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Citation for published version:
Mărgărit, M, Radu, V, Boroneanț, A & Bonsall, C 2018, 'Experimental studies of personal ornaments from the Iron Gates Mesolithic', *Archaeological and Anthropological Sciences*, pp. 1-28.
https://doi.org/10.1007/s12520-017-0522-5

Digital Object Identifier (DOI):
10.1007/s12520-017-0522-5

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Archaeological and Anthropological Sciences

Publisher Rights Statement:
The final publication is available at Springer via http://dx.doi.org/10.1007/s12520-017-0522-5

Experimental studies of personal ornaments from the Iron Gates Mesolithic

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Abstract

Personal ornaments, especially those made from the shells of marine mollusks and animal teeth, have been recovered from many Mesolithic sites across Europe. This paper reviews the evidence of personal ornaments from the Mesolithic of the Iron Gates, where such finds were identified in five sites on the Romanian bank: the cave and rock shelter sites of

Climente II and Cuina Turcului, and three open-air sites—Icoana, Ostrovul Banului, and Schela Cladovei. The ornaments from these sites were made from the shells of several gastropod taxa and at least one species of ~~D~~entaliid scaphopod, as well as the pharyngeal teeth of cyprinids, the teeth of several species of terrestrial mammal, fish vertebrae, and pieces of antler, and bone. Particular attention is given to taxonomic identification and questions of taphonomy, provenance, selection, manufacture, and use. Experiments were conducted in which several types of ornament were replicated. Archeological and experimental pieces (at various stages of production) were examined under a microscope, to establish the durability of the beads and estimate the length of time over which they were worn. Our results show that shells of *Lithoglyphus* and *Theodoxus* sp. were simply perforated and fixed in composed adornments, as were shells of *Tritia neritea* in the early part of the time range. In the later Mesolithic, *T. neritea* shells were processed in a different way and fixed to clothing in the manner of *appliqués*. No technological modification of the cyprinid teeth was observed; these were sewn individually onto clothing by means of a thread coated with an adhesive substance. The other categories of personal ornament were used mainly as pendants. Experimental use-wear analysis suggests that many ornaments were used over long periods, with broken or missing pieces replaced when necessary.

Keywords

Iron Gates
Mesolithic
Personal ornaments
Experiments
Functional analysis

Introduction

AQ2

Some of the richest evidence for Mesolithic decorative traditions in Southeast Europe comes from sites in the Iron Gates section of the Danube valley along the border between Serbia and Romania. Among the decorative objects from these sites are what have been loosely termed “body ornaments,” comprising items that were perforated for stringing as beads or pendants, and objects that were processed differently probably for attachment to clothing or coverings in the manner of appliqués.

While the different types of body ornament found at sites on the Serbian bank of the Danube have been the object of detailed study with emphasis on how they were attached to clothing (e.g., Cristiani and Borić 2012; Cristiani et al. 2014a), those from sites on the Romanian bank have been described mainly from a typological perspective (e.g., Păunescu 1969; Boroneanț 1969, 1990, 2011). Very few studies (e.g., Mărgărit 2008) have focused on how these ornaments were made and used.

In this paper, we re-examine the evidence from the Romanian bank of the Iron Gates, placing it in the wider regional and European contexts. The focus is on raw material acquisition, and the way blanks were produced, transformed, used and, ultimately, found their way into the archeological record.

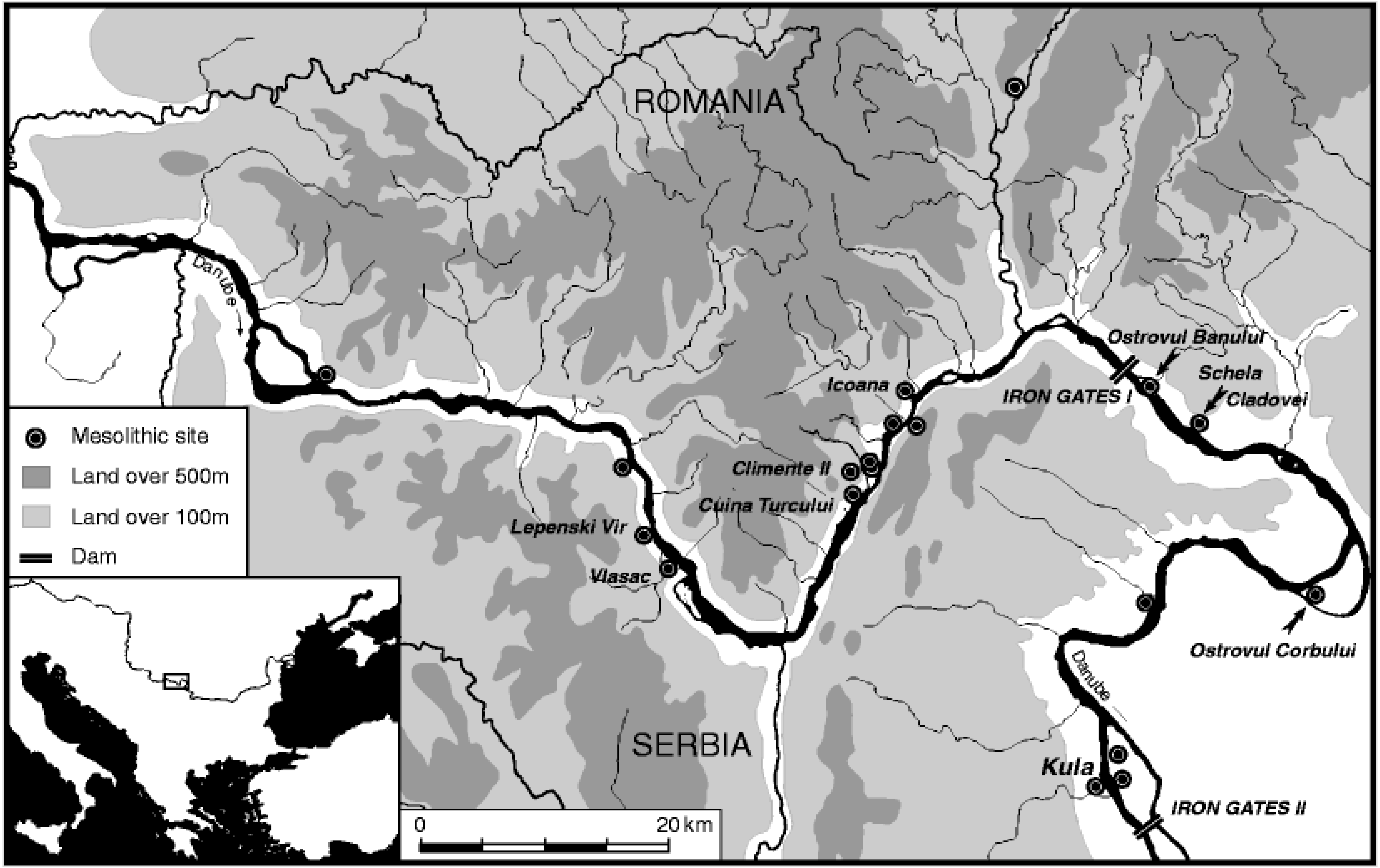
Archeological context

In the context of the Iron Gates, we use the term *Mesolithic* to refer to the period from *c*. Fourteen thousand seven hundred to 8000 years ago, although some authors refer to the earlier part of the time range (corresponding to the Late Glacial, *c*. 14.7–11.7 ka cal BP) as "Final Paleolithic" or "Epipaleolithic"—for discussion, see Bonsall and Boroneanț (2016).

Body ornaments were identified in Mesolithic contexts ~~at~~ five sites on the Romanian bank: the cave and rock shelter sites of Climente II and Cuina Turcului in the Iron Gates gorge, and three open-air sites—Icoana, in the gorge, and Ostrovul Banului and Schela Cladovei, in the area downstream of the Iron Gates I dam (Fig. 1). The first four sites were the focus of salvage excavations in the 1960s, while Schela Cladovei has been excavated more systematically on various occasions since 1965 and is the only one of the ~~Romanian~~ sites where body ornaments have been found in funerary contexts.

Fig. 1

Mesolithic sites in the Iron Gates (named sites are those where personal ornaments have been reported)



The ornaments from these sites were made from the shells of several gastropod taxa and at least one species of dentaliid scaphopod (tusk shell), as well as the pharyngeal teeth of cyprinids, the teeth of several species of terrestrial mammal, fish vertebrae, and pieces of antler and bone (Table 1). Shells of several species of small gastropod with little or no dietary significance were used to produce beads. Most numerous are the shells of the freshwater snail, *Lithoglyphus naticoides*, which were found in association with burials at Schela Cladovei and in non-funerary contexts at Cuina Turcului. The total number of *L. naticoides* shells recovered in the excavations at Schela Cladovei is not known (some finds from excavations in the 1960s and 1980s are missing from the site archive), but 107 perforated examples from burial M38 were examined in the present study. Also from Cuina Turcului are perforated shells of two other freshwater mollusks, *Lithoglyphus apertus* (three specimens) and *Theodoxus danubialis* (eight specimens), and one species of land snail, *Zebrina detrita* (one specimen)—all apparently from non-funerary contexts. In addition, ornaments made from shells of *Tritia neritea* (formerly *Cyclope neritea*), a species of marine gastropod native to the Mediterranean and Black Sea, were found in several of the Romanian sites. These occur in two forms—whole shells with a single perforation near the aperture ("beads") and shells that had the upper whorls removed ("appliqués"). *Tritia*/*Cyclope* beads were recovered from non-funerary contexts at Cuina Turcului and in association with a burial at Schela Cladovei, while appliqués were apparently found in a non-funerary context at Ostrovul Banului and with burials at Schela Cladovei.

Table 1

Ornaments from Mesolithic sites in the Romanian Iron Gates

AQ3

Period	Settlement	Raw material	Species	Typology	No. of pieces
Early Mesolithic	Climente II	Scaphopod shell	*Antalis (Dentalium)* sp.	Tubular bead	1
		Tooth	*Vulpes vulpes*	Pendant	1
			Cervus elaphus	Pendant	3
	Cuina Turcului	Gastropod shell	*Lithoglyphus naticoides*	Bead	37
			Lithoglyphus apertus	Bead	3
			Tritia (Cyclope) sp.	Bead	3
			Theodoxus danubialis	Bead	8
			Zebrina detrita	Bead	1
		Scaphopod shell	*Antalis (Dentalium)* sp.	Tubular bead	1
		Tooth	*Cervus elaphus*	Pendant	11

Period	Settlement	Raw material	Species	Typology	No. of pieces
			Sus scrofa	Pendant	1
			Canis lupus	Pendant	1
			Herbivore	Pendant	1
			Castor fiber	Pendant	1
			?	Pendant	1
		Bone	Fish	Pendant	2
			?	Pendant	1
		Antler	*Cervus elaphus*	Pendant	1
Middle Mesolithic (?)	Icoana	Scaphopod shell	*Antalis (Dentalium)* sp.	Tubular bead	1
Late Mesolithic	Schela Cladovei	Gastropod shell	*Lithoglyphus naticoides*	Bead	107 (M38)
			Tritia (Cyclope) sp.	Bead	1
			Tritia (Cyclope) sp.	Appliqué	4
		Tooth	*Rutilus* sp.	Appliqué	324 (M38)
Late Mesolithic (?)	Icoana	Tooth	*Sus* sp.	Circular bead	2
			Rutilus sp.	Appliqué	1
	Ostrovul Banului	Gastropod shell	*Cyclope* sp.	Appliqué	20

Ornaments made from scaphopod (tusk) shells were identified at Climente II and Cuina Turcului—one example in each case. In addition, a fragment of a tusk shell—interpreted as an ornament—was reported from Mesolithic “level I” at Icoana (Păunescu 2000: 400), but was not available for analysis. This type of shell has a natural conical form, with a curved profile and hollow interior, which allows segmentation into tubular beads without a major investment of time or technology.

Among the raw materials of aquatic origin, the pharyngeal teeth of cyprinids are by far the most numerous. At Schela Cladovei, they occurred in burial and non-burial contexts dating to the Mesolithic, while unmodified cyprinid teeth were also recovered in large numbers from Early Neolithic pit features (A. Boroneanț and C. Bonsall, unpublished data). A cyprinid pharyngeal tooth was also found in a box containing postcranial bones from Burial M3 at Icoana (Boroneanț and Bonsall 2016).

