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ORIGINAL PAPER

The use of bone retouchers in a Mousterian context of Discoid lithic technology

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Abstract
Bone retouchers are an important behavioural marker in the definition of several Lower, Middle and Upper Palaeolithic cultural complexes. However, their relationship with the assemblages of knapped stone artefacts is still to be investigated particularly in specific but not uncommon lithic contexts of the Middle Palaeolithic in Europe. This paper offers insights to evaluate the use of bone retouchers in a context of Discoid lithic technology, a significant cultural expression largely spread in many regions during MIS3. The study case is the lithic and osseous assemblage of unit A9 at Fumane Cave, in north-eastern Italy. A detailed analysis of the bone retouchers is presented for the first time; their technological features are then correlated with the characteristic of the retouch observed on the lithic tools recovered in the same unit. The study contributes to complete a picture of Neanderthal economic behaviour.

Keywords Bone tool · Retouching · Discoid technology · Middle Palaeolithic · Italy · MIS3

Introduction

Bone retouchers are tools used in manufacturing stone tools, usually obtained by recycling the bones of butchered animals. These retouchers have been the subject of a large number of studies aimed to clarify their definition and using an experimental base, shed light on their function (see Armand and Delagnes 1998; Mozota Holgueras 2012; Hutson et al. 2018, and references therein). Even though they are not always considered in the studies about bone technology, these tools however show strong cross-cultural characteristics. In fact, bone retouchers (hereafter, retouchers) have been part of the human tool-kit since the Lower Palaeolithic, e.g. the Acheulo-Yabrudiuan complex of Qesem Cave (Blasco et al. 2013). Then, they had a massive spread during the Middle Palaeolithic in several Mousterian and other Middle Palaeolithic techno-complexes across Europe and Asia (Mozota Holgueras 2012; Daujeard et al. 2014; Hutson et al. 2018). Finally, their presence stretches until the Upper Palaeolithic, including Aurignacian (Tartar 2012) and Uluzzian (Jéquier et al. 2012) contexts.

Starting from this transversality, it would be interesting to investigate the evolution of human cultures through the technological features expressed by these tools, since the retouch activity, as other behavioural markers, could be closely related to a given cultural complex. That is, retouching is a very important step of the lithic *chaîne opératoire*, since its purpose is to either (1) create a lithic tool specialised for particular functions or aesthetic reasons or (2) reshape/recycling a damaged tool in order to extend its lifetime. Moreover, the features of the retouch-induced stigmata on the bone surface could be influenced by several factors—e.g. the ability of the knapper, the morphology of the lithic edge, the lithic raw material and the sought morphology of the lithic tool (Vincent 1993; Armand and Delagnes 1998; Tartar 2012). This latter parameter, especially, could be dependent on functional or cultural

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factors, or both. In the Mousterian, for example, it is possible to identify such variation among the retouchers recovered in lithic industries produced using the Quina and Levallois technologies. According to different characteristics of the stone tools, it has indeed been observed that retouchers associated with the Quina show a more intense modification than the Levallois. This results in different morphology and distribution of the stigmata, as well as some differences in the morpho-metric characteristics (Jéquier et al. 2012; Thun Hohenstein et al. 2018; Martellotta et al. in press).

An intimate comparison between the key features of retouchers and retouched tools seems to be rarely considered in the literature (e.g. Costamagno et al. 2018). This gap could be ascribable to several factors: sometimes the sample of retouchers recovered from an archaeological context is inadequate to be used in association with the lithic sample, for reasons concerning the amount of finds or the preservation state. In other cases, both the lithic and the faunal assemblage could be too copious, and thus requiring a great amount of time before all the findings are completely analysed. In some other cases, finally, the stratigraphic reliability of the context could be too weak to allow a comparison between different classes of artefacts.

To our knowledge, only a few authors attempted a different approach in Middle Palaeolithic contexts. Mallye et al. (2012) proposed an experimental program to understand the relationship between the stigmata features and the properties and availability of the lithic raw material (flint and quartzite). Some authors suggested a correlation between the amount of retouchers and the retouched tools, at La Quina—locus 2 (Chase 1990), Biache-Saint-Vaast—unit II (Auguste 2002), Les Pradelles—facies 4a (Costamagno et al. 2018) and Saint-Marcel in Ardèche—unit 7 (Daujeard et al. 2014). Finally, Neruda (2017) carried out, through GIS methods, a spatial analysis of the artefacts—including retouched lithic tools and retouchers—recovered from the layers 6a, 7a and 7c and the complex of layer 11 of Kůlna Cave (Czech Republic).

In this paper, we applied an interdisciplinary approach to compare the morpho-technological features of bone retouchers with the economic indicator of a very important cultural expression of the Middle Palaeolithic: the Discoid knapping technology. That is because the Discoid shows a remarkable complexity, both in the sense of core exploitation modalities (unifacial/bifacial) and technological choices and targets. The Discoid was initially defined in comparison with the Levallois method, as it was based on the volumetric exploitation of the core based on the design of the peripheral convexities (Boëda 1993). This definition has been through several changes during the years, which have shed light on the great internal variability of this technological procedure. Following its identification in several European contexts, it has come to identify an actual technological ground of the Mousterian complex widespread in the latest Middle Palaeolithic (see papers in Peresani 2003).

With this in mind, all the elements potentially useful for best defining the features of techno-complexes associated with the Discoid technology should be taken into account. In Europe, there are few sites where bone retouchers are exclusively associated, and at a discrete number, to a Discoid technologically based assemblage. Currently, the best known comes from Kůlna Cave (Neruda et al. 2011) and Fumane Cave (Jéquier et al. 2018), the latter being the subject of this study. In this paper, we investigate bone retouchers in relation to the retouched lithic tools recovered from unit A9, dated to a minimum age of 47.6 ky cal. BP.

Fumane, in the north-east of Italy, is not the only Italian site producing bone retouchers. Tagliente Shelter and Ghiacciaia Cave (Bertola et al. 1999; Thun Hohenstein et al. 2018), Rio Secco Cave (Peresani et al. 2014; Romandini et al. 2018), San Bernardino Cave (Giacobini and Malerba 1998) and De Nadale Cave (Jéquier et al. 2015, 2018; Martellotta et al. in press) have recovered a great amount of these items. At Fumane, retouchers appear throughout the stratigraphic sequence covering the Middle Palaeolithic and the Early Upper Palaeolithic, including the Uluzzian unit (Jéquier et al. 2012). A9 is an excellent context to consider for the purposes of this study, inasmuch as it contains numerous products of the Discoid industry in association with a great number of retouchers. According to the aim of this study, we will debate a poorly known aspect of the Neanderthal economical behaviour.

This comparison moves along a multidisciplinary axis, involving the technological analysis of the bone retouchers, the techno-morphological analysis of the retouched lithic industry and a first assessment on the spatial correlation of the bone and stone tools in the occupation area excavated at Fumane. Thanks to the excellent conditions of preservation, the number of findings is well above average, and the stratigraphic reliability that characterises most of the site allows also for a first exploration of the spatial correlations between these finds.

Materials and methods

At Fumane Cave, both the lithic (Peresani 2012; Delpiano et al. 2018, 2019) and the faunal (Peresani et al. 2011; Romandini et al. 2014; Terlato et al. 2019) assemblages from unit A9 have been extensively studied. Therefore, it is possible to frame the retouchers within a well-documented and articulated economic context, characterised by intense habitation by Neanderthal groups. To this day, the retouchers recovered in A9 have been summarily published (Jéquier et al. 2018), but they have never been included in a focused publication nor they have been put in correlation with the respective Discoid lithic assemblage.

Unit A9 at Fumane Cave

Fumane Cave is located 350 m above sea level on the Lessini Mountains (Verona, Italy) in the Veneto Pre-Alps. Systematic excavations during the last three decades exposed a stratigraphic sequence covering the Middle and Early Upper Palaeolithic with identification of Mousterian, Uluzzian and Aurignacian cultural complexes (Broglio et al. 2006; Peresani et al. 2008; Peresani 2012; Peresani et al. 2016). Unit A9 is embedded in the Late Mousterian sequence, sandwiched between sterile layer A7 on the top and layer A10I below, containing Levallois industry (layer A6 has also produced Levallois implements; Peresani 2012). The upper part of A9 was formerly labelled A8; it is now considered to be facies of A9. The excavation campaigns investigated the whole cave entrance and a large part of the cave mouth, leaving unexplored the inner cavity. According to excavation methodology, in Fumane Cave, the surface is divided in 1 × 1 m^2, identified by a number, which are in turn divided in nine 33 × 33 cm^2 squares, identified by a lowercase letter. The bone retouchers analysed in this study were found in almost the whole excavated area of A9 squares; the same holds for the stone tools. Diversely, the taxonomically determinable faunal remains belong to the assemblage analysed in a previous work (Romandini et al. 2014), thus leaving a small discrepancy between the retouchers and the faunal spectrum (Table 1). However, this variance does not affect in any significant manner the inferences regarding the utilisation of the faunal remains as retouchers, and it is therefore negligible.

Paleoclimatic and palaeoecological conditions have been inferred on the base of the micromammal assemblages of A9 (López-García et al. 2015). Radiocarbon dating assigned to the unit a minimum age of 47.6 ky cal. BP (Peresani et al. 2008; Higham et al. 2009). Finally, two deciduous teeth, belonging to a young Neanderthal individual, were recovered (Benazzi et al. 2014). Some of the materials selected for this study also come from unit A8.

The Discoid lithic assemblage

The lithic assemblage is composed of almost 9000 knapped products and by-products; the target of the discoid cores' exploitation were mainly thick flakes, pseudo-Levallois points, backed pieces with a sharp opposite edge, polygonal and triangular flakes and several retouched flakes (Peresani 1998, 2012; Delpiano and Peresani 2017).

Different types of raw material were used, and some blanks were recycled, in accordance with a complex economic organisation (Peresani et al. 2015; Delpiano et al. 2018, 2019). Use-wear analysis revealed that different flakes, both raw and retouched, were used for working soft, medium-hard and hard materials; some of them could also have been hafted (Lemorini et al. 2003; Delpiano et al. 2019).

