

## Osseous artefacts from the Mesolithic levels of Pradestel rockshelter, (north-eastern Italy): A morphological and techno-functional analysis

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**SUMMARY** - *Osseous artefacts from the Mesolithic levels of Pradestel rockshelter, (north-eastern Italy): A morphological and techno-functional analysis* - The results of a morphological and techno-functional analyses carried out on 21 osseous artefacts from the Mesolithic levels of Pradestel rockshelter (Trento, north-eastern Italy) are presented here. Curated points, awls, bevel-end artefacts, harpoons, tool-related manufacturing waste and shell ornaments compose the archaeological sample. The results of the study allow characterising modalities of exploitation for different osseous materials from the early to late Mesolithic. Comparisons to Epigravettian contexts from the same region suggest that these techniques of manufacturing were already defined during the Late Glacial. Harpoons appear at the end of the Sauveterrian period similar to other sites of the north-eastern Alpine region. According to the faunal remains, their presence might indicate a shift in hunting techniques that continued throughout the Castelnovian. Manufacturing and use traces on the osseous artefacts were examined under a stereoscope at low magnifications (8x-100x) and then under a metallographic microscope with incident light at 200x magnifications. They were interpreted by comparison to experimental samples.

**RIASSUNTO** - *I manufatti ossei dei livelli mesolitici del Riparo Pradestel (Italia nord-orientale): Analisi morfologica e tecno-funzionale* - Vengono presentati i risultati di un'analisi morfologica e tecno-funzionale condotta su 21 manufatti in materia dura animale provenienti dai livelli mesolitici (Sauveterriano e Castelnoviano) del Riparo Pradestel (Trento, Italia nord-orientale). Gli oggetti analizzati comprendono punte cosiddette "curate", punteruoli, strumenti *bevel-end*, arpioni, ornamenti in conchiglia, oggetti in fase di lavorazione e scarti di manifattura. I risultati dello studio hanno permesso di caratterizzare le modalità di sfruttamento delle differenti materie dure animali tra Mesolitico antico e recente. Confronti con contesti dell'Epigravettiano finale della regione prealpina e alpina nord-orientale sottolineano che tali tecniche di lavorazione sono, in parte, già delineate nel Tardiglaciale. Come in altri siti alpini nord-orientali, alla fine del Sauveterriano compaiono i primi arpioni. La presenza di tali strumenti potrebbe indicare, in accordo con i dati faunistici, un cambiamento nelle tecniche di caccia che perdura anche nel Castelnoviano. Le tracce di manifattura ed utilizzo sui manufatti ossei sono state analizzate con uno stereomicroscopio a basso ingrandimento (da 8x a 100x) e con un microscopio metallografico a luce riflessa con ingrandimenti fino a 200x. L'interpretazione delle usure archeologiche è avvenuta mediante confronto con manufatti sperimentali.

**Key words:** osseous industry, ornaments, technology, tools function, hunting strategies

**Parole chiave:** strumenti ossei, ornamenti, tecnologia, analisi funzionale, strategie di caccia

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### 1. INTRODUCTION

The exploitation of bone, antler, ivory and shell is well documented since the Late Glacial in the north-eastern Alps as well as in the pre-Alpine region of Italy. Tools, manufacturing waste, ornaments and so-called portable art were found in rockshelters as well as in burials (Bagolini 1980). Nevertheless, up to now, technological analyses have only been undertaken on some Epigravettian industries (for Dalmeri rockshelter see Cristiani 2008; Gurioli 2008; for Tagliente rockshelter see Cilli 2002; Cilli *et al.* 2006) while, as far as the Mesolithic evidence is concerned, we are left with the techno-typological analysis of the Mondeval de Sora burial goods only (Cilli *et al.* 2001 a, b).

The analysis of the Mesolithic osseous artefacts of Pradestel rockshelter represents one of the first attempts to define the strategies of hard animal tissues exploitation during the Late Glacial and at the beginning of the Holocene in

the north-eastern Alpine region of Italy.

Pradestel rockshelter constitutes an important testimony of the Mesolithic occupation of the Adige valley. Its stratigraphical frame and sequence depth have interesting similarities with other famous sites of the region: Romagnano III rockshelter - located downstream at about 10 km from Pradestel - as well as with Gaban rockshelter. A typological study of the lithic assemblage from the site has confirmed the importance of Pradestel for furthering of our knowledge of the Mesolithic sequence of the region (Dalmeri *et al.* 2008).

### 2. THE SITE

Pradestel rockshelter is located at 20 m from the actual flood level of the Adige River, in the locality of Ischia Podetti (TN), at c. 225m asl (Fig. 1).

Museo Tridentino di Scienze Naturali (fieldwork sea-

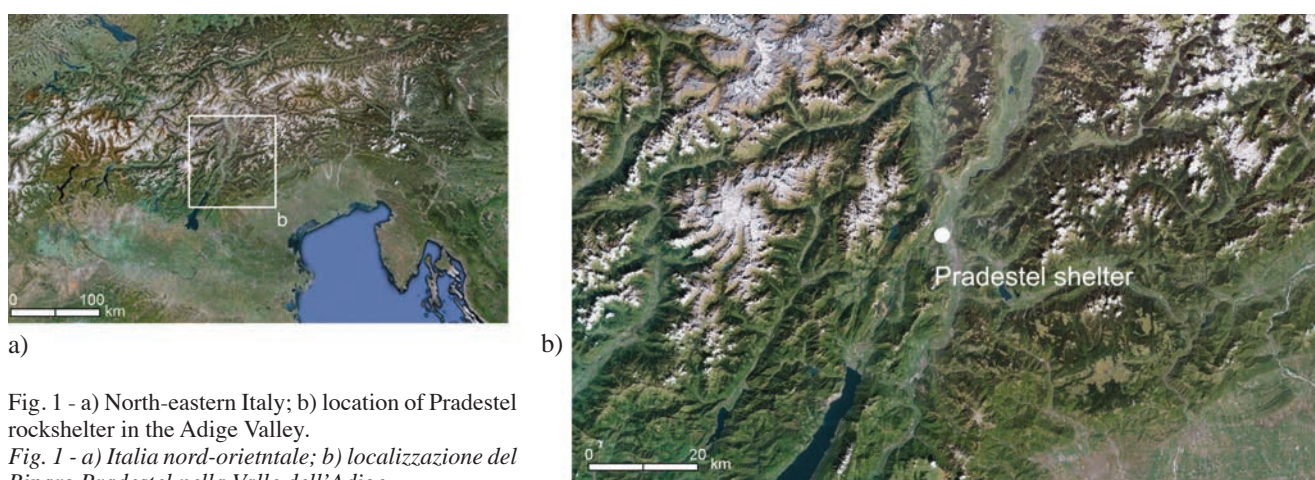


Fig. 1 - a) North-eastern Italy; b) location of Pradestel rockshelter in the Adige Valley.

Fig. 1 - a) Italia nord-orientale; b) localizzazione del Riparo Pradestel nella Valle dell'Adige.

sons 1973-1974 for sectors 1-2-3-4) in collaboration with the Institute of Geology, Palaeoethnology and Human Palaeontology of the University of Ferrara (sector 5) carried out preliminary research at the site (Bagolini & Broglio 1975).

The stratigraphic sequence at Pradestel refers to the same chronological span documented at Romagnano III rockshelter and covers the period of more than 2500 years from the Preboreal to the beginning of the Atlantic (Dalmeri *et al.* 2008) (Fig. 2).

In sector 5, in 5 m thick sequence, 36 levels were recognised, representing occupational sequences from the early Mesolithic (Sauveterrian - from the early to final phases) to the late Mesolithic (Castelnovian - from the early to late phases) and the Early Neolithic when the first pottery appears at the site (Dalmeri *et al.* 2008). The early Sauveterrian is dated to 8734-8352 cal. BC (layers L7÷L8); the middle phase of the Sauveterrian (layers L1÷L3) has yielded a date of 7605-6655 cal. BC; an age of 7352-7065 cal. BC is available for the recent Sauveterrian occupation (layers H÷H2) while layers D1÷D3, assigned to the late Castelnovian, were dated to 5878-5661 cal. BC<sup>1</sup> (Tab. 1).

### 3. MESOLITHIC BONE AND ANTLER ARTEFACTS FROM PRADESTEL ROCKSHELTER. METHODOLOGY OF STUDY

The Mesolithic osseous assemblage from Pradestel includes 21 artefacts and tool-related manufacturing waste made from red deer antler and mammal bones (Fig. 3, 6, 12; Tab. 2), 16 *Columbella rustica* and 1 *Theodoxus fluviatilis* perforated shell beads (Fig. 15; Appendix 3).

Out of these 21 antler and bone artefacts, 14 come from the early Mesolithic levels (Sauveterrian) (Appendix 1) and 7 from the later ones (Castelnovian) (Appendix 2).

All artefacts were inventoried and their morphology and dimensions recorded. Manufacturing and use traces as well as natural modifications (burning, weathering,

root etching and accidental breakage) were examined with a stereoscopic microscope Leica MZ12.5 (magnifications 8x-100x) and a reflected light microscope Leica DM2500 (magnifications 50x-200x).

The morphometric data recorded include length, width and thickness of each piece. For the pointed tools the width and thickness of the pointed end at 10 mm from the tip was also measured (according to Stordeur 1985) as well as point cross-sections and profiles. For the bevelled tools the location, profile, length and the number of bevels were recorded as well as the morphology and length of the edge.

The manufacturing technique was studied for each specimen. Technological modifications were compared to experimental samples prepared by the author as well as against bibliographic references (Christidou 1999; David 2000). The nature, localization and extent of the manufacturing and use traces were recorded. The functional analysis took into account the extent of traces on the active end of the tools and the distribution of use-wear traces in relation to the initial form (profile, cross-sections) of the tools. The function of the artefacts was evaluated by comparing the morphometric features of their active ends (invasiveness of the edges, profile, section of the distal part) (Voruz 1984; Christidou 1999; Cristiani 2008 for an application of a similar method in the analysis of the Epigravettian tools of Dalmeri rockshelter).

The bone raw materials were also identified for each object on the basis of the faunal comparative collection of the Museo Tridentino di Scienze Naturali and the author's personal reference collection.

The artefacts show a high frequency of fragmentation and thermal alteration of the surfaces already documented for the faunal remains (Clark 2000). Root etching has also been identified as a less important taphonomical modification.

Below, bone and antler artefacts are presented by cultural phases.

### 4. EARLY MESOLITHIC (SAUVETERRIAN). TECHNO-FUNCTIONAL ANALYSIS

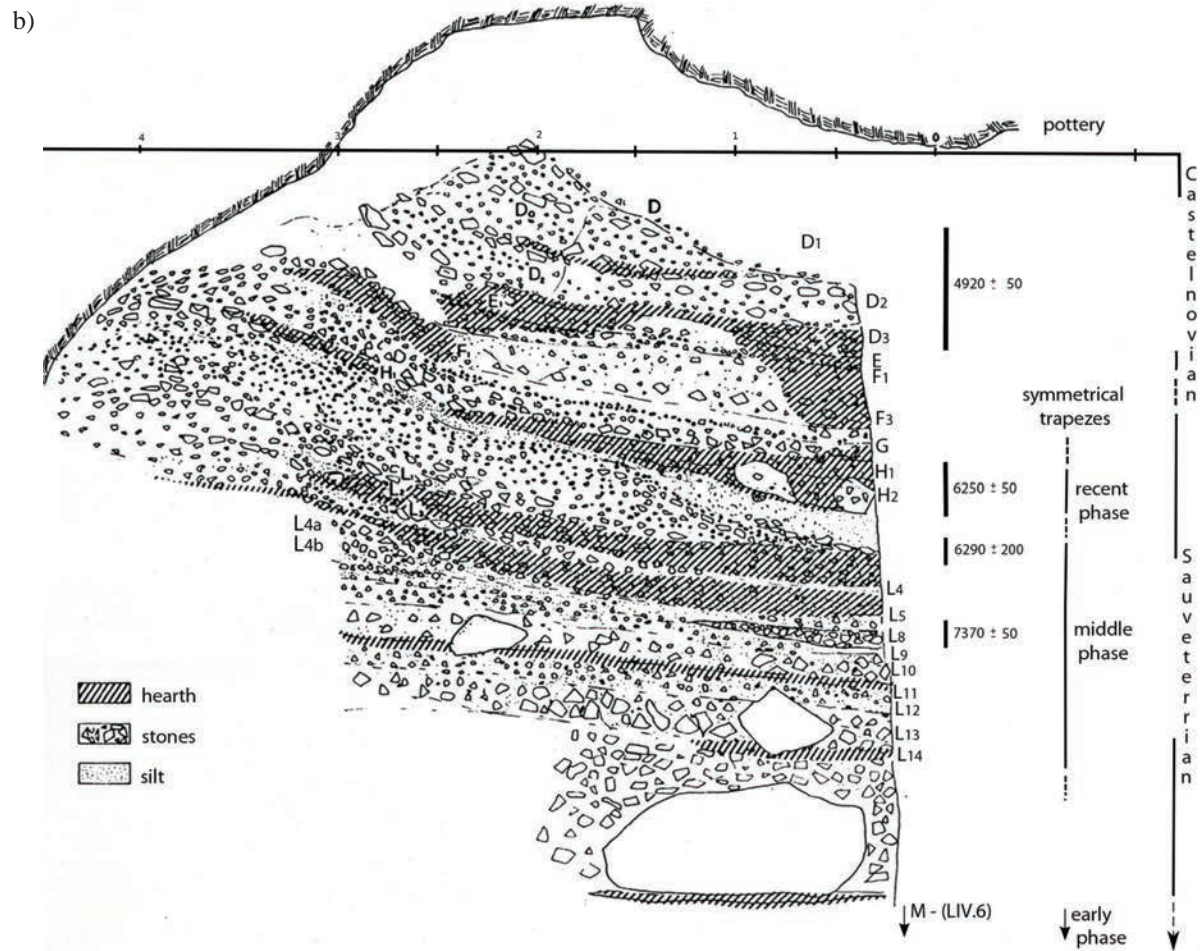
The sample includes 4 awls, 1 curated point, 5 harpoons and 3 objects related to manufacturing operations (Appendix 1).

