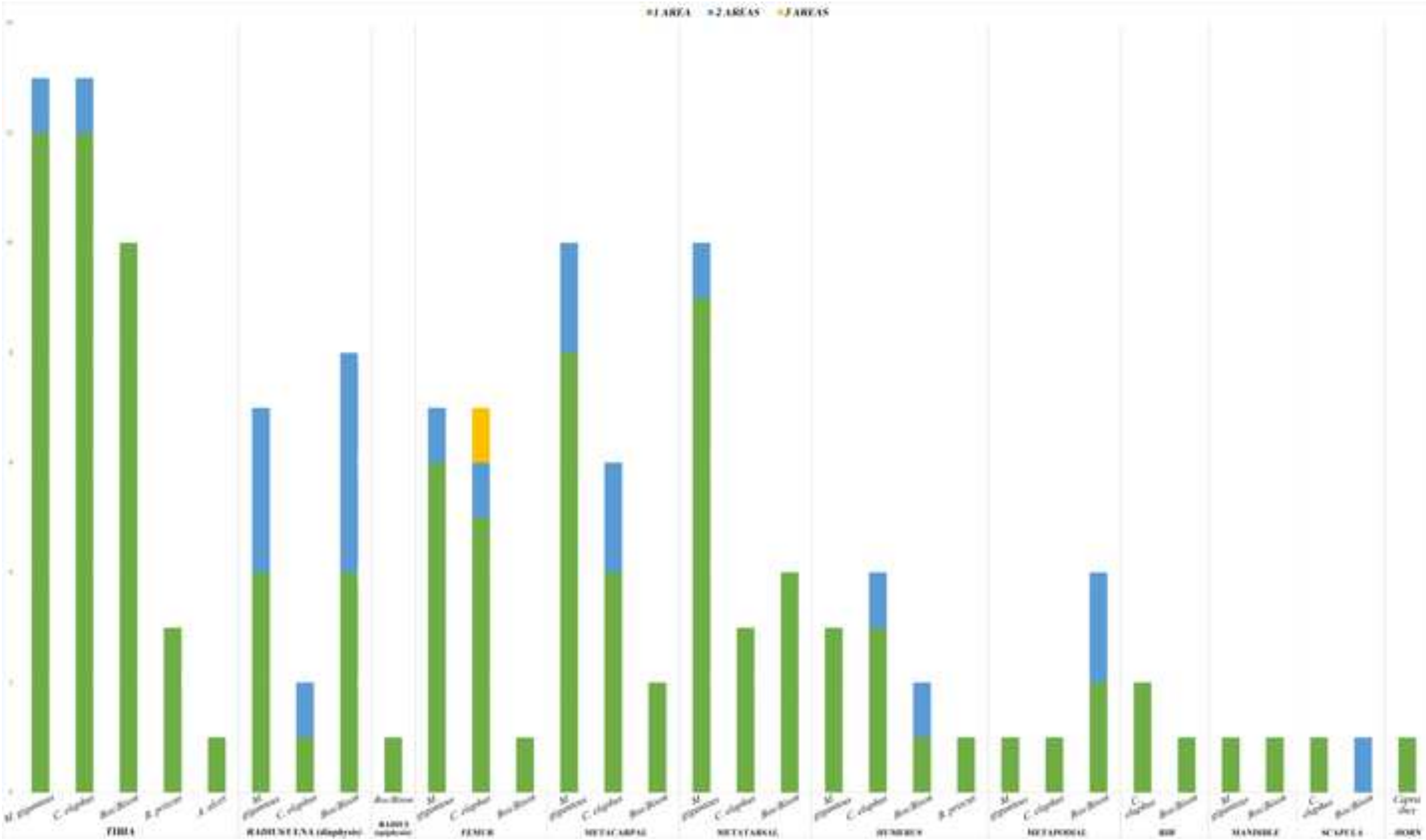


Figure 11



1 AREA
2 AREAS
3 AREAS
TIBIA
RADIUS-ULNA (diaphysis)
FEMUR
METACARPAL
METATARSAL
HUMERUS
METAPODIAL
RIB
MANDIBLE
SCAPULA
HORN

