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## Adornment in the early Mesolithic: Analysis of marine shells from La Baume de Monthiver (Jabron, Var, France)

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### ABSTRACT

The widespread distribution of the Sauveterrian complex across Europe suggests the presence of networks connecting distant groups, facilitating the dissemination of concepts and techniques on a large scale. This hypothesis is largely based on the analysis of lithic tools in terms of provisioning, knapping techniques and the typology of tools produced. However, to gain a detailed understanding of the social dynamics of early Holocene groups, it would seem necessary to include other aspects of Sauveterrian societies. In particular, ornamental practices played an important role in social relations, due to their function in the construction and expression of personal and collective identities. Through the study of ornaments, we aim to unravel the interactions between Sauveterrian groups. The study of the ornaments from La Baume de Monthiver (Var, France) has enabled us to address both the diachronic and synchronic dimensions of ornamental practices. Here we analyze the entire biography of ornamental objects, from the collection of raw materials, the methods of manufacture, to the mounting of the ornamental composition, revealing a certain stability in practices at the beginning of the Holocene. Several dynamics seem to be intertwined, between the shared choice of raw material on a very large scale and possible regional dynamics visible especially in the type of ornamental compositions adopted.

### 1. Introduction

The Sauveterrian is an early Holocene technocomplex (10th-8th millennium) that extended across Europe. It is characterized by technological variability in the lithic assemblages, which has alternatively been interpreted as being linked to site function (Ricci, 2018; Visentin et al., 2014), regional variability or diachronic evolution (Angelin et al., 2018; Broglio and Kozłowski, 1984; Guilbert, 2003). Recent research trends suggest a growing emphasis on regional differentiation, between Provence, Liguria, and the Tuscan Apennines on the one hand, and south-western France on the other (Guilbert, 2003; Valdeyron, 2008; Visentin, 2017). Discussion surrounding the material culture of these early Mesolithic groups has predominantly been centered on lithic tools. It highlights the high degree of homogeneity of the technical systems (mode of knapping) and provisioning (strictly local), which contrasts with the typological heterogeneity of the assemblages (Ricci et al., 2021).

Within this dichotomy, technological research tends to highlight the similarities in technical systems rather than purely focusing on typological differences (Angelin et al., 2016; Flor et al., 2011; Perrin and

Defranould, 2016; Ricci, 2018; Serradimigni, 2016; Visentin, 2017; Visentin et al., 2014). Consequently, some authors recognize the Sauveterrian as a techno-complex wherein internal variations should be interpreted from a techno-economic perspective (lithic resource management cf. mode of knapping and provisioning strategies, Franco, 2011; Moroni et al., 2016; Ricci, 2018; Ricci et al., 2021) rather than being linked to processes of cultural differentiation among populations at a regional level (Lo Vetro and Martini, 2016; Martini, 1993; Tagliacozzo et al., 2016).

One of the key characteristics of the Sauveterrian period is the contraction of lithic raw materials procurement areas, making it a distinctive feature of this cultural facies.

However, given the wide geographic extent of the techno-complex this phenomenon should not be interpreted as evidence of cultural fragmentation—i.e., cultural differentiation resulting from a lack of contact between groups. Instead, it implies frequent interactions between groups and constant exchanges that played a pivotal role in the rapid dissemination of innovations, contributing to the common adoption of production methods and tools characteristic of the Sauveterrian (Visentin, 2017).

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Ornaments, particularly the use of marine shells, are one of the proxies testifying to a vast network of circulation and mobility (Cvitkušić, 2017; Eriksen, 2002; Komšo and Vukosavljević, 2011; Märgärit et al., 2020). This is evident both in terms of the type of species selected, used, and shared over a wide territory (notably the species *Columbella rustica*), and the fact that they are also found in sites sometimes far from the coast (Álvarez-Fernández et al., 2008; Cucart-Mora et al., 2022; Komšo and Vukosavljević, 2011).

In this study, to gain a better understanding of the social dynamics of early Holocene groups, we propose to look at ornamental practices that provide insights into social strategies for expressing individual and collective identities (Álvarez-Fernández, 2010; Cristiani and Borić, 2017; Cucart-Mora et al., 2022; Rigaud, 2011; Rigaud et al., 2019; Stewart et al., 2020; Wiessner, 1982).

We analyse the shell ornaments from La Baume de Monthiver (Var, France), which is one of the few Provençal stratified sites documenting occupations around the 10th-9th millennium cal. BP. It has also yielded a significant amount of shell ornaments given the surface excavated (29 artefacts, 23 of which are associated to Sauveterrian levels on 8 m<sup>2</sup> excavated) that will allow us to investigate ornamental practices and their place in the mosaic of variations in material culture from the early Mesolithic period. To achieve this, we employ a biographical approach to reconstruct the entire life cycle of the ornamental objects (Baysal and Yelözer, 2022; Cvitkušić et al., 2024; Fontijn, 2013; Hoskins, 2006; Joy, 2009; Rigaud et al., 2022; Schiffer, 1972). It includes the selection of the shells, the manufacturing methods employed to transform them into ornaments, their mode of use, and their abandonment. This approach, which takes into account the entire life trajectory of objects, is an ideal tool for gaining access to the social and symbolic aspects of hunter-gatherer communities.

## 2. Site presentation

La Baume de Monthiver site (Porraz et al., 2018; Ricci et al., 2023b; Ricci et al., 2023a) faces east along the Baumes cliff on the Monthiver Jurassic massif at an altitude of around 900 m, above the Montade valley (Fig. 1). The site is a small terrace about ten meters wide and five meters

deep.

The site have been excavated in 2017 (Porraz et al., 2018; Porraz et al., 2017) and 2022 (Ricci et al., 2022; Ricci et al., 2023a). The sequence at La Baume de Monthiver (BMV) consists of seven sedimentary phases (designated with capital letters and preceded by 'M-') corresponding to 34 stratigraphic units (thereafter SU). It can be subdivided into two main archaeological groups: the lower group dating from the Late Glacial period and the upper group from the Early Holocene period, separated by a sterile sedimentary phase (M–D). We will focus here on the upper section, which has yielded numerous remains in the form of lithics, fauna, malacological remains, and iron oxides (Ricci et al., 2022). The upper section is composed of five sedimentary phases (M–C, M–B', M–B, M–A' and M–A).

Here, we will focus on phases M–C, M–B' and M–B, for which radiometric dating (Fig. 2) and the first interdisciplinary studies (see Ricci et al., 2023b) have placed human occupations in the 10th and 9th millennia cal. BP, corresponding to chrono-cultural levels to the Sauveterrian techno-complex. Initial analyses of the lithic remains have also revealed practices that are consistent with current data on the Sauveterrian culture (Ricci et al., 2021; Ricci et al., 2023a; Ricci et al., 2023b).

Modern excavation techniques and the well-controlled stratigraphy, supported by several radiocarbon dates (Fig. 2), represent ideal conditions for carrying out a detailed study of the ornaments.