<sup>1</sup> All dates cited in this paper are calibrated with OxCal v. 4.1 (Bronk Ramsey 1995; 2001).





Fig. 2 - a) Pradestel rockshelter; b) stratigraphic section of the site.  
Fig. 2 - a) Il Riparo Pradestel; b) sezione stratigrafica del sito.



Tab. 1 - Datazioni dei livelli mesolitici del Riparo Pradestel.

Tab. 1 - *Dates from the Mesolithic layers of Pradestel rockshelter.*

Site	Layer	Cultural attribution	Date reference	Date BP	Date cal. BC (2σ)	Date sample
Pradestel shelter	D1-D3	Late Castelnovian	R1148	6870±50	5878-5661	Charcoal
Pradestel shelter	H-H2	Recent Sauveterrian	R1149	8200±50	7352-7065	Charcoal
Pradestel shelter	L1	Middle Sauveterrian	R1150	8240±200	7605-6655	Charcoal
Pradestel shelter	L7-L7c-L8	Early Sauveterrian	R1151	9320±50	8734-8352	Charcoal

Tab. 2 - Classificazione morfo-funzionale dei manufatti ossei dei livelli mesolitici del Riparo Pradestel.

Tab. 2 - *Morpho-functional classification of osseous industry from Mesolithic levels of Pradestel rockshelter.*

	Curated points	Awls	Harpoons	Bevel-ended tools	Percussion tool	Manufacturing blanks	Manufacturing waste	Total
Early Mesolithic phases (Early to Final Sauveterrian)	1	4	5	1		1	2	13
Late Mesolithic phases (Early to Late Castelnovian)	2	1	1		1		2	7
Total								21

#### 4. 1. Pointed tools (N= 5)

With the exception of a complete awl (layer L5), all the pointed tools are fragments of the active part of the objects<sup>2</sup> (layers L3 and F1). A complete artefact (Fig. 3a) was made on a red deer metatarsal. The identification of an impact cone on one side of the tool indicates that hammer-stone percussion was used to fracture the bone. The rest of the tools (Fig. 3b-d, h) were all manufactured on indeterminate long bone diaphyses.

A flint cutting tool was used for shaping all of the pointed tools. The state of fragmentation makes it difficult to determine the original extent of shaping along the length of the tools but the complete awl shows that only the point of the specimen was shaped. Functional modifications are well preserved on this object. Under the stereomicroscope, the surfaces of the active part appear rounded and characterised by transverse fine striations (Fig. 4b, c). The wear extends up to the end of the distal end. The topography of the surfaces was not completely regularised and the wear mainly affects the high relief of the initial surface. Micro-relief is smoothed and homogenised (Fig. 4e, f) and finely scratched. Longitudinal striations appear very often as well as transverse ones. The pits on these surfaces are small sized and have circular and oval shape. The profiles of worn elevated surfaces are rounded. Large, deep and rough bottomed transverse striations also appear (Fig. 4d, e, f). Central and proximal edges of the awl are heavily rounded as a result of the prolonged handling of the tool.

The organisation and appearance of the use-wear can be compared to experimental traces that occur from

working plants (e.g. basketry). Similar modifications were identified on other two distal fragments (Fig. 5). the fragment of curated point is too small for a techno-functional analysis.

#### 4. 2. Harpoons (N= 5)

Harpoons were recovered in the final Sauveterrian layers (G3-G2-G1 and F3). Their morphological characteristics allow us to describe them as bilateral harpoons with straight barbs and basal bilateral gorge (Averbough *et al.* 1995). All the specimens are fragmented: distal fragments (Fig. 6a, b), a barb (Fig. 6c), and two basal fragments (Fig. 6d, e). Harpoon blanks were extracted from the antler beam using longitudinal grooving and put into shape by flint scraping (Fig. 7). Barbs and lateral gorges were created by a sawing motion (Fig. 8b, c, e, i) and, in one case, by percussion (Fig. 9m). Indirect resting percussion was used for engraving the shallow gorge visible on the superior surface of one of the bases (Fig. 9b, c, h, l, o) while the bevel-end proximal ends were shaped by scraping (Fig. 9b, c, l, o).

The harpoon fragments show longitudinal macro-fracture from use. The bases display jagged distal break in proximity of the gorge, the most fragile part of the tool (Fig. 9b, c, l, m). Barbs are totally missing in the central and distal portions of the harpoons and the single barb shows a distal bending fracture (Fig. 9h, g, i).

#### 4. 3. Bevel-end tool (N= 1)

A bevel-end tool comes from the very top of early Mesolithic layer F3 (Fig. 10a). It was made from a long fragment of red deer antler (length: 27,5 mm; width: 4,6 mm; thickness: 11mm) extracted by longitudinal grooving: traces of this technique can be observed on both sides of the tool (Fig. 11d). The active part was shaped convex and the base of

<sup>2</sup> From here onwards these type of fragments will be called *distal*.



Fig. 3 - Pointed tools. a) Sauveterrian layer L5; b) Sauveterrian layer F1 c) general Sauveterrian levels; d) Sauveterrian layer L3; e) Castelnovian layer C; f) Castelnovian mixed layers D3-E1; g) Castelnovian layers E1-E3; h) Sauveterrian layer F1.

Fig. 3 - Strumenti appuntiti. a) livello L5 (Sauveterriano); b) livello F1 (Sauveterriano) c) livelli Sauveterriani; d) livello L3 (Sauveterriano); e) livello C (Castelnoviano); f) livelli D3-E1 (Castelnoviano); g) livelli E1-E3 (Castelnoviano); h) livello F1 (Sauveterriano).



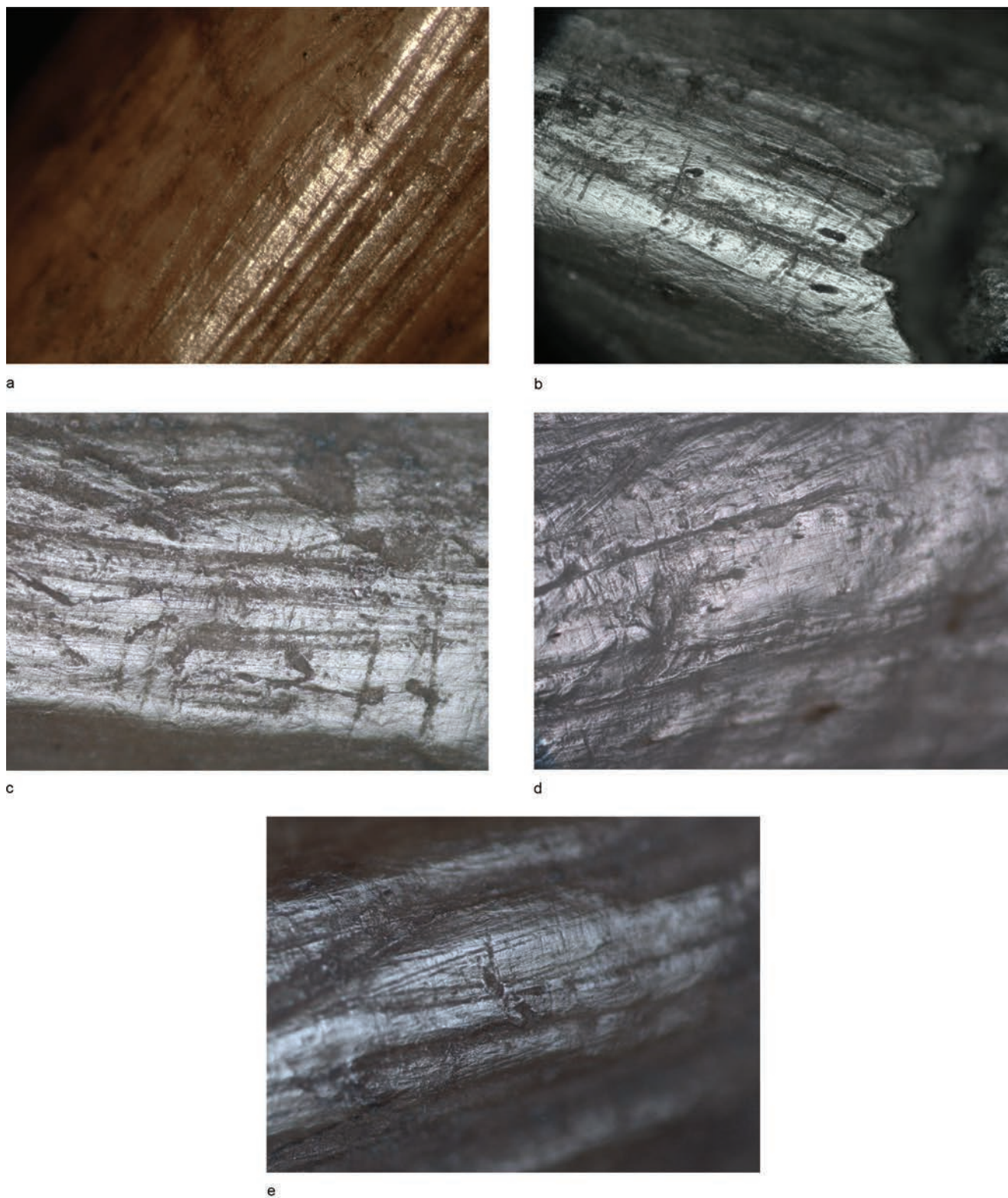


Fig. 4 - Use-wear on pointed tools (awl from layer L5). a) Macro-rounding of the tip (3,2x); b) transverse striations on the distal part of the awl (5x); c-d) archaeological use-wear trace located on the very tip of the tool (100x); e) experimental use-wear trace produced after working vegetal fibres (100x).

