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Perforation techniques and traces of use on the Mesolithic adornments of the Trench Area at Cabeço da Amoreira Shellmidden (Muge, central Portugal)

Techniques de perforation et traces d'utilisation sur des ornements mésolithiques de la tranchée Shellmidden de Cabeço da Amoreira (Muge, Portugal central)

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ABSTRACT

The opening of a new excavation area, in 2010, at the Mesolithic shell mound of Cabeço da Amoreira (Muge, central Portugal), known as Trench, uncovered a set of personal adornments made of gastropod shells (*Theodoxus fluviatilis* and *Trivia arctica/monacha*), a cervid tooth and a clay ring fragment. This paper reports the provenance, the description of the objects, their distribution in the archaeological context, the techno-typological analysis of the perforations and the presence of traces regarding their use as adornments. The perforation analysis was made by comparison to experimental actions performed on sets from other archaeological contexts, but with similar characteristics regarding the taxa and tools that were used to perform these actions.

RÉSUMÉ

L'ouverture d'une nouvelle zone de fouille, en 2010, sur le tertre de coquilles de Cabeço da Amoreira (Muge, Portugal central), connue sous le nom de « Trench » (tranchée de fouille), a mis à découvert un ensemble d'ornements personnels faits de coquilles de gastéropodes (*Theodoxus fluviatilis* et *Trvia arctica/monacha*), une dent de cervidé et un fragment d'anneau en argile. L'article concerne la provenance et la description des objets, leur répartition dans le contexte archéologique, l'analyse techno-typologique des perforations et la présence de traces relatives à leur utilisation en tant qu'ornements. L'analyse des perforations a été menée par comparaison à des actes expérimentaux exécutés sur des ensembles en provenance d'autres contextes archéologiques, mais avec des caractéristiques similaires quant aux taxons et aux outils utilisés.

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1. Introduction

Since its first archaeological excavation in the early 1930s (Corrêa, 1933), the Mesolithic shell mound of Cabeço da Amoreira has provided more than 2000 specimens (mostly riverine and estuarine gastropod species) with perforations (André, 2015; André and Bicho, 2015; Arnaud, 1987; Corrêa, 1931; Roche, 1966; Rolão, 1999). To this date, apart from the identification of the species and/or materials that comprise this large collection, there has never been an attempt to know how they were manipulated and altered by humans, although there is a range of important studies conducted for the Paleolithic and Mesolithic, including Iberian assemblages, particularly those located along the Atlantic façade and the Mediterranean coast as well as in the Cantabrian region (Álvarez Fernández, 2006, 2010; Chauviére, 2002; Francis, 1982; Gutiérrez-Zugasti and Cuenca Solana, 2015; Martinez-Moreno et al., 2010; Rigaud et al., 2010, 2014; Taborin, 1993; Tátá et al., 2014; Vanhaeren and d'Errico, 2002; Vanhaeren et al., 2005, 2013), that helped to determine the technology used to produce ornamental beads.

This paper presents the results of the analysis performed on the perforations found on the specimens recovered from the Trench area of the Cabeço da Amoreira shell mound (Muge, central Portugal) based on previous experimental procedures conducted in Portugal (Cabral and Monteiro-Rodrigues, 2015; Chauviére, 2002; Stiner et al., 2013; Tátá, 2011; Tátá et al., 2014; Vanhaeren and d'Errico, 2002; Vanhaeren et al., 2013) as well as on the identification of wear traces in order to define the techniques and tools used to alter the shells and the cervid tooth and to determine if they were used as personal adornments or not.

2. Archaeological background of Cabeço da Amoreira

2.1. The Mesolithic shellmidden of Cabeço da Amoreira

Known for more than 150 years, Cabeço da Amoreira is part of the Muge Mesolithic shellmiddens discovered by Carlos Ribeiro in 1864 along with Moita do Sebastião and Fonte do Padre Pedro (Ribeiro, 1884), only 1 year after locating the first two middens, Arneiro-do-Roquete and Cabeço da Arruda (Cardoso and Rolão, 1999/2000). Apart from two of the middens, Cabeço da Arruda and Cabeço da Amoreira, which have been excavated, first by Ribeiro's team in the 19th century, then by Mendes Corrêa in the 1930s, by Roche and Veiga Ferreira in the 1950s and 1960s, by Rolão from 1999 to 2001 and, since 2008, by Nuno Bicho's team, the other sites were completely destroyed by agricultural activities. Located in the Tagus valley, more precisely in the Muge region (Fig. 1), the site is one of the largest mounds in the area, exhibiting an elliptic shape mound of c. 60 × 40 meters in diameter and approximately 3.5 meters height at its centre, mostly composed of very large concentration of shells (Bicho et al., 2011). Like all other middens in the region, it stands on a lower plain and is approximately 15 meters high. Its southern exposure takes advantage of sunlight during most of the day (Gonçalves, 2014). According to the large extension of the sites around the Muge area, and the incredible number of artefacts, shells and its more than 300 human burials, it has been stated that these shell middens represent extensive residential occupations associated with long term stays (Arnaud, 1986, 1987, 1993) though Rolão (1999) refers to the fact that there might be two types of sites: the large ones (Moita do Sebastião, Cabeço da Amoreira e Cabeço da Arruda) that could represent residential *loci*; and smaller middens (Vale da Fonte da Moça and Cabeço dos Morros) that may be associated with seasonal and/or logistical functions. Recent studies (Bicho et al., 2010, 2011) revealed that the Mesolithic people from Muge had important stylistic differences, suggesting the presence of regional social differentiation: while their material culture and economy are identical within the region, there are differences in lithic materials characterized by a higher presence and frequency of geometric microliths at some sites (Cascalheira et al., 2015; Jesus et al., in press) as well as in the origin of both animal and plant diets (Bicho et al., 2013; Umbelino, 2006; Umbelino et al., 2007).