## 3. Material and methods

A total of 29 marine shells has been discovered at this site, 23 of which are from phases M–B' and M–C (Table 1). The shells from these phases, attributed to the Sauveterrian, are the subject of the study presented here. They were identified using the reference collection compiled by J. Cattalioti and kept at the CEPAM, as well as the manual by Poppe and Goto (1991). We thus determined that all the Mesolithic shells belong to the species *Columbella rustica* (Fig. 4). During the excavation, the shells were collected wearing gloves, with no direct contact between the hands and the shells so as not to deposit any residue that would prevent the surfaces from being read on a microscopic scale.

The shells were observed at macro (x10 to x80) and microscopic

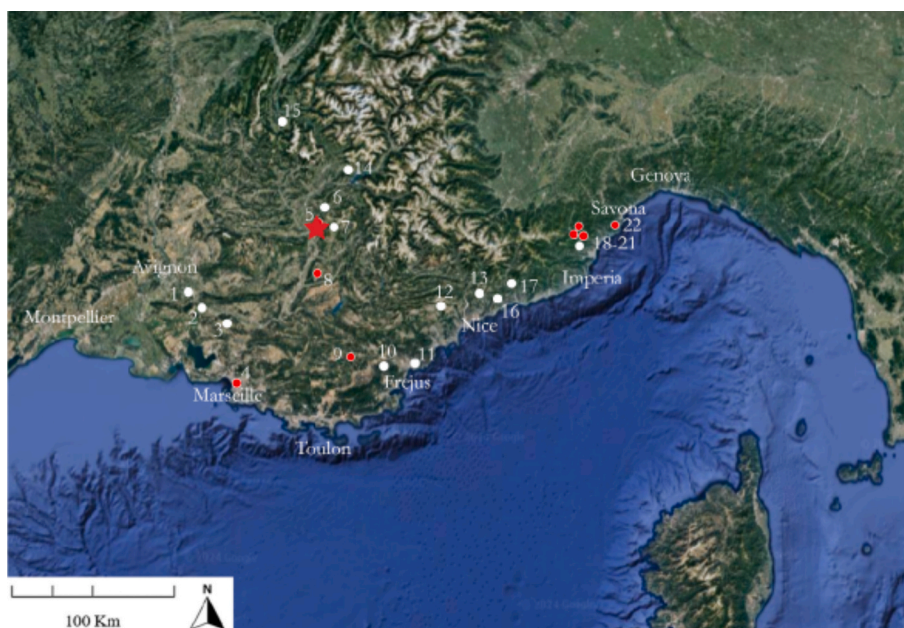
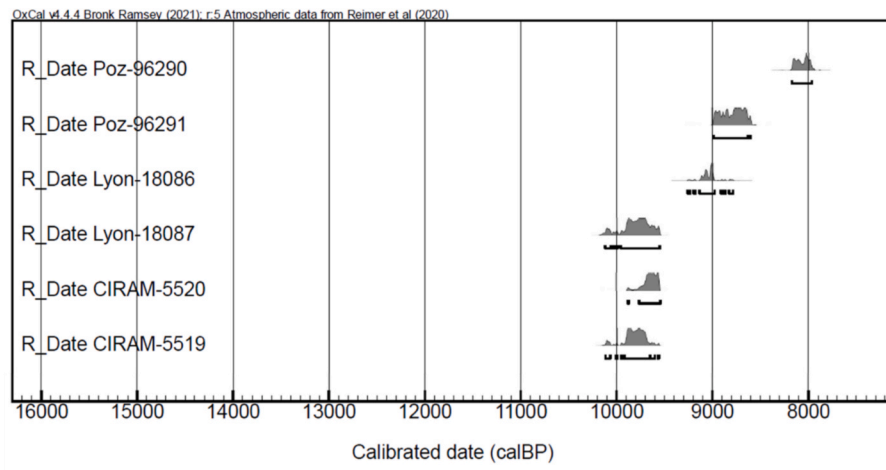


Fig. 1. Map of the Sauveterrian sites within the Liguro-Provençal arc. In red are the sites that have yielded ornaments, in white are the Sauveterrian sites that have yielded no ornaments. The red star is the Baume de Monthiver. 1: Le Sansonnet, 2: Les Agnells, 3: Pey-de-Durance, 4: Grotte de la Montade, 5: Baume de Monthiver, 6: Baume Rouyer, 7: Baume de la Bruyère 3, 8: Saint-Mitre, 9: Fonbregoua, 10: B. Colle Rousse, 11: Figueurs de la Cabre, 12: G. Lombard, 13: Pendimoun, 14: Faravel XIII, 15: La Grande Rivoira, 16: Punta della Mortola, 17: Pian del Re, 18: Ortovero, 19: Arma di Nasino, 20: Arma dello Stefanin, 21: Arma Veirana, 22: Arene Candide.



**Fig. 2.** radiocarbon dating of La Baume de Monthiver, M–B’ et M–C phases: (Poz-96290 M–B’3.1; Poz-96291: M–B’3.1; Lyon-18086: M–B’3.2; Lyon-18087: M–B’3.6; CIRAM-5520: M–B’4.7; CIRAM-5519: M–C 9b.3, Feat. 3). Radiocarbon dating calibrated with OxCal v4.4.4, IntCal20 calibration curve (Reimer et al., 2020).

**Table 1**

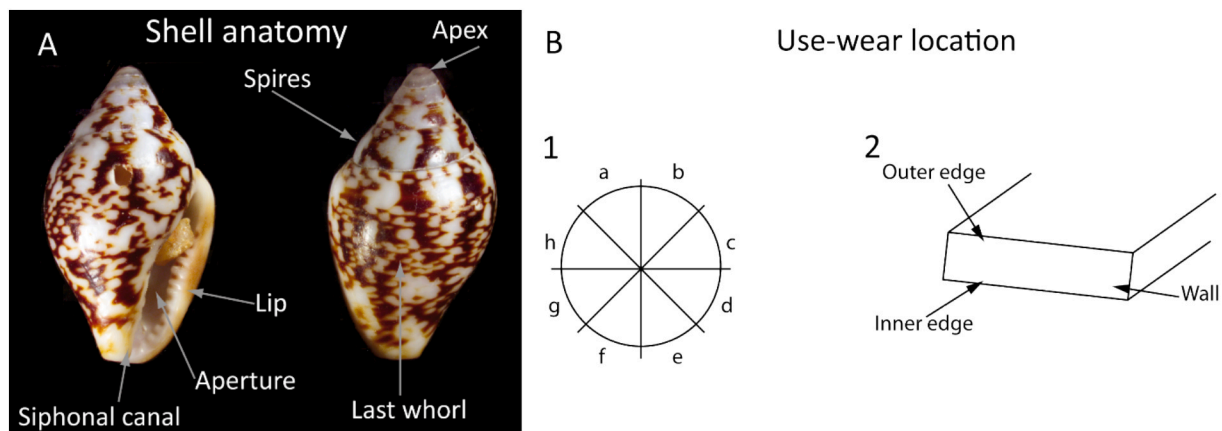
Number (nb) of marine shells in the different levels (here designated SU for Stratigraphic Unit). The out-of-context element was recovered during sieving of the backfill of the clandestine excavation during the 1<sup>st</sup> excavation campaign in 2017. Items highlighted in yellow are those from the Sauveterrian occupations and taken into account for this study.