Table 1 NISP and %NISP calculated among the whole faunal assemblage in A9

Taxa	NISP	NISP%	NMI
Mammalia			
Erinaceus europaeus	1	0.1	1
Marmota marmota	8	0.6	3
Mustela nivalis	4	0.3	2
Mustelidae	1	0.1	
Canis lupus	4	0.3	2
Vulpes vulpes	6	0.5	2
Ursus arctos	4	0.3	2
Ursus spelaeus	8	0.6	3
Ursus sp.	5	0.4	4
Crocuta crocuta spelaea	3	0.2	1
Panthera leo spelaea	1	0.1	1
Sus scrofa	2	0.2	2
Alces alces	17	1.4	3
Megaloceros giganteus	79	6.3	6
Cervus elaphus	495	39.3	14
Capreolus capreolus	281	22.3	11
Cervidae large size	166	13.2	
Bos primigenius	6	0.5	2
Bison priscus	6	0.5	3
Bos/Bison	29	2.3	
Capra ibex	46	3.7	4
Rupicapra rupicapra	68	5.4	6
Caprinae	19	1.5	
Total mammals NISP	1259	100	72
Ungulata	1137		
Identified by size	1631		
Unidentified	107,263		

For this study, a total of 354 retouched and/or thinned lithic tools were considered. The retouched tools mainly consisted of scrapers, but a few denticulates, notches and pointed tools were also present (Peresani 1998, 2012). In order to identify the Discoid pieces, morpho-metrical and morpho-technical analysis focused on all the elements that had a role in the reduction sequence (Delpiano et al. 2018). After a first screening of the whole collection, a total of 434 retouched and/or thinned tools were isolated and classified on a typological base. Some tools were left out of the analysis because the retouching or thinning detachments were not compatible with the percussion carried with organic retouchers, characterised by wide functional surfaces. Some morphological and technical features on the retouched edges, such as the sequence of removals, the longitudinal and transversal profile, the morphology, initiation and termination of scars and presence of incipient cones were considered in this selection. For instance, many denticulated tools present irregular edges' profiles with narrow and steep notches, only compatible with the use of a thin stone retoucher; furthermore, some backed tools bear traces of bipolar retouching carried out with stone retoucher and the use of an anvil, as experimentations would suggest (Delpiano et al. 2019). Then, the retouch was defined and described following the criteria established in the literature (Inizan et al. 1995):

- The position of the retouch—on one or both the surfaces of the flake; it could be direct, inverse, alternate, alternating, crossed or bifacial;
- The localisation of the retouch, looking at the tool oriented following its debitage axis; it could be distal, mesial, proximal, right, left or basal;
- The delineation of the retouched edge; it could be rectilinear, concave, convex, notched, denticulate, backed, regular or irregular;
- The angle of the retouched edge, which could be abrupt, crossed-abrupt, semi-abrupt or low;
- The morphology of the retouch negatives, based on which the retouch could be defined scaled, stepped, sub-parallel or parallel;
- The distribution of the retouch within each retouched edge; it could be continuous, discontinuous or partial;
- The extent of the retouch on the surface of the flake; it could be short, long, invasive or covering;
- The techno-functional area affected by retouch, following Lepot (1993); it could be the active/transformative portion of the tool, or the prehensive portion, given the presence of retouched backed tools in the A9 assemblage (Delpiano et al. 2019).

The faunal assemblage

The faunal assemblage in unit A9 shows a great variety of ungulates, carnivores and birds (Table 1). Each bone was anatomically and taxonomically determined using the complete Alpine faunal reference collection of the Section of Prehistory and Anthropological Sciences at the Department of Humanities of the Ferrara University. The majority of the faunal remains belongs to *Cervus elaphus* (NISP = 39.3%) and *Capreolus capreolus* (NISP = 22.3%). To a lesser extent, *Megaloceros giganteus* (NISP = 6.3%), *Rupicapra rupicapra* (NISP = 5.4%) and *Capra ibex* (NISP = 3.7%) are also present, followed by *Alces alces*, *Bison priscus* and *Bos primigenius*. *Vulpes vulpes*, *Canis lupus*, *Ursus arctos* and *Ursus spelaeus* are the most represented among the carnivores (Table 1).

In the mammal assemblage, when the identification of the species/genus/family or order was not possible, the remains were categorised on the basis of the cortical bone thickness and bone surface size: I—small (*Marmota marmota*, *Mustelidae*, *Vulpes vulpes*); II—small-medium (*Capreolus capreolus*, *Rupicapra rupicapra*, *Canis lupus*); III—medium (*Capra ibex*, *Sus scrofa*); IV—medium-large (*Cervus elaphus*, *Megaloceros giganteus*, *Alces alces*, *Ursidae*); V—large (*Bovinae*) (Table 1).

Lowland species include elk, giant deer, red deer, roedeer and wild boar that would have been found at lower elevations in open, sparsely forested environments, grasslands, wetlands and forests while mountain species include ibex and chamois at higher elevations or in rocky habitats. Bisons and aurochs can be found on the plain or above the timber line (7000–1000 m a.s.l.) not far from the site. The distinction between these types of habitats can be better defined considering the bird assemblage (Fiore et al. 2016; Romandini et al. 2016).

For uniformity with on-going studies on bone retouchers from Fumane and other Middle Palaeolithic sites in the region, this classification slightly deviates from the one applied in the zooarchaeological study of the A9 fauna assemblage previously published in Romandini et al. (2014). According to the ecological ungulate characteristics, the Fumane Cave could thus well be inserted in a context comparable with open-spaced forests, in conditions of transitive to discontinuous Alpine grasslands or pioneer vegetation on carbonate rocks.

The observation of the bone surfaces showed the presence of several butchering activities, preserved on all ungulates, including skinning, dismembering and filleting. The analysis of the cut marks and the skeletal element present in the unit revealed that the processing of the carcass started at the killing site, and it was then finished in the cave. Here, the human groups carried only the anatomical portions containing a greater nutritional intake (i.e. meat and marrow), such as limbs—especially for large cervids and bovids—and, to a lesser extent, the cranium (Romandini et al. 2014; Terlato et al. 2019). Finally, cut marks are also present on birds and large raptors and relate to consumption and extraction of wings and feathers (Peresani et al. 2011; Fiore et al. 2016; Romandini et al. 2016).

This picture therefore confirms that hunting activity was not specialised to target one or several selected taxa but was rather shaped by the game availability in the western Lessini.

The bone retouchers

The retouchers considered in the present study were isolated from the whole faunal assemblage recovered during the excavation campaigns from 2006 to 2012. The sample is currently located in the Department of Humanities of Ferrara University. It consists of 67 bone retouchers; of these, 8 show more than one use area, giving back a total of 75 use areas. Tibiae, femurs, metapodials, radii and humeri from red deer, roe deer, giant deer/moose and, to a lesser extent, from other ungulates, were used as retouchers, as previously revealed (Jéquier et al. 2018). The identification was carried out during the excavation stage or during the sieving as concerns the smaller fragments. The surfaces were observed to the human eye and portable 10X magnification lens, when necessary, with the aid of a stereomicroscope Leica S6D (magnification × 6.3–40X). The pictures of the use areas were taken using a camera Leica EC3 (scale in millimetres).

The maximum values of length and width (mm) were recorded for all the blanks. The weight (g) was recorded for the sake of completeness, considering this value underestimates the original one of the bones and cannot be used for speculations.

The preservation state of the bone surfaces did not prevent distinguishing the anthropic modifications from the ones caused by post-depositional animal activities (pits, punctures, scores, furrowing, scooping out etc.) and from the trampling and other mechanical modifications produced by the use of modern digging tools, referring to the well-established literature (see Romandini et al. 2014 for references). Among the anthropic traces, butchery marks were distinguished from the retouch-induced stigmata on the basis of their morphology, position and orientation. Butchering marks were classified as incisions and scraping marks. Anthropic marks related to the fracture of the bone for marrow extraction, such as percussion marks, impact flakes, peeling, percussion pits etc., were identified following a well-established literature (Potts and Shipman 1981; Bromage and Boyde 1984; Shipman and Rose 1984; Capaldo and Blumeschine 1994; Blumeschine and Selvaggio 1998; Blasco et al. 2013; Fernandez-Jalvo and Andrews 2016; Vattese et al. 2017).

The study of the retouch-induced stigmata was carried out following Mallye et al. (2012) and Mozota Holgueras (2012). The localisation of the use areas, the intensity of the retouch (defined as the degree of concentration of the stigmata in the use area) and the number of areas on each retoucher were recorded. The maximum length and width (mm) of the use areas were measured only for the complete ones—defined as areas which are not interrupted by any post-depositional fracture of the osseous blank. With regard to the orientation of the retouchers and the localisation of the use areas, the anatomical identification of the blanks was not taken into consideration; on the contrary, each retoucher was oriented on the basis of its major axis (i.e. its greater length); when a retoucher showed more than one use area (i.e. double retoucher), it was re-oriented and each area was analysed individually.

The stigmata were counted and grouped in four morphological categories:

– Pits: depression of the bone surface, triangular or ovoidal in shape; they could be associated to the impact between the bone surface and the dihedral morphologies related to the uneven lithic edge;
– Linear impressions: long, narrow, deep depressions, with a V-shaped asymmetrical section; they show a linear profile, which could also be sinuous, concave or convex; the inner surface could be rough or smooth; these marks could be associated with the impact between the bone surface and the sharp edge of the lithic flake;
– Retouch-induced striae: linear, or slightly curved, striations; they are short, shallow, often grouped and parallel to each other; they could result when the impact between the bone surface and the lithic edge has oblique direction: the blow is then arrested less abruptly and the lithic edge scratches on the bone surface;
– Notches: massive, deep and wide depressions, they could be defined as an erosion of the cortical bone caused by continued/repeated percussion; their morphology varies according to their extension and to the type of stigmata mainly present in the use area.

All of these morphological categories are often together in the same use area. With regard to the intensity of retouch, four categories were identified, according to (Mallye et al. 2012, Fig. 1c, p. 1133): (1) isolated, (2) dispersed, (3) concentrated and (4) concentrated and superimposed (hereafter, superimposed). During the analysis, both the morphological and the intensity criteria have not been modified in relation to the features of the retouched tools.

Results

Bone retouchers

Raw materials

We analysed 67 retouchers in total, of which 56.7% (NR = 38) was determined at a species level; among them, the red deer (NR = 28, 41.8% of the total assemblage) dominates the sample. The giant deer represents 9% of the assemblage (NR = 6). To a lesser extent, the chamois (3%, NR = 2), the moose (1.5%, NR = 1) and the roe deer (1.5%, NR = 1) are also present (Fig. 1). These results are only partially consistent with the general faunal spectrum recognised in A9 (Romandini et al. 2014): although the predominance of red deer is comparable, in the general assemblage, a greater amount of roe deer is present (Table 1), while in the retoucher assemblage, this species is represented only by one remain; 25.4% (NR = 17) of the assemblage could only be identified as ungulates, but it was possible to group the bone remains into size categories, showing that most of them belong to medium-large-sized animals. Finally, 13.4% of the sample was determined at a family level, revealing the presence of *Cervidae* (NR = 9).