According to radiocarbon dating performed on human remains, shells and charcoal samples from different areas (Bicho et al., 2011, 2013), the shell midden (Fig. 2) was used from c. 8000 cal BP up to 6600 cal BP (with few and short interruptions), and its abandonment coincided with the increase in soil aridity and the end of salinity of the rivers that compose the Tagus valley (Bicho et al., 2010, 2013).

Several habitat features found under the shell deposits, such as hearths, post-holes and different types of storage pits may indicate that the site was first used as a residential camp, from c. 8000 to 7900 cal BP, before the accumulation of a shell midden that took place between c. 7800 and 7600 cal BP. The presence of ceramic fragments on top of the midden, some of them bearing decorative features, reveals a Neolithic occupation which is supported by radiocarbon dates from two skeletons found on the top layers (7146–6847 and 7570–7320 cal BP), along with isotopic analysis that revealed an absence of marine dietary indications on one of the individuals (Bicho et al., 2013).

The identification of both Mesolithic and Neolithic contexts was the main reason for opening several test pits around the main shell midden area, including in the 2010 field season a 1 × 12-meter long trench (Fig. 3), which allowed the identification of five archaeological layers, formed during and after the shell midden, containing thousands of lithic artefacts, several ceramic fragments and two hearth pits (Cascalheira et al., 2015). The collection of shell ornaments used in this study comes from this trench.

2.2. The ornamental shells from Cabeço da Amoreira

The first time that ornamental artefacts (bearing artificial perforations) from Cabeço da Amoreira were mentioned was at the *XV Congrés International d'Anthropologie et d'Archéologie préhistorique*, held in Paris in 1931. Mendes Corrêa (1933) acknowledged the presence of several perforated gastropod shells from both salt and freshwater environments such as *Cypraea europaea*, *Nassa reticulata*, *Bythinia tentaculata* and *Neritina fluviatilis*, presently known as *Theoduxus fluviatilis* (Montfort, 1810), as well

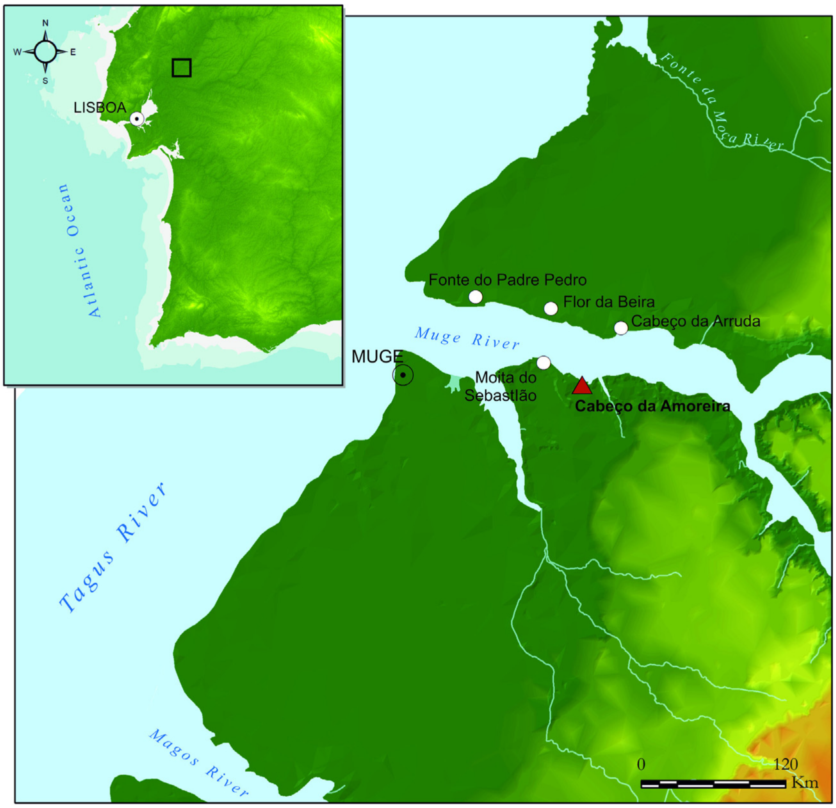

Fig. 1. Map of the Muge region with the site locations.
Fig. 1. Carte de la région de Muge avec la localisation des sites.