Figure 12

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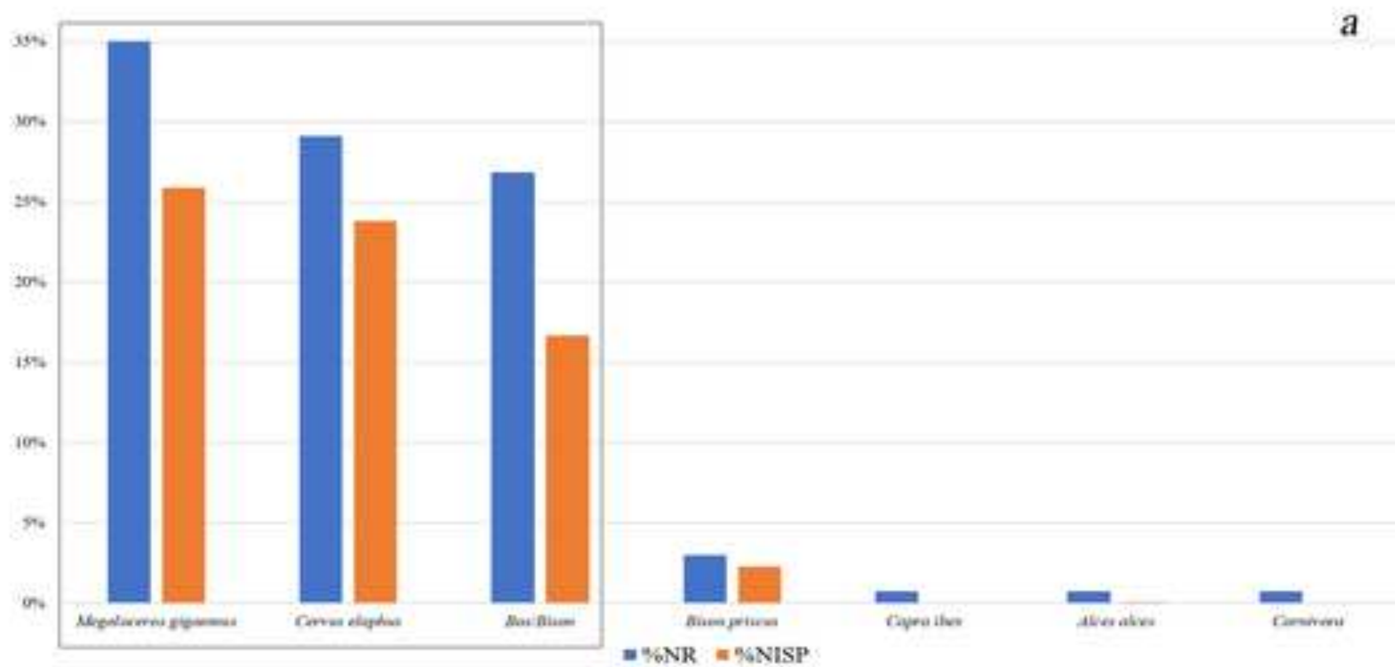