*Fig. 4 - Tracce d'uso su manufatti appuntiti (punteruolo dal livello L5). a) Arrotondamento dell'estremità (3,2x); b) strie trasversali localizzate sulla parte distale del manufatto (5x); c-d) micro-traccia archeologica localizzata sull'estremità distale (100x); e) micro-traccia sperimentale prodotta in seguito alla lavorazione di fibre vegetali (100x).*

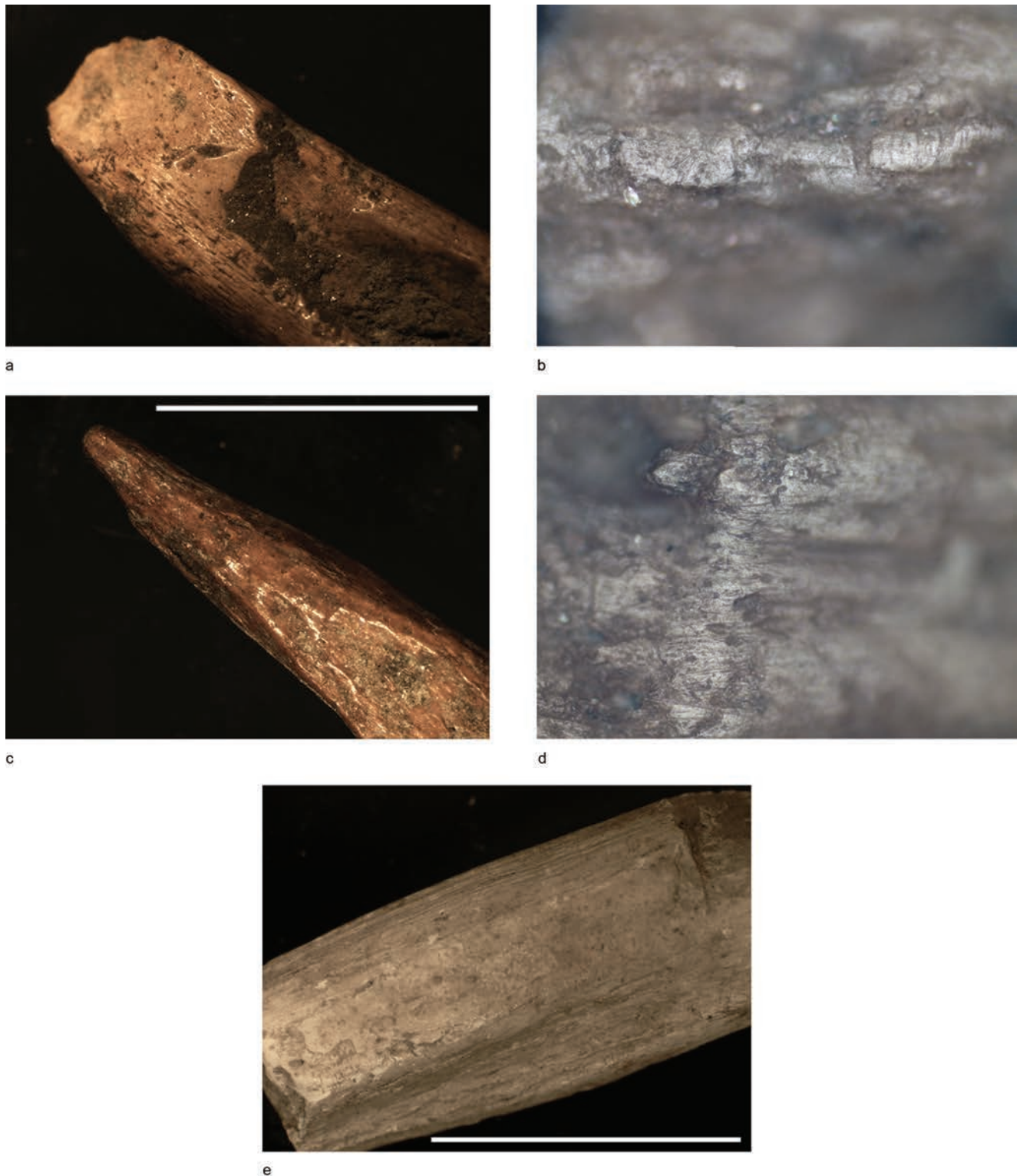


Fig. 5 - Pointed tools from Sauveterrian levels. a) distal fractures with rounded edges on a bone awl from Sauveterrian layer F1 (the bar is 1 cm); b) archaeological use-wear trace (100x); c) rounding of the tip and surfaces on a bone awl from mixed Sauveterrian levels (the bar is 1 cm); d) archaeological use-wear trace (100x); e) longitudinal grooving traces observed on a curated point fragment from the Castelnovian layer C (the bar is 1 cm).

*Fig. 5 - Strumenti appuntiti dai livelli del Sauveterriano. a) frattura distale con arrotondamento su un frammento di punteruolo dal livello F1 (Sauveterriano) (la barra indica 1 cm); b) micro-traccia archeologica (100x); c) arrotondamento dell'estremità distale e delle superfici su un frammento di punteruolo dai livelli Sauveterriani (la barra indica 1 cm); e) micro-traccia archeologica (100x); f) incisione longitudinale osservata su un frammento di punta curata dal livello C (Castelnoviano) (la barra indica 1 cm).*





Fig. 6 - Harpoon fragments from late Sauveterrian and Castelnovian levels. a) Fragment from layer G3; b) distal fragment from layer G2; c) single barb from layer G3; d) base fragment from layer G1; e) base fragment from layer F3; f) base fragment from layer D.

Fig. 6 - Frammenti di arpione dai livelli del Sauveterriano finale e del Castelnoviano. a) Fragment from layer G3; b) distal fragment from layer G2; c) single barb from layer G3; d) base fragment from layer G1; e) base fragment from layer F3; f) base fragment from layer D.

the tool is not preserved. No shaping traces can be identified on either superior or inferior surfaces since they were erased by later use. Functional traces show an invasive distribution from the distal end (about 1,7 cm from the edge) and also affected the spongy tissue (Fig. 11b). Macroscopic rounding of the outline (Fig. 11c) and the profile as well as the presence of striations perpendicular to the edge (Fig. 11b) might be attributable to scraping of soft materials (e.g. hide) carried out with a low working angle.

#### 4. 4. Manufacturing waste (N=3)

A long blank of antler compact tissue extracted by grooving comes from final Sauveterrian layers F2 (Fig. 12d; Fig. 13). Its morphology and manufacturing traces relate it to the production of harpoons and bevel-end tool debitage technique which appeared in final Sauveterrian layer F3.

Another fragment of waste is represented by a quadrangular blank from red deer antler showing grooving and percussion marks<sup>3</sup> (Fig. 12a). This object comes from layer F3, attributed to the final Sauveterrian. Traces observed on the artefact, as well as its position on the antler suggest that the object could be associated with the production of elongated blanks subsequently shaped into harpoons as well as to beams partitioning.

The last waste is a proximal fragment of the diaphysis of a red deer metatarsal coming from early Sauveterrian layer L6 α. On its anterior surface it shows longitudinal flint striations while percussion and fracture marks are visible on the proximal end of the object (Fig. 12e).

#### 4. 5. Manufacturing techniques during the early Mesolithic at Pradestel rockshelter

The typological and morpho-functional data shed light on a differential use of animal tissues for bone tools manufacturing in the course of the early Mesolithic.

Bone raw material seems to have been mainly used during the earliest part of the Mesolithic: most of the bone artefacts come from layers L6 to L4 to F1. This raw material was used for the production of pointed tools such as awls and curated points. During this earlier phase of Sauveterrian no antler tools seems to have been utilised. This raw material begins to be used by the final Sauveterrian (layer F2) when elongated antler blanks appear.

On the basis of the presence of manufacturing blanks and waste fragments showing technological traces compatible with the finished tools, we suggest that the processing of bone and antler for the production of artefacts was carried out *in situ*. Moreover, from the middle Sauveterrian levels came a single pedicle with two clear chopmarks aimed at its removal from the red deer head (Clark 2000: 84).

The beams represent the most frequently used part of red deer antler. Bilateral grooving was employed to cut the beams longitudinally in order to produce harpoons as

<sup>3</sup> A similar artefact was found in the Castelnovian levels (see below).



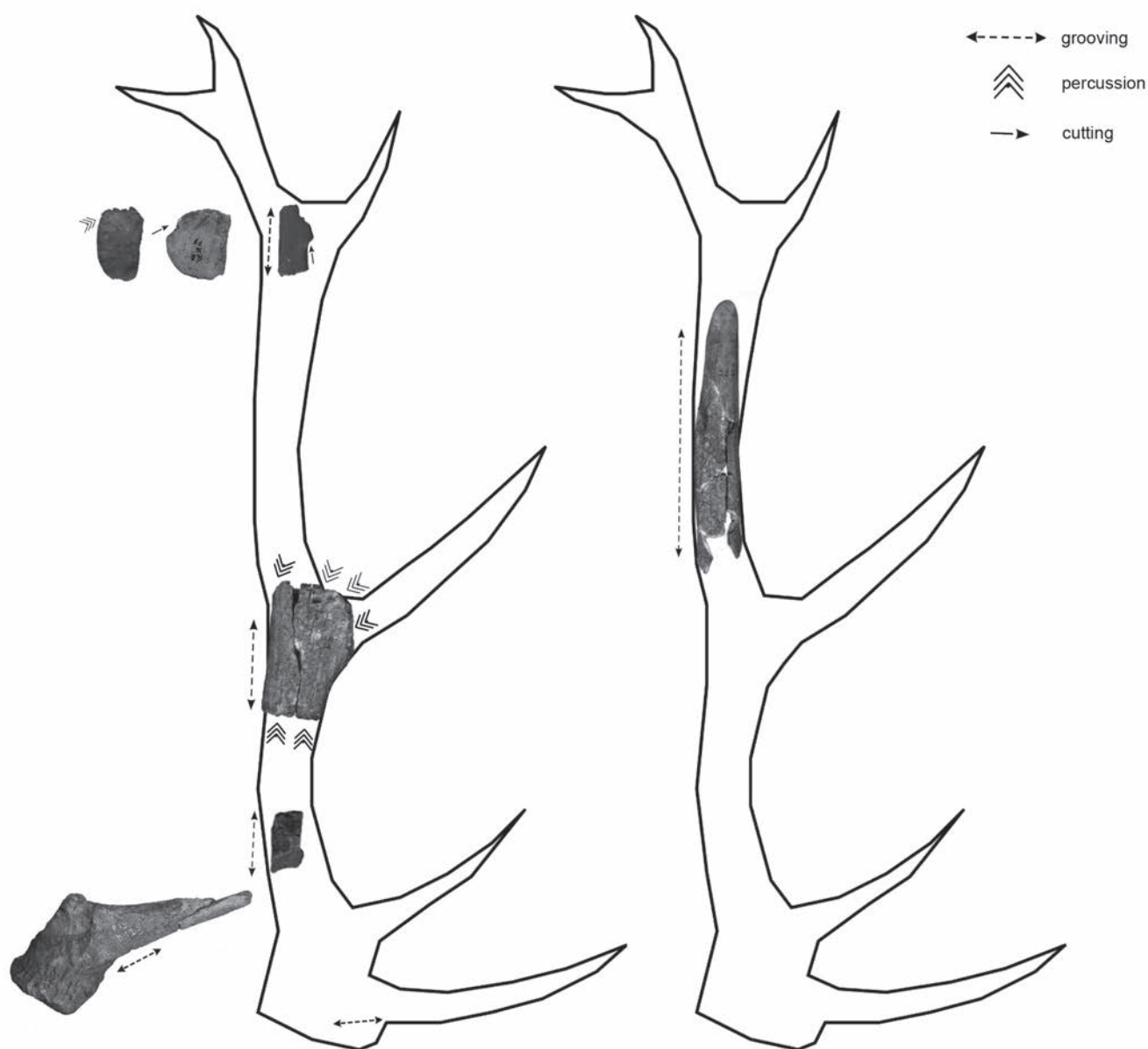


Fig. 7 - Antler technology. The figure shows mesolithic modalities of antler exploitation, the provenance of the main formal tools described in the text and the techniques utilised for raw material processing.

Fig. 7 - Tecnologia del palco cervide. La figura mostra le modalità di lavorazione del palco cervide nel corso del Mesolitico e la provenienza dei principali manufatti descritti nell'articolo.

well as for bevel-end tools (Fig. 6, 10, 13). This technique is testified by macroscopical traces observed on fragments of antler waste, blanks as well as on harpoons and bevel-end tools. Transverse percussion marks are observed on one fragment of waste only and traces of this technique were noticed neither on the harpoons nor on the bevel-end tool distal or proximal ends. Even if this technique might have been used for partitioning the beam only, it should be noted that the proximal end of the bevel-end tool – where percussion traces could have been located – is missing.

Bone was worked mostly with the aim of producing long splinters utilised in awls and curated points manufacturing. A cone impact trace observed on one awl shows

that hammerstone percussion was used to break the bone.

Splinters used in awl manufacturing were likely selected among the food remains. In fact, archaeozoological analyses demonstrate that phalanges and metapodials were often split longitudinally for the extraction of marrow from the bone shaft (Clark 2000).