Phase	Reworked	M–A	M–A’’	M–B’					M–C		
SU	Out of context	17	23	4	5	13	13b	30	25	9a	9b
MNI of shells per SU	1	2	3	5	5	8	1	1	1	1	1
MNI of shells per phase	1	2	3	20					3		

(x100 and x200) scales to understand how they were collected (live underwater or dead on the beach), perforated and used. Observations and photographs were taken using a Leica Z16 APO macroscope linked to a DMC 2900 camera and a Leica DMRM microscope equipped with a DMC 2905 camera. We described the different types of traces and their location (Fig. 3).

The traces observed were compared with a natural reference collection and with experimental pieces documenting the technical traces and use-wear kept at the CEPAM. This reference collection contains more than 250 shells, perforated with six techniques (pressure, percussion, scratching, grinding, rotation, sawing, for more details, see Hoareau et al., 2021). Some of these shells were worn in different ornamental compositions (simply suspended, tied on individually, and

sawn on leather, for more details see Hoareau and Beyries, 2022). We also drew on experimental work conducted elsewhere on technical and functional traces on shells (Álvarez Fernández, 2006; Bar-Yosef Mayer et al., 2020; Bosch et al., 2023; d’Errico et al., 1993; Langley and O’Connor, 2016; Märgärit, 2016; Märgärit et al., 2018; Rodière, 2011; Schechter, 2023; Vanhaeren et al., 2013). We observed the shells from the different stratigraphic unit (SU) separately. We noted a high degree of homogeneity in both technological and functional traces, which is why we present the data here as a single set.



**Fig. 3.** Vocabulary referring to the location of wear. A: shell anatomy. B: vocabulary used to describe the location of use-wear. The perforation was divided in 8 portions, named from a to h as shown in B1 (modified after Claassen, 1998; Bonnardin, 2009). The extent of the rounding of the perforation has been described thanks to the division shown in B2.

## 4. Results

### 4.1. Preservation of the assemblage

Few shells are whole, 78 % are fractured (Fig. 4). Fourteen specimens miss all or part of their spires (BMV-383, 553, 720, 821, 828, 2012, 1099-1, 1099-2, 1100, 1233, 1129, 1235, 1626, 1627). Five shells have lost their lip and almost all of the last whorl (BMV-720, 1129, 1233, 1604, 1801). Only the lower part of the shell is preserved for two shells (BMV-400, 1893), and one specimen (BMV-1129) is represented by only the two penultimate spires. Finally, one specimen has lost part of its base. In all, 13 shells have well-preserved perforations, which can be used to identify perforation techniques.

The surface of the shells is relatively well preserved. Six specimens retain some vestiges of the shell's natural colors on the last whorl. We determined the color modification of the shells following C. Claassen (1998). Most of the shells are white (Fig. 5B), sometimes slightly orange-brown, with a well-preserved surface (n = 12). However, three shells showed a grey, cracked surface, crumbling in some parts, revealing an ostracum that had become white and chalky (Fig. 5D and F). Finally, two pieces are uniformly black in color, and the edges of the perforations reveal that the layers underlying the surface are also black (Fig. 5C and E). The different layers of the shell can no longer be distinguished, and the crystals are reorganised into a homogeneous prismatic structure (C. rustica shells naturally have an internal layer with a lamellar structure, which has disappeared here; Fig. 5A).

The grey to black coloration of the shells can be linked to two factors:

1) exposure to an anoxic environment in thanatocenosis, prior to collection (d'Errico et al., 2015), or 2) to heating (Perlès and Vanhaeren, 2010). The staining of shells in an anoxic environment consists of staining the surface, which does not modify the microstructure of the different layers of the shell. However, in our corpus, staining is systematically accompanied by a modification of the microstructure (Fig. 5). The cause of the staining of archaeological shells is therefore probably exposure to a high temperature, above 300° (d'Errico et al., 2015; Perlès and Vanhaeren, 2010).

Phases M-B' and M-B'' show recurrent thermal alteration. Many flints and faunal elements are burnt and ash is present in the SU (Porraz et al., 2018; Ricci et al., 2022). However, the shells identified as heated are found in several sub-squares, sometimes non-adjacent, and are located close to unheated shells. The spatial distribution suggests that exposure to heat is not linked to post-depositional processes, like conflagration. It should be stressed that potentially heated shells are found in all the SU except SU M-B'13 (Table 2). In this case, the shells may have been deliberately heated to change their color, but this was not systematically controlled (Perlès and Vanhaeren, 2010). It should be noted that during the heating process, the change in the microstructure of the shells makes them more fragile and possibly easier to perforate (Claassen, 1998; Perlès and Vanhaeren, 2010), so technical interest cannot be ruled out. However, experiments on the heating of the shells and more detailed spatial analyses of the distribution of the various burnt remains are currently carried out to test (1) the intentionality of the heating and (2) the potential purpose of using this technique.