We identified at a skeletal element level 68.7% (NR = 46) of the sample. Except for one mandible of red deer, the

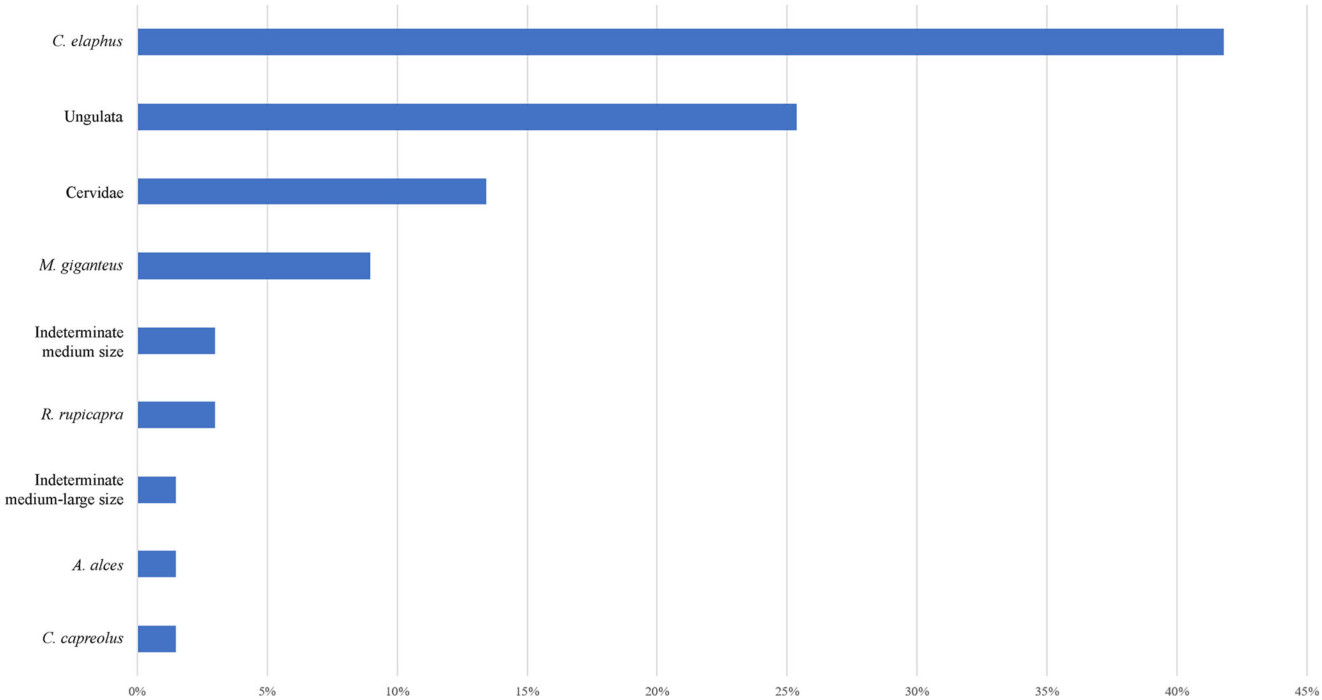

Fig. 1 Faunal spectrum of the bone retouchers in unit A9. The computations have been made taking into account the entire sample (NR = 67)

assemblage is entirely composed of long bones. Of these, tibia is the most represented skeletal element (23.9% of the total assemblage, NR = 16) then metatarsal (9%, NR = 6), radius (10.4%, NR = 7), metacarpal (7.5%, NR = 5), humerus (10.4%, NR = 7) and femur (4.5%, NR = 3). Finally, only one ulna was recognised. The entire sample—including the remains unidentified at a skeletal element level—is composed of diaphysis and no epiphyses were identified. We identified the specific portions of the diaphysis of the tibia, the radius/ulna and the humerus; however, this was not possible for femur and the metapodial bones. The frequency of the identifiable bone shaft portions used as retouchers varies depending upon the skeletal element (Fig. 2). Among the humeri, the mesial portion of the diaphysis is most represented, followed by the proximal portion (Fig. 2a); radii/ulnae result used in their entirety, with a slight predominance of the distal portion (Fig. 2b); finally, tibias show predominance of the mesial portion, while proximal and distal portions are equally distributed (Fig. 2c).

With regard to the metrical data, the analysed bone fragments show, on average, a length of 65.7 mm, a width of 23.3 mm and a thickness of the cortical bone of 6.8 mm; the average weight is 13.2 g. We are aware that some of the tools are fractured by post-depositional processes; therefore, these measurements are only indicative.

Regarding the taphonomy, the most common surface modification is the degradation due to root etching (33.3% of the total recognised taphonomical traces), followed by trampling traces (18.4%), carbonate concretions (16.3%) and manganese stains (14.2%). To a lesser extent, carnivores' tooth-marks (3.5%), abrasion agents (2.8%) and weathering (2.8%) traces were also recognised. Degree corrosion and weathering flaking (0.7%, respectively) are present in a very small amount. Finally, the 8.7% of the assemblage display burning traces. Although the remains from unit A9 are generally well preserved, in some cases (NR = 2), films of carbonate concretions cover some stigmata, compromising the observation of the areas in their entirety.

Traces of anthropic nature, due to butchering activities, were identified on all the analysed retouchers. Cut marks constitute 79.6% of the identified evidences. Some retouchers present impact notches (18.4% of the total identified traces), and one of them was recognised as a percussion cone. Finally, longitudinal scraping marks are observed on 32.8% (NR = 22) of the analysed bone retouchers. They are always located underneath the retouch-induced stigmata; they are long, shallow and parallel to the long axis of the shaft.

Use areas

Among the 67 analysed tools, 8 of them were used as double retouchers, giving back a total of 75 use areas (Table 2). Use areas are always located in correspondence to the extremity of the shaft. On double retouchers, in general, one area usually was more intensively used than the other, and the two areas are systematically set at diametrically opposed positions (Fig. 3a). Only one case, however, has two areas adjacent, and differentiates in the orientation of the linear impressions (Fig. 3b); 57.3% of the analysed use areas is complete, while the others are interrupted by post-depositional fractures. The

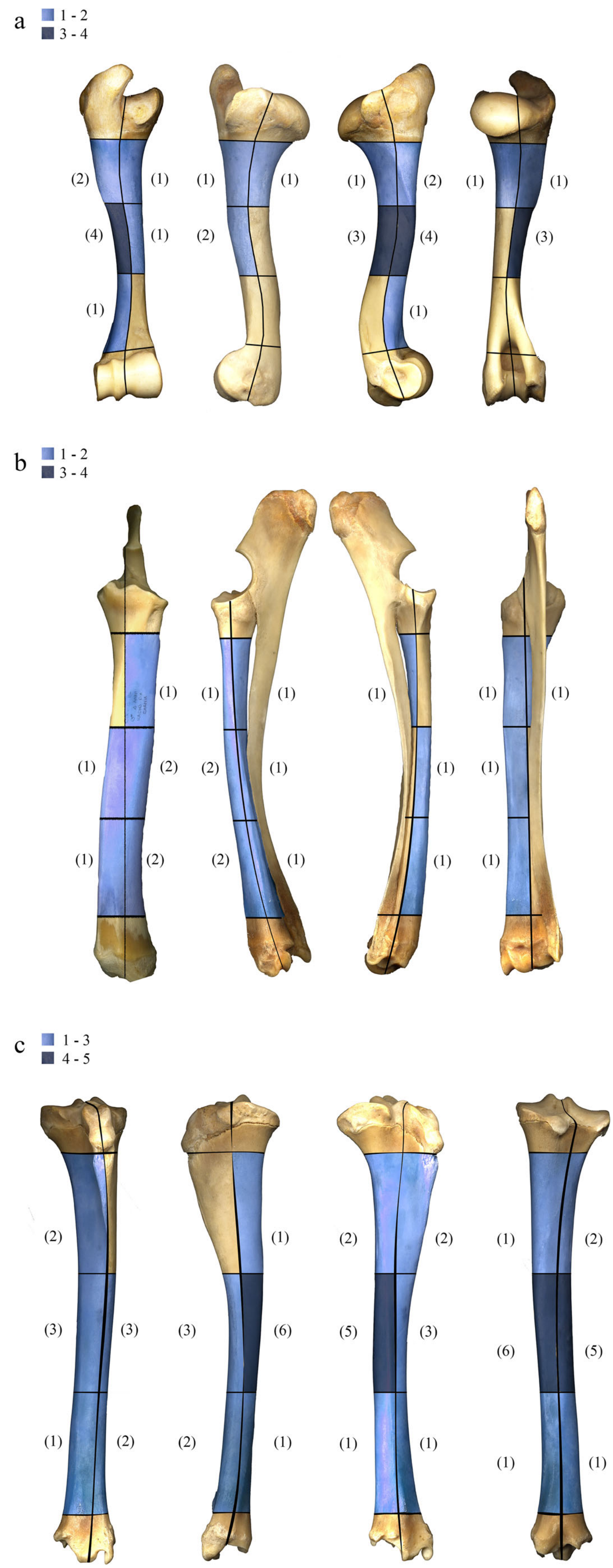

Fig. 2 Distribution of retouchers shaft portions: **a** humerus (NR = 5), **b** radius (NR = 4) and **c** tibia (NR = 12) of *Cervus elaphus*. The illustration takes into consideration only the identifiable shaft portions. Numbers between brackets indicate the number of portions represented