Raw material selection was performed according to hunting choices carried out at the site (Clark 2000). As showed before, *Cervus elaphus* was used for its antler and for the long bones, especially metatarsals (the use of which is testified by the presence of both bone tools and waste fragments). Given the high state of fragmentation that characterises the bone tools, it is difficult to say if ibex (*Capra*



a



b



c

Fig. 8 - Harpoons technology. a,b) incisions marks on the superior (a) and inferior (b) surfaces created during the production of the barb on the distal fragment of a harpoon from layer G2 (late Sauveterrian) (the bar is 1cm). The distal end of the barb was broken after use; incision marks on the superior surface (the bar is 1cm). c) distal fragment of a harpoon from layer G2 (late Sauveterrian); The distal end of the barb was broken after use (the bar is 1cm).

Fig. 8 - Tecnologia degli arpioni. a,b) tracce di incisione sulle superfici superiore (a) ed inferiore (b) del frammento distale di arpione dal livello G2 (Sauveterriano finale) create durante la produzione del dentello (la barra indica 1cm). L'estremità distale del dentello è rotta in seguito all'uso; c) tracce di incisione sulla superficie superiore del frammento distale di arpione dal livello G2 (Sauveterriano finale) (la barra indica 1cm); l'estremità distale del dentello è rotta in seguito all'uso.

*ibex*) or chamois (*Rupicapra rupicapra*) long bones were used for tool making as well as a source of food (Clark 2000).

## 5. LATE MESOLITHIC (CASTELNOVIAN). TECHNO-FUNCTIONAL ANALYSIS

The sample contains two curated points (Fig. 3e, g), an awl (Fig. 3f), a percussion tool (Fig. 10b) and two fragments of waste from the process of manufacturing red deer antler (Fig. 12b, c).

### 5. 1. Pointed tools (N=3)

Curated tools come from layer C and mixed layers E1-E3. Their long blanks were extracted from long bone diaphysis by longitudinal grooving. Traces of this technique are visible on the sides of one specimen (Fig. 5e, f). No debitage marks are preserved on the awl's surfaces found in unspecified layers D3-E1 as a result of shaping. This phase is identifiable all along the pointed tools as longitudinal striations produced by flint scraping.

Taphonomic alterations affecting the archaeological surfaces have limited the functional analysis of the tools. Their surfaces appear burnt and damaged by root-etching, thermic mechanical detachments and exfoliation.

### 5. 2. Harpoons (N=1)

A base fragment of a harpoon comes from generic Castelnovian layers D (Fig. 6f). It consists of antler compact tissue flake bearing scraping traces (Fig. 9l) and percussion marks on the superior surface at the level of the gorge (Fig. 9o). Sawing motion was used to create the lateral gorge. The distal end shows a partly recent fracture.

### 5. 3. Artefacts with proximal or distal diffuse end (N=1)

A fragmentary percussion tool on a shed red deer antler burr was recovered from layer E (Fig. 10b). It shows a post-depositional alteration (mainly exfoliation) and a recent fracture at the level of the conjunction between the burr and the first beam, which is absent. No technological traces are present on the tool but flattening due to use is visible on its base. The microscopic marks observed on the surface suggest contact with hard material through direct percussion. The described surface could be the active end of a deer antler hammer or the base of a chisel.

### 5. 4. Manufacturing waste (N=2)

The fragments of waste include a quadrangular blank of red deer antler (Fig. 12b) showing grooving and percussion marks (Fig. 14a-c). The technological traces might



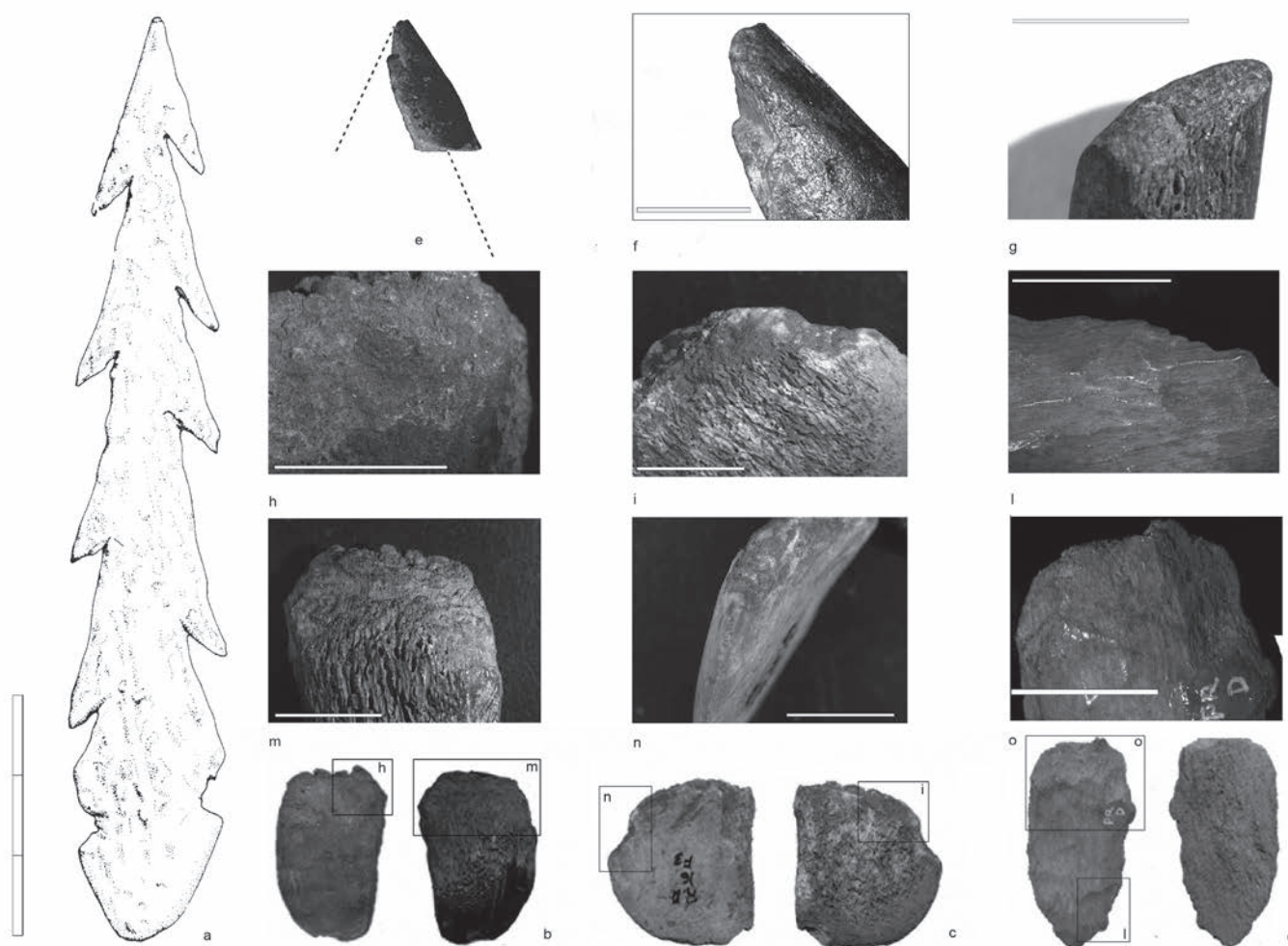


Figure 9 - Harpoon technological and functional modifications. a) Complete harpoon from the Castelnovian levels of Romagnano shelter showed here as a reference; e) single barb location; f) use-fracture on the single barb (the bar is 1 cm); h) magnification of the superior surface gorge on the fragment of the base from layer G1 (the bar is 1 cm); i) magnification of the left side of the gorge from layer F3 showing sawing marks and use-fracture on the distal end (the bar is 1 cm); l) scraping traces on the superior surface of the base from Castelnovian D layer (the bar is 1 cm); m) inferior surface of the gorge on the base from the Sauveterrian layer G1 showing percussion marks (the bar is 1 cm); n) left side of the base from Sauveterrian layer F3 showing sawing marks (the bar is 1 cm); o) technological traces on the gorge on the fragment of the harpoon base from the Castelnovian layer D (the bar is 1 cm).

Figure 9 - Modificazioni tecnologiche e funzionali sugli arpioni. a) arpione completo dai livelli castelnoviani di Romagnano III presentato qui come riferimento; e) localizzazione del singolo dentello; f) frattura funzionale sul dentello (la barra indica 1 cm); h) ingrandimento della gorge superiore presente sul frammento di base proveniente dal livello G1 (la barra indica 1 cm); i) ingrandimento del lato sinistro della gorge basale dal livello F3 con tracce di taglio e frattura funzionale sull'estremità distale (la barra indica 1 cm); l) tracce di raschiamento sulla superficie superiore della base dal livello D (Castelnoviano) (la barra indica 1 cm); m) superficie inferiore della gorge basale dal livello G1 (Sauveterriano finale) con tracce di percussione indiretta (la barra indica 1 cm); n) parte sinistra della base dal livello F3 (Sauveterriano finale) con tracce di taglio (la barra indica 1 cm); o) tracce tecnologiche sulla gorge basale dal livello D (Castelnoviano) (la barra indica 1 cm).

have been aimed at beam partitioning and compact tissue extraction from the antler. Unfortunately, tools related to these debitage techniques have not been found so far. The manufacturing waste comes from layer E2 and shows anatomical and technological similarities to the quadrangular object from late Sauveterrian layer F3.

Another waste is represented by a fragment of burr and beam from a shed red deer antler found in late Castelnovian layer D (D1-2-3) (Fig. 12c). Longitudinal grooving marks are visible on the beam and transverse sawing marks can be observed in proximity of the first tine, on the oppo-

site side of the beam (Fig. 14d-f). The deep grooving incisions are related to the extraction of longitudinal *baguette* of antler compact tissue although no tools coming from the late Castelnovian layers show marks of this specific *debitage* technique.

##### 5.5. Manufacturing techniques during the Late Mesolithic at Pradestel rockshelter

As for the early Mesolithic, some characteristics can be identified in strategies of different raw material exploita-

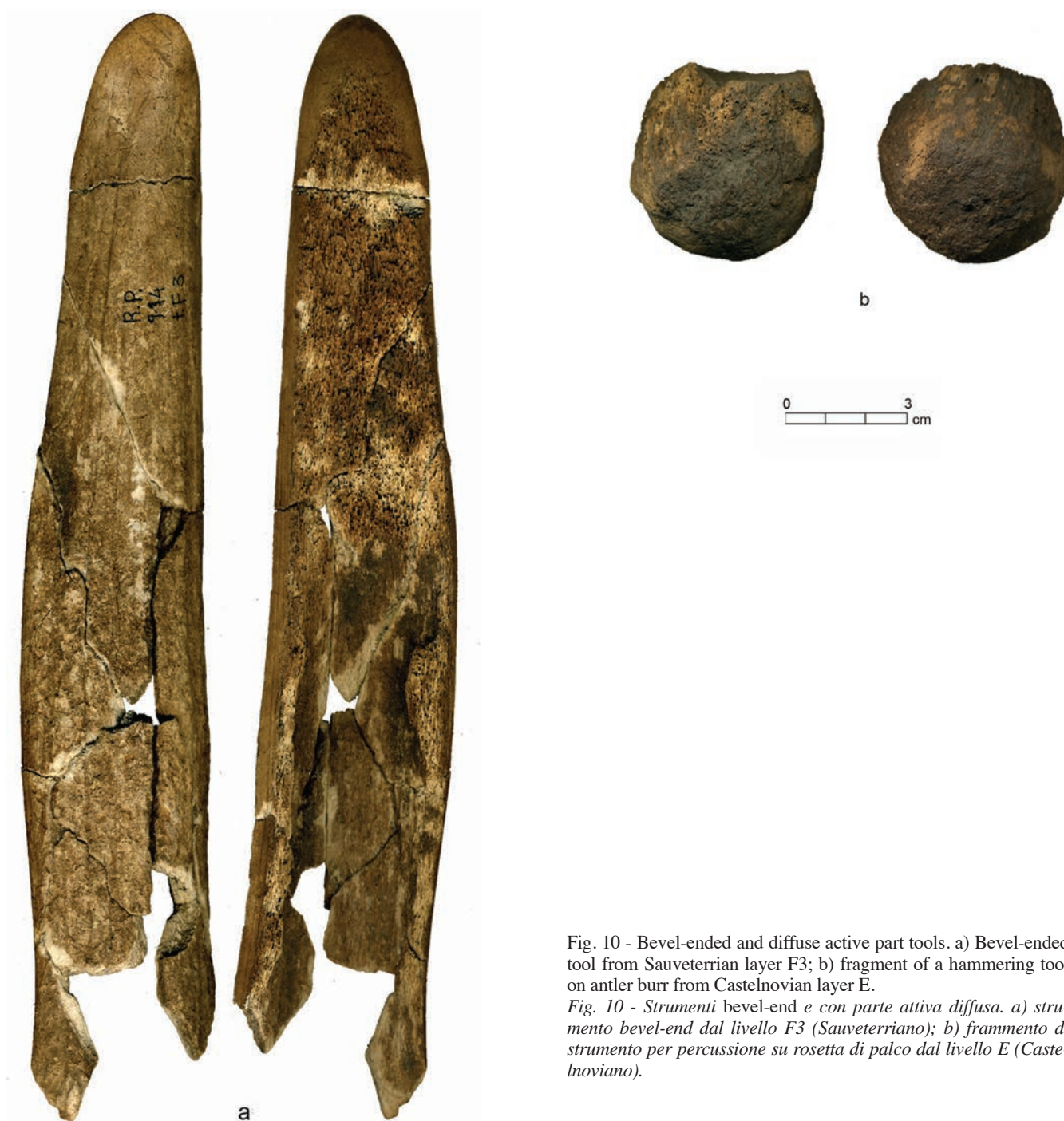


Fig. 10 - Bevel-ended and diffuse active part tools. a) Bevel-ended tool from Sauveterrian layer F3; b) fragment of a hammering tool on antler burr from Castelnovian layer E.