Eleven shells have very fine pitting, generally scattered throughout

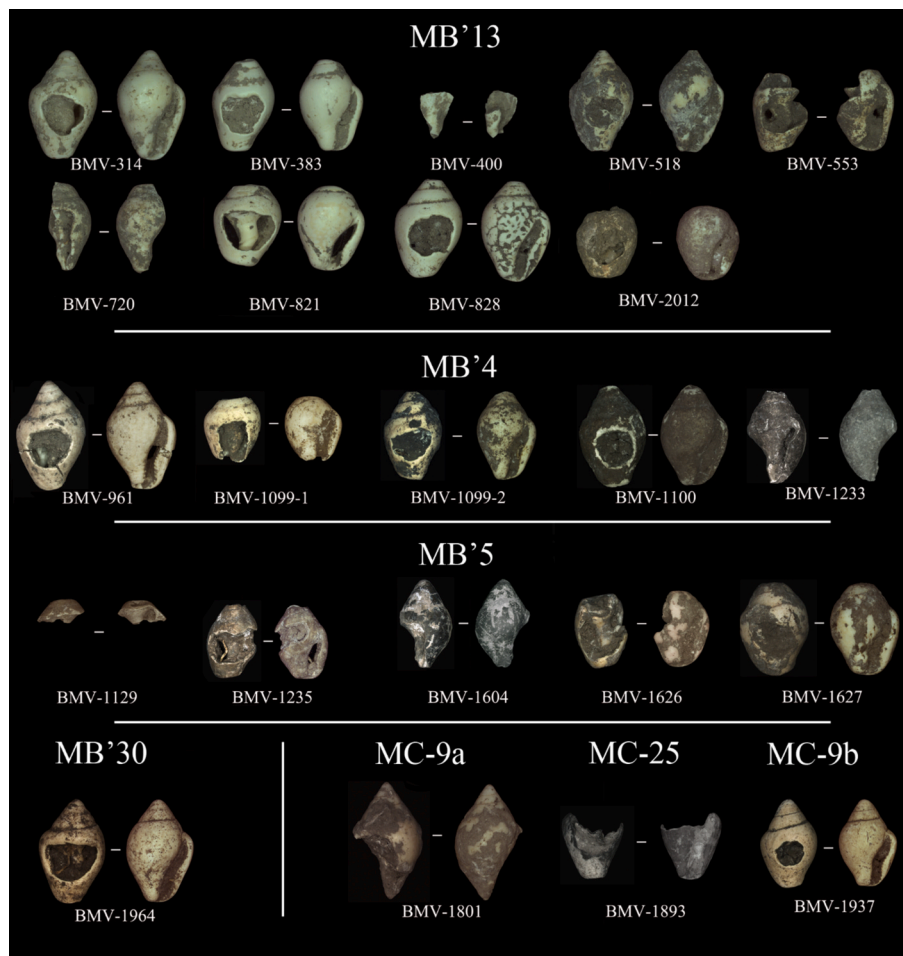
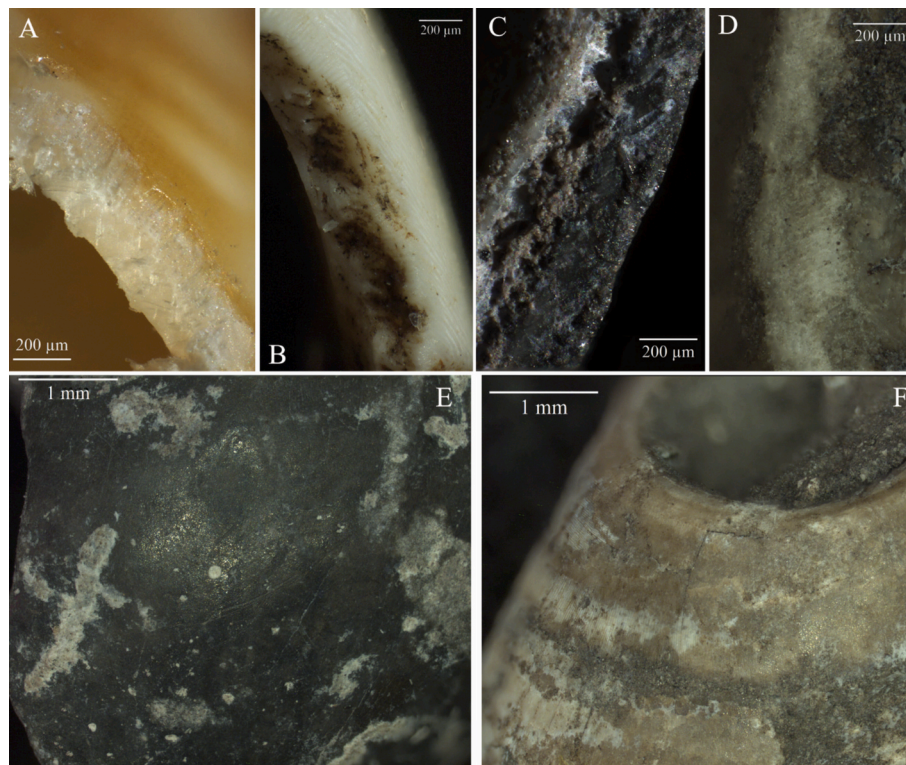


Fig. 4. *Columbella rustica* discovered during the excavation of La Baume de Monthiver (2017 and 2022), corresponding to the Sauveterrian occupation levels (M-B', M-B'' and M-C phases).



**Fig. 5.** Structure and surface conditions of heated and unheated *C. rustica* shells. A: Modern *C. rustica* shell, perforated by percussion, allowing the different layers and structures of the shell to be read in cross-section when it is unaltered. Three layers can be seen from the inside of the shell outwards: a relatively thick layer in which the crystals have a criss cross structure; an equally thick layer of crystals organized in a prismatic structure (forming perpendicular lamellae); the thin external layer, the structure of which is not clearly visible under the binocular. B: transverse view of an archaeological white *C. rustica*. The layers described above are clearly visible. C: transverse view of a black archaeological *C. rustica*. The structure is similar to an irregular prismatic organization. D: cross-section of a grey archaeological *C. rustica*. The structure is similar to an irregular prismatic organization. E and F: surface of archaeological black and grey shells. In E, the coloration is intense black, and the surface shows a network of fine cracks, but there are no flakes. In F, the coloring is closer to light grey, and the surface shows both a network of fine cracks and flakes, revealing a white, chalky ostracum.

**Table 2**  
Characteristics linked to shell heating (color, surface condition).

N°	SU	Square	Color				Surface condition	
			White	Grey	Black	Brown	Cracks	Chalky
720	M-B' 13	E10d	X					
314	M-B' 13	E10d	X					
400	M-B' 13	E10d	X					
553	M-B' 13	F10c	X					
821	M-B' 13	F10d	X					
828	M-B' 13	F10d	X					
383	M-B' 13	F10d	X					
518	M-B' 13	F11d	X					
2102	M-B' 13b	E9c	X					
1964	M-B' 30	E10d	X					
1233	M-B' 4	F10d		X			X	X
1099-1	M-B' 4	F10a	X					
1099-2	M-B' 4	F10a	X					
1100	M-B' 4	F10c		X			X	X
961	M-B' 4	F10d	X					
1129	M-B' 5	G11a		X			X	
1235	M-B' 5	G11a		X			X	X
1604	M-B'' 6	G11c			X			
1626	M-B'' 7	G11c				X		
1627	M-B'' 7	G11c	X					
1893	M-C 25	E11a			X			
1801	M-C 9a	G11b				X		
1937	M-C 9b	F10d				X		

the shell, which is reminiscent of the pitting that develops on shells after the animal dies, due to exposure to marine abrasion (Mougue et al., 2011). Eight shells have circular microperforations on the surface,

which are traces left by lithophagous organisms after the mollusk has died (Mougue et al., 2011). The solidity of the shell affected by the state of preservation when collected. In particular, shells bearing numerous

microperforations (such as BMV-828 and BMV-1604, which are strongly affected) are much more brittle, which facilitates the perforation process.

These indications point to the collection of dead shells on the coast (Bosch et al., 2015). The loss of the apex of most shells may also be linked to the collection of empty shells, as this type of fracture is highly represented in thanatocenosis (Perlès, 2016).

This shows that the integrity of the material is not an important factor for the groups, we can highlight the probable loss of some of the whorls of certain shells at the time of collection. This shows that it was not necessarily the general rhombic shape of the shell that was sought after. We cannot rule out the possibility that there was an intentional combination of the variety of shapes within the compositions. The variety of *C. rustica* shapes could even have been a part of what the groups were looking for and therefore be a criterion for selection.

#### 4.2. Modes of perforation

In order to identify the mode(s) of perforation, we analyzed the morphology, the regularity of the contours, and the sections of the whole perforations (n = 13). Although the shells were worn, for most of the pieces (12/13) it was still possible to read the inclination of the perforation edge sections. Bearing in mind the possible biases associated with wear, we recorded the perforation characteristics and compared them with our technical and functional references (Table 3).

The perforations were very large, generally circular (n = 10), but sometimes oval (n = 3). The contours are mostly sub-regular (n = 12). In one case, the perforation outline was regular. For nine pieces, the sections are partially truncated and partially externally beveled. Two pieces have only truncated sections. These traces are consistent with pressure or percussion from the external surface. The very large size of the perforations brings the archaeological evidence closer to direct percussion with a pebble, although we cannot rule out the possibility of enlargement during use. The presence of two shells with partially truncated sections, beveled internally and externally, supports the hypothesis of widening during use (Hoareau, 2023). Such a combination of sections has never been observed in our technical experimental references (Hoareau et al., 2021). On the other hand, these traces have been observed on perforations that have been widened during use as part of functional experiments (Hoareau, 2023; Hoareau and Beyries, 2022). Since the only experimental evidence of this type of use-wear comes from a widening of the perforation during use, we favour this hypothesis (see section 4.3. on the experimental observation of perforation widening during use).