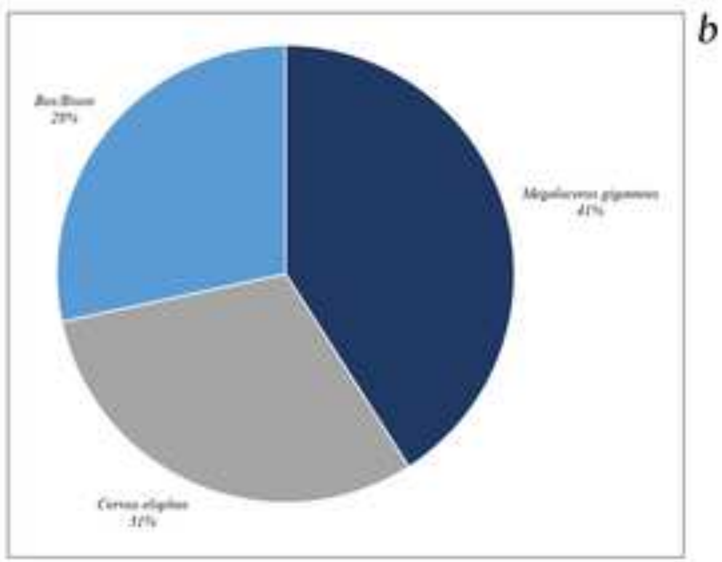

Figure 13

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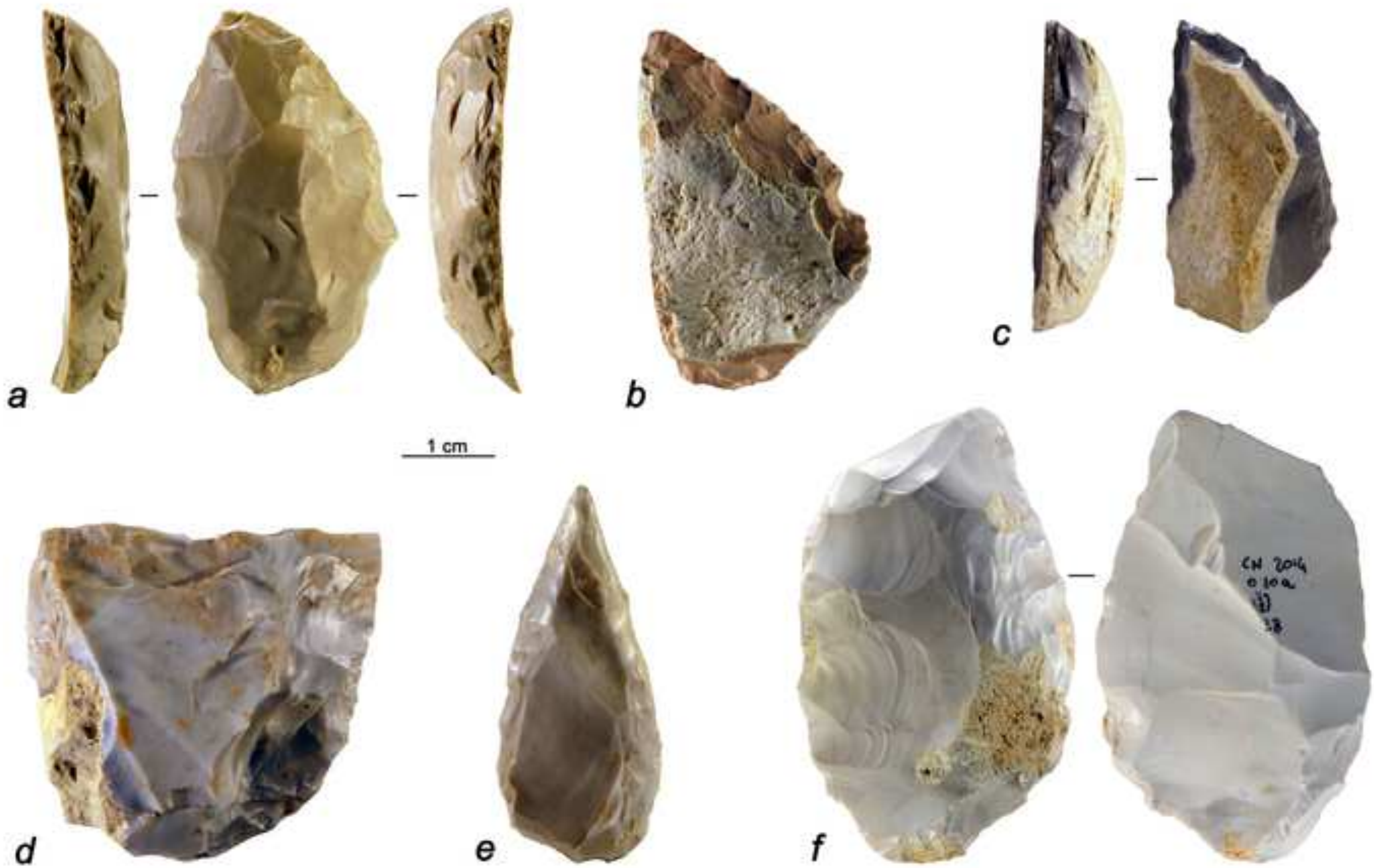