Fig. 10 - Strumenti bevel-end e con parte attiva diffusa. a) strumento bevel-end dal livello F3 (Sauveterriano); b) frammento di strumento per percussione su rosetta di palco dal livello E (Castelnoviano).

tion. Bone continues to be used for manufacturing pointed tools. The osseous blanks related to the production of curved points were extracted by longitudinal grooving on long bone diaphysis and then shaped using flint scraping. Bone awls were manufactured on long flakes coming from deers' metapodials and indeterminable long bone diaphysis. No traces of debitage have been observed on these artefacts since they were erased during the shaping phase carried out by longitudinal flint scraping.

Operational sequences connected to antler processing refer to the *debitage* phase only. No antler tools were found in the Castelnovian layer.

Technological marks identified on the manufacturing waste suggest that blanks of compact tissue were extracted

by longitudinal grooving and transverse percussion. The same technique was identified in the Sauveterrian period.

As for the Sauveterrian phase, raw material selection was made according to animals hunted at the site, in particular red deer (Clark 2000: 89-93).

## 6. ORNAMENTS

Ten *Columbella rustica* perforated shell beads were recovered from the Sauveterrian levels and seven from Castelnovian ones, which also have yielded a perforated *Theodoxus fluviatilis* shell (Fig. 15, Tab. 5).

*Columbella rustica* represents a non edible marine



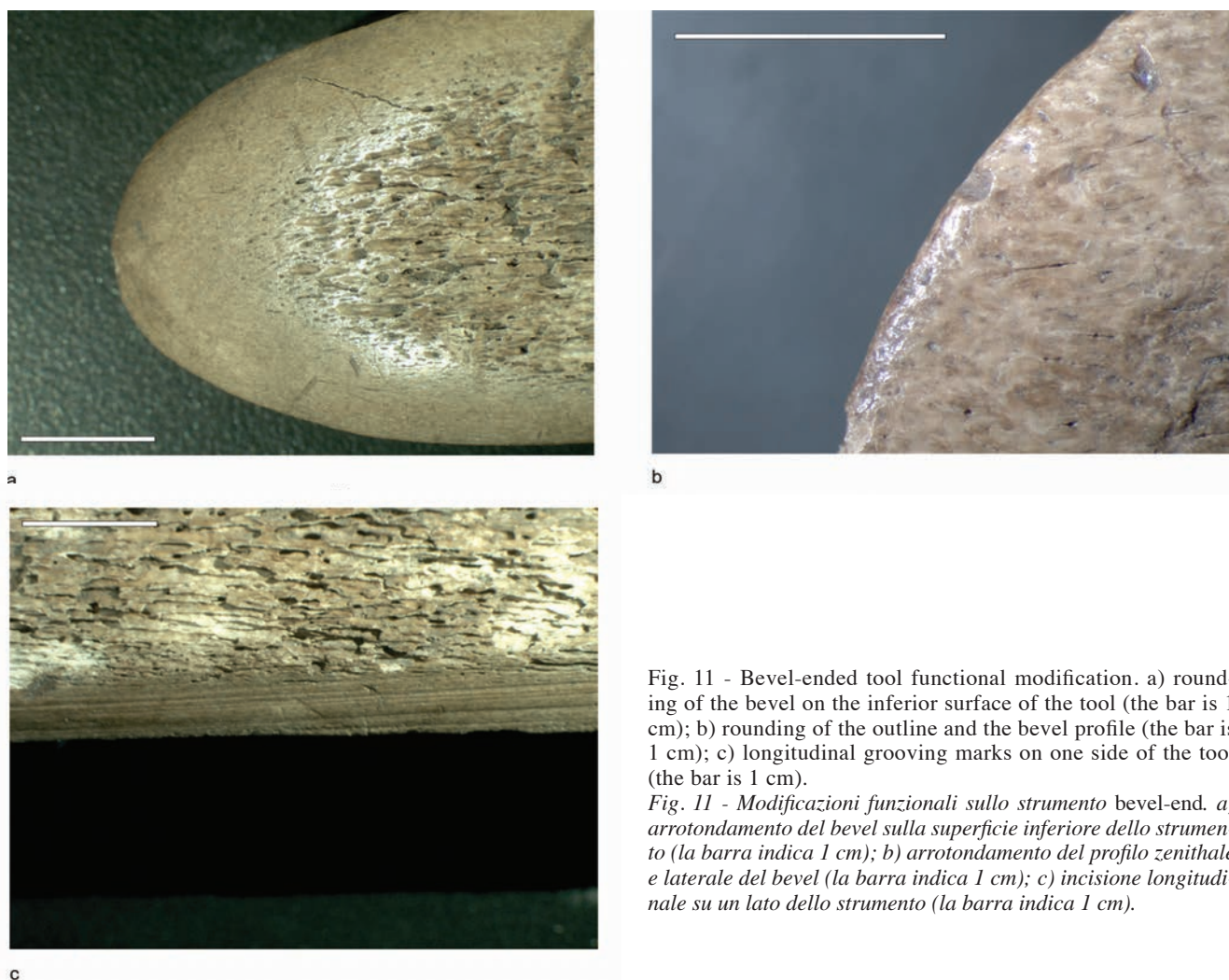


Fig. 11 - Bevel-ended tool functional modification. a) rounding of the bevel on the inferior surface of the tool (the bar is 1 cm); b) rounding of the outline and the bevel profile (the bar is 1 cm); c) longitudinal grooving marks on one side of the tool (the bar is 1 cm).

Fig. 11 - Modificazioni funzionali sullo strumento bevel-end. a) arrotondamento del bevel sulla superficie inferiore dello strumento (la barra indica 1 cm); b) arrotondamento del profilo zenitale e laterale del bevel (la barra indica 1 cm); c) incisione longitudinale su un lato dello strumento (la barra indica 1 cm).

gastropod, which lives in most of the Mediterranean rocky seabed. Even if no absolute dates are available for them, it is likely that the shells were contemporaneous with the site occupation and not fossil ones. Their procurement might have been carried out directly on the shell detritus on the shore. The distance between Pradestel rockshelter site and the coast might suggest long distance contacts (Borrello 2004; Micheli 2004; Benghiat *et al.* 2008) or movement of groups (Grimaldi 2005).

Dimensions of holes on shells vary from 4 to 6,5 mm in width and 3,5 to 6 mm in length. They were created by inserting a thin stick between the columella and the labial edge of the shell and pressing it by indirect percussion. The largest holes, which are very rounded, could also have been enlarged by pressure or created directly by direct percussion (for archaeological comparisons see Benghiat *et al.* 2008). Nevertheless, the experimental activity has shown that the dimension of a hole can vary according to the thickness of shell walls and the type of pressure exercised on the stick (Fig. 16a). The morphology of holes varies from rectangular to circular. The latter are the ones which show the most developed wears on the edges.

Rounding traces are located around the hole, on the inferior surface of the shell, in particular on the outer lip, on the labial teeth and on the columellar plicae (Fig. 16b-f), with no distinctions between early and late Mesolithic ornaments. The wear is more developed on the upper, lower

and left sides of the hole, as shown in figure 6. Six out of ten entire perforated shells bear a less intense use-wear on the right side of the hole. Four shells do not present the labial edge and three are apex fragments. No evaluation of wear intensity and distribution can be done on these specimens.

On four Sauveterrian ornaments red residues have been identified on the columella (2 specimens) and around the hole's sides (2 specimens). Another ornament showing red concretions on the columella comes from generic early Mesolithic layers E/F. The presence of the residue inside the shell could be due to the use of a coloured string for suspension. Since no residue has been observed on the outer surface of the shells, coloring of the entire bead surface seems less likely.

Based on use-wear and residue characteristics and distribution, the use of the shell beads for pendants (Fig. 17) seems more likely than clothing decoration. No red residues were observed on the late Mesolithic ornaments.

## 7. DISCUSSION

The analyses performed allow defining preferences in bone raw materials and manufacturing techniques chosen by early Holocene groups to shape their artefacts. The collection of manufacturing blanks and fragments of waste helps in reconstructing more precisely the stages of manufacture of specific products. Some diachronic differences in



Fig. 12 - Bone and antler manufacturing waste and blanks. a) Fragment of antler waste from the Sauveterrian layer F3; b) fragment of antler waste from the Castelnovian layer E2; c) fragment of antler waste from Castelnovian layer D1-2-3; d) antler blank from Sauveterrian layer F2; e) manufacturing waste on a metapodial from Sauveterrian L6.

*Fig. 12 - Supporti e scarti della lavorazione del palco cervide. a) scarto dal livello F3 (Sauveterriano); b) scarto di lavorazione del palco dal livello E2 (Castelnoviano); c) scarto di lavorazione dai livelli D1-2-3 (Castelnoviano); d) supporto in palco cervide dal livello F2 (Sauveterriano); e) scarto di lavorazione su metapodiale proveniente dal livello L6 (Sauveterriano).*

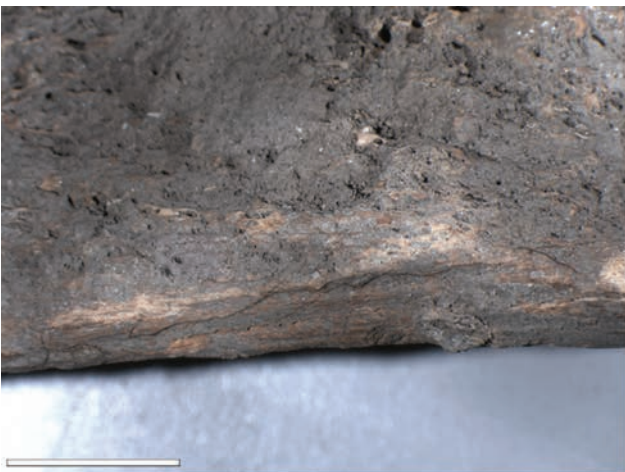




a

Fig. 13 - a) Traces of longitudinal grooving on the baguette made of antler compact tissue from layer F2 (Sauveterrian) (scale 1:1); b) (the bar is 1 cm).

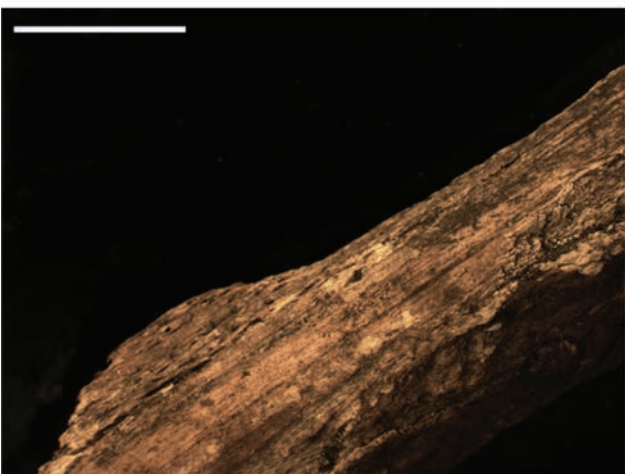
Fig. 13 - a) tracce di incisione longitudinale sulla bacchetta prodotta in tessuto compatto di palco cervide dal livello F2 (Sauveterriano) (la barra indica 1 cm).