For two pieces, the perforation is sub-regular with truncated and internally beveled sections. These traces are generally associated with pressure through the opening, however we have never been able to achieve this technique on *C. rustica* experimentally, as the aperture is very narrow. So, either the tool is too thin and breaks, or the tool is thicker and more resistant, but does not pass through the aperture. We therefore interpret this type of perforation with widening during wear. Finally, the specimen 828 has very strong rounding that makes it impossible to read the potential technical evidence.

**Table 3**

Technical traces on the whole shells. The inclination of the edges of perforation 828 is not legible due to encrustations.

		314	383	518	821	828	961	1099-2	1100	1235	1627	1937	1964	2102
Morphology	Circular	X	X	X		X	X		X		X	X	X	X
	Oval-shaped				X			X		X				
Outline	Regular								X					
	Sub-regular	X	X	X	X	X	X	X		X	X	X	X	X
	Irregular													
Section	Truncated	X	X	X	X	N/A	X	X	X	X	X	X	X	
	Internal bevel			X		N/A		X						
	External bevel		X		X	N/A	X		X		X	X	X	X
	Thinned					N/A								

#### 4.3. Modes of use: Reconstructing of the ornamental composition

The shells with complete, undamaged perforation hole (n = 13) allow us to observe the distribution of wear traces. On all observed specimens (n = 13) the whole perforation is systematically used. For two pieces, this trace develops evenly over the entire perforation, with a rounded blunt located on the outer edge, and a smoothing of the wall. For eight pieces, the rounding localized on the edge is associated, on all or part of the upper left zone of the perforation (zones g-h-a-b), with a rounding of the edge which extends on the external surface (Fig. 6C). On four of these pieces, a flat use-wear also develops over part of the perforation (Fig. 6C). It forms a flat spot on the outer edge, slightly inclined towards the inside of the perforation, located in the lower right-hand areas of the perforation (c-d-e-f). For two pieces no extended rounding on the outer surface was observed, only the flat use-wear is present, this time in the upper or upper left part of the perforation.

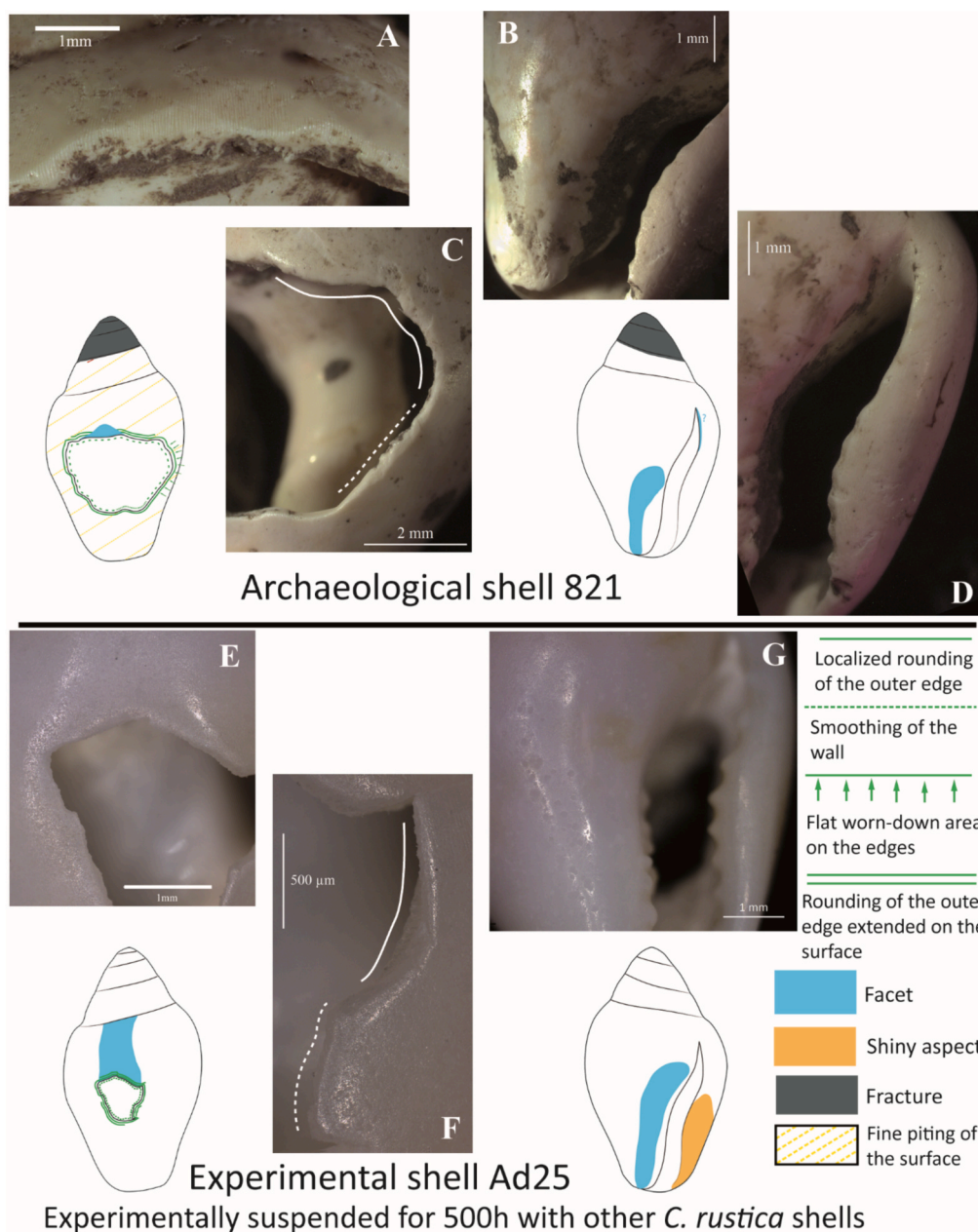
Five pieces have a flat, semi-circular facet near the perforation, always on the upper half (zones g-h-a-b-c, each facet only develops on one zone or straddles two adjacent zones; Fig. 6A). For one shell, the facet is also aligned with a circular facet on the penultimate spire. For the traces on the ventral side, we present here the use-wear traces observed on shells that have preserved their last whorl (n = 21). The columella displays a shiny appearance (n = 3) or even a facet (n = 4) which develops along the aperture, with an oval shape (Fig. 6B). In two cases, the lip is flattened and in three others it presents a very shiny aspect (Fig. 6D). Two pieces bear a slight depression on the side of the lip. Two shells have a slight rounding and widening of the hollow of the siphonal canal on the right side.

The distribution of these traces on the shells is similar to the use-wear obtained experimentally by wearing *C. rustica* shells on the wrist simply suspended one after the other (Hoareau and Beyries, 2022; Fig. 6 E-G).