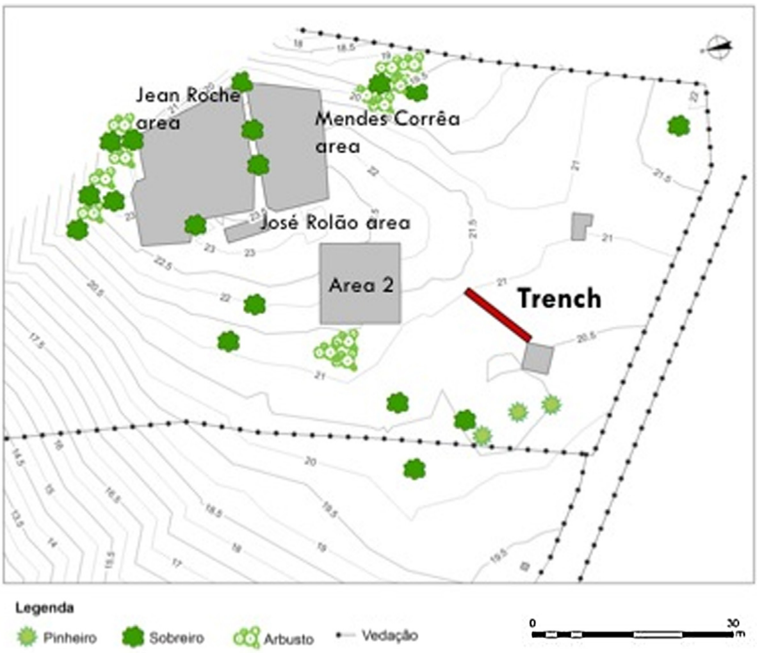

Fig. 2. General plano of Cabeço da Amoreira with the excavation areas.
Fig. 2. Plan général de Cabeço da Amoreira, avec les zones d'excavation.

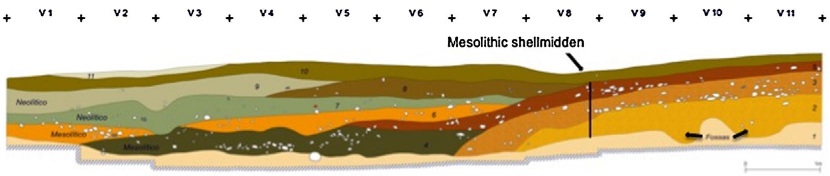

Fig. 3. Trench area West profile.
Fig. 3. Profil ouest de la tranchée.

as other personal ornamental items including those made from animal teeth (e.g. *Cervus elaphus*) and small clay plaques. Later, Jean Roche (1966) addressed the ornamental ensemble found in the shell midden by reporting for the first time the presence of perforated items made of *Pecten maximus* and *Cardium norvegicum* alongside quartzite, schist and mammal bone pendants, some of them bearing visible wear marks. The variety and quantity of gastropod species, together with the amount of different raw materials that compose the ornamental set from the midden, led Rolão (1999: 197) to state that it is “the most complete set of all the (Muge) shellmiddens known to this date”. Apart from those previously referred, perforated specimens of *Trivia europaea*, *Ostrea* sp., *Scrobicularia plana* and *Cardium edule* comprise the more than 2000 shells altered by humans, recovered from the 19th and 20th centuries past excavations with little or no provenience information and thus, no data on chronology, stratigraphy or associated features and burials. According to Rolão’s description, *Theodoxus fluviatilis* is the most common gastropod species at Cabeço da Amoreira with c. 1600 specimens, followed by *Trivia europaea* and *Nassarius reticulatus*, with c. 300 and c. 100 specimens, respectively. No technological or taphonomic information has been published for these specimens.

Since 2008, the projects entitled “The last hunter-gatherers in the Tagus valley: The Muge Shell middens” and “The last hunter-gatherers of Muge (Portugal): the origins of social complexity”, both funded by the Portuguese National Science Foundation (Fundação para a Ciência e Tecnologia) to Bicho, have recovered perforated gastropod shells, along with other materials such as mammal teeth and bones, and clay beads have been found during excavations of the Cabeço da Amoreira shellmound. These have not yet been analysed, but we expect to perform this study starting in 2016. The macroscopically observation of the set tends to reveal that these items were altered and are likely similar to those referred to in previous publications.

3. The Trench area ensemble

The trench area is on the outskirts of the shell mound. It was excavated during the 2010 field season to connect one of the areas outside the midden (Area 2) and to verify the stratigraphic and horizontal relationship between Area 2 and the midden itself.

The sediments are mostly fine sands with different colours due to the input of organics. Some of the layers also have shells because they are the southernmost edge of the midden. Excavation was carried out in artificial 5 cm spits and all sediments were screened with a 2-mm mesh. The sequence shows a series of Mesolithic horizons followed by two Neolithic occupations, those found in Area 2. Based on radiocarbon dating of the mound, the Mesolithic horizons are dated to between 7800 and 7400 cal BP (Bicho et al., 2013).

3.1. Sample and Methods

A total of 21 items bearing ornamental characteristics, such as perforations, were recovered from the Trench area during the 2010 excavation campaign (Bicho et al., 2011; Cascalheira et al., 2015). The set is composed of 19 non-edible gastropod specimens, 15 specimens of *Theodoxus fluviatilis* and 4 *Trivia* sp., 1 cervid tooth and a fragment of a clay ring. The majority of the items were found in the Mesolithic shell midden context (layers 5, 3 and 2), except the clay ring fragment that comes from layer 7, identified as Early Neolithic, and 1 specimen of *Trivia* sp. that comes from layer 8 (Table 1), a non-archaeological layer (Cascalheira et al., 2015). The sample is mostly well preserved, which made its identification easier, apart from the 4 specimens of *Trivia* which had their top surface absent, allowing only the identification of the genus.