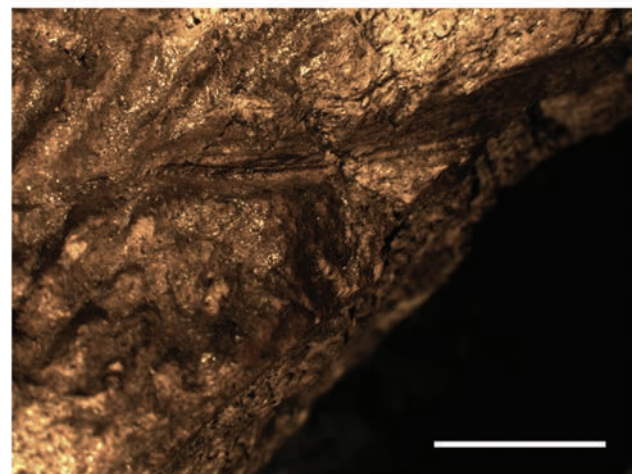
a



b



c



d

Fig. 14 - Antler manufacturing waste. a,b) longitudinal grooving marks (a) and traces of direct percussion (b) on the fragment of waste from layer E2 (Castelnovian) (the bar is 1 cm); c,d) traces of longitudinal grooving from the fragment of waste (mixed Castelnovian layers D1-2-3).

Fig. 14 - Resti della lavorazione del palco cervide. a,b) tracce di incisione longitudinale (a) e percussione diretta (b) su un resto di lavorazione dal livello E2 (Castelnoviano) (la barra indica 1 cm); c,d) tracce di incisione longitudinale sullo scarto della lavorazione dai livelli D1-2-3 (Castelnoviano) (la barra indica 1 cm).



Fig. 15 - Selection of *Columbella rustica* and *Theodoxus fluviatilis* (last specimen on the right) ornaments from the Mesolithic levels of Pradestel shelter.

Fig. 15 - Selezione di ornamenti in *Columbella rustica* e *Theodoxus fluviatilis* (ultimo sulla destra) provenienti dai livelli mesolitici del Riparo Pradestel.

the technological habits have also been observed (Tab. 2).

Bone and antler processing aimed at producing different types of tools. Awls and curated points were manufactured on red deer long bone fragments or longitudinally cut blanks while antler was used for creating bevel-end tools and harpoons since the end of the early Mesolithic. Differences in the techniques used for extracting the longitudinal blanks were observed in relation to different kinds of materials (bone or antler) as well as diachronically as well. Direct percussion was used to work bone only during the early Mesolithic while in the Castelnovian phase this technique was utilised together with longitudinal grooving.

Antler was worked by longitudinal grooving (Fig. 14c, e, f) and transversal percussion (Fig. 7; Fig. 14b). Traces left by this technique on the archaeological manufacturing waste have been verified experimentally (Fig. 18). The distribution of marks on the beam allows excluding the application of an indirect percussion technique. The grooving technique was used since the late Sauveterrian period throughout the Mesolithic. In this period, in fact, the presence of harpoons, *baguette* made out of compact tissue and quadrangular blanks are documented. Later on, even if no evidence of harpoons or bevel-end tools come from the Castelnovian, the presence of a waste fragment from antler points to grooving marks at the level of the beam and may suggest that this technique was still in use during this period (then confirmed by the presence of Castelnovian harpoons in other sites).

No ivory tools were identified at the site. Their absence in all occupation levels could highlight a techno-functional choice more than a bias in the sampling method (it must be considered, in fact, that even small distal ends of pointed tools were collected during the excavation). Further, the remains of wild boar are present in the faunal assemblage both in the Sauveterrian and Castelnovian phases (Clark 2000). Moreover, tools made from tusks of *Sus scrofa* are documented in the early Mesolithic phases at Dos de la Forca

and also in the Mesolithic occupation of Gaban rockshelter.

The selection of raw material for ornaments is quite the same between the early and late Mesolithic, as well as in the technique of the hole production and use. The shell of *Columbella rustica* represents the only material with the exception of a single *Theodoxus fluviatilis*<sup>4</sup> (from the Castelnovian). At Pradestel rockshelter, bone and teeth were not used as raw materials for ornaments production. Nevertheless, antler atrophic canines, bone and carnivore teeth are well documented in other pre-Alpine Late Glacial contexts (Tagliente and Villabruna rockshelters, Verdi di Pradis Caves, etc.: Bertola *et al.* 2007) as well as in Mesolithic site along the Adige Valley (Dalmeri & Nicolodi 2004).

At least a part of the bone and antler tools production activity was carried on the site since manufacturing waste and blanks were found both in the early and late Mesolithic levels.

Artefacts are well defined not only technologically but also typologically. Bone pointed tools are the most prominent category, well represented both during the early Mesolithic (5 objects) and the late Mesolithic (3 objects). The 6 fragments of harpoons complete the pointed-end ensemble pointing out some “functional” specificities of the late Sauveterrian occupation of Pradestel rockshelter that continued throughout the Castelnovian. The production and use of pointed tools for acquisition (hunting) or plant transformation activities (e.g. basketry making) might have been, in effect, a techno-functional aspect of this period since 10 out of the 14 osseous artefacts correspond to this morpho-functional category. Among these tools, curated points (*sensu* Binford 1968) are represented only by one object while awls on diaphysis splinters, carried out by di-

<sup>4</sup> *Theodoxus* (cfr. *danubialis*) was used also at Biarzo rockshelter (Giovannelli 1996).



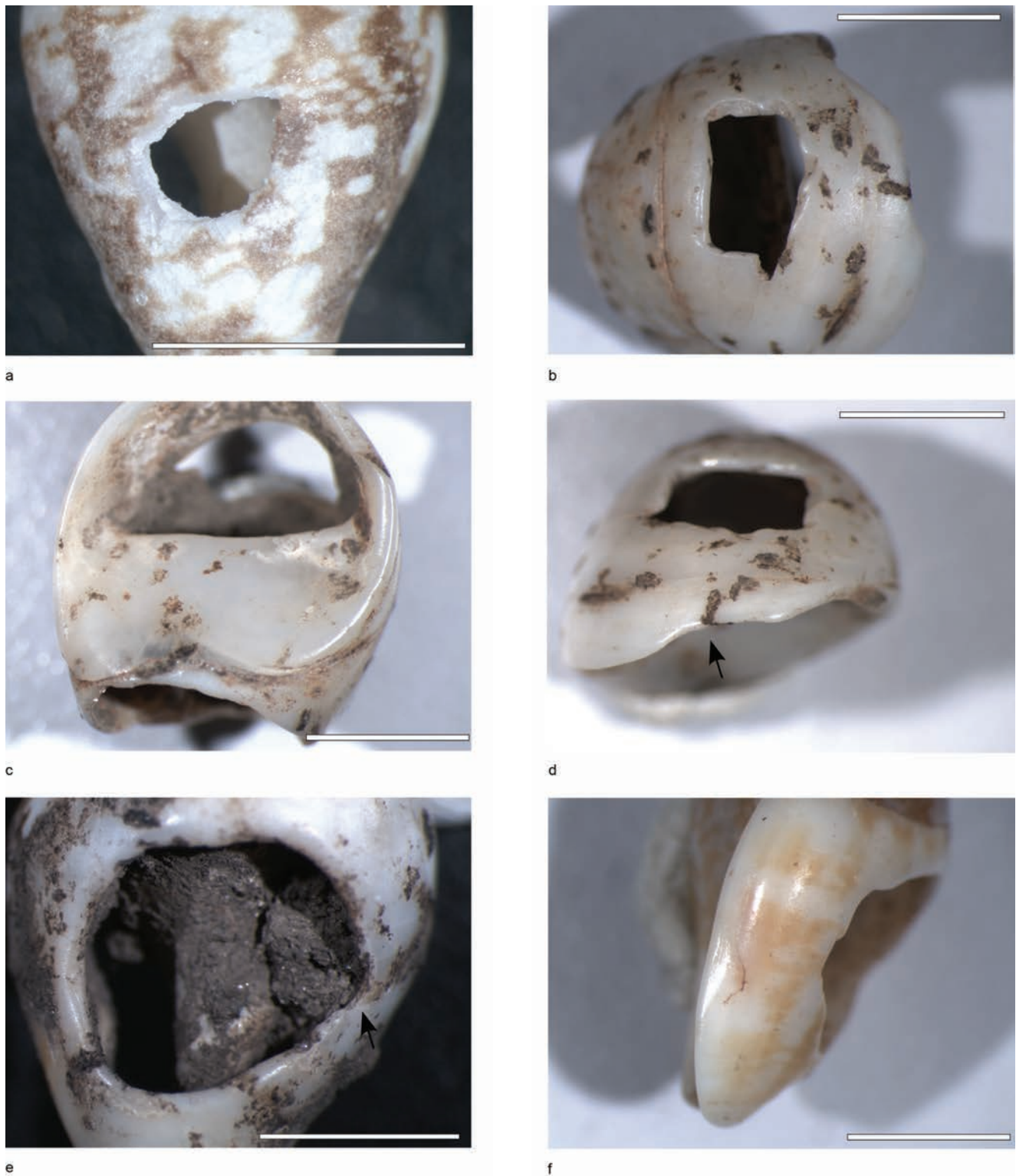


Fig. 16 - Experimental and archaeological traces on shell ornaments. a) Experimental hole created by indirect percussion on a *Columbella rustica* shell (the bar is 1 cm); b) hole on the *Theodoxus fluvialis* shell. On the right part of the perforation a developed rounding is visible; c) rounding of the inferior surface of the same ornament; d) the arrow shows a developed edge rounding on the *Theodoxus fluvialis* ornament; e) ornament made on *Columbella rustica* shell. The arrow shows sharp edges at the right side of the hole while rounding is high developed on the left side; f) ornament on *Columbella rustica* shell. Rounding of the lateral part of the shell due to use.

Fig. 16 - Tracce sperimentali ed archeologiche sugli ornamenti in conchiglia. a) foro sperimentale creato mediante percussione indiretta su una conchiglia di *Columbella rustica* (la barra indica 1 cm); b) foro su ornamento archeologico in *Theodoxus fluvialis*. La parte destra del foro è arrotondata in seguito ad utilizzo; c) arrotondamento della superficie inferiore dello stesso ornamento; d) la freccia indica un arrotondamento sviluppato del margine visibile sull'ornamento in *Theodoxus fluvialis*; e) ornamento prodotto su *Columbella rustica*. La freccia indica margini freschi sul lato destro del foro mentre un arrotondamento sviluppato è localizzato sul margine sinistro; f) ornamento archeologico in *Columbella rustica*. Arrotondamento della parte laterale della conchiglia in seguito ad utilizzo.