Microscopic observation of the shells also enabled us to identify several types of polish similar to the experimental use-wear. We only looked at shells that did not show traces of heating (n = 14), as the lack of experiments on the impact of heating on microscopic traces prevents the comprehension of polishes on this type of objects.

We observed three types of polish on the edge of the perforations (Fig. 7):

- A polish with a smooth, undulating, shiny texture, which develops in a covering manner with a compact linkage (n = 3, Fig. 7A). It is located on the edge and the upper part of the perforation wall. There are a few small circular micropits with a dark bottom and the edges are coated with polish. Rectilinear striae are present, which are fine, short to moderately long, with a dark bottom. Their edges are straight, and they develop transversely to the perforation, sometimes slightly oblique. This polish has the same characteristics as the polish observed experimentally on perforations in contact with a sinew thread (Fig. 7B).
- A smooth to irregular, shiny polish with a compact linkage (n = 5). It develops on the outer edge and extends widely over the outer surface (Fig. 7C). There are numerous micropits of varying shape (circular or irregular) and size, with a dark bottom and edges that are not always



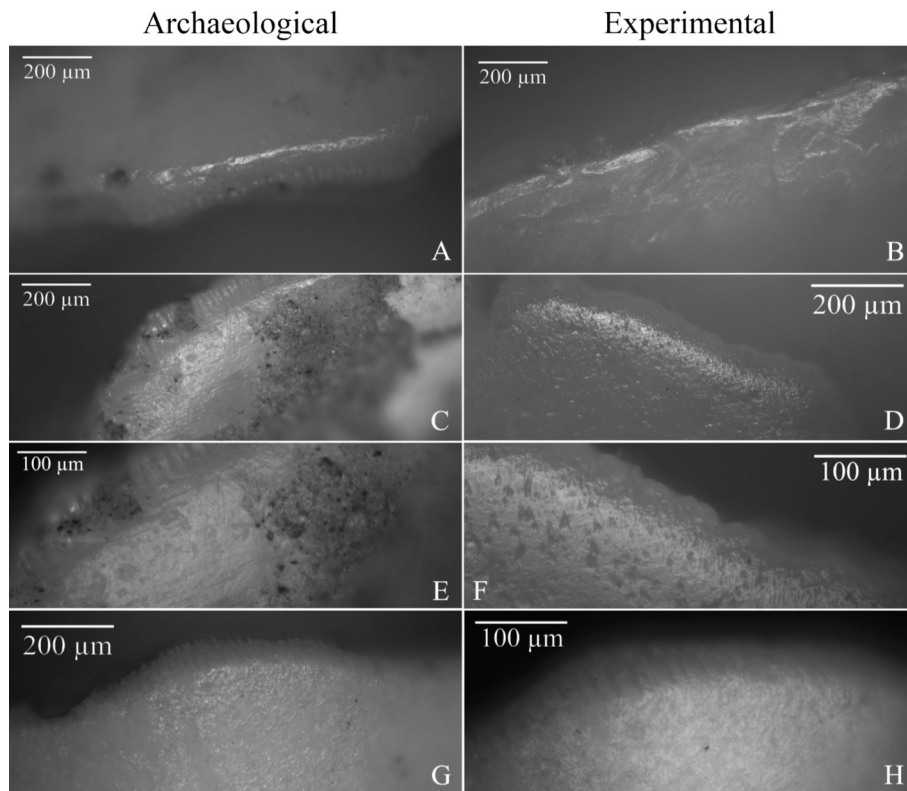
**Fig. 6.** Comparison between archaeological and experimental functional use-wear. A to D, archaeological traces and E to G, experimental traces. A: Semicircular flat facet developing near the top of the perforation. B: Flat oval facet developing on the columella, along the natural aperture. C: Perforation edge with a rounded blunt on the upper surface (solid line) and a flat blunt on the side (dotted line). D: Flat facet on the lip. E: Flat facet developing near the top of the perforation. F: Perforation edge with a rounded blunt slightly extended at the top (solid line) and a flat blunt (dotted line). G: Flat oval facet developing near the natural aperture.

covered in polish. This polish is similar to that which develops experimentally when the perforation is in contact with another shell (Fig. 7D).

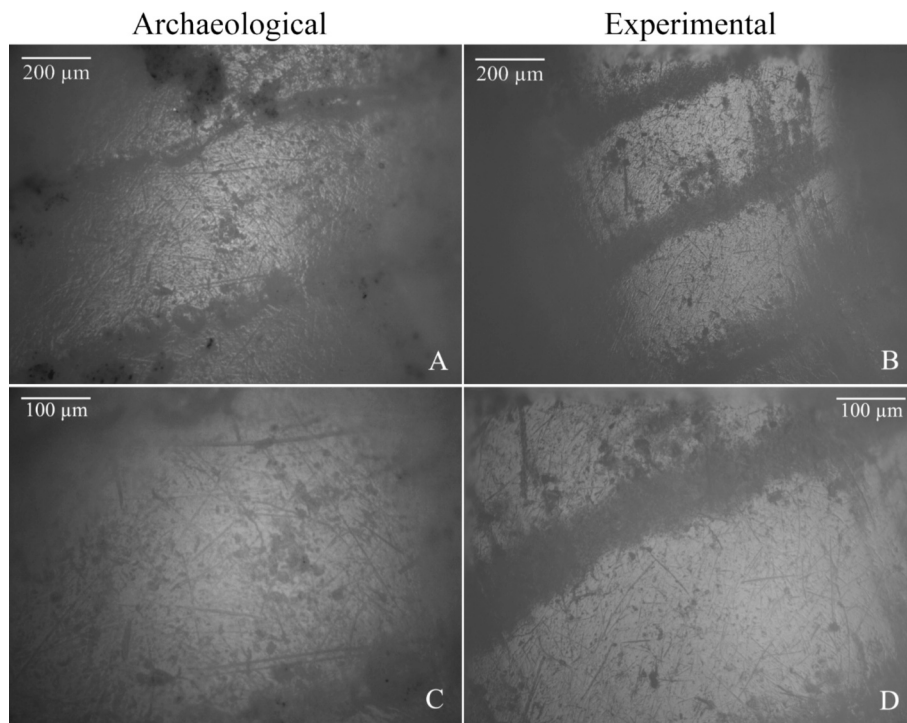
- A shiny, irregular polish, deposited on the high points of the microtopography in a scattered linked manner, without any striae (n = 3, Fig. 7E–F). This polish has not been observed experimentally (shell, wood, leather, cf. Hoareau, 2023), and we hypothesise that it is linked to taphonomic deterioration, which is to be tested with the expansion of the experimental references.

On the surface of the shells near the perforation in zones a-h and e-f, as well as on the columella and lip (zones where facets tend to develop), we observed two types of polish (Fig. 8).