Table 2 Description of the studied bone retouchers

Number	#Code	Species	Size	Skeletal element	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Use areas					Retouch-induced stigmata					
									N	Complete	Length	Width	Cortical bone thickness	Linear	Punctiform	Striations	Notches	Scrapers marks	Retouch intensity
1760		*C. elaphus*	M-L	Femur	70	26	10	16.2	1	Yes	15	9	6	22	2	0	0	Yes	Concentrated
2144		*Cervidae*	M-L	Tibia	115	34	11	15.6	1	Yes	14	7	8	17	19	0	0	No	Dispersed
1480		*C. elaphus*	M-L	Tibia	98	28	7	17.6	1	Yes	14	7	5	15	8	0	0	No	Concentrated
61		*C. elaphus*	M-L	Humerus	59	40	12	33.2	1	Yes	12	13	7	27	15	0	0	Yes	Concentrated
	N3425	*Ungulata*	M-L	Indet.	78	22	8	15	2	Yes	18	7	8	15	12	0	1	No	Concentrated
	N3425	*Ungulata*	M-L	Indet.	78	22	8	15	2	Yes	7	6	8	4	5	0	1	No	Isolated
2156		*C. elaphus*	M-L	Radius	60	27	12	12.1	1	Yes	12	7	7	14	5	0	1	Yes	Concentrated
2182		*Cervidae*	M-L	Radius	89	25	6	14	1	Yes	16	11	5	22	5	2	2	No	Concentrated
3692		*M. giganteus*	M-L	Humerus	70	35	16	20	1	Yes	10	11	8	21	12	0	0	No	Superimposed
1263		*M. giganteus*	M-L	Tibia	109	30	32	44.4	1	Yes	15	11	7	29	25	7	0	Yes	Concentrated
1695		*C. elaphus*	M-L	Tibia	90	24	13	19.7	1	Yes	9	7	8	6	7	4	0	No	Concentrated
3672		*M. giganteus*	M-L	Tibia	82	41	9	26.5	1	Yes	16	9	6	9	7	0	0	Yes	Concentrated
2373		*C. elaphus*	M-L	Femur	118	30	14	26	1	Yes	7	8	5	6	8	0	0	No	Dispersed
	N1217	*Cervidae*	M-L	Tibia	81	28	13	22.7	2	Yes	14	7	8	12	10	0	2	No	Superimposed
	N1217	*Cervidae*	M-L	Tibia	81	28	13	22.7	2	Yes	17	10	8	7	11	15	0	No	Dispersed
335		*C. elaphus*	M-L	Metatarsal	85	17	17	21.8	1	Yes	13	9	12	16	20	0	1	Yes	Concentrated
1943		*C. elaphus*	M-L	Tibia	62	22	12	12.7	2	Yes	11	6	5	13	11	0	0	No	Dispersed
1943		*C. elaphus*	M-L	Tibia	62	22	12	12.7	2	Yes	7	6	7	6	5	0	0	No	Dispersed
	N3186	*C. elaphus*	M-L	Metatarsal	119	28	19	42.2	1	Yes	15	12	7	25	12	0	0	No	Concentrated
1696		*C. elaphus*	M-L	Tibia	49	21	8	10	1	No	–	–	6	3	0	0	0	No	Indet.
1978		*M. giganteus*	M-L	Metatarsal	77	27	14	26.5	1	No	–	–	8	2	0	0	1	No	Concentrated
484		*C. elaphus*	M-L	Metacarpal	57	24	13	17.4	1	Yes	7	6	8	10	4	0	1	No	Concentrated
927		*C. elaphus*	M-L	Metacarpal	92	17	12	15.6	1	No	–	–	7	6	5	0	0	No	Dispersed
	N3187	*C. elaphus*	M-L	Metacarpal	50	22	13	10.8	1	No	–	–	7	6	0	0	1	No	Concentrated
	N1400	*Ungulata*	S-M	Indet.	38	13	4	1.8	1	No	–	–	3	11	9	0	0	No	Dispersed
	N2172	*C. elaphus*	M-L	Femur	74	28	13	17.5	1	Yes	10	8	6	16	14	0	0	Yes	Concentrated
	N1964	*Cervidae*	M-L	Indet.	56	16	9	7	1	No	–	–	8	18	6	0	1	No	Concentrated
	N2675	*R. rupicapra*	S-M	Tibia	68	18	14	3.9	1	Yes	7	9	4	17	19	0	0	No	Superimposed
963		*C. capreolus*	S-M	Tibia	80	18	10	9.4	1	Yes	25	9	5	12	11	0	1	Yes	Concentrated
	N552	Indet.	M-L	Indet.	22	8	8	1.5	1	No	–	–	8	5	5	0	0	Yes	Dispersed
1217		*C. elaphus*	M-L	Indet.	61	32	10	13.2	1	No	–	–	6	13	9	0	0	Yes	Dispersed

Table 2 (continued)

Number	#Code	Species	Size	Skeletal element	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Use areas					Retouch-induced stigmata					
									N	Complete	Length	Width	Cortical bone thickness	Linear	Punctiform	Striations	Notches	Scrapers marks	Retouch intensity
1400		*Cervidae*	M-L	Humerus	88	36	13	26.3	1	Yes	12	8	7	6	9	0	0	Yes	Concentrated
4241		*Cervus elaphus*	M-L	Humerus	63	43	18	21.3	2	Yes	12	5	5	6	4	0	1	No	Dispersed
4241		*C. elaphus*	M-L	Humerus	63	43	18	21.3	2	No	–	–	–	11	4	0	0	No	Concentrated
896		*M. giganteus*	M-L	Radius	50	22	12	12.3	1	Yes	10	3	10	6	6	0	0	No	Dispersed
2276		*C. elaphus*	M-L	Radius	60	26	10	11.8	1	No	–	–	6	3	9	0	0	No	Dispersed
	N919	*Cervidae*	M-L	Humerus	75	22	8	12.6	1	No	–	–	6	11	11	0	1	Yes	Concentrated
3903		*Ungulata*	M-L	Indet.	36	36	13	7	2	Yes	7	4	7	5	10	0	0	No	Concentrated
3903		*Ungulata*	M-L	Indet.	36	36	13	7	2	Yes	5	4	7	6	4	3	0	No	Concentrated
	N1684	*Ungulata*	M	Indet.	34	19	6	3.9	1	No	–	–	4	15	20	0	1	Yes	Concentrated
	N1279+ N18-30	*Ungulata*	S-M	Indet.	48	18	4	3.3	1	No	–	–	4	30	10	0	0	No	Concentrated
	N3149	*Ungulata*	S-M	Indet.	38	8	3	0.7	1	No	–	–	2	10	0	0	0	No	Dispersed
1456		*Ungulata*	M-L	Indet.	73	20	11	10	1	Yes	11	11	7	6	3	4	0	No	Isolated
	N3253	*C. elaphus*	M-L	Radius	101	21	18	24.6	1	Yes	11	8	6	22	7	0	0	Yes	Dispersed
	N1580	Indet.	M	Indet.	43	4	7	1.9	1	No	–	–	7	6	7	0	0	No	Indet.
	N1386	*Ungulata*	S-M	Indet.	28	18	4	1.4	1	No	–	–	3	7	10	0	0	Yes	Isolated
	N788	*Ungulata*	S-M	Indet.	44	12	8	5.2	1	Yes	6	7	6	8	8	0	0	No	Concentrated
2472		*Alces-Megaloceros*	M-L	Metatarsal	47	24	9	9.1	1	No	–	–	7	17	1	0	0	No	Dispersed
1544		*Ungulata*	M-L	Indet.	73	19	10	8.4	1	Yes	14	6	9	17	2	3	0	No	Concentrated
1596		*C. elaphus*	M-L	Tibia	74	26	12	17.9	2	Yes	15	6	8	4	5	0	3	No	Superimposed
1596		*C. elaphus*	M-L	Tibia	74	26	12	17.9	2	Yes	19	14	8	8	10	3	0	No	Dispersed
	N2097	*R. rupicapra*	S-M	Tibia	55	18	11	7.7	1	Yes	8	7	5	3	8	0	1	No	Superimposed
380		*Ungulata*	M	Indet.	64	17	7	6.7	1	Yes	19	8	5	16	2	0	0	Yes	Isolated
	N216	*Cervidae*	M-L	Indet.	48	20	9	8.1	2	Yes	15	5	8	17	2	0	0	No	Dispersed
	N216	*Cervidae*	M-L	Indet.	48	20	9	8.1	2	No	–	–	8	6	3	7	3	No	Dispersed
3353		*C. elaphus*	M-L	Radius	71	16	10	11.4	1	Yes	10	6	8	0	1	9	0	No	Isolated
4753		*Ungulata*	M-L	Indet.	45	9	9	5	1	No	–	–	8	7	6	0	0	No	Dispersed
	N235	*Cervidae*	M-L	Tibia	59	23	12	15.8	1	No	–	–	10	0	4	0	0	No	Isolated
1770		*C. elaphus*	M-L	Tibia	76	20	12	14.4	1	Yes	11	6	9	14	5	0	0	Yes	Concentrated
2250		*C. elaphus*	M-L	Mandible	75	18	7	9.2	2	No	–	–	7	12	9	0	0	Yes	Concentrated
2250		*C. elaphus*	M-L	Mandible	75	18	7	9.2	2	No	–	–	7	24	25	0	0	Yes	Dispersed

Table 2 (continued)

Number	#Code	Species	Size	Skeletal element	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Use areas					Retouch-induced stigmata					
									N	Complete	Length	Width	Cortical bone thickness	Linear	Punctiform	Striations	Notches	Scrapers marks	Retouch intensity
1303		*Ungulata*	M-L	Indet.	91	15	8	12	1	No	–	–	8	8	1	0	0	No	Dispersed
	N2550	*M. giganteus*	M-L	Metatarsal	81	37	21	24	1	Yes	12	10	11	22	11	0	0	No	Isolated
1399		*C. elaphus*	M-L	Metacarpal	51	22	10	9.6	1	Yes	7	4	8	5	6	0	0	No	Dispersed
1775		*Cervidae*	M-L	Metatarsal	68	28	14	6	1	Yes	6	7	6	11	1	0	0	Yes	Dispersed
1114		*Ungulata*	M-L	Indet.	62	26	10	12.6	1	No	–	–	6	17	6	0	0	No	Concentrated
	N447	*Ungulata*	M-L	Tibia	45	9	8	3.5	1	No	–	–	8	10	5	10	0	No	Concentrated
	N2313	*C. elaphus*	M-L	Humerus	39	31	9	7.6	1	No	–	–	5	15	12	0	0	Yes	Concentrated
	N1814	*A. alces*	M-L	Ulna	49	14	8	6.1	1	No	–	–	8	8	0	0	0	No	Dispersed
	N867	Indet.	M	Indet.	23	12	5	1.4	1	No	–	–	4	8	6	0	0	No	Concentrated
	N2073	*Ungulata*	M-L	Indet.	44	10	7	2.5	1	No	–	–	5	19	6	0	0	No	Dispersed
1847		*C. elaphus*	M-L	Tibia	96	38	12	20	1	No	–	–	6	6	2	0	0	No	Dispersed
	N2352	*C. elaphus*	M-L	Metacarpal	85	25	12	20.8	1	Yes	10	10	7	21	14	0	0	Yes	Superimposed
	N2156	*C. elaphus*	M-L	Radius	46	19	11	7.8	1	No	–	–	8	5	10	0	0	No	Dispersed
	N3424	*C. elaphus*	M-L	Humerus	55	27	10	11.6	1	No	–	–	6	15	11	0	2	No	Concentrated

Double retouchers have been analysed separately: their reference number shows is set in italics for the study of the primary use area and in bold for the secondary use area. The remains were categorised based on the cortical bone thickness and bone surface size (small (S); small-medium (S-M); medium (M); medium-large (M-L); large (L)). The length and the width of the uncompleted use areas were not recorded