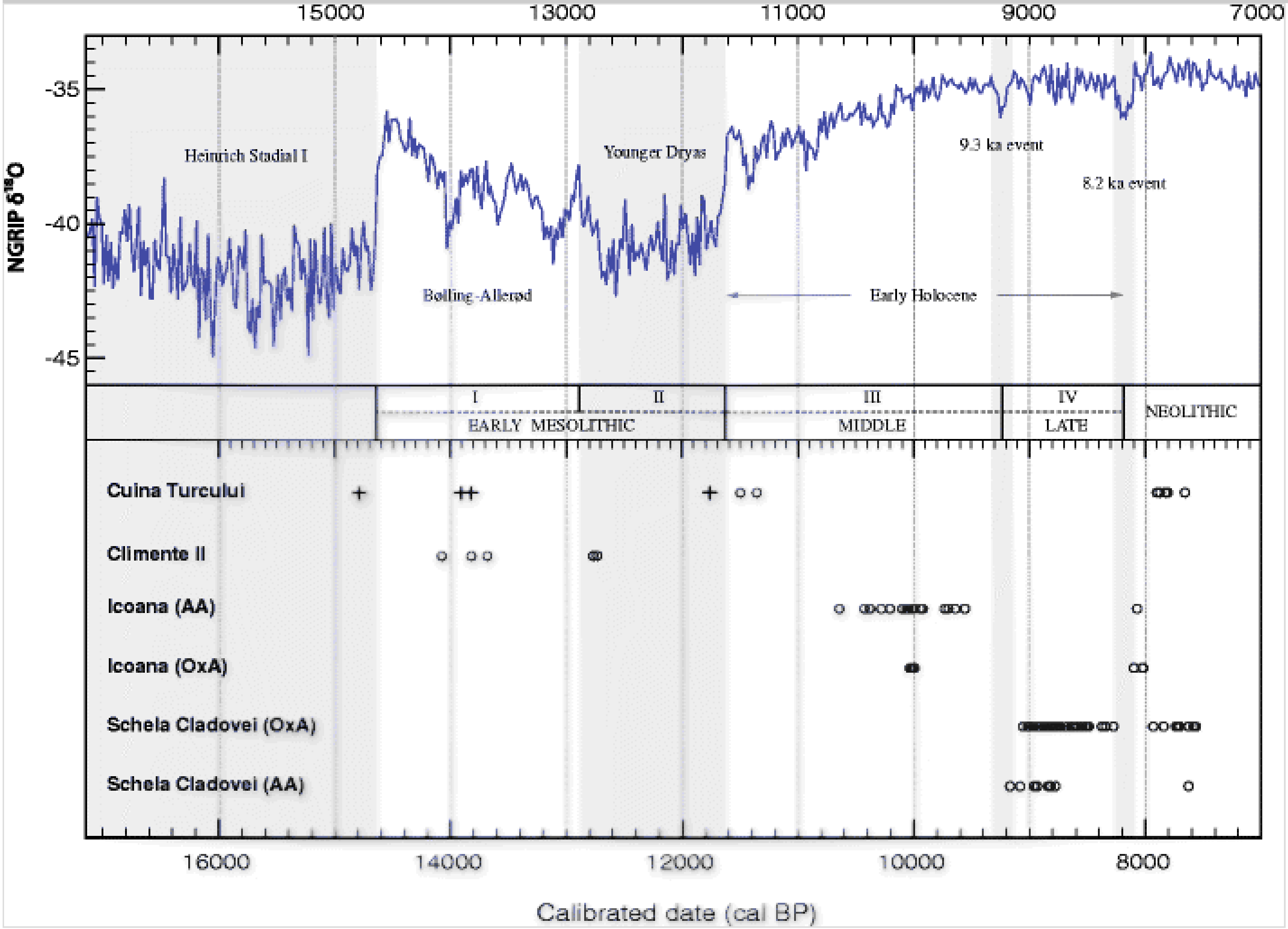
Modified mammal teeth were found in Mesolithic contexts at three sites on the Romanian bank of the Danube. Most were modified with a single perforation (“pendants”); they include (i) single examples of incisors of wolf, beaver, wild boar, and an unidentified herbivore species from the rock shelter of Cuina Turcului; (ii) a fox canine from the cave site of Climente II; and (iii) red deer canines from Climente II (3 specimens) and Cuina Turcului (11 specimens). In addition, two flat “beads” made from boar canines came from the open-air site of Icoana.

The only ornaments made of bone are a mammalian bone pendant and two perforated fish vertebrae from Cuina Turcului, while there is an antler pendant from the same site.

There are no direct dates for any of the personal ornaments from the Romanian Iron Gates sites. Therefore, dating rests on two principal lines of largely circumstantial evidence—excavators’ chronological interpretations based on stratigraphy and/or artifact typology and radiocarbon evidence of the timing of Mesolithic occupation at individual sites. In Fig. 2, the radiocarbon dates from Climente II, Cuina Turcului, Icoana, and Schela Cladovei are plotted against the Late Glacial–Mid Holocene paleoclimate record, which is used to subdivide the Mesolithic into four phases. For present purposes, phases I–II (corresponding to the Bølling–Allerød and Younger Dryas) are treated as “Early Mesolithic,” while phases III and IV are characterized as “Middle” and “Late” Mesolithic, respectively.

Fig. 2

Chronological and palaeoclimatic divisions of the Iron Gates Mesolithic: *plus sign* represents bulk sample (radiometric) dates and *circle* represents single-entity (AMS) dates. For details of the ^{14}C dates, see Bonsall (2008); Bonsall et al. (2015); Bonsall and Boroneanţ (2016); Boroneanţ and Bonsall ~~2016~~. Climatic curve generated with OxCal 4.2.3 (Bronk Ramsey 2009)



The small series of single-entity AMS ^{14}C dates on animal and human bone from Climente II indicates use of the site during the Bølling–Allerød interstadial and the beginning of the Younger Dryas stadial.

At Cuina Turcului, two Early Mesolithic occupation horizons were identified by the excavators and labeled “Romanellian I and II” (Păunescu 1970) or “Tardigravettian I and II” (Păunescu 2000). This stratigraphic division has not been adequately tested (by, e.g., single-entity ^{14}C dating of anthropogenically modified bones), although radiometric dates on bulk charcoal and AMS dates on loose human bones imply there was occupation of the site during the Bølling–Allerød and again at the beginning of Holocene. It is interesting to note, however, that while site records suggest perforated red deer canines occurred in both horizons, the other perforated mammal teeth and the single tusk shell "bead" were attributed to horizon I, and the perforated gastropod shells, fish vertebrae, and the single bone pendant to horizon II. Similar bone pendants were found at Vlasac on the Serbian bank of the Danube (Srejović and Letica 1978: pl. CVI) where the chronological context is almost certainly Early Holocene.

The large series of single-entity AMS ^{14}C dates on animal and human bone from Schela Cladovei (Bonsall 2008) indicates that Mesolithic activity there belongs to the period between the 9.3 and 8.2 ka BP climatic cooling events, *c.* 9200–8200 cal BP. Burial M38, which was accompanied by 324 pharyngeal teeth and 107 shell beads, has not been ^{14}C dated, but radiocarbon dates for other Mesolithic burials at the site (some accompanied by shell beads and/or cyprinid teeth appliqués) range between *c.* 9000 and 8600 cal BP (after correction for the freshwater reservoir effect [cf. Cook et al. 2002]).

Boroneanţ (1973) suggested that the Mesolithic occupation of Icoana was contemporaneous with that at Schela Cladovei. However, this is not supported by a large series of single-entity AMS dates on animal and human bone from Icoana, which implies that there were two main phases of Mesolithic occupation of the site—the first between *c.* 10,600 and 9400 cal BP and the second around the end of the 8.2 ka event *c.* 8100–8000 cal BP. Judging from the find locations of the two flat beads from Icoana, it is not inconceivable that they date to the later Mesolithic occupation phase or even to the Early Neolithic (for discussion of the chronology of Icoana, see Boroneanț and Bonsall 2016).

AQ4

Dating of the group of 20 *Tritia neritea* shell appliqués from Ostrovul Banului (Boroneanț 2000: 194, fig. 113) rests partly on the stratigraphic observations of the excavator. Boroneanț recognized three Mesolithic occupation horizons at Ostrovul Banului. The shell ornaments were attributed to the uppermost horizon (III), which was considered to be contemporaneous with the Late Mesolithic at Schela Cladovei. Three ^{14}C dates—two on bulk charcoal samples from horizon III (Boroneanț 2000) and one on a pig bone (Dinu et al. 2007) probably from horizon III—range between *c.* 9200 and 8350 cal BP, which is consistent with this interpretation.

Methods of analysis

Taxonomic identification

Taxonomic identification of the gastropod shells was made on both macroscopic and metric criteria—the general appearance of the shell, the number of whorls, color, and whorl morphology/sculpture. Measurements taken into consideration were height and breadth of the shell, applying the methods advocated by Grossu (1993).

For the cyprinid pharyngeal teeth, genus was determined from the external morphology. All the pharyngeal teeth examined were from cyprinids. The crown of the tooth is globular, with enamel in this region. The pharyngeal bone usually presents five or six teeth in a single row, distinct from the common carp (*Cyprinus carpio*—the largest of the cyprinids) which has the teeth arranged in three rows. The largest teeth of the carp (except the first) are molar shaped, with striations on the active surface. The pharyngeal bone is the fifth ceratobranchial bone belonging to the gill arches, adapted to include teeth. Those teeth crush food (vegetation, insects, or fish) against the basioccipital posterior process which is covered by a keratinous pad.

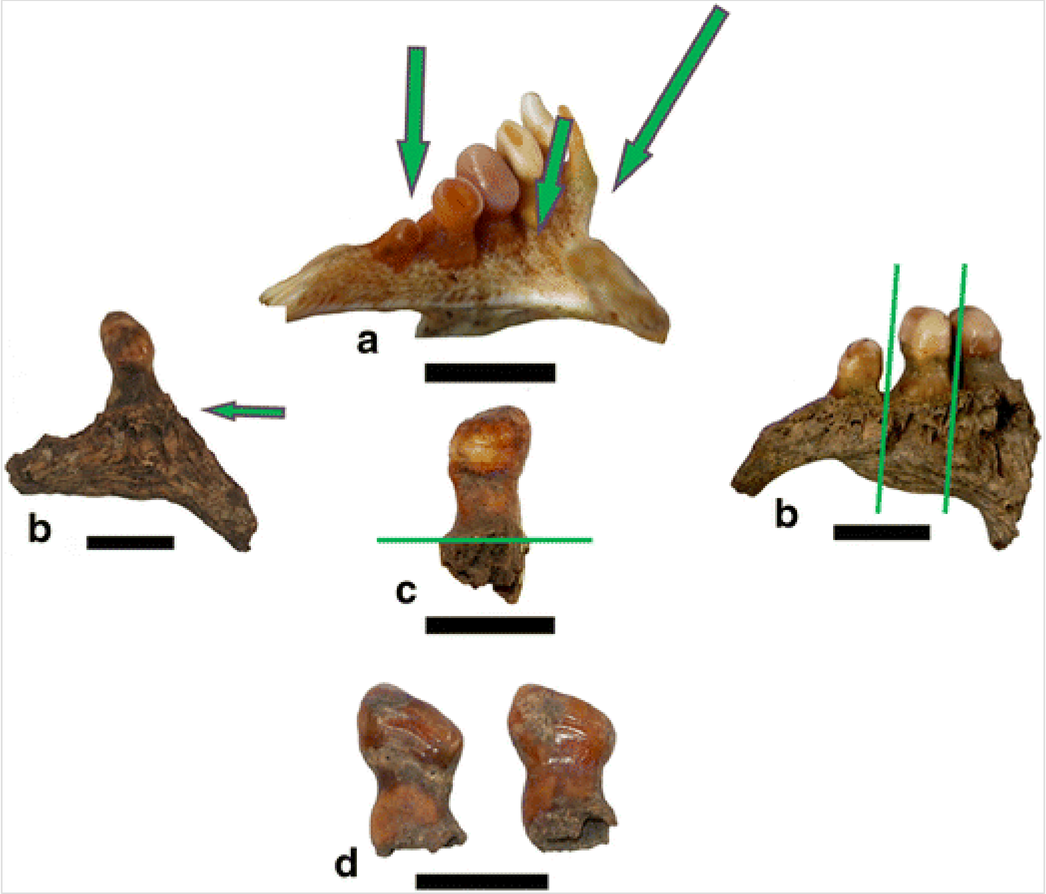
Several species of roach live in the Danube Basin and in the Black Sea. Among these, *Rutilus rutilus* and *Rutilus pigus virgo*, which are present in the Iron Gates area, never exceed 50 cm in total length (Lelek 1987). *Rutilus frisii* reaches the greatest size, often exceeding 50 cm. It is a marine species that makes spawning migrations (in March–April) along rivers entering the Black Sea from the north and south. However, there are no records of this species migrating along the Danube, and in Romania, it is attested only in the Danube Delta (Bănărescu 1964: 312). Today, *Rutilus meidingerii* is a very rare species. Its habitat is limited to Central Europe, several lakes in the Alps, Austria, and Germany (Chiemsee, Traunsee, Mondsee, etc.) and, more recently, it was also encountered along the Lower Danube and within the lakes and rivers that connect with the Danube (Zauner and Ratschan 2005; Lelek 1987: figs. 57 and 59). This species prefers deep mountain waters, well oxygenated, and with moderate currents. Reproduction takes place in April–May, when individuals swim upriver toward lakes (Lelek 1987: 233; Schmall and Ratschan 2010). They also spend winter in the deeper waters of rivers. *R. meidingerii* can reach dimensions of over 50 cm and 5 kg. Although they live in different environments, analysis of their mitochondrial DNA (Ketmaier et al. 2008) has shown little genetic difference between samples of *R. meidingeri* and *R.*

frisii. Of all these species, only individuals of *R. meidingeri* and *R. frisii* reach over 50 cm in length and develop pharyngeal teeth with dimensions comparable to the archeological examples discussed in this paper.