- A smooth to irregular and shiny polish (n = 7, Fig. 8A and C). The microtopography appears smooth and the polish develops on this surface in a compact linkage. The depressions in the topography, due to the natural undulations of the shell, are not affected by the polish. There are numerous micropits of varying sizes and shapes (circular or irregular), with a dark bottom and sometimes polished edges. Fine rectilinear striations with a dark bottom and straight edges develop on the surface. This polish is similar to that which was observed on areas in contact with other shells, although the archaeological polish appears slightly less smooth than the experimental polish (Fig. 8B and D).
- An irregular, fairly shiny polish deposited on the high points in a scattered linked manner (n = 5). There were no micropits. This polish is not documented in our experimental reference system and



**Fig. 7.** Polishes observed on the edge of the perforation at magnification x100 and x200. A: Archaeological polish on the edge of the x100 perforation. The texture is smooth, undulating, and shiny, developing in a covering manner with a compact linkage. B: Experimental polish resulting from contact with a sinew thread, x100. The texture is smooth, undulating, covering with a compact linkage. C: archaeological polish on the edge of the perforation, magnification x 100. The texture is smooth to irregular, shiny, with a compact linkage, developing from the edge of the perforation to the external surface. D: Experimental polish due to contact with shells x100. The polish is smooth to irregular, shiny, with a compact linkage. E-F: same areas as C and D respectively, at 200x magnification. G and H: irregular archaeological polish, deposited on the high points of the microtopography in a loose to tight pattern. Photo G is at 100x magnification and H at 200x.



**Fig. 8.** Polishes observed on areas where facets tend to develop. A and C: archaeological polish, smooth to irregular and shiny, at 100x and 200x magnification respectively. B and D: Experimental polish caused by contact with another shell, at 100x and 200x magnification respectively.

the presence of long, wide and deep striations suggests that the polish is the result of taphonomic alteration.

The macro- and microscopic data support the hypothesis that the shells were simply suspended loose one after the other, causing friction between them. In most cases, microscopic traces around the perforation and on its edges indicate contact with shells. This polish, as we have observed in the experimental work, tends to expand the perforation edges, hiding the microscopic traces associated with rubbing against the rope. However, shells whose perforation is located at the end of the string of beads, and which therefore have no contact with other shells, develop a polish caused by the contact with the string. In our archaeological assemblage, three shells preserve a polish at the edge of the perforation that is different from the shell polish and whose characteristics are very close to the polish associated with suspension on a sinew thread. Our experimental reference collection do not yet allow us to totally rule out other hypotheses. However, we can observe that the plant polish (flax) and the polish associated with leather contact are both matt, and therefore do not correspond to the traces observed here (Bar-Yosef Mayer et al., 2020; Hoareau and Beyries, 2022). Other materials could be tested (nettle, *Tilia* sp. bast, for example).

We can note that the widening of the perforation that we observed in our experimental reference collection is observed regardless of the type of thread (flax or sinew). The type of material of the thread appears to be an important factor in how quickly blunting occurs (Álvarez Fernández, 2006; Minotti, 2015), but does not seem to be a determining factor in perforation enlargement (Hoareau and Beyries, 2022).

## 5. Discussion

Detailed study of the ornaments here provides us with crucial elements for discussion, giving us a better grasp of the questions surrounding the variability of the Sauveterrian and its causes. Finds from La Baume de Monthiver support the idea of a certain unity in the Liguro-Provençal arc regarding the species used. It also provides unique data on territorial organisation, which was more extensive in terms of ornamental practices than in terms of the provisioning of lithic materials: lithic raw materials are strictly local in origin, contrary to marine shells, which come from greater distances. It also shows that the variability of the Sauveterrian does not appear to be linked to cultural fragmentation.

### 5.1. Continuity in ornamental traditions during the early Holocene

The site of La Baume de Monthiver, with its long-term occupation, allows us to observe the evolution of ornamental practices. The assemblage is very homogeneous throughout the stratigraphy, in terms of choice of species, perforation techniques, and mode of use. The assemblage is composed of a single marine gastropod species, *C. rustica*. Only one technique could be identified, perforation by direct percussion. Similarly, only one mode of use seems to have been employed, simply stringing the shells one after the other. The continuity of ornamental practices at Baume de Monthiver echoes the continuity observed in the lithic record and in subsistence methods (Ricci et al., 2023b; Ricci et al., 2021).

By contrast, the provisioning distances are very different for lithics and ornaments. The lithic tools are made entirely of strictly local materials (less than 5 km from the site, see Ricci et al., 2023b; Ricci et al., 2021). The marine shells from Baume de Monthiver come from the coast, which is around 40 km from the site (the minimum distance between the site and the coast). Ornaments therefore attest to direct or indirect links with much wider areas than the lithics suggest. All the shells discovered on the site (sufficiently intact that it is possible to determine whether they have been perforated) have a perforation and display intense use-wear traces. It suggests that the shells most probably arrived at the site as finished beads, strung on a thread, and that there was no *in situ* production.

### 5.2. Sauveterrian ornamental practices within the Liguro-Provençal arc

Ornamental practices are scarcely documented in the Liguro-Provençal arc for the Sauveterrian, where the presence of ornaments is reported from only five sites: Saint-Mitre (Escalon de Fonton, 1974), Arma Veirana (Gravel-Miguel et al., 2022), Grotte de la Montade (Onoratini et al., 2017), Fontbregoua (Onoratini et al., 2017), Arma di Nasino (Sparacello et al., 2023). We do not have an exhaustive inventory of the ornaments found at some of these sites, but we can stress the systematic presence of *C. rustica*. Therefore, the choice of species in Provence and Liguria seems to indicate a certain homogeneity.

In terms of technical and functional choices, only the assemblage from the Arma Veirana site has benefited from traceological analysis, allowing comparison with the data from La Baume de Monthiver (Gravel-Miguel et al., 2022). The methods of perforation and use are similar in the two sites. At Arma Veirana, the *C. rustica* were perforated by percussion on the outer surface and were strung in rows one after the other. According to the position of the shells in the burial, these rows would have been sewn onto a support that surrounded the body of the young deceased, although this could not be confirmed by microscopic analysis (Gravel-Miguel et al., 2022). Groups at Arma Veirana and La Baume de Monthiver both chose to thread the shells in rows, but the sewing of the rows is not attested at La Baume de Monthiver, as no polish other than the contact of the shells with one another has been observed.

Ornamental practices suggest connections between the groups of the Liguro-Provençal arc through the preferred choice of *C. rustica* for adornment. Despite the lack of data on technical choices and mode of use, there are strong similarities between Provence and Liguria, reinforcing the idea of a defined territorial unit, that of the Liguro-Provençal arc.

### 5.3. What inter-regional variability?

The typo-technological analyses of the lithic assemblages suggest some kind of differentiation between the Liguro-Provençal arc and the regions north and west of the Rhône (Valdeyron, 2008; Visentin, 2017; Visentin et al., 2022). Data on ornamental practices provides a more unified picture. Indeed, the use of *C. rustica* does not seem to be restricted to the Liguro-Provençal arc and several sites on the other side of the Rhône and in the Alpine region have yielded assemblages primarily composed of this species (Clos de Poujol in Aveyron, Bobœuf and Bridault, 1997; Abri de la Fru in Savoie, Pion et al., 1990; Abri Sous Balme in Ain, Vilain, 1961). Sometimes *C. rustica* is present more discreetly (e.g. Grotte de l'Ermitage and Grotte A des Balmes in Isère, Taborin, 1974).