As stated by Álvarez Fernández (2010), the presence of small molluscs with no dietary importance at archaeological sites might indicate that these were collected with the main purpose of being altered and used as ornaments. The holes as well as the surfaces were microscopically analysed with a Lumar V12 Stereo-Microscope from Zeiss, equipped with an AxioCam MRC, which allowed us to determine the origins of the perforations and its wear characteristics, perform taphonomic analysis and gather all the perforation measurements.

3.2. *Theodoxus fluviatilis*

Theodoxus fluviatilis (Monfort, 1810) is a small, oval freshwater gastropod that can be found in rivers and springs, preferably with high levels of calcium like those found in limestone bedrock environments. When present in shallow waters, they may reach a maximum diameter of 10 mm (Nobre, 1941), although they can also adapt to high salinity waters near the Atlantic coast (Nicol, 1938). Its shell has a high chromatic and pattern variation, which might be one of the reasons, together with its availability around the Muge area, for the high quantity of specimens found in Cabeço da Amoreira.

Table 1
Ornaments from the Trench area, Cabeço da Amoreira.
Tableau 1
Ornements provenant de la Tranchée, Cabeço da Amoreira.

	Layer 5 Mesolithic	Layer 3 Mesolithic	Layer 2 Mesolithic	Layer 7 Early Neolithic	Layer 8 Non-archaeological	Total of specimens
T. fluviatilis	2	7	6	–	–	15
Triva sp.	2	–	1	–	1	4
Cervus elaphus	1	–	–	–	–	1
Clay ring fragment	–	–	–	1	–	1
Total of specimens per layer	5	7	7	1	1	21

3.3. *Trivia*

Five different species comprise the genus *Trivia*, present in both Atlantic and Mediterranean shores of Iberia (Alba et al., 2001). Commonly known as cowrie (Graham, 1988:326), its natural habitat is from the intertidal zone down to circalittoral (Toreli, 1982), but they can also be found post-mortem on the sandy shores near the rocky areas where they lived.

Two types of species, *T. arctica* (Pulteney, 1789) and *T. monacha* (da Costa, 1778), are very alike and, despite the differences in their coloration, they were once thought to belong to the same species, *Trivia europaea* (Montagu, 1808). The only difference between the two shell species is the presence of three dark dots on the top surface of *T. monacha*, visible only on adult specimens. Both species have solid elongated shaped shells with a narrow and slightly curved aperture, and the outside surface is characterized by the presence of striations (Pelseneer, 1926). Concerning the dimensions of the Iberian population, the adult specimens of *T. arctica* can grow to a maximum of 12.75 mm (Alba et al., 2001) and the *T. monacha* specimens can achieve 15.4 mm (Pelseneer, 1932).

3.4. *Other ornaments*

Commonly known as red deer, *Cervus elaphus* (Linnaeus, 1758) was the large mammalian species most hunted by the Muge Mesolithic population (Detry, 2007). Though it is a common species in Europe and Asia, living in various temperate climate habitats such as flat lands, prairies or mountain landscapes, in Portugal, due to demographic pressure, they are today confined to specific regions. The clay ring fragment recovered from the study area has a semi-circular shape, with round edges, and is characterized by the presence of a hole in its centre.

4. Techno-typological analysis of the perforations

4.1. *Perforation techniques used to produce shell adornments*

According to several studies of experimental manufacture of shell beads in both Paleolithic and Mesolithic contexts (Álvarez Fernández, 2006; Benghiat et al., 2009; Cabral and Monteiro-Rodrigues, 2015; Francis, 1982; Stiner et al., 2013; Taborin, 1993; Tátá et al., 2014; Vanhaeren et al., 2013), there are six different methods that can be applied in shell perforation and can be used to identify the techniques with morphological results similar to those from archaeological contexts. These are direct pressure, direct and indirect percussion, rotation, scratching and abrasion, performed with the aid of several lithic, bone and antler pointed implements manufactured specifically that, when combined with different movements, can reproduce a wide range of perforating shapes (Table 2).

Table 2
Techniques for perforation of shells.
Tableau 2
Techniques de perforation des coquilles (d'après Tátá et al., 2014).

Technique	Species	Morphological characteristics of the perforation
External direct pressure with rotation	*T. fluviatilis* *Trivia* sp.	Circular holes, with regular contours; external wedge is present
Internal direct pressure with rotation	*T. fluviatilis*	Circular holes, with regular contours; internal wedge is present
External scratching	*T. fluviatilis* *Trivia* sp.	Oval to circular holes, with irregular contours; some external wedging is present
External direct pressure	*T. fluviatilis* *Trivia* sp.	Circular holes, with irregular contours, sometimes angular edges; with internal wedging
Internal indirect pressure	*T. fluviatilis*	Circular holes, with irregular contours, sometimes angular edges; with external wedging
Direct abrasion	*T. fluviatilis* *Trivia* sp.	Oval to circular holes with irregular contours. Some external wedging is present along with thinning of the surface

After Tátá et al., 2014.