In most cases, the cyprinid teeth from burial M38 had been detached from the anatomical matrix by percussion (Fig. 3). The first stage involved either the removal of the anterior process (including the first tooth) or the posterior process (with the last tooth), if the former was too small, and the central body of the bone where teeth were located was thinned. Next, each tooth (with the respective part of the pharyngeal bone) was detached by lateral percussion. The final ("trimming") stage involved the removal of parts of the pharyngeal bone. The tooth was only slightly affected or damaged by these operations, so that all the teeth from the pharyngeal bone (except those too worn or too small) reached their final/finished form, with few accidents. Of the 322 teeth analyzed, 251 (77.95%) still preserved fragments of the pharyngeal bone. Flexion/bending of the bone was occasionally used for detaching the teeth, and this was observed among some of the remaining 71 teeth. For attachment, the natural ("waisted") shape of the tooth was used opportunistically.

Fig. 3

Stages of cyprinid teeth removal from the pharyngeal bone



The number of ornaments made from mammalian teeth recovered from the Romanian Iron Gates sites is small (Table 1), except for the vestigial canines of *Cervus elaphus*. There ~~are~~ no comparative reference series at our disposal (as in the case of *Rutilus*) that would allow us to test metrically whether there was deliberate selection based on size. Using the methodologies for determining age and sex of red deer based on vestigial-canine morphology established by d’Errico and Vanhaeren (2002), we concluded that all are unpaired canines. The canines of Climente II cave were obtained from three males aged 4–8 years (2) and 6–11 years (1) and those from Cuina Turcului of males aged 3–8 years (3) and 9–16 years (7) and a female with an age of 13–20 years. The sample from Cuina Turcului is dominated by worn teeth from mature (>5 years) animals, with variable morphologies and dimensions.

Comparison with recent cyprinid teeth

The data obtained from the pharyngeal teeth analysis were processed statistically, to establish frequencies or MNI (minimum number of individuals). From Schela Cladovei archeological contexts, we selected pharyngeal bones with teeth. Also, a modern specimen of *Rutilus frisii kutum* was obtained. The dimensions recorded for the pharyngeal bones allowed us to reconstruct the sizes of the fish. From this, we made a reference dataset with teeth dimensions corresponding to each class, for the individuals of known size. The aim was to make comparisons with isolated teeth and establish the dimensions of the individuals from which the teeth came. Although this method is not very precise, it provides an approximation of the size and number of *Rutilus* sp. individuals from which the teeth buried with M38 at Schela Cladovei were derived.

Technological and taphonomic analysis

Macroscopic and microscopic examination of the technological and wear traces present on the archeological specimens was undertaken. The location and character of manufacturing marks, use-wear, and pigment spots were systematically recorded. Analysis of taphonomic damage was based on the work of d’Errico et al. (2005); Vanhaeren et al. (2013); Cristiani and Borić (2012); Stiner et al. (2013); Cristiani et al. (2014a); and Langley and O’Connor (2015), to distinguish anthropogenic perforations from those caused by natural processes (e.g., predators) or areas of wear resulting from friction with clothing from those resulting from the friction with beach sand or gravel (i.e., prior to collection). Microscopic examination and photography were undertaken with a Keyence VHX-600 digital microscope, at magnifications of ×30 to ×150. Our interpretations were informed by recent studies of the manufacture and use of personal ornaments from prehistoric contexts in Europe and elsewhere (e.g., d’Errico et al. 2005; Bonnardin 2009; Rigaud 2011, 2013; Cristiani and Borić 2012; Vanhaeren et al. 2013; Cristiani et al. 2014a; Tátá et al. 2014; Rigaud et al. 2015) and their possible socio-cultural significance (e.g., Vanhaeren 2005; Rigaud 2011, 2013).

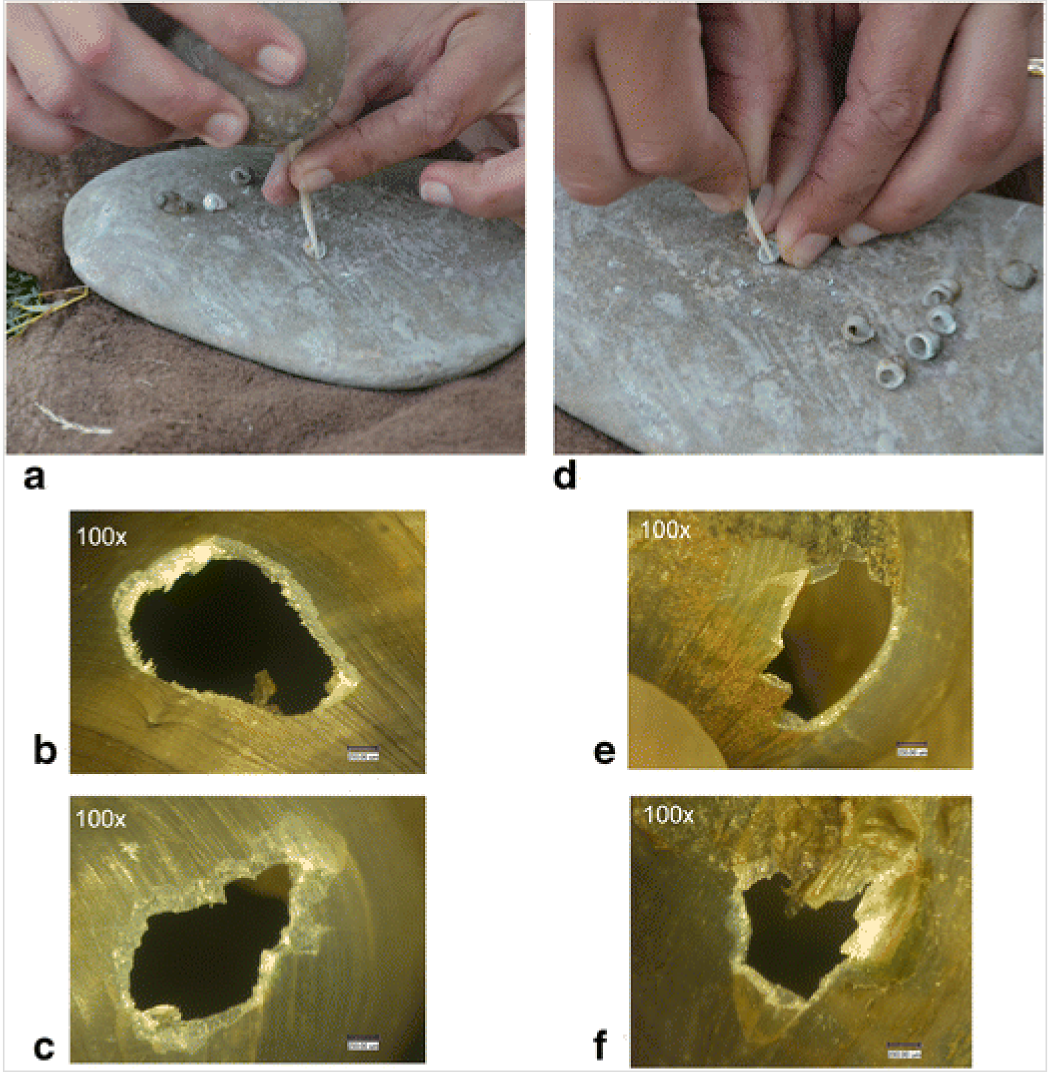
Experimental studies

Observations on archeological specimens were compared with those on experimental artifacts manufactured on similar raw materials. We replicated beads from pierced shells of *Lithoglyphus naticoides*, *Tritia neritea*, and *Theodoxus danubialis* and from cyprinid teeth. The evolution of the use-wear on experimental pieces was evaluated periodically to establish the durability of the experimental beads and to estimate the amount of time they were worn.

For the experiments with *Lithoglyphus,* raw material was collected from a sandy beach along the Danube, which was flooded during the springtime. Collection of the shells took place in August, after a fall in the water level left empty shells accessible on the beach. Two gatherers collected a hundred shells in just 10 min. In our experiments, the modern shells were processed immediately after gathering. From among those collected, 60 shells of *Lithoglyphus* sp. were experimented with. This number was considered sufficient to determine accurately the likely method of manufacture and the time needed to obtain the finished item. Half of the experimental beads were suspended, creating a reference series from which detailed information on the evolution of the wear and durability of these ornaments could be derived. Two perforation techniques were tested. The first was indirect percussion (Fig. 4a), using a limestone pebble as a hammer and a bone point as the intermediary tool. The second perforation technique was pressure, involving the use of a fine bone point (Fig. 4d).

Fig. 4

Experimental replication procedures for the *Lithoglyphus naticoides* beads. **a** Indirect percussion. **b**–**c** Details of perforations made by indirect percussion. **d** Pressure. **e**–**f** Details of perforations made by pressure

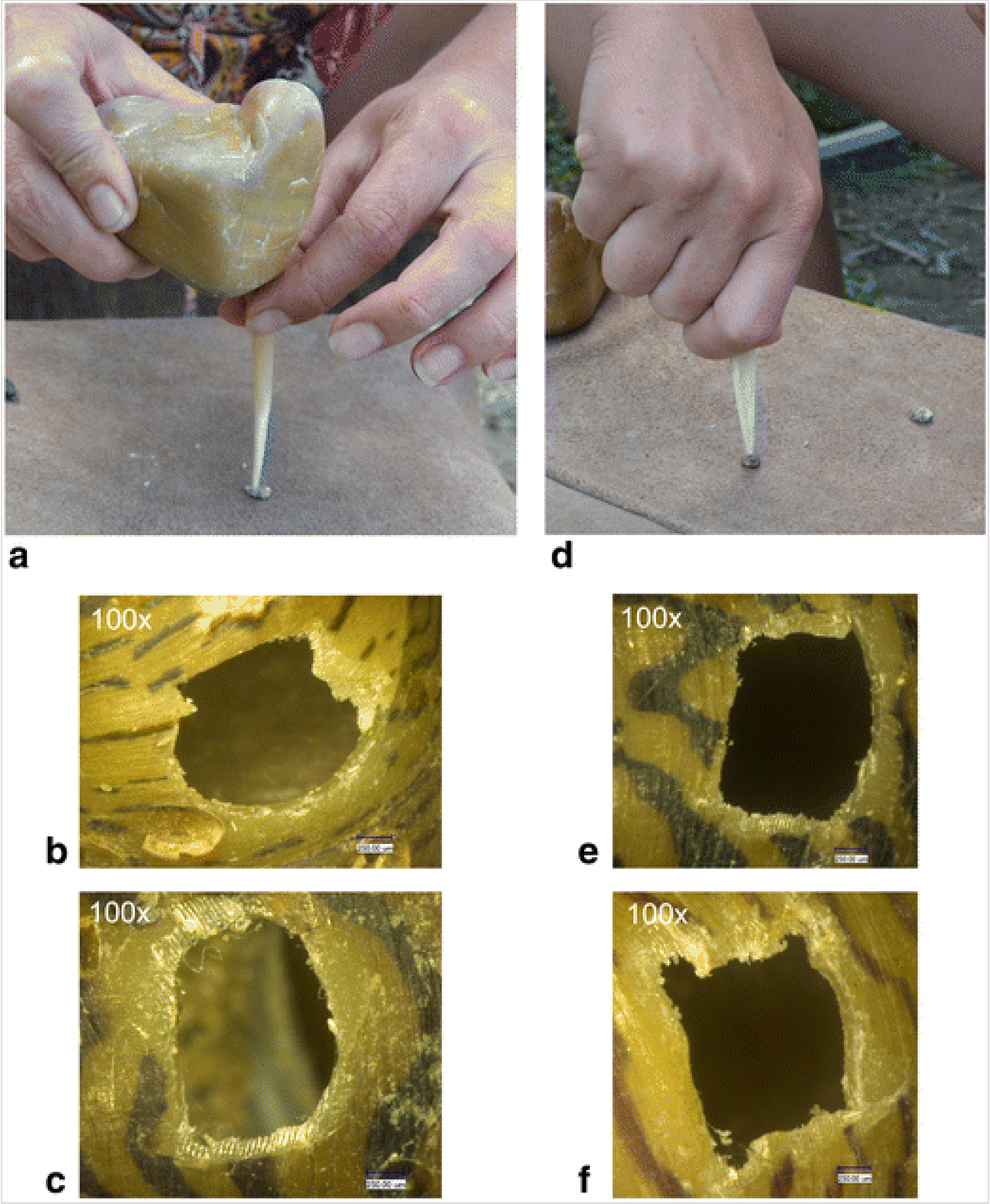


There are two ways in which these shells might have been used as decorative elements—either sewn onto clothes or suspended on a thread. If each individual shell had been sewn onto skins, leather or textile, we would expect to see different patterns of wear. First, the ventral side of the shell would have been affected by rubbing against the material (e.g., flattening of the surface, modification of the external structure, macroscopic polish); whereas on all the archeological pieces examined, this face is not obviously affected by wear. Second, the wear area developed between aperture and perforation would be more localized. Third, the apex would not be affected by wear from contact with the material. From these observations, we concluded there was no evidence the shells had been fixed individually to clothing, and so this was not reflected in the experiments. In contrast, if the shells had been strung together in composite ornaments, we should see marks resulting from the hitting of one piece against another, and from pressure generated by hanging from a thread. Since the wear patterns observed on the archeological pieces seemed to correspond with this second mode of use, series of experimental pieces were strung as bracelets. A thread made of vegetal fiber (hemp) was chosen, and the beads strung by passing the thread through the artificial perforation and the aperture. The bracelet was worn on the wrist continuously (day and night) for 2 years by the senior author. A careful record was kept of the times when the thread broke, giving an average of 2 months of continuous use for this type of material. The choice of vegetal fiber was dictated by ease of acquisition. However, we do not think that a thread made of animal sinew or hair would have produced significantly different results. When shells are strung together in bracelets, the wear is determined mainly by the arrangement of the pieces and by the friction/hitting of pieces against one another.