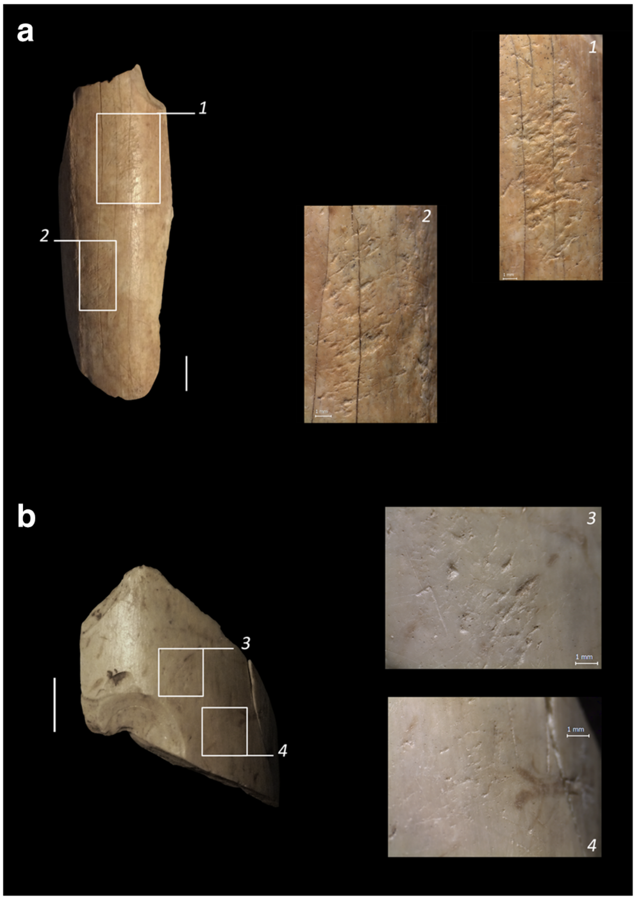

Fig. 3 **a** *Cervidae*, tibia (fragment), used as a double retoucher; the two areas are located on the two extremities of the shaft, and the difference between the more (1) and less (2) intensively used areas is observed; **b** fragment of a shaft of a medium-large-sized ungulate, bearing two adjacent use areas with different spatial distributions and orientations of the stigmata (scale = 1 cm)

length of the complete areas ranges from 5 to 25 mm, and the width goes from 3 to 14 mm.

With regard to the morphology of the stigmata, the linear impressions prevail (56.8% of the total recognised stigmata), while the punctiform impressions consist of 37.3%; the striations are present at a lower rate (4.3%), and they are always associated with other categories of stigmatas; the notches represent only 1.6% of the retouch-induced stigmata (Table 2). The liner impressions (Fig. 4a) are often marked and deep, as well as the punctiform impressions (Fig. 4b). When present, the striations are shallow, grouped and parallel to each other. Finally, notches are rare, and they appear well defined, wide and deep only in few cases (Fig. 4c).

The intensity of retouch was also taken into consideration (Table 2). The majority of the stigmata is concentrated (44% of the retouchers), followed by dispersed (36%), isolated (9.3%) and superimposed (8%). On only two retouchers, the intensity was not definable, either because the bone fragment was too small or the surface too altered.

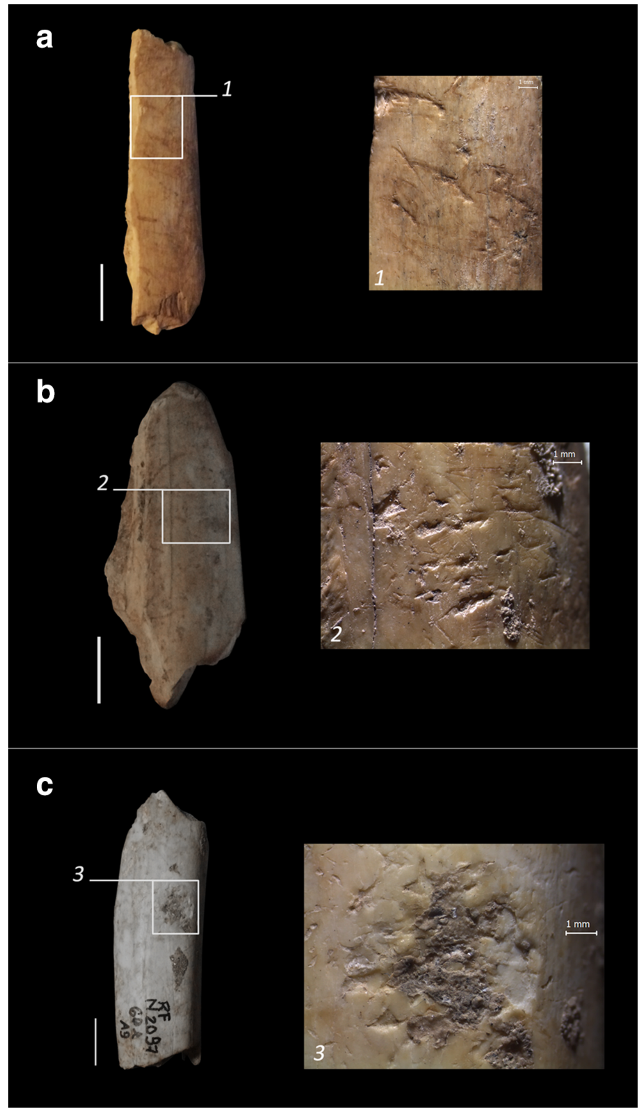

Fig. 4 Morphological categories of stigmata: **a** use area mostly composed of linear impressions, located on a fragmented ulna of *Alces alces*; **b** use area mostly composed of punctiform impressions, identified on a fragmented radius of *Cervus elaphus*; **c** use area mostly composed of notches, identified on a fragmented tibia of *Rupicapra rupicapra* (scale = 1 cm)

Carrying out a correlation between the stigmata's morphological categories and the skeletal elements, some patterns emerge. First of all, the striations are present only on tibias (NR = 16, of which 5 have striations) and radii (NR = 7, of which 2 have striations) (Table 2). Furthermore, a difference in the percentages between the linear and the punctiform impressions could be observed in relation to the skeletal element. In fact, looking at both tibia and humerus (see Fig. 2 for the frequency of the bone shaft portions), there is a short percent variance between the two morphological categories—i.e. linear and punctiform impressions are present in similar amounts on these two skeletal elements.

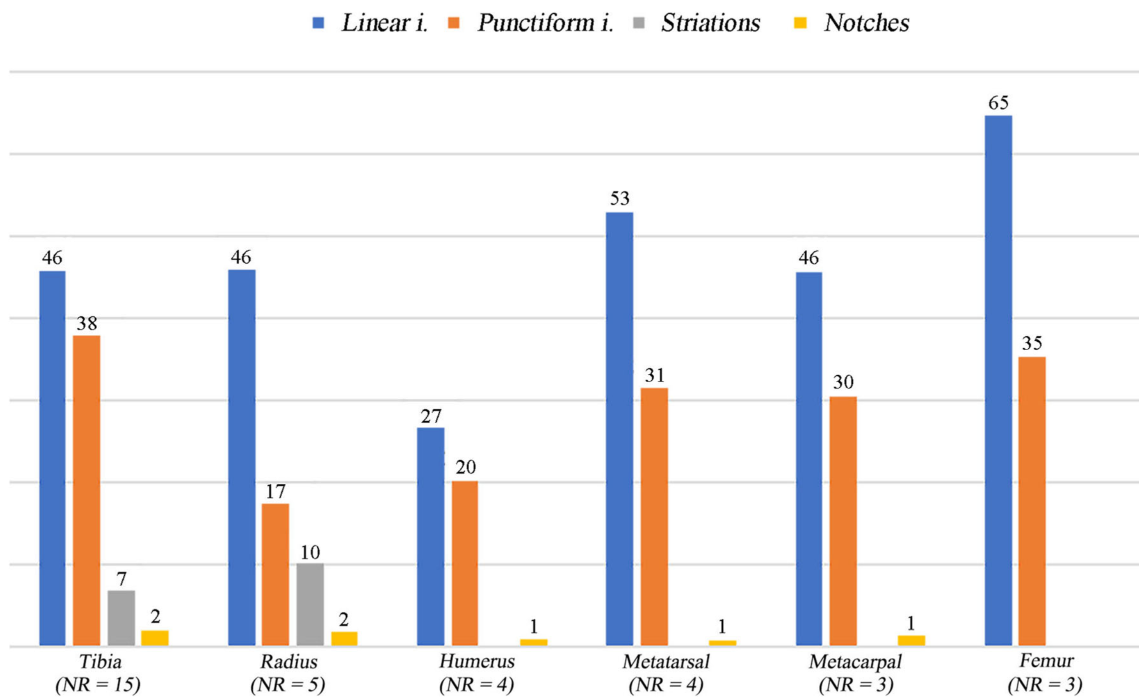

Fig. 5 Distribution of the four morphological categories of stigmata to the skeletal element; linear and punctiform impressions have similar incidence on both tibias and humeri, but the percent variance is less evident on radii and femurs; moreover, striations are present only on tibias and radii. Computations are based only on the complete used areas observed on the remains defined at a skeletal element level (NR = 34)

However, looking at the radius (and, to a lesser extent, the femur), the percent variance is wider—i.e. the linear impressions are much more abundant than the punctiform ones (Fig. 5).

Lithic assemblage

Raw materials and blanks

On a total of 354 analysed retouched artefacts, 324 (91.5%) are manufactured in local cherts attributable to Cretaceous formations. Among these, the most common is the Maiolica (NR = 194), followed by Scaglia Variegata Alpina (SVA) (NR = 76) and Scaglia Rossa (NR = 54). The rate of SVA chert is relatively high (21.5% of the total tools), especially if compared with the relative amount in the whole lithic assemblage of A9 (10.9%). A preference of SVA for longer-life tools could be hypothesised, but their use in prolonged expeditions can only be conjectured in the absence of specific petrographic analysis. Particularly as SVA outcrops are located within a few kilometres of the site. However, SVA facies with yellowish-green finely textured chert, while they are not very common in local outcrops, they were selected to produce retouched tools maybe for aesthetic reasons.

In the same way, semi-local and allochthonous raw materials are slightly more represented in the retouched tools' assemblage (8.2%) compared with the whole unit. These include Eocenic, Oolitic and Rosso ad Aptici cherts. For these materials, targeted exploitation was recognised through specific former studies (Delpiano et al. 2018); semi-local cherts, outcropping between 5 and 10 km from the site, were introduced after partial configuration and core shaping or, in the case of Oolitic chert, as cores-on-flake blanks. In this case, the reduction was carried through a Discoid operational sequence applied to flake blanks, a so-called Kombewa-type Discoid (Bourguignon and Turq 2003).

With regard to the raw blanks, these are mainly flakes whose dimensions well characterise the assemblage, being averagely short (38.8 mm) and relatively wide (27.5 mm) and thick (9.6 mm). Cortical flakes are very common in the assemblage (NR = 130), including 27 samples with cortex on over 50% of the surfaces: these blanks were mainly used for scrapers and, to a lesser extent, denticulated tools. Twenty-three flakes with cortical back were also exploited for retouching, mainly for prepared backed tools, taking advantage of the raw back. The high productivity of Discoid technology is thus confirmed from the first reduction stages. Moreover, the so-called cordal products are manufactured during the advancement of the reduction: among these, 28 core-edge-removal flakes and 17 pseudo-Levallois points were retouched and included in our sample; also, in this case, the re-configuration of the technical back through retouch was the main goal of the knappers (Delpiano et al. 2019). Around 60 centripetal and unidirectional flakes were retouched in order to manufacture scrapers or marginally retouched flakes, as well as 6 artefacts produced with knapping on parallel planes (Levallois technology). Backed tools are also common among the 25 sampled Kombewa-type flakes, while around 15 retouch and resharpening flakes of scrapers and denticulated tools are also present.