According to the experimental procedures performed in the *Theodoxus fluviatilis* specimens, the better results were obtained by three techniques:

- rotation with lithic implements on the exterior surface – this technique results in a highly patterned, very circular hole with a regular contour and frequent external wedging;
- internal indirect percussion with bone or antler perforators with a cork anvil – though this technique turned out to be the fastest one, because it is performed by a single controlled movement, there is an important negative aspect related to the difficulty in controlling the impact

Fig. 4. *Theodoxus fluviatilis* shells: (a) perforated specimens; (b) broken specimens.
Fig. 4. Coquilles de *Theodoxus fluviatilis* : (a) spécimens perforés ; (b) spécimens cassés.

force – the rate of accidental fracture of the shell is very high. The holes resulting from this method are mostly circular with irregular contours, visible external wedging and no internal scaling;

- internal direct pressure with bone or antler perforators with a cork anvil – with no accidental fractures, this technique had a higher success rate, though it resulted in less patterned holes in terms of morphology than the other techniques applied. The holes are circular, with a similar morphology to indirect percussion, with external wedging and no internal scaling.

Regarding the *Trivia* specimens, its morphology prevents internal perforation due to the very small and narrow opening and also, in result of the shell shape and size, indirect percussion was not attempted. Nevertheless, the experimental procedures using other techniques such as rotation, direct percussion and scratching revealed that perforation is very easy, as long as a lithic implement is applied. While rotation is the technique that produces the most perfect holes, direct percussion is the one that results in a less wear for the lithic point.

4.2. Results of the analysis performed on the perforations

The formal analysis of the perforations was carried out only on those shells that were complete, which comprises 10 of the 15 specimens of *Theodoxus fluviatilis* and the cervid dental piece.

Most of the *Theodoxus fluviatilis* specimens recovered from the Trench area are intact and exhibit single holes (Fig. 4a) apart from 5 that were missing the top section (Fig. 4b), either consistent with the perforation action (Álvarez Fernández, 2006; Tátá et al., 2014) or caused by post-depositional actions. The external surface of the shells show some degree of discoloration, possibly due to the high levels of calcium carbonate present in the midden, but the original patterns are still visible in most cases and, apart from the 5 broken specimens, all maintain their original shape which means they were collected alive or

Table 3
Dimensions of the *Theodoxus fluviatilis* perforations according to each technique.
Tableau 3
Dimensions des perforations de *Theodoxus fluviatilis*, selon chaque technique.

Item number	Maximum Diameter (mm)	Minimum Diameter (mm)	Average Diameter (mm)	Perforation technique
2	3.2	2.6	2.9	Rotation with lithic implement
4	3.6	2.6	3.1	Rotation with lithic implement
6	3.5	2.7	3.1	Rotation with lithic implement
9	3.5	2.6	3.1	Pressure with bone or antler implements
10	3.0	1.9	2.5	Pressure with bone or antler implements
11	3.3	2.5	2.9	Pressure with bone or antler implement
14	2.7	1.7	2.2	Pressure with bone or antler implements
15	3.3	2.3	2.8	Pressure with bone or antler implements
16	2.3	2.1	2.2	Rotation with lithic implement
17	3.1	2.5	2.8	Rotation with lithic implement

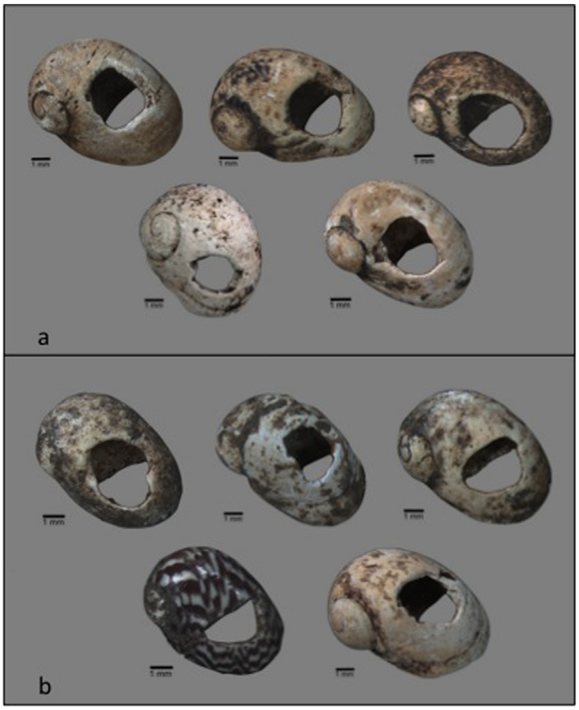

Fig. 5. *Theodoxus fluviatilis* shells: (a) specimens perforated by rotation technique; (b) specimens perforated by pressure technique.
Fig. 5. Coquilles de *Theodoxus fluviatilis* : (a) spécimens perforés par la technique de rotation ; (b) spécimens perforés par la technique de pression.

Fig. 6. Cervid tooth with bi-conical perforations on both sides of the root.
Fig. 6. Dent de cervidé avec perforations bi-coniques des deux côtés de la racine.

immediately prior to death, on the river shore (Dupont, 2006; Dupont et al., 2014).