Therefore there is no clear difference in the selection of species used in ornaments between the east and west of the Rhône. It is probable that the nuances in the choice of materials (which species are favoured, which are in the minority in the assemblages) are important elements in understanding the differentiation between the territories. Systematic, exhaustive inventories would therefore be essential to understand this aspect of ornamental practices.

### 5.4. Sauveterrian ornamental practices on a macro-regional scale

On a macro-regional scale, we note that the use of *C. rustica* is widespread around the Mediterranean basin and along the Rhône valley as far as Germany (Álvarez-Fernández et al., 2008). The recurrent use of this species on a large-scale points to the hypothesis of networks between Mesolithic groups through which different ideas, techniques and concepts, as well as goods or people, were disseminated. However, this species is found throughout the Mediterranean basin, and it is difficult to trace how the shells themselves passed from hand to hand and from group to group. Similarly, the presence of deer canine at many Mesolithic sites in Europe (Rigaud et al., 2010) suggests common practices but tracing the origin of the objects themselves and how far they

travelled between groups remains difficult. Freshwater shells, on the other hand, provide an opportunity to observe circulation networks. Indeed, at Abri de la Fru, the presence of *Microcolpia daudebartii acicularis*, a freshwater shell formerly known as *Fagotia acicularis*, shows contacts with groups located several hundred kilometres to the east (Pion et al., 1990). This species has only been documented in the freshwater rivers of Illyria and the Danube, pointing to two possible circulation routes: one through northern Italy, the other through southern Germany (Pion et al., 1990). Although we have not found any records for the use of this species within contemporary sites, we can note that the practice of using freshwater species in adornment is widespread in the western Balkans (Cvitkušić, 2017; Cvitkušić and Vujević, 2021) and in north-eastern Italy (Bertolini et al., 2016; Cristiani, 2009, 2012).

##### 5.5. The turning point in ornamental practices change: The Late Glacial – Holocene transition

The dichotomy in ornamental practices seems to be linked to the evolution of practices over time, with the transition between the Late Glacial and Holocene periods being the tipping point. Indeed, the predominance of *C. rustica* is specific to the Sauveterrian assemblages, with the Late Epigravettian assemblages being more diverse in terms of the species chosen. Within the Liguro-Provençal Arc, at the end of the Late Glacial, the sites of Cuges-les-pins, Abri Martin, the Arene Candide, Arma dello Stefanin and Riparo Mochi (Alhaique and Molari, 2006; Hoareau et al., 2020; Leale Anfossi and Palma di Cesnola, 1972; Mourre et al., 2014; Stiner, 1999) show the presence of numerous marine shell species, among which *C. rustica* is sometimes present but discreet (up to 4 % of assemblages). Only L'Abri Martin also documents technical choices and methods of use, pointing to an asynchronous evolution. The perforation techniques differ between the Epigravettian site and La Baume de Monthiver (rotation/pressure at the Abri Martin, quite distinct from direct percussion at the Baume de Monthiver). However, the ornamental composition remains consistent, with only simple sequential suspension of shells documented at both sites (Hoareau et al., 2020).

It should be noted that, more broadly in socio-economic systems, from the Holocene onwards there was an intensification in the exploitation of plant resources, suggested in particular by the functional analysis of lithic tools (Guéret, 2013a; Jacquier, 2015). Certain traces on lithic tools sometimes suggest the processing of flexible plants, which may indicate the manufacture of threads or ropes (Guéret, 2013a, 2013b; Guéret et al., 2014; Jacquier, 2015). Analysis of the microscopic polish on the shells from La Baume de Monthiver is one of the few clues to the use of threads in the Mesolithic period but indicates the use of thread made from animal materials. It is possible that different types of threads were used in different ways.

## 6. Conclusion

Analysis of the ornaments from La Baume de Monthiver reveals that, when the shells are well preserved, it is possible to identify not only macroscopic traces but also microscopic wear indicative of contact with various materials used in the ornaments of past populations. This makes it possible to reconstruct ornamental compositions with precision, including in non-burial contexts, where we cannot rely on the primary position of the elements. In this way, it is possible to access the visual effects sought by the groups and integrate this information more systematically into our understanding of ornamental practices. This is particularly important for the Sauveterrian period, during which the choice of raw materials was restricted to a very small number of marine shell species, giving a very homogenous image of ornamental practices over large areas. In this context, reconstructing ornamental compositions is essential to understanding the ways in which individuals and groups expressed their identity.

This work also raises questions about the place of pyrotechnic

practices in ornamental practices. Heating techniques have been used to give shells a black color since the Middle Stone Age in Africa (Bouzouggar et al., 2007; d'Errico et al., 2009; Steele et al., 2019), but it seems to gain ground in Europe from the beginning of the Mesolithic, as shown in particular by the Franchti site (Perlès, 2018). Here the long stratigraphy covering the Paleolithic and Mesolithic periods shows a trend towards an increase in the proportion of shells heated in the Mesolithic (Perlès, 2018). A better understanding of these techniques would be essential to differentiate between accidental and intentional heating, and to understand the mechanisms that led to the increased use of black ornaments. We are currently setting up experimental protocols to answer these questions.

The identification of the type of thread used is also a groundbreaking result that opens a window onto the use of perishable resources by past groups. Until now, the identification of ropes or threads has been rare, since it was based on preserved perishable materials, which is exceptional for this period (Soffer et al., 2000; Hardy et al., 2020; Conard and Rots, 2024). Microscopic analysis of ornaments presents a more accessible opportunity to grasp this part of the technical practices.

The ornamental practices identified at La Baume de Monthiver appear to be stable over time, which coincides with the data from other remains, revealing stability in lithic tools and subsistence patterns despite climatic changes (Audiard et al., 2021; Ricci et al., 2023b). The detailed analysis of a proxy other than lithic tools provides a better understanding of the socio-economic changes in early Mesolithic societies. In particular, linking the technical and symbolic spheres enables us to perceive complementary facets of societies. The territories traced by the raw materials provisioning from the different spheres reveal networks of very distinct sizes. While lithics indicate the exploitation of restricted territories around sites, the recurrent presence of *C. rustica* throughout the Mediterranean basin, and sometimes at very great distances from the coast (Álvarez-Fernández et al., 2008), shows the existence of extensive networks linking Sauveterrian groups. These long-distance connections are maintained by the circulation of goods, which regularly reactivates and perpetuates social ties. The discovery of shells from the Balkans at Abri de la Fru in Savoie testify to this (Pion et al., 1990).

Data on ornaments and lithic technical systems therefore converge to reveal dense and active networks of connections that enabled the rapid dissemination of technical knowledge, ideas and goods. While the long-distance exchanges of lithic material known from the Late Paleolithic have disappeared, ornaments seem to have taken over occasionally in the exchange of goods on a wide geographical scale, while certain types of tools (Sauveterre points or geometric armatures) seem to bear witness to the transmission of concepts. This is difficult to trace in the case of Mediterranean species, as the extent to which they passed from hand to hand along the coasts is impossible to determine. However, the occurrence of certain freshwater species whose origin is more restricted gives us a glimpse of the very wide scale on which ornaments could circulate. A comprehensive insight into ornamental practices thus enables us to go further in understanding the social dynamics of past groups.

### Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepL in order to translate. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

Data will be made available on request.

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