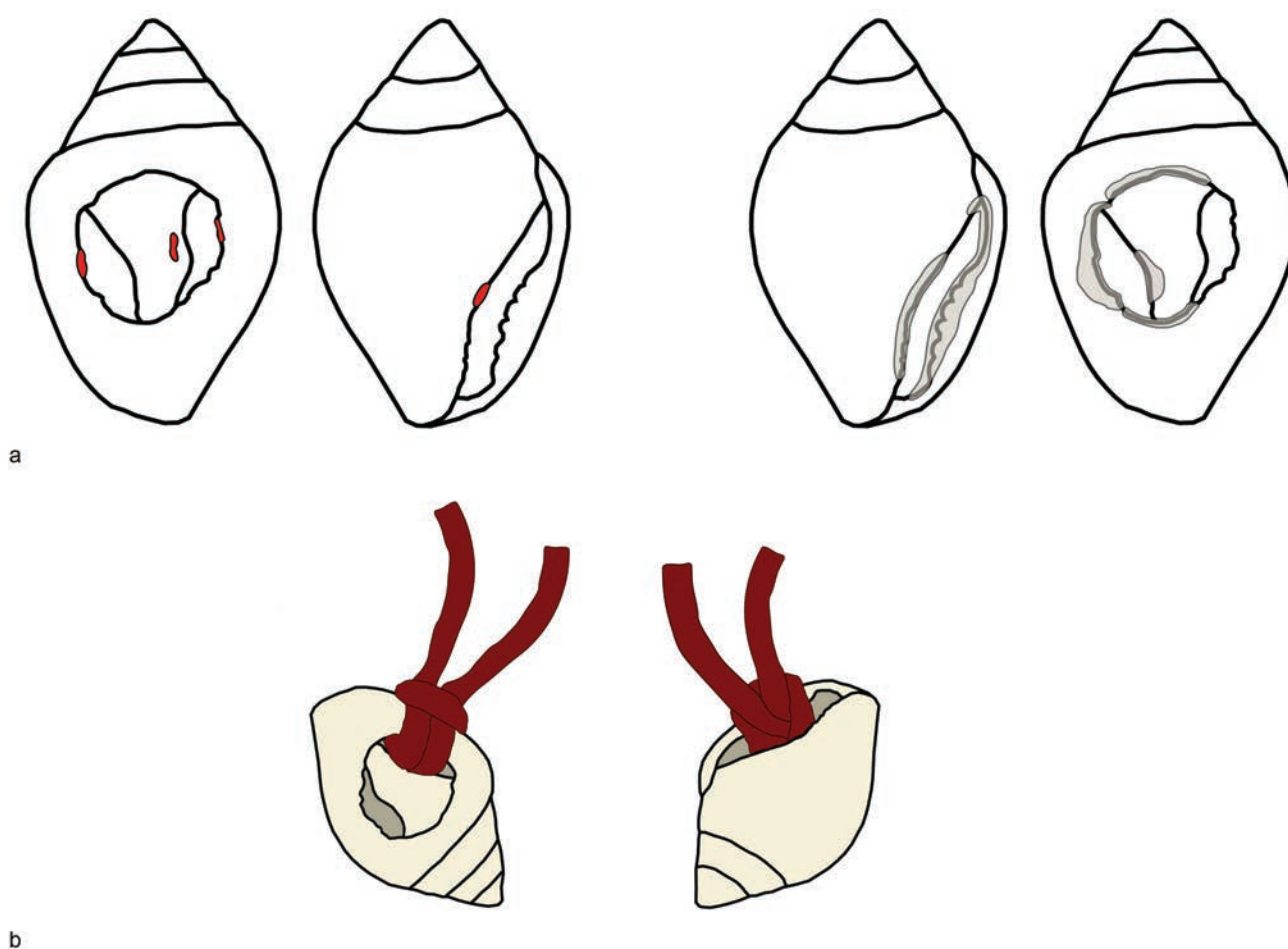


Fig. 17 - a) Residues (left) and rounding (right) distribution on the shell ornaments from Pradestel Mesolithic layers; b) reconstruction of the archaeological shell ornaments use on the base residues location (left) and use-wear pattern (right).

Fig. 17 - a) Distribuzione dei residui (sinistra) e dell'arrotondamento (destra) sugli ornamenti in conchiglia del Riparo Pradestel from Pradestel; b) Ricostruzione della modalità di utilizzo degli ornamenti in conchiglia sulla base della distribuzione dei residui (sinistra) e delle tracce d'uso (destra).

rect percussion on deer and medium ungulates long bones, are more frequent (4 specimens).

At the end of the Sauveterrian occupation, hunting activities are testified with certainty by the presence of harpoons. The presence of bilateral engravings on both bases (Fig. 9) allow us to define the category of Pradestel barbed points as “detachable head harpoons”, tools which are related to fishing or aquatic hunting, both in ethnographic and archaeological contexts (David 1997; Luik *et al.* 2005; Rozoy 1978; Rudenko 1961). In the region, harpoons are known from Romagnano rockshelter and the Mondeval de Sora burial (both late Mesolithic). There is also an almost complete specimen from Dos de la Forca (Mezzocorona)<sup>5</sup> (the final Sauveterrian levels). The barbs that characterise the latter tools (Dos de la Forca and Mondeval de Sora)

show a different morphology in comparison to the Pradestel harpoons which more resemble the Romagnano artefact.

The absence of this category of tools in the early Mesolithic period seems to characterise all the contexts of the Adige valley and also of the pre-Alpine region as well as north-western Europe (Razoy 1978). Also at Birmatten-Basisgrotte (Northern Swiss), as an example, harpoons appear at the end of the early Mesolithic (in particular in layers H2 and H1 attributed to the Boreal-early Atlantic and early Atlantic transition characterised by lithic Tardenosian industries) (David 2000). It must be stressed out that at this Swiss site, bone harpoons and some other tools with proximal perforations were also present. Both of these features are completely absent in the Adige valley. At Pradestel rockshelter, the presence, of ichthyic remains could validate the hypotheses of harpoons' use during fishing activities (Clark 2000: 83) although any functional discussion about these tools should await the results of the specific archaeozoological analyses (Daniele Albertini - Laboratorio di Archeozoologia of “L. Pigorini” Museum, Rome). Nevertheless, pike, trout, beaver and otter were hunted/fished

<sup>5</sup> At Dos de la Forca an almost complete harpoon (only its base is missing) and a fragment of A bilateral harpoon shaft are documented (unpublished, studied by the author).





Fig. 18 - Experimental and archaeological traces of percussion. a) Experimental indirect percussion marks; b) experimental direct percussion marks; c) archaeological traces on antler.

Fig. 18 - tracce sperimentali ed archeologiche di percussione. a) tracce sperimentali di percussione indiretta; b) tracce sperimentali di percussione diretta; c) tracce archeologiche su palco.

at Galgenbuhel/Dos de la Forca in the Adige Valley during the middle Sauveterrian phase (Wierer, Boscato 2006; Bazzanella, Wierer 2001; Bazzanella *et al.* 2001). Beavers are also present in the faunal assemblage from both Sauveterrian and Castelnovian phases sometime in association with dismemberment traces (related to skinning or meat consumption) (Clark 2000: 91). The hunting of all of these animals can be carried out using detachable head barbed points (Rozoy 1978; for archaeologically documented fishing of pike by means of harpoons see the Maglemosian site of Kunda - Estonia - Cleyet-Merle 1990: 110) (Fig. 19).

At Pradestel rockshelter, there are few differences in the modalities of antler exploitation between the early and the late Mesolithic. The presence of bevel-end tools is restricted to the late Sauveterrian occupation only but the grooving technique – utilised for extracting the longitudinal fragments of antler compact tissue from which the bevel-end tools were shaped – is represented during the Castelnovian phase too through the presence of fragments of manufacturing waste. During the same period this technique is

also utilised for the production of bone curated points, in association with percussion.

Indications about a shared memory in the modalities of hard animal tissues' technological exploitation during the Mesolithic come from the Castelnovian fragment of burr showing percussion traces. Strict analogies can be traced between this tool and the proximal end of the bevel-end tools recovered from Vatte di Zambana (Rozoy 1978) and Dos de la Forca (studied by the author), both coming from the early Mesolithic levels.

Analysis carried out on osseous artefacts from the Late Epigravettian sites of the eastern pre-Alps suggest analogies in the choices involved in bone and antler tools manufacturing as well as in their utilisation during the Late Glacial and Early Holocene.

As an example, bevel-end antler tools produced on long fragments of compact antler tissue are already known during the Epigravettian occupation of Tagliente rockshelter (Lessini mountains, Venetian pre-Alps). Also at this site, they probably related to soft material processing (hide?) (Bertola



Fig. 19 - Archaeological testimony of pike fishing by means of harpoons at the Maglemosian site of Kunda – Estonia (edited from Cleyet-Merle 1990: 110).

Fig. 19 - Evidenza archeologica di pesca al luccio effettuata mediante arpione nel sito maglemosiano di Kunda – Estonia (editato da Cleyet-Merle 1990: 110).

*et al.* 2007). The grooving technique – used at Pradestel rockshelter for the extraction of long antler blanks, then shaped in harpoons and bevel-end tools – is documented during the Late Glacial occupation of Dalmeri rockshelter (Altopiano dei Sette Comuni, Marcesina karst plateau) and aimed at the production of curated points. At the same site, the percussion technique was also utilised for producing longitudinal splinters then shaped in awls by flint scraping. A bevel-end antler tool was discovered at Dalmeri rockshelter although here used in hard material processing (e.g. wood working activities) (Cristiani 2008; Gurioli 2008).

## 8. CONCLUSIONS

The analyses carried out on the Mesolithic osseous artefacts of Pradestel rockshelter represent one of the first attempts to characterise techno-functional choices related to the utilisation of osseous materials in the course of Holocene hunter-gathers adaptations of the north-eastern Alpine region.

In this area, as well as in the pre-Alps, the exploitation of bone, antler, ivory and shell is well documented since the Late Glacial. Nevertheless, up to now, the value of this class of materials in assessing techno-functional choices carried out in the region during the Tardiglacial and the early Holocene has been underestimated when compared to other aspects of the archaeological evidence. In this light, the analysis of osseous artefacts from Pradestel rockshelter is contributing to the definition of techno-functional choices carried out during the Mesolithic, even if the sample is rather small.

The results of the study (on tools, manufacturing waste and blanks and ornaments) has recognised a series of specific techniques related to bone, antler and shell processing, which can be traced back to the earlier Late Glacial hunters' modalities of osseous material exploitation (as documented at Dalmeri and Tagliente rockshelters). In

particular, the production of both blanks and finished tools was carried out using wear techniques such as grooving – mainly used in the antler working and aimed at extracting compact tissue from the beam – and fracturing techniques such as direct percussion. The former technique was utilised in the transversal sectioning of the beam and the latter in the production of flakes for pointed tools.

Our data do not suggest a profound technological shift in the modalities of bone and antler exploitation in the course of the Mesolithic as far as the shell-working is concerned. Nevertheless, taking into account the functional results, an interesting specificity can be observed in the strategies of bone tools' use at the end of the Sauveterrian phase. In fact, the use of harpoons is documented in layers G (3-2-1) and in layer F3. The utilisation of this category of tools continues in the Castelnovian and a base of harpoon was discovered from layer D. Morphological and stratigraphical comparisons with similar findings in the Alpine region (both of north-eastern Italy and northern Europe - Swiss, Germany, etc - Rozoy 1978; David 2000) as well as fish remains coming from other Mesolithic sites of the Adige Valley could highlight specific techno-functional adaptations carried out during the transition between the Boreal-early Atlantic and the early Atlantic (fish remains and fishing activities are already well documented during the Epigravettian at Dalmeri rockshelter, see Albertini & Tagliacozzo 2004).

The characterisation of choices carried out by the first Holocene hunter-gatherer groups of the Adige valley will properly be evaluated only after the integration of the "material culture" techno-functional evidence with the archaeozoological data<sup>6</sup> and subsequent analyses at other

<sup>6</sup> Fish remains from Pradestel rockshelter are still being studied by the Laboratorio di Archeozoologia of Museo Pigorini (Rome)



contemporaneous sites in this territory. Only by putting together different types of information, facets of specific functional adaptation (such as site function, seasonal use of a place, etc.) and traits of a shared techno-functional memory qualitatively new information will be obtained.