Concerning the holes themselves, these are regular with both circular and oblong shapes (Fig. 5a), and irregular shaped ones (Fig. 5b), with a 50% ratio. The circular or semi-circular shaped holes are characterized by a regular contour with soft exterior edging, while the irregular shaped ones are more jagged and external wedging is present in all five specimens. Regarding the size of the perforation, the

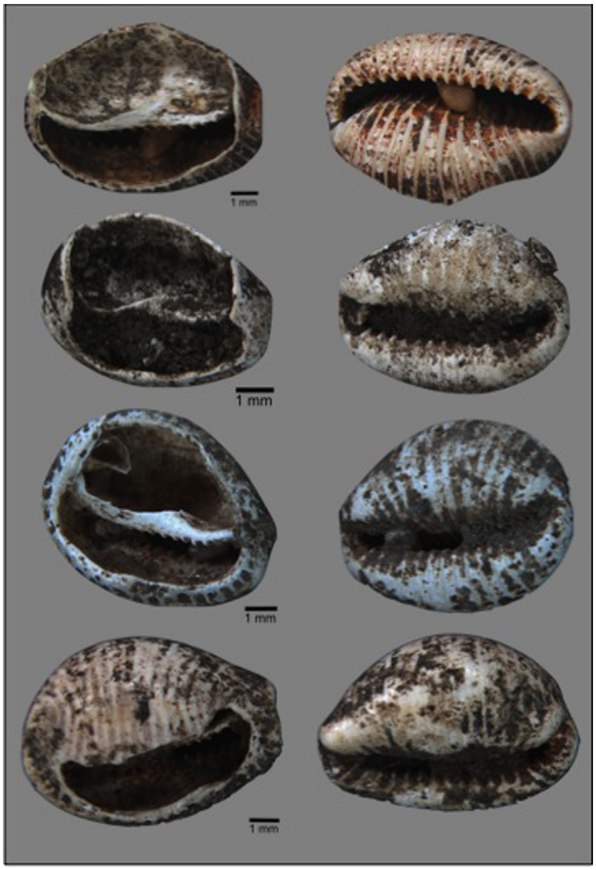

Fig. 7. *Triva* sp. specimens.
Fig. 7. Spécimens de *Triva* sp.

Fig. 8. *Trivia* shell bearing evidences of perforations on both extremities of the exterior surface.
Fig. 8. Coquille de Triva comportant des marques de perforations évidentes aux deux extrémités de la surface externe.

average diameters are slightly higher on the regular and circular shaped holes (Table 3). These characteristics are not consistent with those present on holes that were naturally perforated by predators, with its almost perfectly round and smaller (< 2 mm) holes (Cabral and Monteiro-Rodrigues, 2015).

The perforation morphology varies, as mentioned earlier, but according to the results of the experimental

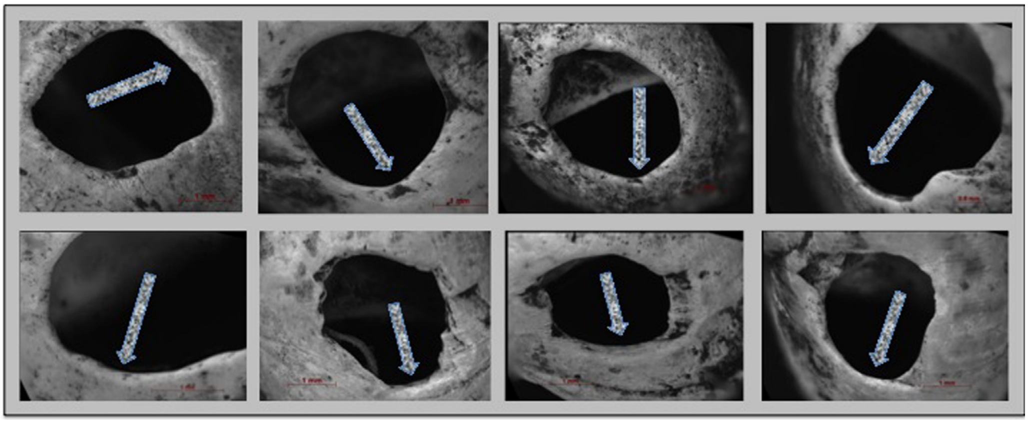

Fig. 9. Wear evidences on the *Theodoxus fluviatilis* specimens.
Fig. 9. Marques d'usure sur les spécimens de *Theoxodus fluviatilis*.

procedures on shells from the same specie (Tátá et al., 2014), both the rotation with lithic implements on the exterior surface as well as internal direct pressure with bone or antler perforators with a cork anvil were likely used. The regular contours of the holes, the presence of external wedging and no internal flaking visible on half of the specimens are consistent with the rotation technique applied on the external surface using a lithic implement. This method requires that a controlled pressure is applied on the shell at the same time the rotation movement is made. The techniques used to perform the holes on the rest of the set, which have less regular or even irregular contours and exhibit exterior wedging and no internal flaking, are consistent with internal direct pressure using bone or antler perforators. Both technique and implements used to perform these holes make it difficult to control their size and morphology.

The perforated dental specimen is an inferior incisor (Hilson, 1992; Schmid, 1972) and is characterized by two circular bi-conical shaped holes, with accentuated wedging on both sides of the root (Fig. 6).