Retouch analysis

As regard to the tool's typology, scrapers prevail in the assemblage (NR = 122); among the non-fragmented, simple scrapers (NR = 53) dominate over transversal (NR = 16), double (NR = 8) and convergent ones (NR = 6) (Fig. 6). Partially—or totally—retouched backed tools follow (NR = 57), as well as scraper-denticulated tools (NR = 20). The lower amount of typical denticulated-notched tools (NR = 18) is due to the already mentioned selection criteria: 40 denticulated tools were discarded after being given their retouching features and width, and typology. Their notched detachments were possibly obtained using narrow pebbles as retouchers. This is the same reason for the discharge of some backed tools, on which other retouching techniques, such as the bipolar percussion on anvil, were recognised (Delpiano et al. 2019). Among other selected tools, a handful of retouched points were present (NR = 9), as well as several pieces thinned on the lower surface (NR = 47) and most of the 'other retouched tools' category (NR = 124), that includes flakes with partial or marginal retouch.

The retouch usually concerns the cutting edge or 'transformative contact' (*Contact Transfomatif* (CT)), which is the tool's subsystem aimed at releasing the energy and transforming the material on which the tool is used; CT is retouched in 303 specimens. On the other hand, the 'prehensive contact' (*contact préhensif* (CP)), which is the part of the tool aimed at handling it and receiving the energy from the user, is retouched in 74 artefacts. In fact, 30 specimens bear retouch on both the CT and the CP. The retouch develops on the upper surface, which means 'direct', in 246 cases; conversely, it is 'inverse' in 44 cases. If the artefacts bear retouch on both the surfaces, it could be alternated (NR = 36), crossed (NR = 24) or generally bifacial (NR = 4).

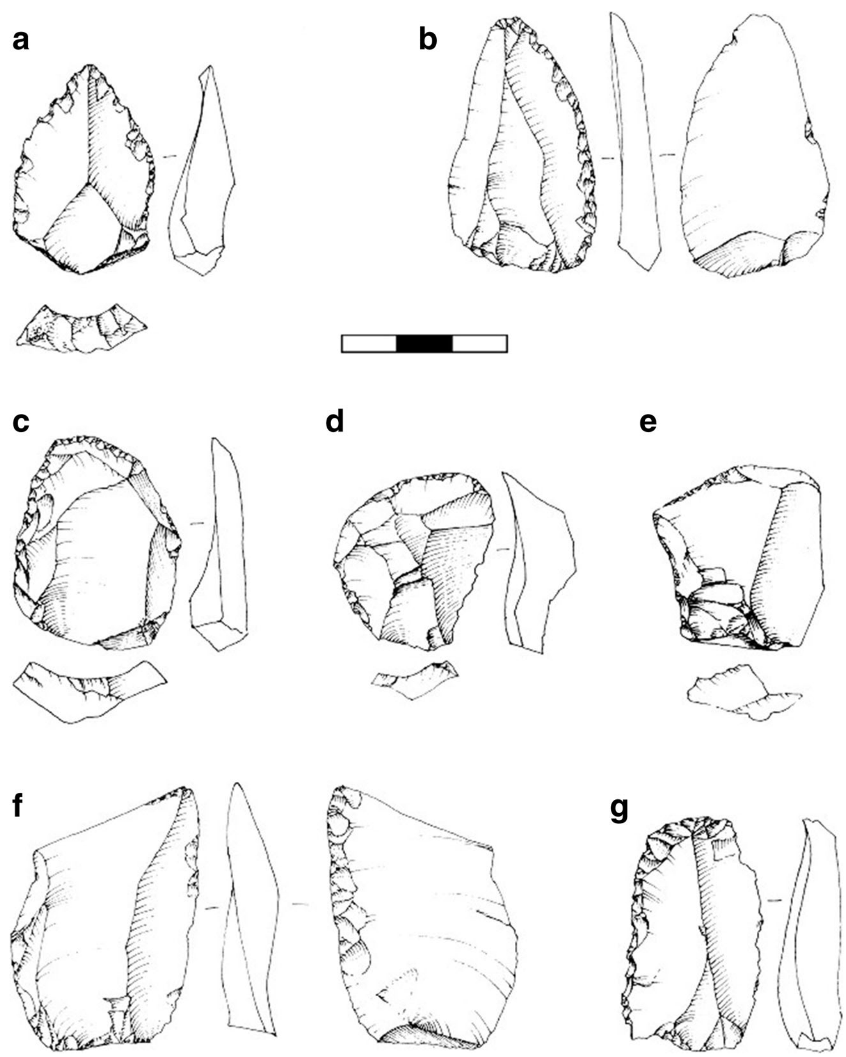

Fig. 6 Retouched tools from unit A9: **a** a scraper-denticulated convergent tool on discoid flake; **b** a simple scraper with thinned base; **c**, **g** lateral-transversal scrapers; **d**, **e** partially retouched flakes with marginal retouching; **f** a partially crossed retouched flake with flat retouching on the lower surface

Concerning the distribution of the retouch on the tool, when it is continuous on an edge, it could be on the left (NR = 108) or the right ones (NR = 96) with comparable incidence. In cases of partial and isolated retouch, the mesial-distal area is slightly preferred, while partial proximally retouched tools are quite rare. When retouching is basal (NR = 21), it refers mostly to inverse or crossed retouching aimed at thinning the bulb.

While CT retouching affects equally left and right edges, with a higher incidence of the distal portion compared with the mesial one, CP retouching is more common on the right edge (almost double) and located mostly on the mesial portion. When retouching is marginal, it is rather well distributed on the different lengths, with minor incidence of the proximal portions.

The delineation of the retouched edge is equally distributed between rectilinear and convex (NR = 97 each) and followed by notched-denticulated (NR = 47), concave (NR = 20) or irregular edges (NR = 49). These features are closely related to the tool types: among scrapers, convex active edges (NR = 51) are slightly more common than rectilinear (NR = 48) and concave (NR = 8), as well as convex backed tools (NR = 20) compared with straight back (NR = 13).

A significant feature, regarding the retouching technique, is the morphology of detachments: these are mainly scaled (NR = 236), at times sub-parallel (NR = 95) and stepped (NR = 63) (Fig. 7). Contrary with scrapers and most of the tools, the backed artefacts show a majority of sub-parallel detachments over the others. These tools imply a different trajectory in the retouching gestures, less 'tangential' and more 'direct' on the edge, that is necessary in order to produce steep edge angles; therefore, sub-parallel detachments could be a consequence of this change in the position of both retoucher and tool.

Indeed, regarding the angles of retouched edges, backed tools are characterised by semi-abrupt or abrupt angles; denticulated tools bear both semi-abrupt and low active angles while scrapers' edges are mainly characterised by low angles, becoming semi-abrupt only when subsequent retouching stages concur to rise the edge angle. Among the other retouched tools, marginal low retouch is common (NR = 59) as well as the semi-abrupt (NR = 40). Inverse retouching is usually flat or low; flat direct retouching, conversely, is uncommon but present in a dozen of tools, among which some scrapers.

Finally, the extension of retouch is recorded as 'long' (> 5 mm) in 179 specimens, while 'short' (≤ 5 mm) in 175; scrapers are mainly included in the first category, while backed and other retouched tools in the second one. Moreover, 26 tools bear invasive retouch, with detachments (usually over 15 mm) covering the affected surface, mainly on the lower one.

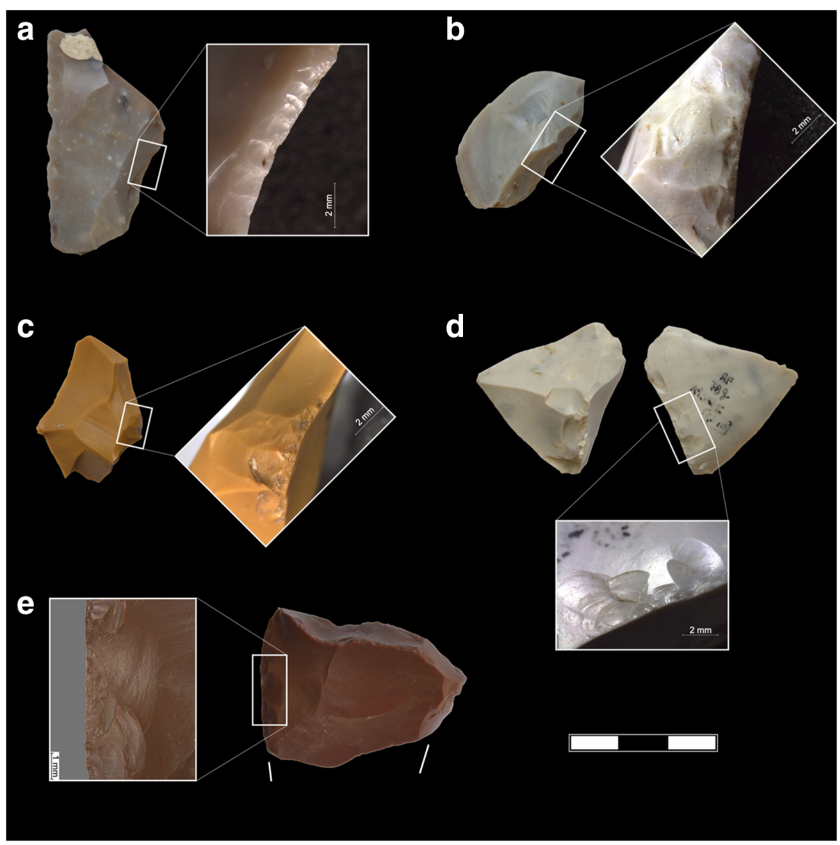

Fig. 7 Examples of variability of retouched edges among the unit A9 lithic toolset: **a**–**c** complete or partially retouched backed tools with abrupt retouching characterised by sub-parallel and occasionally scalar/stepped retouching; **d** pseudo-Levallois point having inverse flat retouching with scaled morphology; **e** simple scraper with low-angle retouching having scaled morphology (scale = 1 mm)

Discussion

In the unit A9 of the Fumane Cave, a great amount of bone retouchers and retouched lithic tools have been identified in excellent conditions of preservation. For this reason, A9 is a suitable sample for discussing the retouch activity within a context characterised by the Discoid technology. In Europe, only two sites show an association between bone retouchers and Discoid retouched tools: the layers 6a, 7a and 7c (Micoquian horizons) of the Kůlna Cave (Czech Republic) and the layers g, h, i and j of Saint-Marcel d'Ardèche (Rhône valley, France). The first contains a retouched lithic industry similar to A9—scrapers and backed tools; layer 7a, in particular, could also be of interest in relation to this study for its chronological position around 50 ky BP (Auguste 2002; Neruda et al. 2011; Neruda 2017). Saint-Marcel shows a great amount of bone retouchers in association of Discoid lithic industry; the unit 7 (sublayers g, h, i and j) is dated at the MIS 3 (Daujeard et al. 2014; Moncel 1998). However, at Saint-Marcel, the analysis of the retouch considers the whole retoucher assemblage, overlooking the specific units. For this reason, an overall comparison with A9 could not be carried out. Therefore, only data about taxa, skeletal elements and morphology of stigmatas will be considered.