For our experiments, gathering of the *Theodoxus danubialis* shells took place on the same sandy beach area as the *Lithoglyphus* shells. Nevertheless, *Theodoxus danubialis* occurred less frequently, and only 30 shells were gathered in 10 min by two people. Of these, 15 pieces were perforated by indirect percussion (Fig. 5a) or pressure (Fig. 5d), and 6 of them were suspended.

Fig. 5

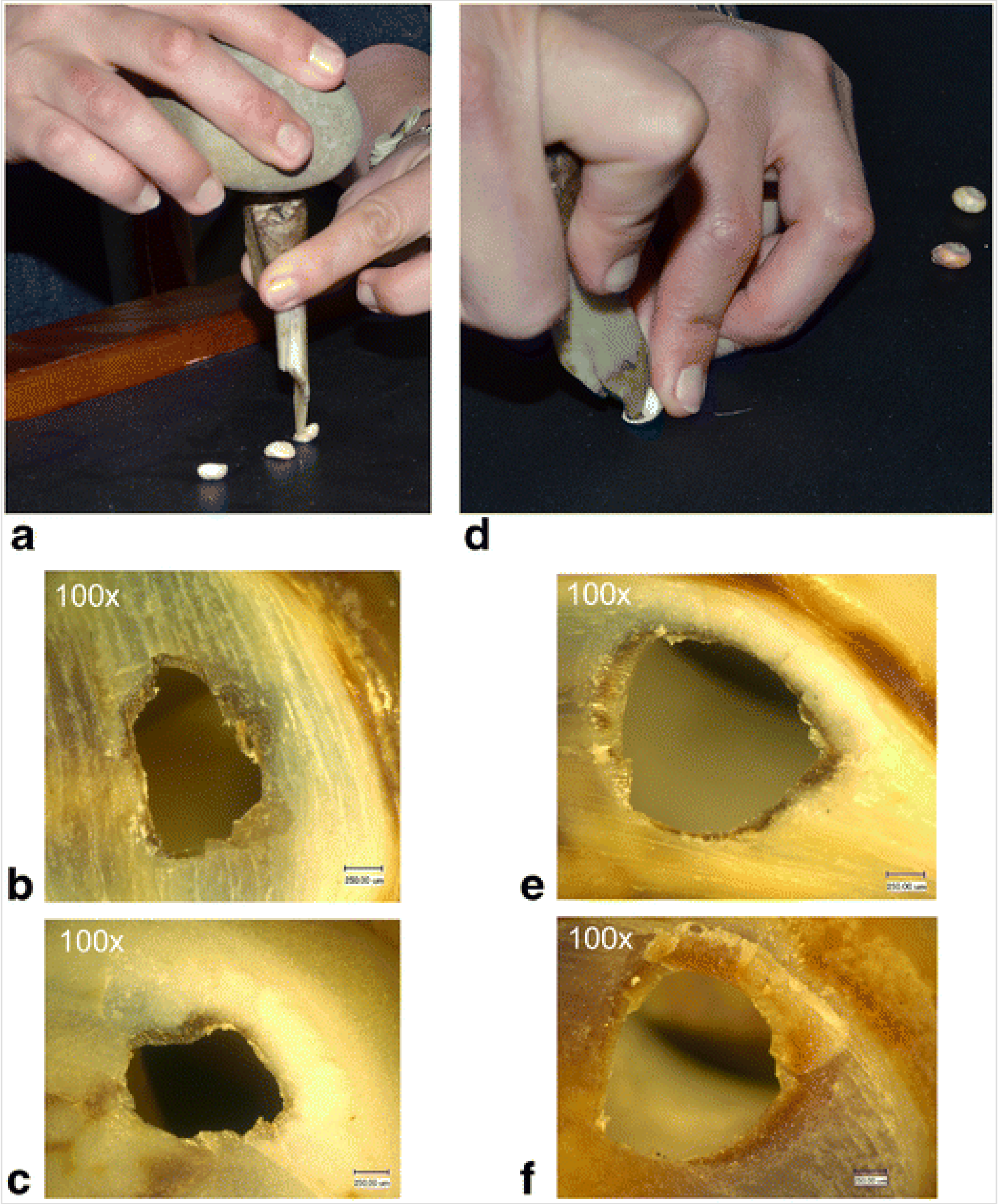
Experimental replication procedures for *Theodoxus danubialis* beads. **a** Indirect percussion. **b**–**c** Details of perforations made by indirect percussion. **d** Pressure. **e**–**f** Details of perforations made by pressure


a
d
100x
b
100x
e
100x
c
100x
f

Tritia neritea is a marine species, available on beaches around the Black Sea. In our experiments, two people gathered 40 shells in 10 min. Of these, 20 were perforated by indirect percussion (Fig. 6a) or pressure (Fig. 6d) and 10 were suspended, using the same kind of thread as for the *Lithoglyphus* shells.

Fig. 6

Experimental replication procedures for *Tritia neritea* beads. **a** Indirect percussion. **b**–**c** Details of perforations made by indirect percussion. **d** Pressure. **e**–**f** Details of perforations made by pressure



Lacking *Rutilus* sp. pharyngeal teeth, we used teeth of common carp (*Cyprinus carpio*). Teeth were extracted from two Danube-fished *Cyprinus carpio* individuals weighing 12 and 9 kg, respectively (Fig. 7a). Extraction of the teeth was done while the bones were still fresh, shortly after catching the fish. Tooth recovery was quite easy and was performed either by means of percussion around the tooth (Fig. 7b) or by bending (Fig. 7c) of the jawbone. The first method also results in preservation of a part of the pharyngeal bone, which was also noticed in the case of some archeological samples. Furthermore, this method allows for more precise control over the breakage, in comparison to the bending procedure where “V-shaped” fractures sometimes develop at the neck of the tooth, hampering secure fixing of the piece. This V-shaped form of fracture is also present on some of the archeological pieces, indicating that both debitage procedures had been employed. The glue we chose to use was a mixture of ~~ochre~~, charcoal, and animal fat (Fig. 7d). A vegetal thread was used for attaching the teeth to a piece of hide (Fig. 7e), and the thread covered with the “glue~~.”~~ Our experiments were informed by the results of previous studies of residues identified on archeological specimens (e.g., Fullagar et al. 1996; Fullagar and Jones 2004; Lombard 2004, 2007; Rigaud 2011; Cristiani et al. 2014a; Rigaud et al. 2014).

Fig. 7

Experimental replication procedures for fish teeth beads. **a** Teeth of common carp. **b** Breaking by means of percussion. **c** Breaking by bending. **d** Experimental adhesive. **e** Experimental sewing


a
b
c
Animal glues
Hammer
Cyprinid teeth
Charcoal
Ochre
d
e

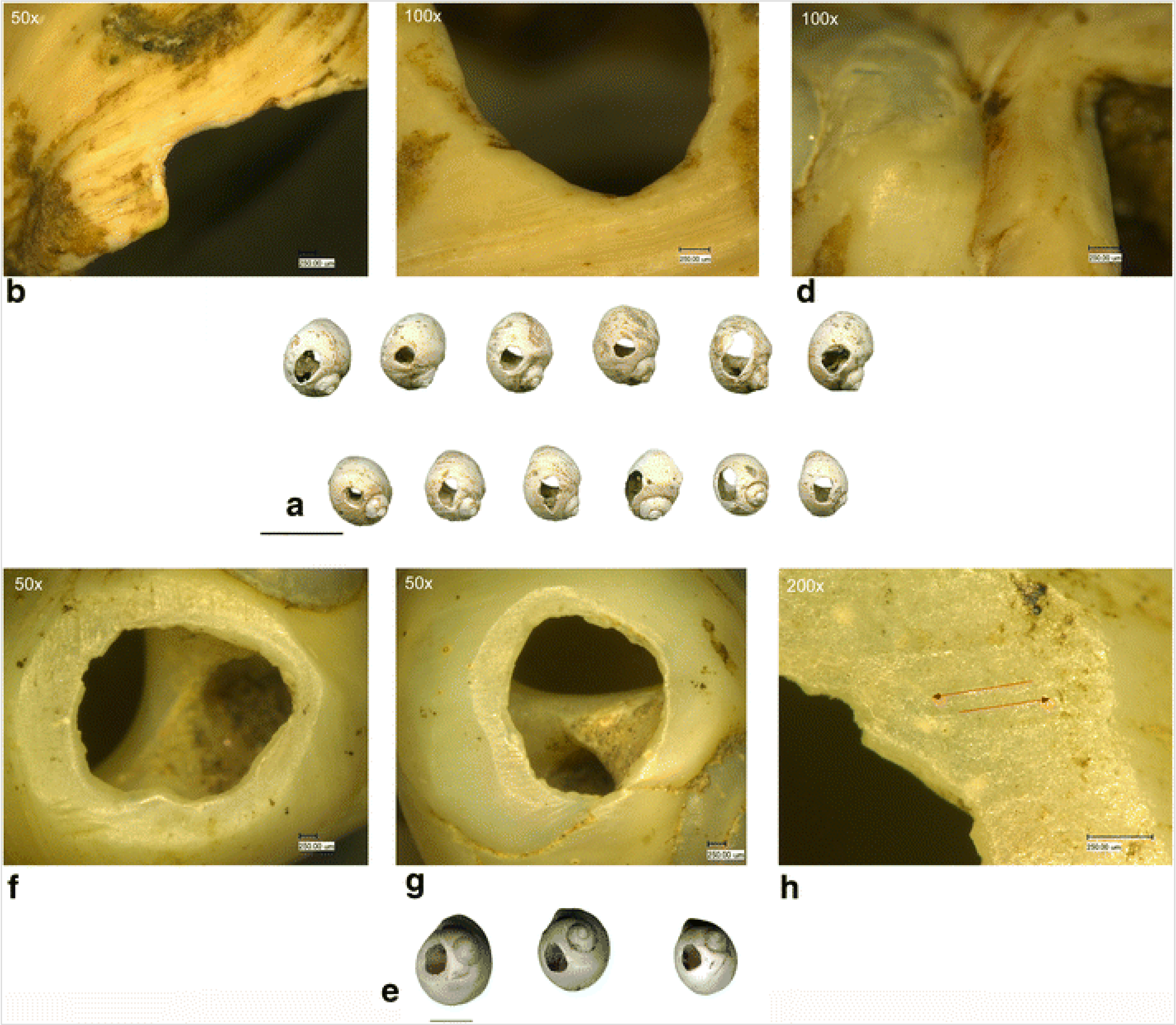
Results

Gastropods

Microscopic examination of the archeological pieces (*Lithoglyphus naticoides* ~~shell~~) revealed the perforations as sub-rectangular holes, rather irregular in shape (Fig. 8a). The edges of the perforations had a faceted aspect. The perforation was made at 7.50–8.30 mm from the aperture. This more or less is the maximum distance from the aperture for placement of the perforation given that it is started from the interior.