The size of the perforation diameters does not differ much from one side to the other, ranging from 3.3 up to 3.5 mm in the maximum axis and 1.6-1.8 mm in the minimum axis. This bi-conical shaped hole was performed by rotating a lithic implement and, at the same time, by applying pressure. This technique had to be performed on both sides of the tooth in order to get this particular morphology.

Even though the entire set of *Trivia* specimens, composed of 4 artefacts (Fig. 7), are missing their top surface, it is possible to observe traces of what might have been two holes, on both extremities of one of the shells (Fig. 8).

4.3. Use-Wear analyses

When microscopically analysed, eight of the whole *Theodoxus* shells and the cervid tooth revealed traces of

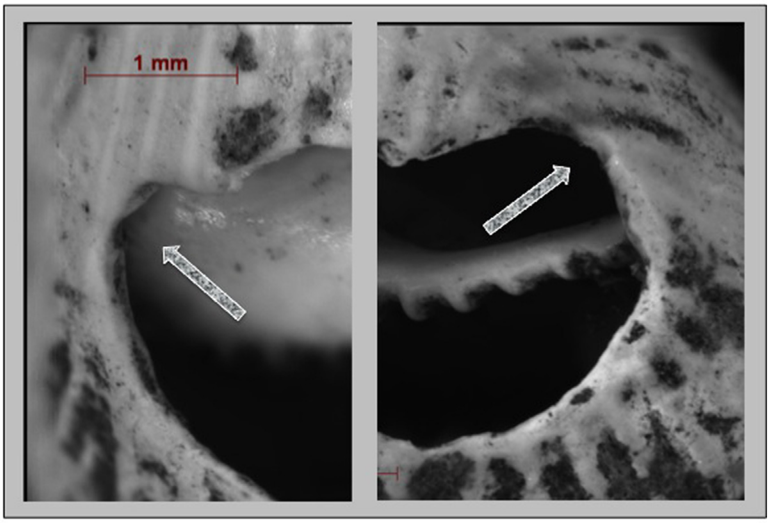

Fig. 10. Wear evidences on both extremities of the *Trivia* specimen.
Fig. 10. Marques d'usure aux deux extrémités du spécimen de *Triva*.

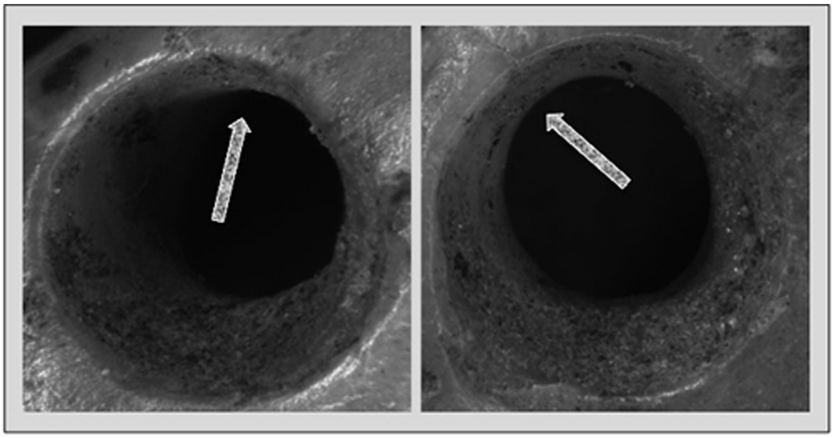

Fig. 11. Wear evidences on both sides of the cervid tooth.
Fig. 11. Marques d'usure sur les deux côtés de la dent de cervidé.

suspension on some kind of element that, after some time, due to movement, caused some areas of the holes to be polished (Álvarez Fernández, 2006; Dupont, 2006; Stiner, 2003; Stiner et al., 2013; Vanhaeren et al., 2005). The location of these traces on the region closer to the natural hole of the shell specimens reveal that they were hanging with the heaviest part of the shell facing down (Fig. 9).

These characteristics can also be found in one of the *Trivia* shells that revealed the presence of what seems to be two holes on both extremities of the top surface, mind the fact that this is partially absent. The analysis revealed two polished areas (Fig. 10). This suggests that the shell was used as an adornment before it was broken. Finally, the cervid tooth also reveals traces of use on both sides of the bi-conical perforation. The friction between the tooth and a suspension element polished both the inside and the border of the hole causing its wear (Fig. 11). Regarding the clay ring fragment (Fig. 12), its whole surface, including the interior of the hole, exhibits several dark dots consistent with fire exposure, which might have been produced during the manufacture of the artefact or after, while exposed to some sort of fire source. The semi-circular hole has no traces of being polished and the absence of the other half makes it difficult to realise if the ring was used as a personal adornment before it was broken.

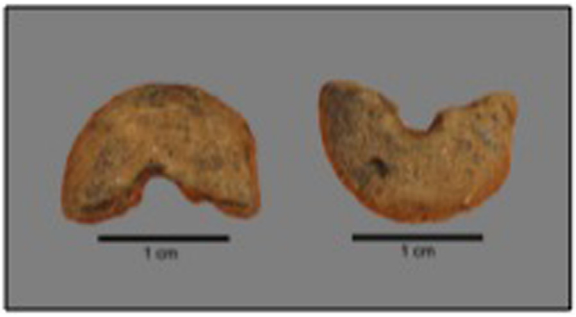

Fig. 12. Clay ring fragment.
Fig. 12. Fragment d'un anneau en argile.