Finally, another site containing a great number of retouchers in association with some Discoid lithic industries is Payre—level F (Rhône valley, France); however, it dates to MIS 7 and most of the retouchers are associated with Quina scrapers.

In Fumane A9, most of the retouchers are made from bones of red deer, and they show a predominance of linear impressions, distributed in concentrated use areas. The retouched lithic industry is mainly constituted by scrapers bearing a direct and scaled retouch and low active angles, and by backed tools with a direct and subparallel retouch and abrupt angles.

Raw materials for bone retouchers

Unit A9 is rich with faunal remains, most of them bearing traces of anthropic nature. Bone retouchers are usually made from the bones of butchered animals, and it is common to use bones belonging to the most hunted species in the site. In A9, however, the faunal spectrum shows that the most represented species are red deer and roe deer, while the 41.8% of the bone retouchers is made using red deer bones, but only one retoucher comes from roe deer. These data suggest Neanderthals selected the most suitable bone blanks to make retouchers, determined by the thickness of the compact bone, a required feature in the retouching activity. The situation observed in Fumane diverges from the one in the Micoquian layers of Kůlna: here, the species used for making retouchers seem to be related more to the availability of the fauna in the site. Indeed, the retouchers are made mostly using medium-sized animals (especially reindeer), which are also dominant in the general faunal assemblage of these layers (Neruda et al. 2011). Moreover, the mammoth appears in the faunal spectrum, and some skeletal elements belonging to this species—ribs and tusks—are used as retouchers (Neruda et al. 2011; Neruda and Lázničková-Galetová 2018). At Saint-Marcel, retouchers recovered in unit 7 are made mostly from red deer, the most dominant species in the general faunal spectrum of this layer; moreover, among the few *Megaloceros giganteus* remains, some are used as retouchers (Daujeard et al. 2014).

In A9, a good portion of the sample has been identified at a skeletal element level, showing the predominance of long bones—especially tibiae. This could be related to the modalities of exploitation of the carcasses (Romandini et al. 2014); however, it could also be suggested that the morphology of the tibiae, and long bones in general, is the most suitable for making retouchers, and that this is the reason why they usually dominate in the retouchers assemblages. At Kůlna, likewise, a predominance of tibiae and long bones is observed in the Micoquian layers (Neruda et al. 2011). These technological features could be related to a pronounced cross-section convexity of the long bones (Neruda et al. 2011)—although future experimental and morphometric studies are necessary to confirm this hypothesis. The exclusive presence of long bones is also observed in the unit 7 of Saint-Marcel. Here, tibias and metapodials dominate the sample (Daujeard et al. 2014).

The totality of the retouchers from A9 is made using diaphyses. This is a well-known pattern among the bone retouchers in the Middle Palaeolithic, even though some examples of the use of epiphyses are also present (e.g. Vincent 1993; Auguste 2002; Valensi 2002; Abrams et al. 2014; Daujeard et al. 2014; Costamagno et al. 2018; Hutson et al. 2018). Epiphyses are also totally absent from the Discoid units of Kůlna (Auguste 2002; Neruda et al. 2011) and from all the units at Saint-Marcel (Daujeard et al. 2014). The lack of this skeletal element could depend on technological factors: diaphyses are more compact and their fracturation produces blanks which are easy to grasp during use; moreover, blanks from diaphyses have regular convex surface that could facilitate the act of retouching. For the aforementioned reasons, diaphyses might be more suitable as retouchers and, therefore, they were preferably selected. However, the absence of epiphyses could also be ascribed to other causes, like the high fragmentation index of the faunal assemblage (Romandini et al. 2014) or the possible use of these bones, rich in fat, as fuel (Costamagno et al. 2005).

Regarding the metric data, length and width values are heavily influenced by the post-depositional processes; hence, these values do not reflect the original size of the osseous tools, and they are therefore not suitable for comparisons. The thickness of the compact bone, on the contrary, should be taken into account; however, more focused techno-morphometric studies, aimed to the investigation of this parameter, are necessary.

Use areas

In A9, the use areas are always located near to the extremities of the shafts; their size ranges 5 to 25 mm in length and 4 to 14 mm in width. They seem to be slightly smaller than the use areas observed on the retouchers of Kůlna, which show a length between 6 and 65 mm and a width between 3 and 26 mm (Auguste 2002). However, for the sake of methodology, it is worth noting that in the present study the measures have been recorded only for the complete use areas (i.e. those areas which are not interrupted by post-depositional fractures), while no details about the measurement methodology are available for the retouchers of Kůlna.

It is common among the Palaeolithic assemblages to find double retouchers (i.e. retouchers with two use areas). In A9, 12% of the sample is composed of double retouchers, less than in the Kůlna assemblage, where double retouchers constitute 23% (Neruda et al. 2011); in unit 7 of Saint-Marcel, the amount of double retouchers varies within the sublayers, and it is comprised between 12 and 21% (Daujeard et al. 2014). The presence of double retouchers could sometimes be linked to the scarcity of osseous raw materials, and it could be the reason why in A9 they are not particularly abundant, since, as suggested by the comparison with the general faunal spectrum, the site was rich in raw material. Moreover, in A9 a difference in the intensity of use between two areas of the same retoucher has been observed. The presence of an area more intensively used than the other is often recorded on double retouchers from Middle Palaeolithic contexts, and it finds comparisons with the retouchers from Kůlna (Auguste 2002). This feature is often linked to a 'primary' and a 'secondary' phase of the retouch, which could be dictated by the availability of the raw material; it could also be related to a different use for the retouchers in order to better exploit their morphology, on the assumption that each bone shows different degrees of convexity in different portions of its surface.

Looking at the morphology of the retouch-induced stigmata, the prevalence of linear impressions, densely distributed, has been observed; punctiform impressions are present to a lesser extent, while striations and notches are rare. This pattern is comparable with the bone retouchers from the Micoquian layers of Kůlna (Neruda et al. 2011), and the unit 7 of Saint-Marcel (Daujeard et al. 2014), where the linear impressions prevail as well. Both in Kůlna and Saint-Marcel, stigmatas are densely distributed but, on average, the retouchers are not intensively used.

In A9, we observed a relation between the morphology of the stigmata and some skeletal elements. For instance, striations do not locate on the blanks indistinctively, but they only appear on tibiae and radii. Although this specific distribution could have a statistical explanation for the tibiae (since they are the most represented skeletal element identified in the sample), it is not the same for the radii, which constitute only 10% of the identified skeletal elements. These data suggest that the striations do not occur randomly, but their presence could be linked to the way the retoucher was handled in relation to its morphology.

Moreover, looking at the differences in the percentages of the two most abundant categories of impressions—linear and punctiform—some patterns are observed in relation to the morphology of the skeletal element. In fact, the difference between linear and punctiform impressions' percentage values is minimal on tibia and humerus (8 and 7 percentage points, respectively), while on the radius such difference consists in 29 percentage points, in favour of the linear impressions. To a lesser extent, the same goes for the femurs, although there are only three of them in the sample, giving a less important statistical value (Fig. 5).

The fact that the morphological categories of the stigmata seem to be related to the skeletal element suggests that the morphology itself has a major role in the selection of the bone blanks suitable for making retouchers, and probably also in the way the retouchers themselves were used. A similar situation has been observed in another context in northern Italy, the Quina site of De Nadale Cave. Here, the radius was among the less represented skeletal elements, but it was also the element showing the most amount of double retouchers. In that context, a hypothesis was proposed that the morphology of the radius was preferred for the exploitation of multiple surfaces on the same retoucher (Martellotta et al. in press).

Finally, scraping marks are observed on the 32% of the A9 sample, diverging from Kůlna, where the 78% of retouchers shows scraping marks (Auguste 2002). It is common to observe scraping marks on bone retouchers; they could be due to a preliminary preparation of the bone blank by removing the periosteum (Armand and Delagnes 1998; Mallye et al. 2012), although experimental studies proved that this action is not strictly necessary in order to carry out the retouch activity (Mozota Holgueras 2012). Scraping marks could also be the results of the preparation of the lithic edge for retouch (Jéquier 2014; Costamagno et al. 2018). In the A9 sample, the presence of scraping marks does not seem to relate with any particular skeletal element: therefore, it could be suggested that they are either due to the butchering activity, or to the preparation of the lithic edge.

Comparison with the retouched lithic assemblage

In the A9 unit at Fumane Cave, bone retouchers are found in association with retouched lithic tools. In our study, it has been possible to define the technological features of the bone retouchers used for retouching the Discoid lithic industry. It is important, however, to consider that a single retoucher should not be directly related with a single retouched tool, because the bone flake could be used for retouching more than one lithic tool. Moreover, other factors involved in the features of the stigmatas should be considered, such as the type of retouch, the orientation of the retoucher in relation to the lithic edge (Tartar 2012 and references therein) and the ability of the knapper. Nevertheless, a global but detailed analysis of the stigmata, and an overall description of the retouchers, could be compared and related to the general features of the retouched industry in a good-quality context as with the A9 unit.

As stated above, linear impressions dominate in the sample, followed by the punctiform. Linear impressions are due to the impact between the bone surface and a sharp lithic edge, while punctiform impressions result from the contact with an uneven lithic edge, characterised by dihedral protuberances. It is therefore possible to infer the morphology of the lithic edge during the retouch activity. Typologically speaking, among the retouched tools of A9, scrapers and backed tools prevail (Fig. 6). The morphology of the detachments is mostly scaled, while it is subparallel in the backed tools (Fig. 7); the angle of the retouched edge varies in relation to the typology of the tools: scrapers have a low active angle, while the backed tools have a more abrupt angle. In the Micoquian horizons of Kůlna Cave the predominance of linear impressions on bone retouchers has been explained with their association with large-sized side scrapers, made of high-quality raw material. In the same site, it is possible to observe a divergence from the Taubachian layers (complex of unit 11, not directly related to the present study), where bone retouchers have mostly punctiform impressions instead and are associated with small-sized scrapers made in coarse-grained raw material (Neruda et al. 2011). Finally, the unit 7 of Saint-Marcel contains retouchers bearing mostly linear impressions; they are associated with Discoid lithic tools with marginal, sometimes scaled, and rarely invasive retouch.