Fig. 8

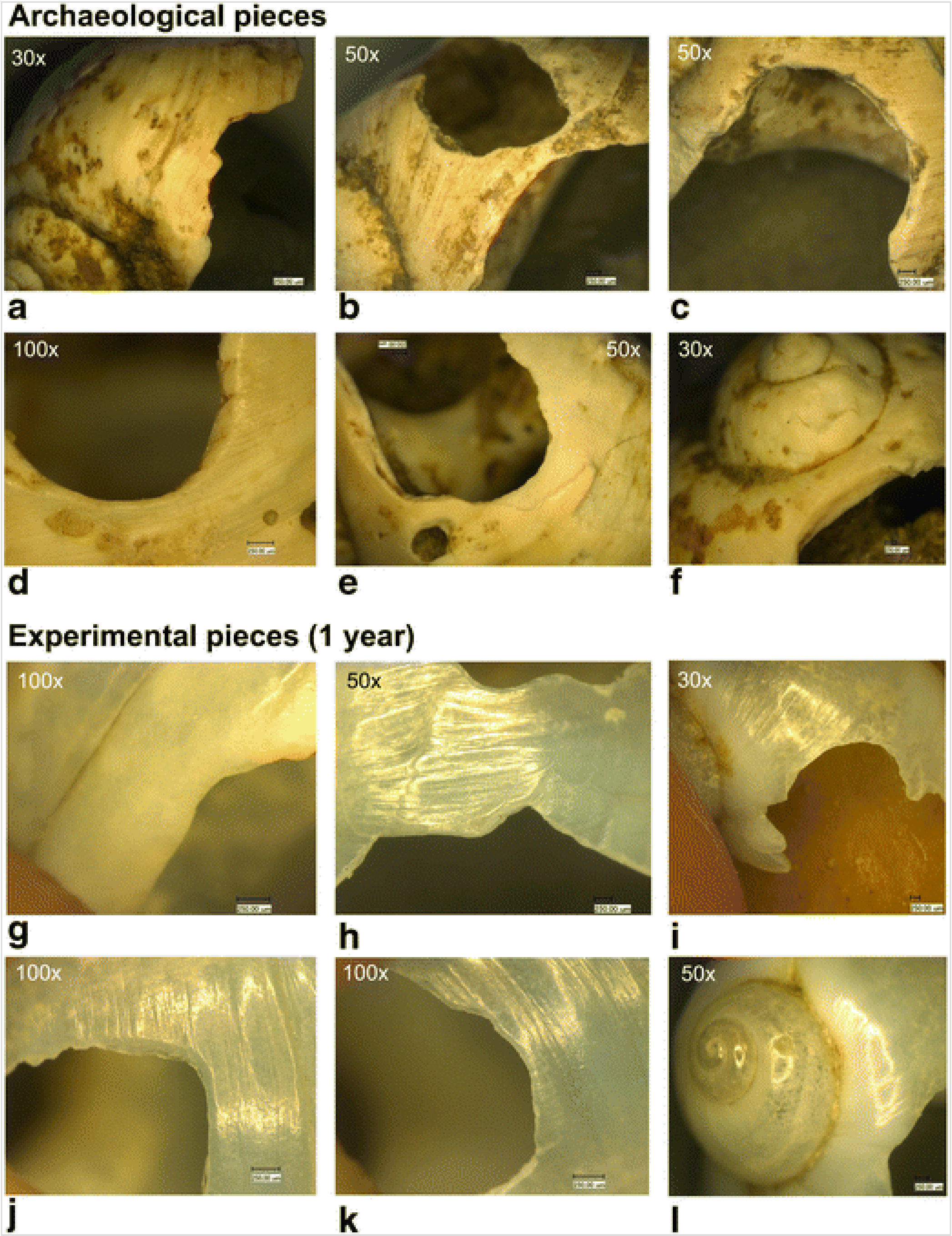
Archeological beads made of *Lithoglyphus* shell. **a** Shells perforated by percussion (Schela Cladovei). **b** Aperture deformation. **c** Perforation deformation. **d** Use-wear at the apex. **e** Shells perforated by abrasion (Cuina Turcului). **f**–**g** Perforations made by abrasion. **h** Abrasion marks



The use-wear observed on the edge of the perforation, on the outer lip, and the parietal wall of the aperture indicate that all the archeological specimens examined had been strung on a thread and worn. Friction against a thread or suspension of several shells touching one another will leave different marks. Thus, we looked for, and identified, two different areas of use-wear development. The first develops on the area between the perforation and the aperture edge, caused by friction with the thread. The surfaces of the pieces show macroscopic use-wear traces, represented by an attenuation of the shell's structural pattern. On the aperture, the wall is fractured, resulting in differing morphologies dictated by the intensity of the use-wear: concave, rectangular, or fractured (Figs. 8b and 9a–c). The perforation becomes strongly deformed toward the aperture, developing a concavity with smoothed walls (Figs. 8c and 9d–e).

Fig. 9

Evolution of the wear traces on beads made of *Lithoglyphus naticoides* shells. **a**–**c** Aperture deformation. **d**–**e** Perforation deformation. **f** Use-wear on the apex (archeological pieces—Schela Cladovei). **g**–**i** Aperture deformation. **j**–**k** Perforation deformation. **l** Use-wear on the apex (experimental pieces)


Archaeological pieces
30x
50x
50x
a
b
c
100x
50x
30x
d
e
f
Experimental pieces (1 year)
100x
50x
30x
g
h
i
100x
100x
50x
j
k
l

The second area with use-wear traces develops on the surface between the perforation and the apex. The surface becomes smooth, with a macroscopic polish (Figs. ~~8 d~~ and 9f). In several cases, a small hole was noted below the apex. The use-wear is the consequence of the way the thread was attached, the strung items thus coming into contact (hitting and rubbing against one another) at the level of the apex.

During the experiment, the time required to make the perforation, by percussion or by pressure, was approx. 2–3 s. The force was applied from inside the shell aperture, as was observed also on the archeological pieces. Our experiments indicated that indirect percussion resulted in sub-rectangular perforations (Fig. 4b–c). In the peripheral zone around the perforation, a series of cracks could be observed, while the debitage edges developed in straight lines. In the case of pressure (Fig. 4e–f), the perforation tends to be rounder in form, while the fracture edges are markedly jagged. Judging by the morphology of the perforations produced in our experiments, the archeological perforations were most likely created by indirect percussion. Our experiments showed that when the distance between perforation and aperture was less than 4 mm, the items fractured within 3 months of continuous usage. Thus, the placement of the perforation could not have been random and was intended to maximize resistance to breakage.

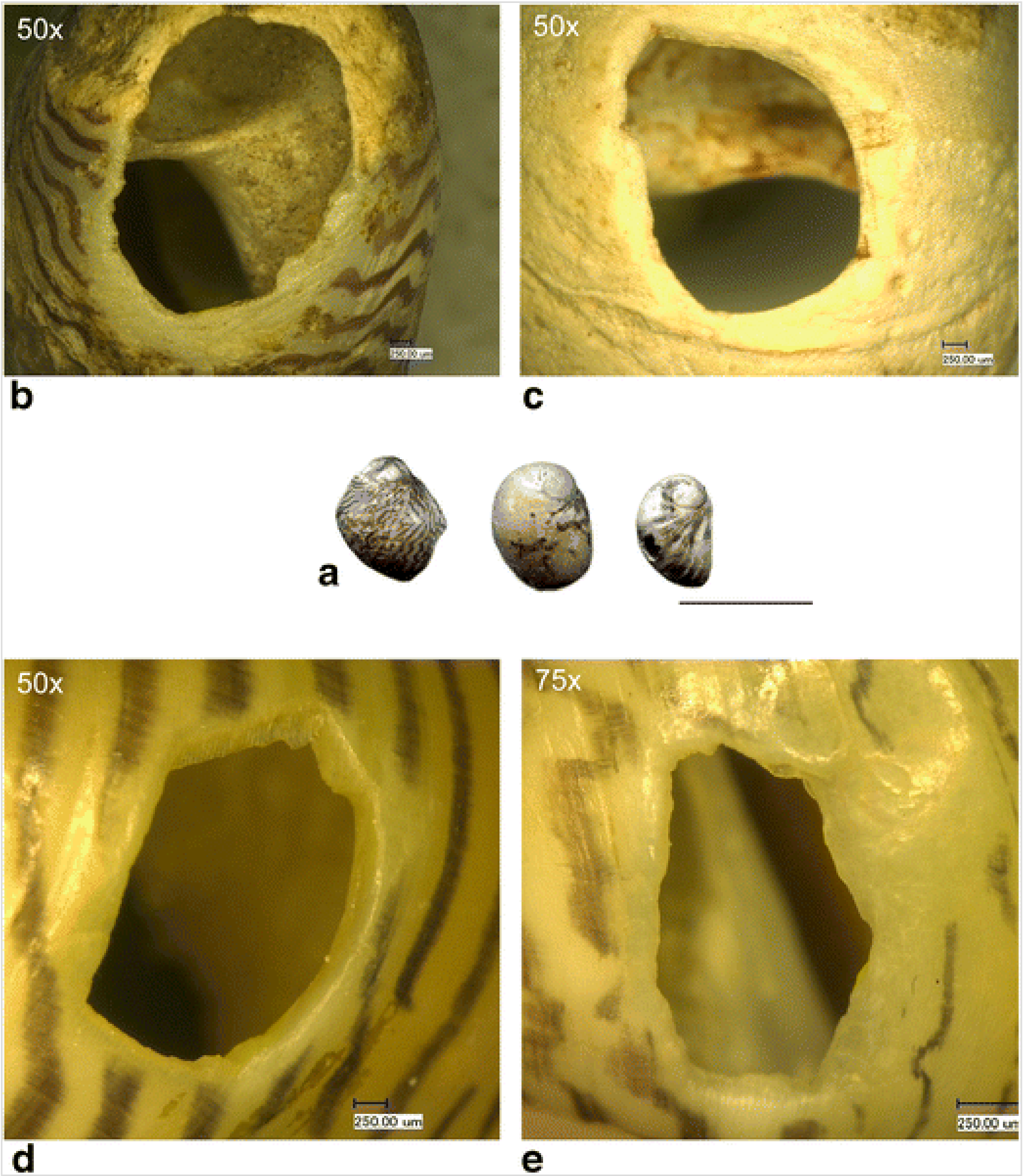
At regular intervals, we recorded the evolution of use-wear on experimental pieces. After 3 months, 6 months, and 1 year, photomicrographs were taken of areas where use-wear developed. These were compared with photomicrographs of the equivalent areas on archeological specimens; the locations and morphologies of the wear between archeological and experimental pieces were found to be very similar, confirming the hypothesis of complex strings of beads, since only shells used for bracelets or necklaces developed such use-wear patterns. Moreover, when comparing the archeological specimens with experimental beads that had been worn for a year (Fig. 9g–l), it was noticed that the use-wear was more advanced on the archeological pieces, suggesting they had been worn for more than 1 year.

In the case of the *L. apertus* shell (Fig. 8e), another perforation technique was used, namely abrasion. The perforation is located at 9.5–9.8 mm from the aperture and has a diameter between 3 and 5 mm. Around the orifice, a flat surface was observed covered with parallel fine scratches (Fig. 8f–g). Moreover, the wear was not very highly developed and the abrasion area (Fig. 8h) was not associated with deformation of the perforation.

The technological observations made on the *Lithoglyphus naticoides* shells also apply to the *Theodoxus danubialis* shells (Fig. 10a). The perforations are similarly heavily deformed (Fig. 10b–c), with more accentuated use-wear on the archeological specimens compared to replicas that were worn for 12 months (Fig. 10d–e).