There is no microscopic evidence of other surface alterations other than those reported above for the studied sample.

5. Discussion and conclusions

Shell beads and other personal ornaments (such as red deer perforated teeth or other bead types) are believed to convey important information on social and symbolic behaviour (Álvarez Fernández and Joris, 2008; Kuhn and Stiner, 2006, 2007). They can be used as visual avowals regarding social information on group identity and affiliation (Kuhn and Stiner, 2007). This was potentially very important in the context of a development of complex hunter-gatherers as in the case of the Mesolithic of Muge. While this emergent complexity in Muge has been noticed in other aspects such as landscape organization (Bicho and Gonçalves, in press; Gonçalves et al., 2014) or in the construction of the mounds (Bicho et al., in press, 2013), there is no relevant information related to the use of personal ornaments. While references to more than 2000 bead specimens have been published, there is no specific data chronology or associated finds, neither there is information on size, technology, color, etc. These are the elements that can be used for both iconographic and social studies and, thus, there is a strong limitation on the cognitive interpretation of this small sample of personal adornments. With the future study of specimens found in the main mound, we will have enough data to move forward to social and economic models of the use of these beads.

Meanwhile, however, we are still restricted to technological analyses of these specimens found in the Trench area of Cabeço da Amoreira in Muge: 19 gastropod shells, (15 *Theodoxus fluviatilis* and four *Trivia arctica/monacha*), one perforated cervid tooth and a fragment of a clay ring.

The high number of *Theodoxus* specimens in this collection (as well as in the assemblages known from previous excavations) are possibly due to the fact that this species was likely easily available locally. Other species such as

Trivia or *Littorina obtusata* (referenced in other excavations in very low numbers) could have been gathered only close to the open sea rocky shores, located at least at a distance of 70 km away, and thus, more temporally and economically challenging. Naturally, the particular shape and colour patterns of each of those species would have provided appealing compositions and possibly convey social information important for the local social groups. Finally, the *Theodoxus* morphology and thickness made the shell fairly resistant, therefore causing less waste during the perforation procedure or afterword, while being worn.

Concerning the production of adornments, ten of the *Theoduxus* specimens bare evidences of perforation consistent with anthropic activities. This action is also visible at least on one *Trivia* shell as well as on the cervid tooth.

Although there are some broken specimens, all the fractures are on the region of the shells where normally the perforations are made. Thus, these specimens could have been broken during the production of the holes or later, by post-depositional reasons.

The microscopic observation, and its comparison with experimental procedures allowed to identify what techniques, and therefore what implements, were used to produce the perforations. According to the analyses, at least five of the *Theodoxus* shells were perforated by applying the rotation technique on the external surface, using a lithic implement, producing a circular hole with a regular contour and frequent external wedging. The technique used to make the holes on the other five specimens of *Theodoxus* was internal direct pressure with bone or antler perforators with a soft anvil, resulting on less regular or even irregular contours and exhibiting exterior wedging and no internal flaking.

The technique applied to the dental piece was rotation using a lithic implement, on both surfaces of the root, resulting in a bi-conical perforation with circular and very regular contours. The use of bone/antler implements is not effective when performing holes in dental pieces due to their similar density.

The existence of polished areas on most *Theodoxus* specimens, as on one of the *Trivia* shells and on the dental piece shows that these were hanged, on a suspension element such as vegetable fibre, sinew or hide, as previously referred by other authors (Álvarez Fernández, 2006; Dupont et al., 2014; Taborin, 2004; Vanhaeren et al., 2005, 2013), therefore causing an asymmetrical cord-wear inside the perforation which suggests that the shells and the cervid tooth were hung in the same position for a long period of time (Stiner et al., 2013). There can be different reasons why this characteristic is not visible on some of the perforations:

- they were not used, and thus, these items were never attached to any suspension element;
- they were used on an non-continuous form;
- they were destined as a votive object and thus never hanged;
- they could have been attached to any static structure, therefore not causing any polishing marks.

Apart from the clay ring fragment, that comes from an Early Neolithic layer, and one *Trivia* shell coming from a non-archaeological layer, all the other items were found on the Mesolithic shell midden layers, dated to between c. 7800 and 7500 cal BP (Bicho et al., 2013). On layer 5, corresponding to the top layer of the midden, also known as the cairn layer (Bicho et al., 2011, 2013), one can find the highest diversity of species (*Theodoxus*, *Trivia* and *Cervus*) while on layer 3 and 2, there is only *Theodoxus* specimens, apart from the presence of one *Trivia* shell on the layer.

Concerning the distribution of the methods applied on performing the holes, the rotation technique is present on all layers, while the pressure technique can only be seen on layer 3 and, particularly, on layer 2. Once the pressure technique applied on the internal surface using bone or antler implements, that produces less regular, or even irregular contours and a higher fragmentation of the shells cannot be seen on the top layer, it is possible that this method was replaced by rotation, which produces more circular holes, with regular contours and a lesser fragmentation risk. This and other questions can only be answered when analyses of other samples from the same chronology and contexts and, at the same time, by performing experimentation on these and other species found on Mesolithic sites around Muge region are carried out.

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