Figure 14

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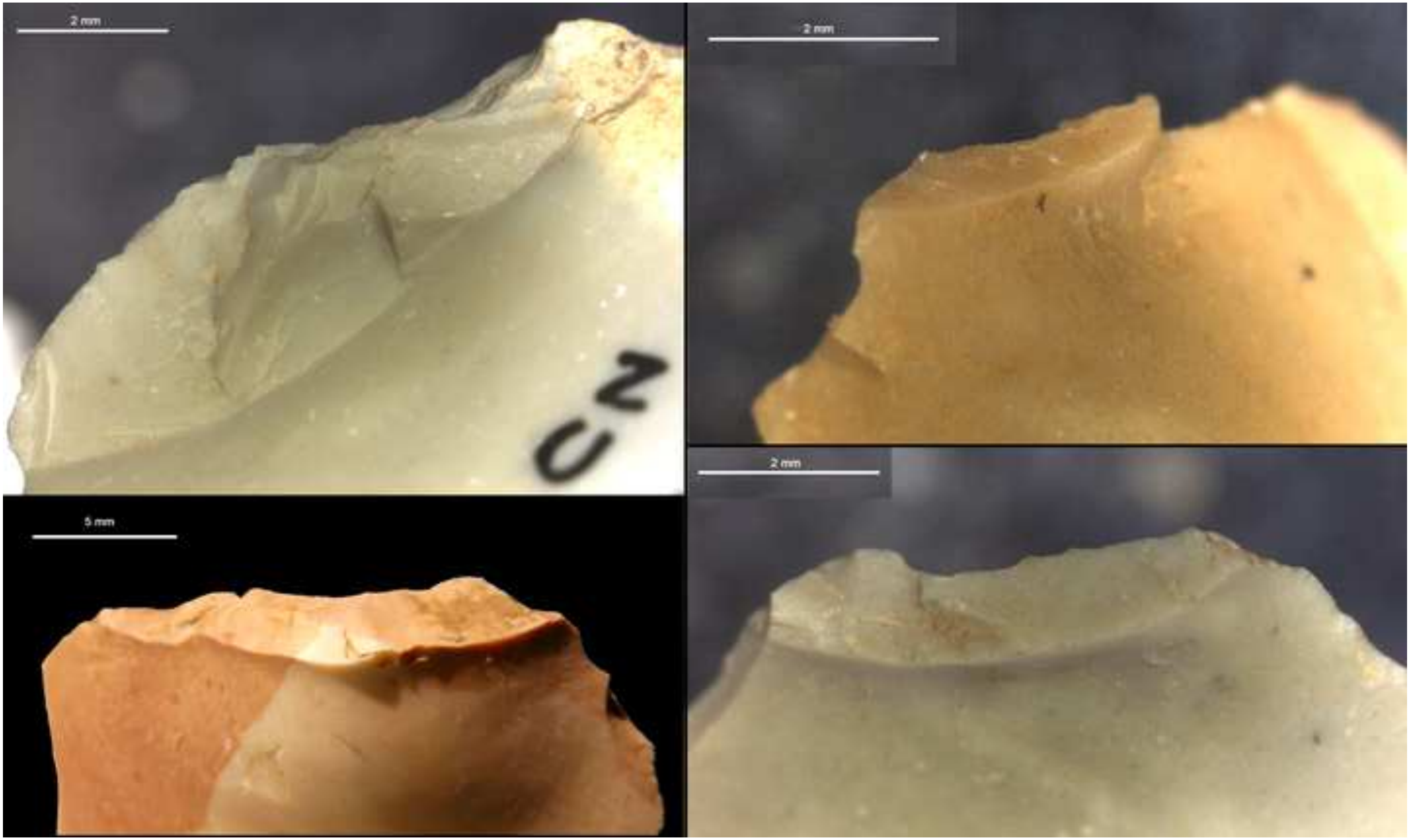

Tab. 1

Taxa	NISP	% NISP
Lepus europaeus	2	0.2
Lepus sp.	8	0.7
TOTAL Lagomorpha	**10**	**0.9**
Canis lupus	5	0.4
Vulpes vulpes	15	1.3
Ursus spelaeus	35	3.1
Ursus sp.	38	3.4
Meles meles	6	0.5
Mustelidae	1	0.1
Martes sp.	2	0.2
Felis sp.	2	0.2
Carnivora ND	35	3.1
TOTAL Carnivora	**139**	**12.3**
Sus scrofa	5	0.4
Alces alces	8	0.7
Megaloceros giganteus	292	25.9
Cervus elaphus	269	23.8
Capreolus capreolus	50	4.4
Cervidae	118	10.5
Bison priscus	26	2.3
Bos cf. *primigenius*	1	0.1
Bos/Bison	188	16.7
Capra ibex	2	0.2
Rupicapra rupicapra	9	0.8
Caprinae	12	1.1
Ungulata ND	2755	
TOTAL Ungulata	3735	
TOTAL NISP	**1129**	**100.0**

Tab. 2

	Units																		Tot
	1Rim		3		5		6		6tana		7		8		13		14		
	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	
Complete	9	11	1	33	1	17	3	31	-	-	13	12	1	20	3	8	4	15	35
Fragment	79	89	2	67	5	83	9	69	15	100	115	88	4	80	48	92	23	85	300
Total	88		3		6		12		15		128		5		51		27		335