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## REFERENCES

- Albertini D. & Tagliacozzo A., 2004 - Fresh water fishing in Italy during the Late Glacial period: the examples of Riparo Dalmeri (Trento). In: Bugal J.P. & Desse J. (eds), *Petits animaux et sociétés humaines. Du complément alimentaire aux ressources utilitaires*. Actes des XXIV rencontres internationales d'archéologie et d'histoire d'Antibes, 23-25 octobre 2003:131-136.
- Averbouh A., (ed), 1995 - *Fiches typologique de l'industrie osseuse préhistorique, vol. VIII, éléments barbelés et appendés*. Cedarc, Treignes.
- Bagolini B., 1980 - *Il Trentino nella preistoria del mondo antico. Dagli accampamenti sotto roccia alla città quadrata*. Temi, Trento.
- Bagolini B. & Broglio A., 1975 - Ricerche e scavi nel Trentino Alto Adige: Pradestel (Trento). *Preistoria Alpina*, 11 (1974-1975), 311 pp.
- Bazzanella M., Betti L. & Wierer U. (2004) - Galgenbühel/Dos de la Forca. Un nouveau site sauveterrien dans la Vallée de l'Adige (Bozen/Bolzano, Italie). *BAR International Series*, 1302: 215-225.
- Bazzanella M. & Wierer U., 2001 - Die mesolithische Fundstelle am Galgenbühel in Salurn, Südtirol. Eine Sauveterrienstation im Etschtal. *Der Schlern* 75, 2: 116-128.
- Benghiat S., Komšo D., Miracle P., 2008 - An experimental analysis of perforated shells from the site of Šebrn Abri (Istria), Croatia: *chaîne opératoire* and social context. In: McCartan S., Woodman P., Schulting R. & Warren G. (eds), *Mesolithic Horizons: Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005*. Oxford Books, Oxford: 730-736.
- Bertola S., Broglio A., Cassoli P., Cilli C., Cusinato A., Dalmeri G., De Stefani M., Fiore I., Fontana F., Giacobini G., Guerreschi A., Gurioli F., Lemorini C., Liagre J., Malerba G., Montoya C., Peresani M., Rocci Ris A., Rossetti P., Tagliacozzo A. & Ziggioni S., 2007 - L'Epigravettiano recente nell'area prealpina e alpina orientale. In: Martini F. (a cura di), *L'Italia tra 15.000 e 10.000 anni fa cosmopolitismo e regionalità nel Tardoglaciale*: 39-94.
- Binford L., 1968 - Methodological considerations for the archaeological use of ethnographic data. In: Lee R., DeVore I., (eds) *Man the hunter*. Chicago, Aldine.
- Boas F., 1988 - *The central Eskimo*. Bureau of American Ethnology, Sixth Annual Report. The Smithsonian Institution, Washington D.C.: 409-669.
- Borrello M. A., 2004 - Le conchiglie nella preistoria e nella protostoria. *Preistoria Alpina*, 40: 19-42.
- Bronk Ramsey C., 1995 - Radiocarbon calibration and analysis of stratigraphy: the OxCal Program. *Radiocarbon*, 37(2): 425 - 430.
- Bronk Ramsey C., 2001 - Development of the radiocarbon program OxCal. *Radiocarbon*, 43(2A): 355-363.
- Christidou R., 1999 - *Outils en os néolithiques du Nord de la Grèce. Étude technologique*. Tesi di Dottorato, Università di Parigi X-Nanterre, 418 pp.
- Cilli C., 2002 - *I manufatti in materia dura animale provenienti da siti del Paleolitico superiore dell'Italia nord-orientale*. Tesi di Dottorato di Ricerca in Archeo-Antropologia, Torino.
- Cilli C., Giacobini G. & Guerreschi A., 2001 - Bone artefacts from the Mesolithic burial of Mondeval del Sora (Belluno, Italy). Preliminary technological and functional observations. *Actes of the Congress "Science and technology for the safeguard of Cultural Heritage in the Mediterranean Basin"*.
- Cilli C., Giacobini G. & Guerreschi A., 2001 - Le mobilier funéraire de la sépulture mésolithique de Mondeval de Sora (Belluno, Italie). Proceedings of the XIV International Congress of Prehistoric and Protohistoric Sciences.
- Cilli C., Giacobini G., Guerreschi A., Gurioli F., 2006 - L'industria e gli oggetti ornamentali in materia dura animale dell'Epigravettiano di Riparo Tagliente (Verona). *Atti della XXXIX Riunione Scientifica Istituto Italiano di Preistoria e Protostoria*. Firenze: 843-854.
- Clark R., 2000 - The Mesolithic hunters of the Trentino. A case study in hunter-gatherer settlement and subsistence from northern Italy. *BAR International Series*, 832 pp.
- Cleyet-Merle J. -J., 1990 - *La préhistoire de la pêche*. Ed. Errance, Paris.
- Cristiani E., 2008 Analisi funzionale dei manufatti in materia dura animale del Riparo Dalmeri (Altopiano della Marcesina, Trento). *Preistoria Alpina*, 43: 259-287.
- Dalmeri G., Cusinato A., Neri S., Nicolodi F., 2008 - Le industrie mesolitiche di Riparo Pradestel (Trento). Aspetti tipologici ed evolutivi. *Preistoria Alpina* 43: 131-186.
- Dameri G. & Nicolodi F., 2004 - Siti e collezioni antropologiche, preistoriche e protostoriche provinciali del Museo Tridentino di Scienze Naturali (verifica di archivio riferita al 1988). *Preistoria Alpina*, 40: 63-81.
- David E., 2000 - L'industrie en matières dures animales des sites mésolithiques de la Baume d'Ogens et de Birmatten-Basisgrotte (Suisse). In: Crotti P. (ed.) 2000, MESO 1997, *Actes de la Table Ronde "Epipaléolithique et Mésolithique"*. Cahiers d'Archéologie Romande, 81: 79-100.
- Giovannelli M., 1996 - I molluschi utilizzati dall'uomo, in Guerreschi A. (a cura di), Il sito preistorico del Riparo di Biarno. «Edizioni del Museo friulano di Storia Naturale», 39: 55-60.
- Grimaldi S., 2005 - Un tentativo di definire un modello di territorio e mobilità per i cacciatori raccoglitori sauveterriani dell'Italia nord-orientale. *Preistoria Alpina*, 41: 73-88.
- Gurioli F., 2008 - Analisi tecnologica dei manufatti in materia dura animale dell'Epigravettiano recente di Riparo Dalmeri (Altopiano della Marcesina, Trento). *Preistoria Alpina*, 43: 237-258.
- Leroi Gourhan A., 1943 - *Evolution et technique. L'homme et la matière*, Paris, Albin Michel; trad. it. 1993, *L'Uomo e la Materia*. Jaka Book, Milano.
- Luik H., Choike A., Batey C. Lougas L., (eds), 2005 - *From Hooves*

- to horns, from mollusc to mammoth – manufacture and use of bone artefacts from prehistoric times to the present*, Proceedings of the 4<sup>th</sup> Meeting of the ICAZ Worked Bone Research Group in Tallin (Estonia). Muinasaja teadus 15.
- Micheli R., 2004 - Gli ornamenti in conchiglia del Neolitico dell'Italia settentrionale. *Preistoria Alpina*, 40: 53-70.
- Rozoy J. G., 1978 - Les derniers chasseurs. *Bullettin de la Société Archéologique Champenoise*, numero speciale.
- Rudenko S. I., 1961 - *Ancient culture of Bering sea and the Eskimo problem*. Artic Institute of North America, University of Toronto Press (tradotto da Tolstoy P.).
- Stordeur D., 1985 - Classification multiple des outillages osseux de Khirokitia, Chypre, VIIe millénaire. In: H. Camps-Fabrer, (ed), *L'industrie en os et bois de cervidé durant le Néolithique et l'âge des métaux*, 3ème réunion du groupe de travail no 3 sur l'industrie de l'os préhistorique. Paris, Ed. CNRS:11-23.
- Voruz J-L, 1984 - Outillage osseux et dynamisme industriel dans le Néolithique jurassien. *Cahiers d'Archéologie Romande*, 29.
- Wierer U., Boscato P., 2006 - Lo sfruttamento delle risorse animali nel sito mesolitico di Galgenbühel/Dos de la Forca: la macrofauna. In: *Archaeozoological studies in honour of Alfredo Riedel*, Bolzano: 85-98.



Appendix 1 - Osseous artefacts from Sauveterrian levels of Pradestel rockshelter.  
*Appendice 1 - Industria in osso dai livelli sauveterriani del Riparo Pradestel.*

Inv. n.	Level	Cultural attribution	Raw material	Specie	Anatomic element	Preservation state	Taphonomy	Integrity	Typology
1950	L6 α	Early Sauveterrian	bone	<i>Cervus elaphus</i>	metatarsal	bad	esfoliation	yes	waste
1969	L5	Early Sauveterrian	bone	<i>Cervus elaphus</i>	metatarsal	good	burnt	yes	awl distal end
1952	L3	Middle Sauveterrian	bone	indet.	long bone	bad	burnt	yes	awl distal end
1934	G3	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	burnt	no	harpoon
1944	G2	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	burnt	no	harpoon
1942	G2	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	burnt	no	harpoon
1941	G1	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	burnt	no	harpoon base
1974	F3	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	good	esfoliation	no	harpoon base
/	F3	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	esfoliation	yes	waste
/	F3	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	esfoliation	no	burnisher
1930	F2	Final Sauveterrian	antler	<i>Cervus elaphus</i>	compact tissue	bad	burnt	no	blank
1931	F1	Final Sauveterrian	bone	indet.	long bone	bad	burnt	no	curated point
1945	F1	Final Sauveterrian	bone	indet.	long bone	good	burnt	no	awl distal end
1951	/	Sauveterrian	bone	indet.	long bone	bad	burnt	yes	awl distal end

Appendix 2 - Osseous artefacts from Castelnuovian levels of Pradestel rockshelter.  
 Appendice 2 - *Industria in osso dai livelli castelnuoviani del Riparo Pradestel.*

Inv. n.	Level	Cultural attribution	Raw material	Specie	Anatomic element	Preservation state	Taphonomy	Integrity	Typology
1943	D3-E1	Middle Castelnuovian	bone	indet.	long bone	bad	burnt	no	awl distal end
1948	D	Middle Castelnuovian	antler	<i>Cervus elaphus</i>	compact tissue	good	burnt	yes	harpoon base
1975	E1-E3	Early Castelnuovian	bone	<i>Cervus elaphus</i>	metatarsal	bad	burnt	no	flat curated point
1990	D1-2-3	Middle Castelnuovian	antler	<i>Cervus elaphus</i>	compact tissue	bad	esfoliation	no	waste/blank
1958	C	Late Castelnuovian	bone	indet.	long bone	bad	burnt	no	curated point
1977	E	Middle Castelnuovian	antler	<i>Cervus elaphus</i>	burr	bad	esfoliation	no	hammer (?)
1989	E2	Middle Castelnuovian	antler	<i>Cervus elaphus</i>	compact tissue	bad	esfoliation	yes	waste/blank



Appendix 3 - Ornaments from Mesolithic levels of Pradestel rockshelter.  
 Appendice 3 - Ornamenti dai livelli mesolitici del Riparo Pradestel.

Inv. n.	Level	Cultural attribution	Specie	Preservation state	Integrity	Columellar plicae rounding	Labial teeth rounding	Hole rounding (low side)	Hole rounding (upper side)	Hole rounding (left side)	Hole rounding (right side)	Side rounding (left)
1960	L2	Middle Sauveterrian	<i>Columbella rustica</i>	good	yes	no	no	yes	yes	yes	no	yes
1963	GH	Final Sauveterrian	<i>Columbella rustica</i>	good	no	no	no	yes	yes	yes	yes	yes
1993	G2	Final Sauveterrian	<i>Columbella rustica</i>	good	yes	yes	yes	yes	yes	yes	no	yes
1928	F3	Final Sauveterrian	<i>Columbella rustica</i>	bad	no	yes	indet	yes	yes	indet	indet	indet
1928	F3	Final Sauveterrian	<i>Columbella rustica</i>	bad	no	yes	indet	indet	indet	indet	indet	indet
1947	F2 ext.	Final Sauveterrian	<i>Columbella rustica</i>	good	no	yes	yes	yes	yes	yes	no	yes
1947	F2 ext.	Final Sauveterrian	<i>Columbella rustica</i>	good	yes	no	no	yes	yes	yes	no	yes
1993	F1	Final Sauveterrian	<i>Columbella rustica</i>	bad	yes	no	yes	yes	yes	yes	no	indet
1966	F	Final Sauveterrian	<i>Columbella rustica</i>	bad	no	indet	indet	indet	ind	indet	indet	indet
1993	E1-E3	Early Castelnuovian	<i>Columbella rustica</i>	bad	yes	no	no	yes	yes	yes	yes	indet
1993	E1	Early Castelnuovian	<i>Columbella rustica</i>	good	no	no	ind	yes	yes	yes	no	indet
1959	E1	Early Castelnuovian	<i>Columbella rustica</i>	good	yes	yes	yes	yes	yes	yes	yes	yes
1968	E F	Early Castelnuovian	<i>Columbella rustica</i>	good	no	yes	indet	yes	yes	indet	yes	indet
1940	D3	Middle Castelnuovian	<i>Columbella rustica</i>	bad	no	indet	indet	indet	ind	indet	indet	indet
1955	D3	Middle Castelnuovian	<i>Columbella rustica</i>	bad	no	no	no	no	yes	yes	indet	yes
1935	D1	Middle Castelnuovian	<i>Columbella rustica</i>	good	no	yes	yes	yes	yes	yes	yes	yes
1976	D1	Middle Castelnuovian	<i>Theodoxus fluviatilis</i>	good	no	indet	indet	yes	yes	yes	yes	yes