Although the general trend shows that linear impressions are more abundant, this study revealed that some skeletal elements (radii and femurs) show a greater variance between linear and punctiform impressions. It suggests that such elements could be preferred to retouch sharper lithic edges. Other skeletal elements (tibiae and humeri) could be used to retouch lithic edges characterised by a more dihedral micro-topography, where linear and punctiform impressions are present more or less in the same percentual amount. As stated above, protrusions and irregularities on the retouched edges are related to punctiform impressions. This is why these retouchers appear to have been used mainly on denticulated tools or flakes with partial retouching, while scrapers and backed tools usually present more regular edges, compatible with linear impressions.

Striations are also interesting; they are due to a more oblique impact between the bone surface and the lithic edge, when the blow is less violent and the two surfaces almost scratch with each other. Possibly, this could be the case of most of scrapers' retouching. The study of the A9 bone retouchers shows that the striations do not follow the same distribution trend of the other stigmata in relation to the skeletal element, inasmuch they are only present on tibiae and radii. This result suggests that the morphology of the retouchers made from these elements might interact in a different way with the lithic edge during the retouch activity. Thus, either their morphology causes them to scratch on the lithic edge more than other skeletal elements, or, due to their morphology, they were specifically selected for an oblique retouch, typical of scrapers, while other morphologies were used for obtaining a more abrupt retouch, typical of backed tools.

Regarding the notches on the retouchers, they are due to an insistent and repeated percussion of the retoucher on the lithic edge. In A9, notches are very rare, but they are present in similar amounts among all the skeletal elements. This could suggest that they are not related neither to the skeletal elements' nor to the lithic edges' morphologies, and that the retouchers were not used insistently, probably because of the abundance of bone raw material, which does not require the knapper to use the same retoucher for several retouch activities.

With regard to the retouch intensity, most of the stigmata in this study are concentrated, followed by dispersed. Isolated—indicative of a marginal and/or brief retouch activity—and superimposed—due to a heavy retouch activity—impressions are rare. These results also suggest that the retouchers of A9 were not used in an intense way. This is in accordance with the overall features of A9 retouched lithic assemblage, as well as most contexts characterised by the Discoid knapping method, where retouched tools count between 2 and 8% of the total lithic assemblage (Faivre et al. 2017). Fumane unit A9 confirms this data attesting slightly below 5% (including all retouched tools). In fact, the Discoid method is generally oriented to the production of blanks having short use-life and low reuse and resharpening potential, as opposed to Quina blanks (Delagnes and Rendu 2011). These features affect the lithic tools' retouch intensity: here, heavily retouched tools are quite rare if compared with partially retouched flakes. Even scrapers are generally characterised by one or two retouch cycles, as opposed to Quina or demi-Quina scrapers, characterised by scalar retouching derived from different use and resharpening stages (Bourguignon 1997, 2001; Lemorini et al. 2016). From these data, implication on mobility strategies and on the structuration of the toolkit can be developed. If the Discoid techno-complex is generally conceived as a technological response to human groups associated with cyclic and seasonal mobility, strictly adapted to local territory (Delagnes and Rendu 2011; Turq et al. 2017), the primary products of flakes were unlikely to be part of the portable toolkit during daily routes. In the Discoid technology, the major investment lies in the core's management, which through the ramification of the reduction sequences allows high productivity rates and notable versatility (Peresani 1998; Bourguignon et al. 2004; Turq et al. 2013; Romagnoli et al. 2018): this is why cores and core-on-flakes could have represented the portable blank, as techno-economical analyses on A9 raw materials suggested (Delpiano et al. 2018). When needed, these cores could have produced a wide variety of raw blanks (centripetal and core-edge-removal flakes, *dejeté* points), whose multifunctionality has been attested by widespread use-wear analyses (Lemorini et al. 2003; Locht 2003; Arrighi 2009; Delpiano et al. 2019). These products could have been retouched as well during the mobility patterns according to ergonomic and functional reasons, as some retouched backed tools seem to attest (Delpiano et al. 2019).

If we compare the data on retouch rate and mobility with the data on bone retouchers, the average-low exploitation of the latter becomes clear, noticeable in the small use areas and the low frequency of double retouchers. It follows that bone retouchers were also unlikely to be part of the mobile toolkit since they were not strictly needed, as opposed to hard stone hammers, necessary for most of the knapping operations. Their utilisation was probably related to strictly on-place activities where stone tools had to be shaped or tended to wear out, thus requiring retouching and partial reconfiguration or slight resharpening. This could be the case of butchery and game processing, which also provided suitable raw bones.

Spatial distribution

In this study, we carried out a preliminary observation on the spatial distribution pattern of bone retouchers and retouched lithic tools in the excavated area of A9 unit (Fig. 8).

The results show that the majority of the retouchers are located in the north-eastern sector of the cave, in proximity of its left wall. The greatest concentration of retouchers is in the squares nos. 101, 102, 103, 111 and 112, in proximity of the tunnel C (Fig. 8a). Other retouchers are found, isolated, in the central portion of the cave surface, and their concentration seems to decrease approaching the southern portion of the surface. In the western portion of the cave, retouchers are absent, as well as in proximity to the wall and the tunnels A and B.

The retouched tools seem to follow a less defined pattern in the spatial distribution (Fig. 8b). A dense pattern is observed in the central area of the cave (squares nos. 105, 110, 115 and 120), where the retouchers are absent or very rare. The same goes for the south-eastern and south-western portion of the cave entrance area, where only a few retouchers are present, compared with the significant number of total retouched tools. In the inner zone, finally, several retouched tools are identified in and around the squares nos. 147 and 157. However, dense

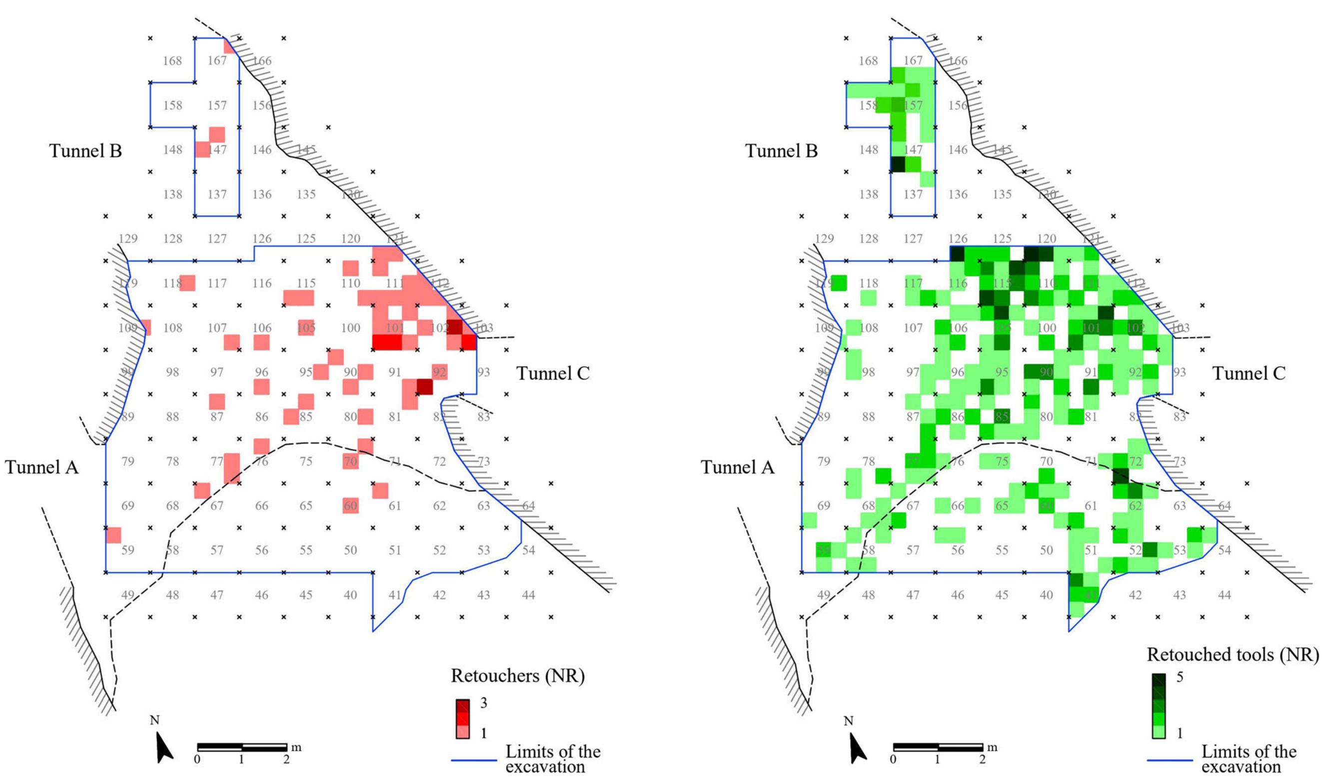

Fig. 8 Spatial distribution of bone retouchers (**a**) and retouched lithic tools (**b**) recovered in the whole excavated area of A9; the previous zooarchaeological analysis of the faunal remains had took into account a slightly less-extended surface (Romandini et al. 2014)

distributions of both lithic and bone tools overlap in squares nos. 101 and 102, in proximity of tunnel C. Future studies will put in relation tools, faunal remains, and structures, to better understand the space management operated by the human groups associated with the Discoid technology.

Conclusions

Building on the concept of cultural transversality of bone retouchers, this study underlines the importance of including the retouch activity among the principal behaviour markers within the analysis of the evolution of human cultures. The comparison between the technological features of bone retouchers and retouched lithic tools sheds light on the economical strategies associated with the Discoid knapping technology, a remarkable cultural expression of the Middle Palaeolithic, in the unit A9 of Fumane Cave.

The retouchers from A9 do not reveal an intense and continued use during the retouch activity, suggesting a moderate abundance of osseous raw material, combined with particular features of the lithic edges.

The comparison of retouchers and retouched tools reveals that the morphology of the bone blanks seems to play a major role, as it seems to influence both the selection and the use of these tools. Finally, a relationship between the shape of the retoucher, the morphology of the retouched edge, and the categories of stigmata is observed. Indeed, it seems that some skeletal elements (e.g. radii) where selected for an oblique retouch, typical of the scrapers. This result should be taken into account in future experimental studies, to clarify the association between the characteristics of the retouch and the technological features of the retouchers.

The unit A9 of Fumane Cave confirms to be a valuable context to investigate aspects of Neanderthal behaviour. Specifically, the economic use of the by-products of animal bone processing for making tools, driven by specific, required technological features.

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