Tab. 3

SPECIES	SIZE	SKELETAL ELEMENT	BONE PORTION	NR	% NR / NISP
Ungulata	large	indeterminate	diaphysis	142	12.6
Ungulata	large	rib	diaphysis	3	0.3
Ungulata	large	mandible	indeterminate	1	0.1
Ungulata	large	metapodial	diaphysis	1	0.1
Ungulata	large	humerus	diaphysis	1	0.1
Ungulata	large	tibia	diaphysis	4	0.4
Ungulata	large	femur	diaphysis	1	0.1
Ungulata	medium/large	indeterminate	diaphysis	9	0.8
Ungulata	medium	tibia	diaphysis	2	0.2
Ungulata	medium	rib	diaphysis	1	0.1
Ungulata	medium	indeterminate	diaphysis	1	0.1
Ungulata	indeterminate	indeterminate	diaphysis	8	0.7
Megaloceros giganteus	medium/large	mandible	body + M3	1	0.1
Megaloceros gignteus	medium/large	femur	diaphysis	7	0.6
Megaloceros gignteus	medium/large	metacarpal	diaphysis	10	0.9
Megaloceros gignteus	medium/large	metapodial	diaphysis	1	0.1
Megaloceros gignteus	medium/large	metatarsal	diaphysis	10	0.9
Megaloceros gignteus	medium/large	humeus	diaphysis	3	0.3
Megaloceros gignteus	medium/large	radius	diaphysis	6	0.5
Megaloceros gignteus	medium/large	radius/ulna	diaphysis	1	0.1
Megaloceros gignteus	medium/large	tibia	diaphysis	13	1.2
Cervus elaphus	medium/large	rib	diaphysis	2	0.2
Cervus elaphus	medium/large	femur	diaphysis	7	0.6
Cervus elaphus	medium/large	metacarpal	diaphysis	6	0.5
Cervus elaphus	medium/large	metapodial	diaphysis	1	0.1
Cervus elaphus	medium/large	metatarsal	diaphysis	3	0.3
Cervus elaphus	medium/large	humerus	diaphysis	4	0.4
Cervus elaphus	medium/large	radius	diaphysis	2	0.2
Cervus elaphus	medium/large	scapula	caudal	1	0.1
Cervus elaphus	medium/large	tibia	diaphysis	13	1.2
Bos/Bison	large	rib	diaphysis	1	0.1
Bos/Bison	large	mandible	body	1	0.1
Bos/Bison	large	femur	diaphysis	1	0.1
Bos/Bison	large	indeterminate	diaphysis	1	0.1
Bos/Bison	large	metacarpal	diaphysis	2	0.2
Bos/Bison	large	metapodial	diaphysis	4	0.4
Bos/Bison	large	metatarsal	diaphysis	4	0.4
Bos/Bison	large	humerus	diaphysis	2	0.2

SPECIES	SIZE	SKELETAL ELEMENT	BONE PORTION	NR	% NR / NISP
Bos/Bison	large	radius	diaphysis	6	0.5
Bos/Bison	large	radius	epiphysis	1	0.1
Bos/Bison	large	radius/ulna	diaphysis	2	0.2
Bos/Bison	large	scapula	caudal	1	0.1
Bos/Bison	large	tibia	diaphysis	10	0.9
Cervidae	medium/large	pelvis	ileum	1	0.1
Cervidae	medium/large	femur	diaphysis	3	0.3
Cervidae	medium/large	indeterminate	diaphysis	2	0.2
Cervidae	medium/large	metapodial	diaphysis	1	0.1
Cervidae	medium/large	metatarsal	diaphysis	1	0.1
Cervidae	medium/large	humerus	diaphysis	1	0.1
Cervidae	medium/large	radius	diaphysis	4	0.4
Cervidae	medium/large	tibia	diaphysis	7	0.6
Mammal indeterminate	indeterminate	indeterminate	diaphysis	4	-
Mammal indeterminate	medium	indeterminate	diaphysis	1	-
Mammal indeterminate	medium/large	indeterminate	diaphysis	2	-
Bison priscus	large	humerus	diaphysis	1	0.1
Bison priscus	large	tibia	diaphysis	3	0.3
Carnivora	large	indeterminate	diaphysis	1	0.1
Alces alces	large	tibia	diaphysis	1	0.1
Capra ibex	medium	horn	indeterminate	1	0.1

Tab. 4

	Length	Width	Thickness cortical bone
Minimum	54	20	5
Maximum	150	46	19
Average	88.7	30.4	8.9
Standard deviation	20.3	6.5	2.9

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.
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Sincerely,

On behalf of all authors