Fig. 10

Evolution of the wear traces on beads made of *Theodoxus danuabialus* shells. **a** Archeological pieces (Cuina Turcului). **b**–**c** Details of the perforations (archeological items). **d**–**e** Details of the perforations (experimental items)

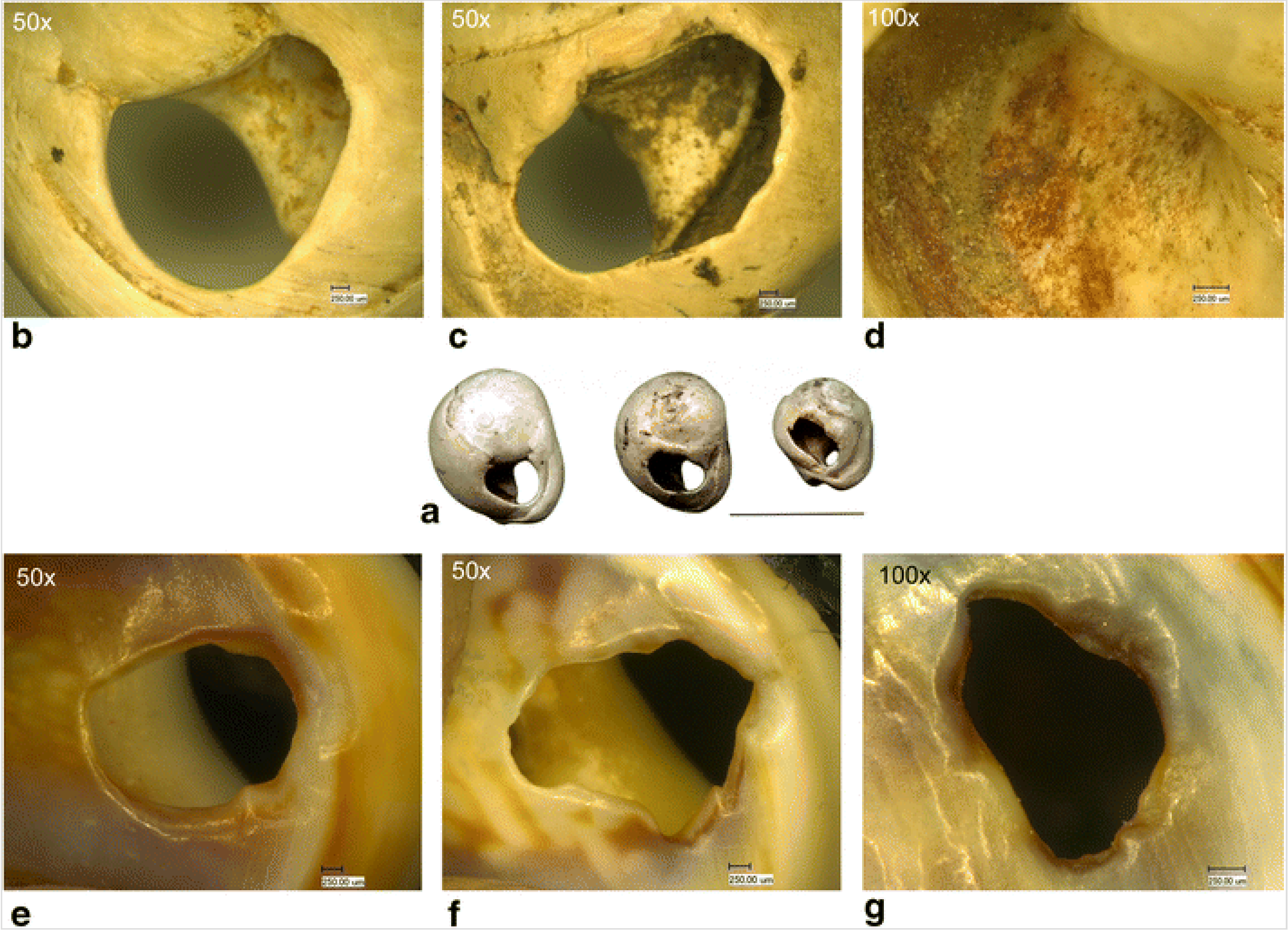


Indirect percussion had been used to perforate the *Tritia neritea* shells identified at Cuina Turcului (Fig. 11a). An accentuated use-wear pattern, strongly deforming the perforation toward the aperture (Fig. 11b–c) was noted. In one case, the presence of red pigment was identified (Fig. 11d). The experimental pieces, although ~~continuously worn~~ for over a year

(Fig. 11e–g), did not develop the advanced use-wear present on the archeological items, which ~~point~~ either to use of the latter for an extended period of several years or to sequential wear over a much longer period.

Fig. 11

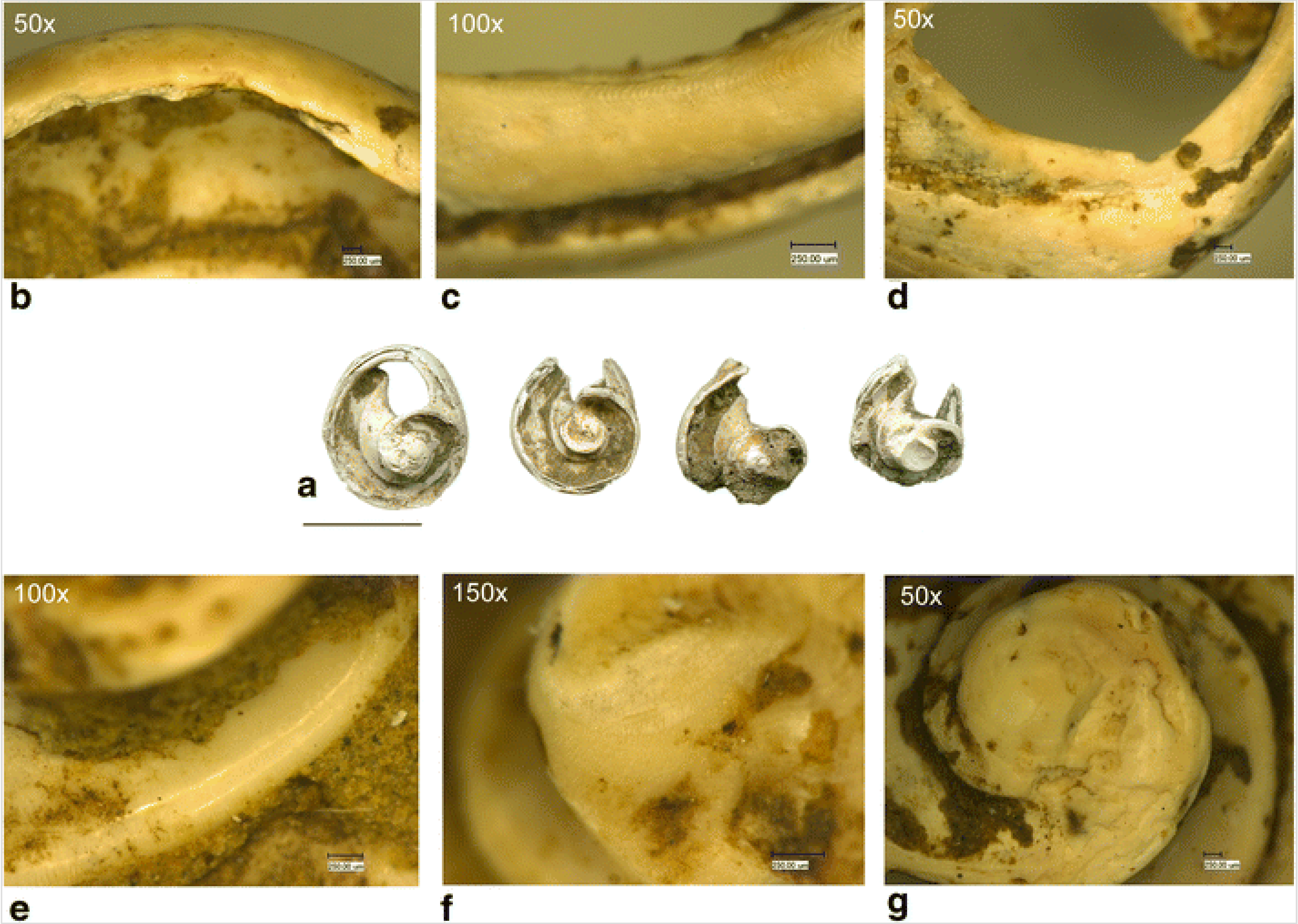
Evolution of wear traces on beads made of *Tritia neritea* shells. **a** Archeological pieces (Cuina Turcului). **b**–**c** Details of the perforations (archeological items). **d** Pigment. **e**–**g** Details of the perforations (experimental items)



At Schela Cladovei and Ostrovul Banului, the pressure technique was employed to eliminate the walls of the whorls and apex and thus obtain the special shape of the *Tritia neritea* shells shown in Fig. 12a. Fracture patterns specific to this type of debitage are sometimes present (Fig. 12b). The pieces are heavily worn, the aperture wall obviously thinned out, presenting a concavity and a macroscopic polish (Fig. 12c–d). Moreover, the surfaces of the apex and spiral walls are flattened and exhibit a macroscopic polish (Fig. 12e–g), possibly resulting from friction with clothing. The different character and degree of use-wear of these pieces suggest their function as *appliqués* that were sewn onto clothing (cf. Cristiani and Borić 2012). No pigment was identified on these *Tritia* ornaments. It should be noted that out of the five examples from Schela Cladovei, one was found in association with *Lithoglyphus naticoides* shells and worn together with them. The use-wear on this piece is advanced, with a strong deformation caused by thread pressure, indicating that it was strung in a composite ornament together with the other shells.

Fig. 12

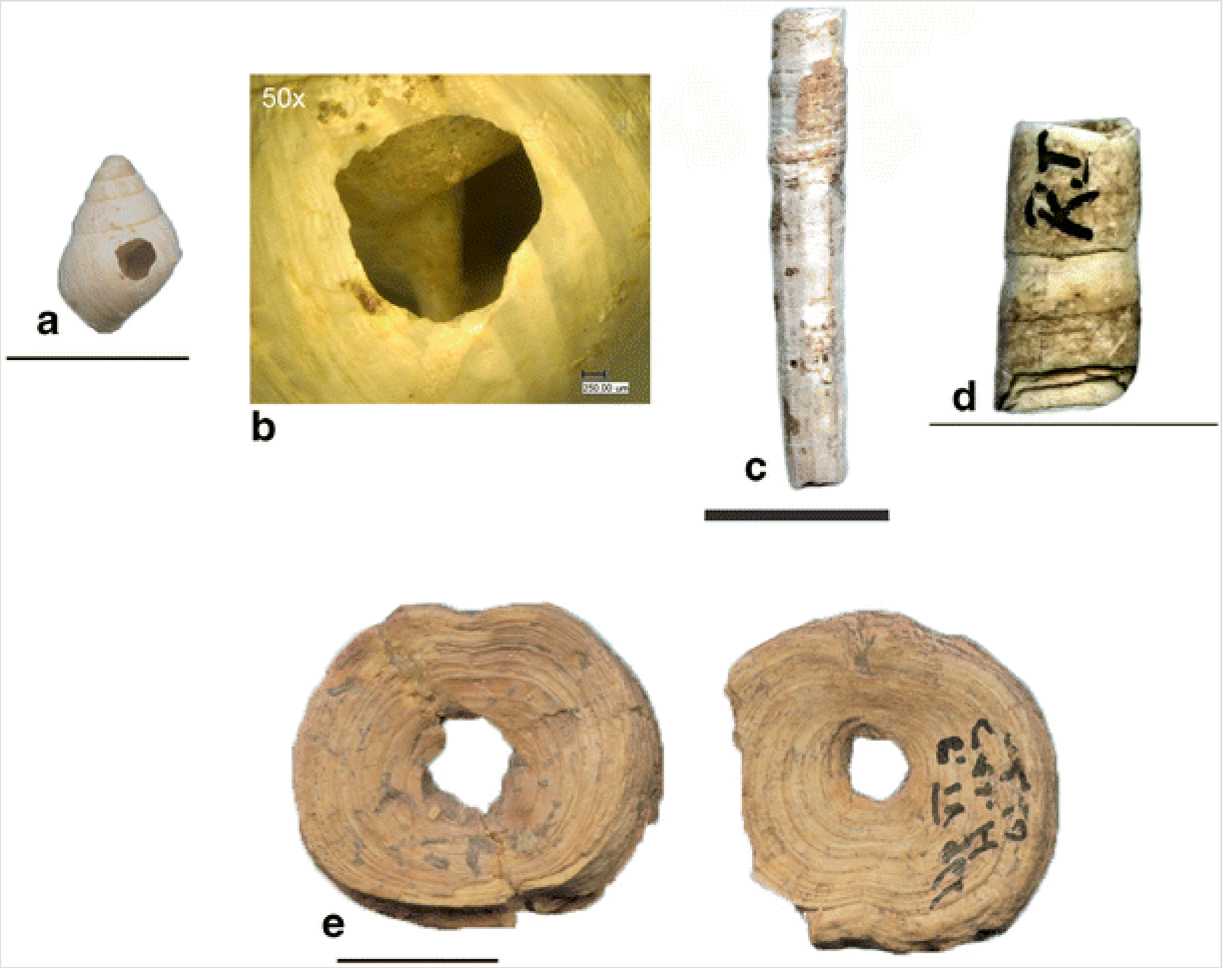
Appliqués made of *Tritia neritea* shells. **a** Archeological items (Schela Cladovei). **b** Breaking by pressure. **c–d** Aperture deformation. **e–g** Macroscopic polish



The *Zebrina detrita* shell from Cuina Turcului (Fig. 13a) was perforated through the last whorl, starting from the inside. The main characteristics are the sub-circular orifice and the irregular edges of the perforation (Fig. 13b), suggesting the use of pressure technique. No use-wear is visible on this specimen.

Fig. 13

Ornaments made of various raw materials. **a** *Zebrina detrita* shell (Cuina Turcului). **b** Detail of the perforation. **c**–**d** Scaphopod shells (**c** Climente II, **d** Cuina Turcului). **e** Perforated fish vertebrae (Cuina Turcului)



Scaphopods

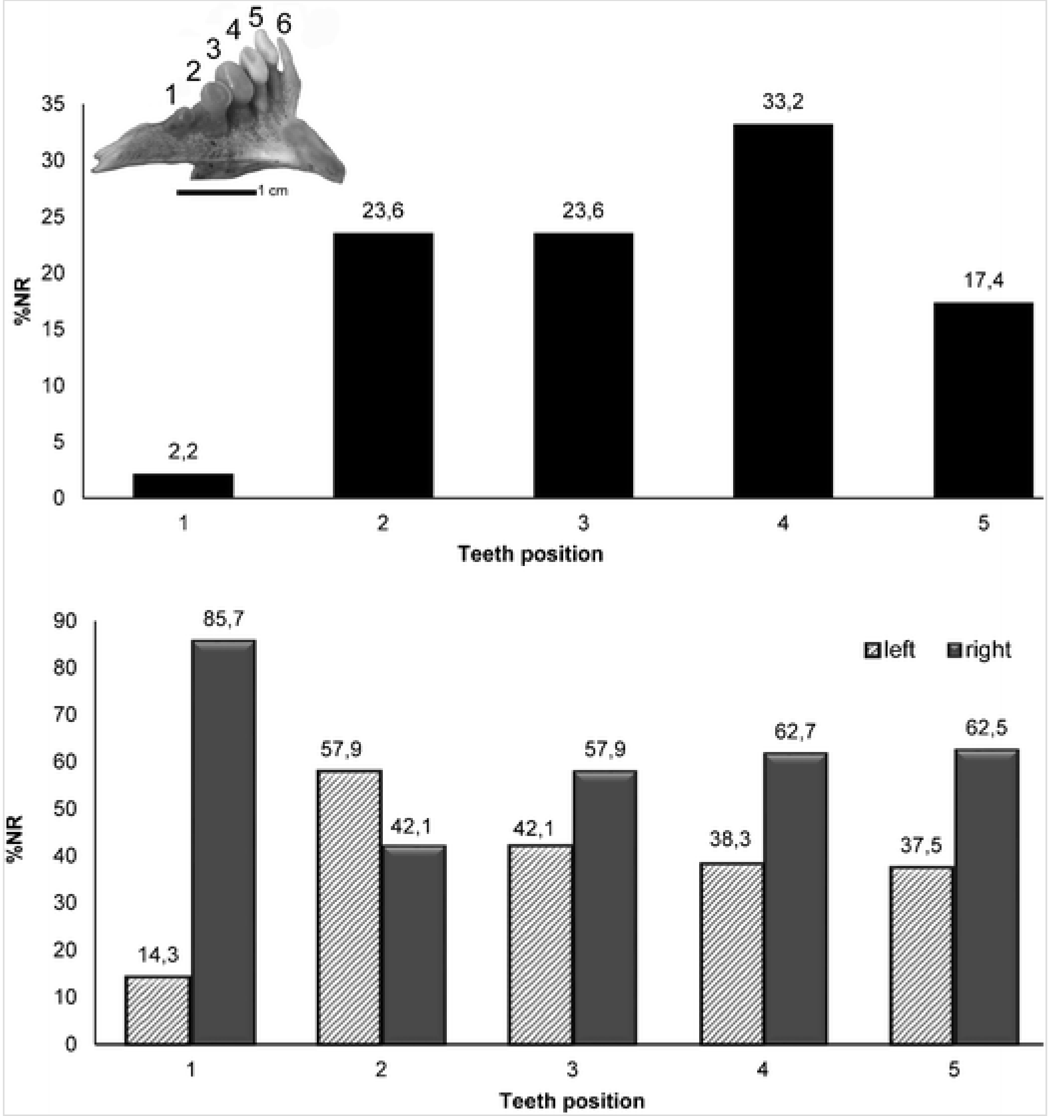
The two scaphopod specimens from Climente II and Cuina Turcului, respectively, do not have a pronounced conical form, suggesting use of the segmentation procedure. Two techniques used for the segmentation of tusk shells are known: sawing and bending (Vanhaeren and d'Errico 2001). Unfortunately, in both examples examined (Fig. 13c–d), the extremities are worn away, hindering identification of the technique used to produce the beads.

Cyprinid pharyngeal teeth

Three hundred twenty-four pharyngeal teeth of *Rutilus* sp. were found with burial M38 at Schela Cladovei. Of these, 322 were analyzed (the other two were too fragmented), with the aim of identifying the minimum number of individuals and their dimensions. The minimum number of individuals in the analyzed sample is 66. This value was calculated based on the position 4 teeth, which are the most numerous ($n = 107$ or 33.24%). Among these 322 teeth, those from positions 2, 3, and 4 ($n = 259$) were the best represented, followed by those from position 5 ($n = 56$) (Fig. 14a), while those from position 1 were the fewest ($n = 7$). Within this sample, only 9% of the teeth from the first position and 53% of those from the fifth or sixth positions were kept for processing. The teeth from the pharyngeal bone extremity were the least used. The ratio of left/right varies within narrow limits but the right-side teeth, from positions 3 to 5, are better represented than those on the left side (Fig. 14b). The causes may be natural or deliberate; teeth wear and fall out (especially those from positions 2 to 6), or are too thin (positions 5 or 6). First position teeth were less frequently selected (seven examples), because of their small dimensions, even in large specimens, but also their shape, which made them less suitable for attachment to clothing. Deliberate selection may have been influenced by various factors—esthetic (certain teeth were too worn, which affected the appearance of the enamel) or technological (some teeth may have broken or cracked during detachment from the pharyngeal bone, rendering them unsuitable for attachment).

Fig. 14

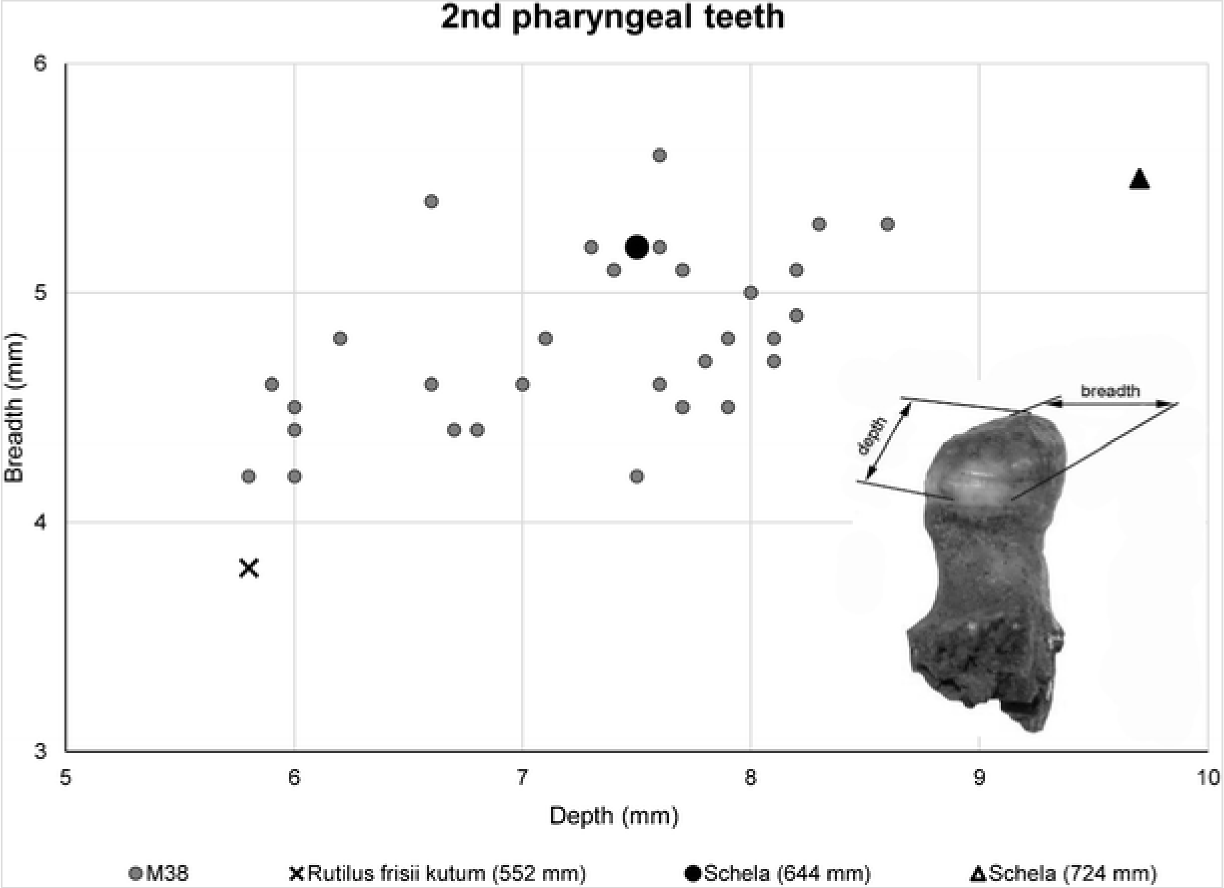
a Occurrence of tooth positions 1 to 5 within the archeological sample. **b** Occurrence of tooth positions on the two sides (*left* and *right*) of the mandible



Pharyngeal bone measurements were used to calculate the approximate size of the fish that provided the teeth (Fig. 15). Measurements on teeth from the second position found with burial M38 were compared with those from modern and archeological fish of known size. The smallest values are close to those from a 55-cm modern individual, weighing 2.18 kg, while the largest measurements fall into the range of archeological specimens from Schela Cladovei with estimated dimensions of 64.4 cm (3.4 kg) and 72 cm (4.8 kg). This points to deliberate selection of large individuals, with teeth of similar size. Only reproductive individuals reach such large dimensions; their numbers peak during the breeding season, in April–May, when individuals move up the rivers in shoals (Lelek 1987: 233). During this period, they are particularly vulnerable to capture where there are submerged ridges, sandbanks, or gravel bars in the riverbed or during low water conditions.

Fig. 15

Dimensions of *Rutilus* sp. second pharyngeal teeth from burial M38, compared with equivalent measurements on a modern specimen of *Rutilus frisii kutum* of known size, and two archeological specimens from non-burial contexts at Schela Cladovei where the size of the fish can be reliably estimated



The teeth (Fig. 16a) show intensive use-wear, testifying to their mode of attachment and use prior to deposition in the grave. The intensity of the use-wear is variable among the teeth, ranging between “fresh” surfaces, to surfaces with a strong macroscopic polish and the appearance of a groove with use-wear traces—resulting from the pressure of the thread that was used for attachment. The variation in use-wear development between individual teeth in a group indicates that some (those that were less worn) were replacements. Overall, the wear is characterized by a smoothing of the external surface associated with an intense polish. Analysis of the archeological finds identified three areas where use-wear developed, which are indicative of the fixing of each tooth (sewn onto cloth/leather) individually (Fig. 16b–d). Several traceological details seem to confirm this hypothesis. First, two of these areas develop on only one of the sides of the tooth facets, because of friction between the tooth and the garment. The first appears as a fracture edge (Figs. 17a–b), gradually acquiring a round shape, and displaying macroscopic polish and fine striations. The second occurs on the crown of the tooth (Fig. 17c), adjacent to the neck, and shows the same polish, traces of compression, and fine striations. The third use-wear area is on the neck itself (Fig. 17d), caused by fastening the tooth onto cloth or leather. This area shows striations with differing morphologies disposed on the entire surface, showing that the thread was wrapped around the entire circumference of the neck and then it was sewn. These range from fine striations to deep incisions, likely depending on the duration of the tooth’s life as an ornament, or on the characteristics of the fixing thread.

Fig. 16

a Cyprinid teeth from burial M38 (Schela Cladovei). **b**–**d** Use-wear traces on the neck

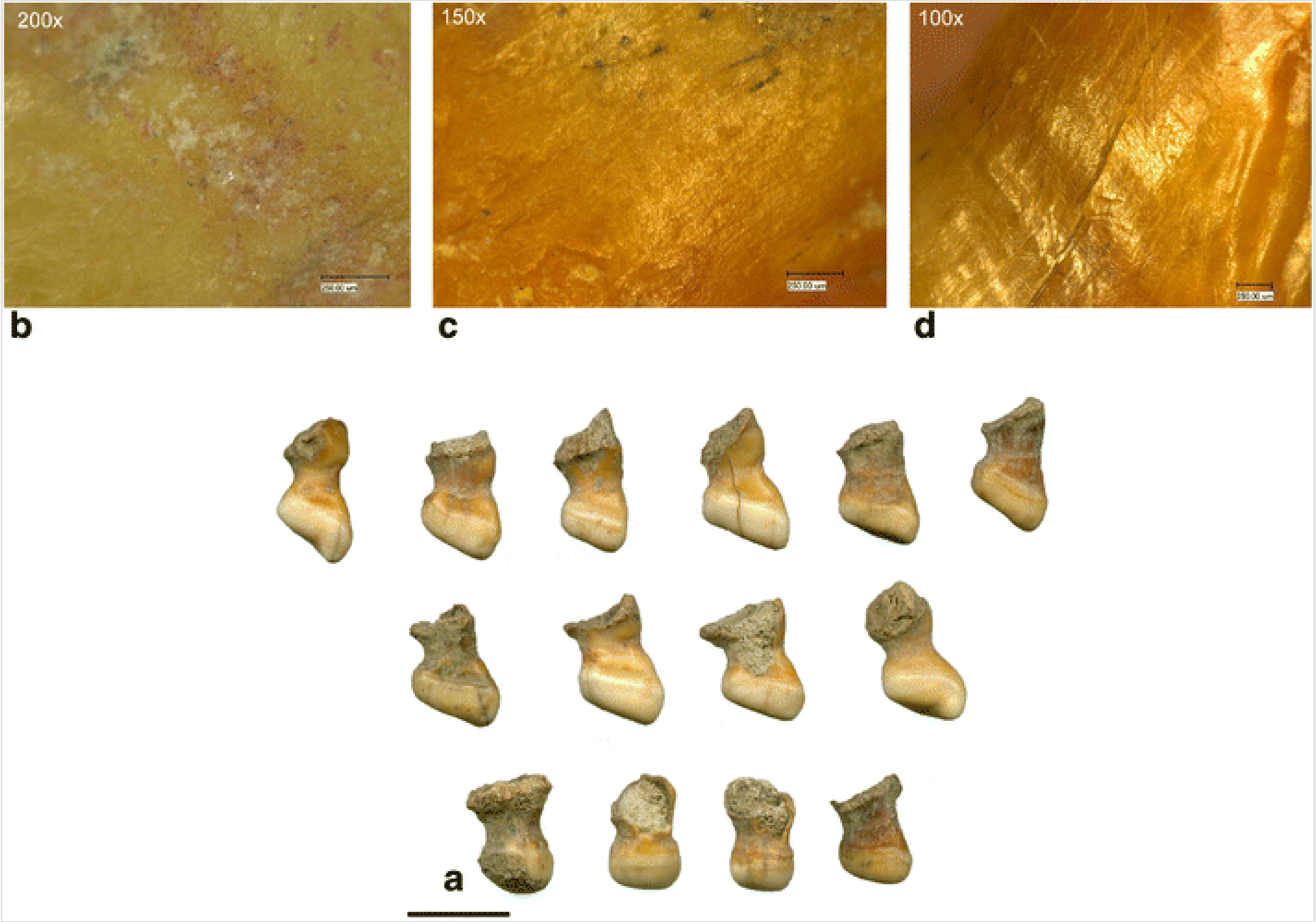
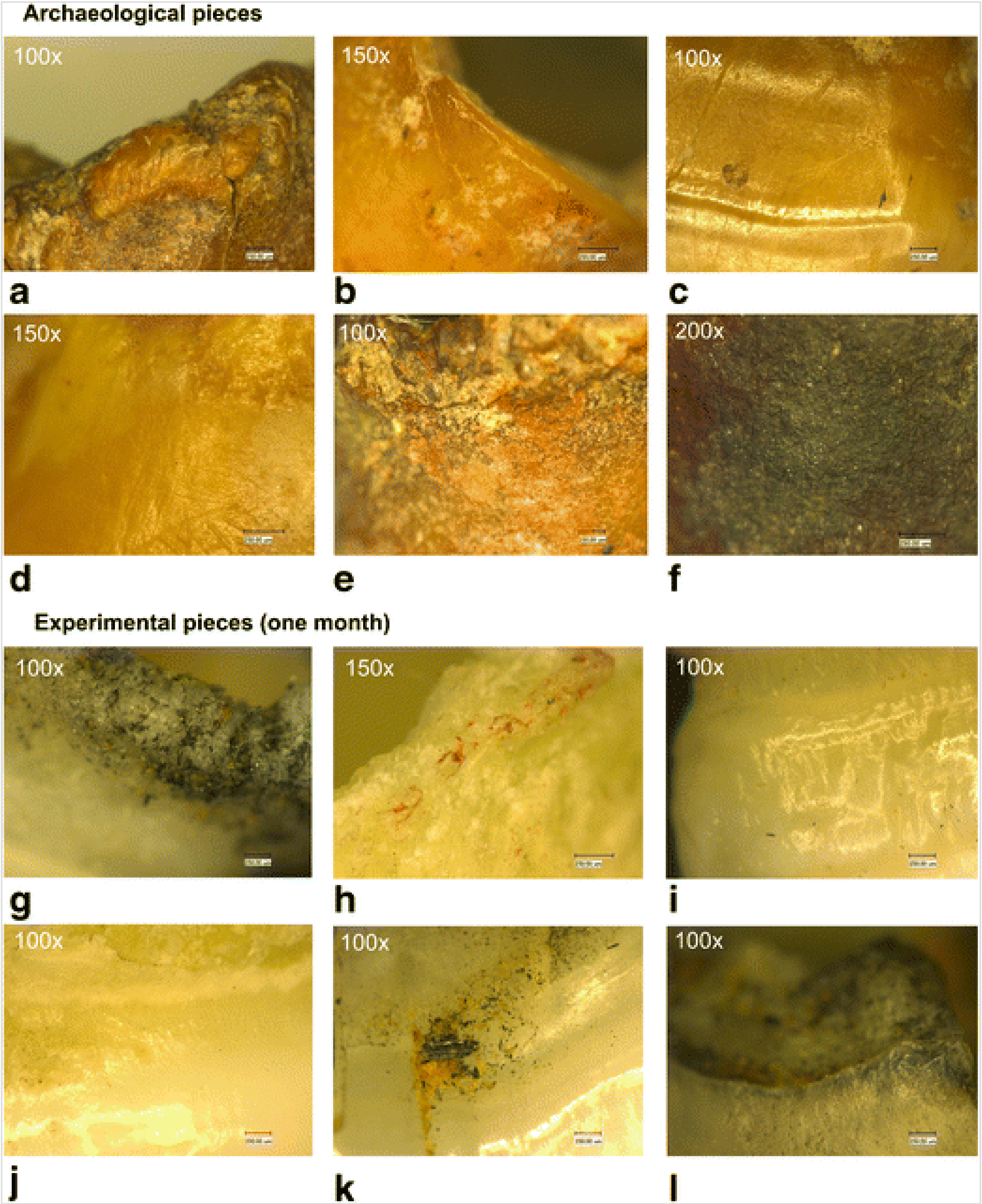


Fig. 17

Evolution of wear traces on cyprinid teeth ornaments. **a**–**b** Use-wear traces at the fracture edge. **c** Use-wear traces on the globular body. **d** Use-wear traces on the neck. **e**–f Traces of residue (archeological items—Schela Cladovei). **g**–**h** Use-wear traces at the fracture edge. **i** Use-wear traces on the globular body. **j** Use-wear traces on the neck. **k**–**l** Traces of residue (experimental items)

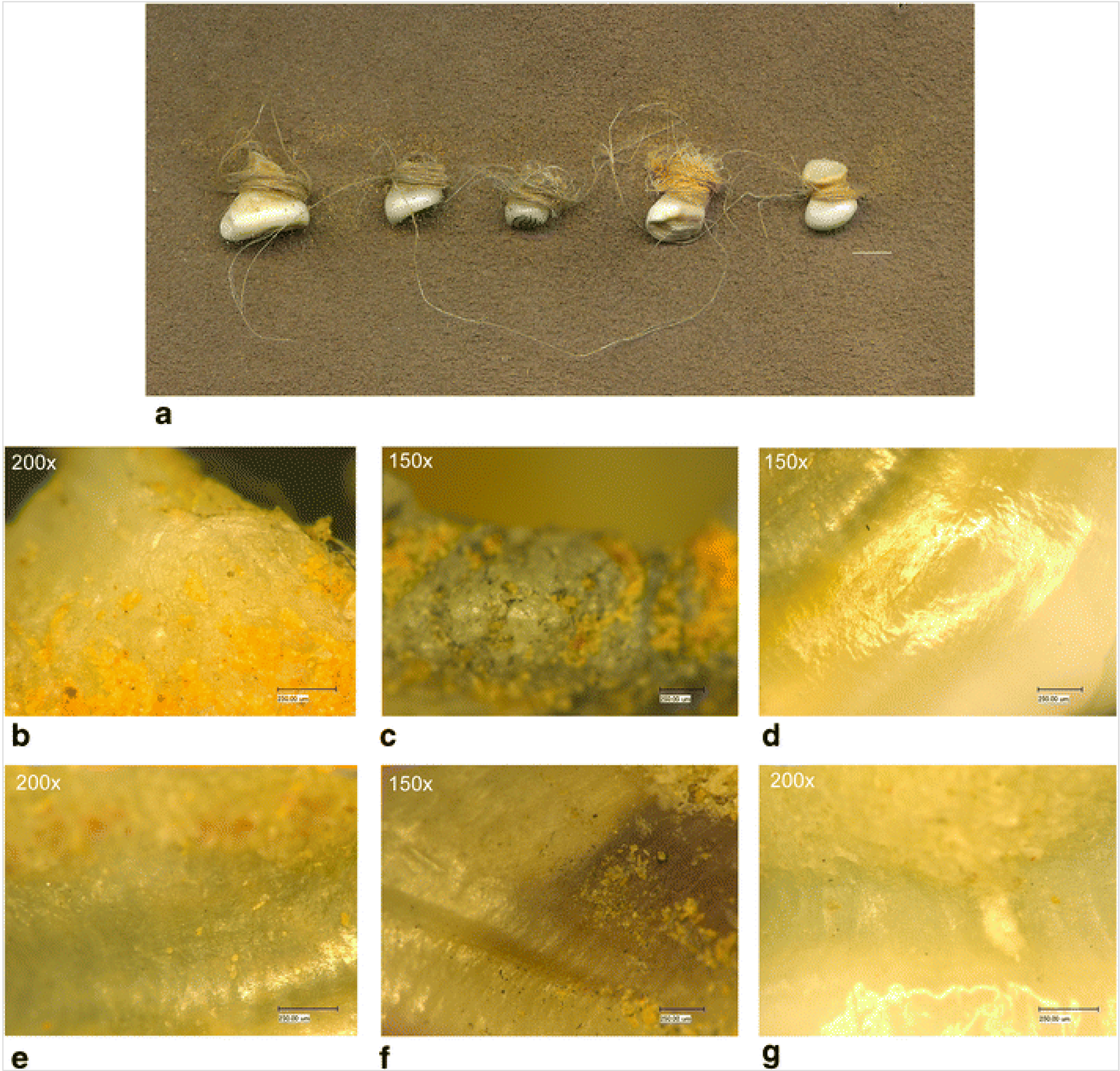

Archaeological pieces
100x
150x
100x
a
b
c
150x
100x
200x
d
e
f
Experimental pieces (one month)
100x
150x
100x
g
h
i
100x
100x
100x
j
k
l

Most (306) of the cyprinid teeth associated with M38 exhibited red (Fig. 17e) and 6 pieces black (Fig. 17f) specks on the neck of the tooth and/or the fracture edge. These are likely remains of some form of fixative, although we were unable to isolate enough of the residue for reliable compositional analysis. Those traces on the neck of the tooth occurred along the fine, use-related striations. Similar traces were noted on pharyngeal teeth appliqués from Vlasac and Kula and described as a “pasty compound” (Cristiani et al. 2014a) or “organic glue” (Rigaud et al. 2014).

Our experiments shed some light on the use of the *appliqués* and the purpose of the fixative. We attached the cyprinid teeth to leather using vegetal cordage and an adhesive. To create a pasty compound, we started from our own microscope observations, which revealed the massive presence of a reddish pigment sometimes associated with localized black spots. These observations suggested ~~ochre~~ and charcoal as the main constituents. We then considered the results obtained by Rigaud (2013) and Cristiani et al. (2014a), which supported our interpretation of a mixture of ~~ochre~~ and charcoal, in combination with a binder. For our experiments, we purchased the ~~ochre~~ and obtained charcoal by burning oak wood. As a binder to mix the ~~ochre~~ and charcoal, we used animal (pig) fat. Thus, we obtained a reddish paste with black inclusions, which closely resembled the adhesive identified on the archeological pharyngeal teeth. Beads were worn continuously for a month and then examined microscopically. Areas of use-wear like those present on the archeological pieces were already apparent on the fracture edges (Fig. 17g–h), on the crown of the tooth (Fig. 17i), and on the neck (Fig. 17j). Traces of paste were also present, both on the neck and the fracture edge (Fig. 17k–l). In the case of the cyprinid teeth from Vlasac, Cristiani et al. (2014a) suggested an esthetic purpose for the paste, based on ethnographic comparisons. In our experiments, we found that because of the smoothness of the enamel surface the thread tended to slip when the tooth was fastened to leather or cloth. The use of an adhesive paste increased the friction between tooth and thread and thus helped to fix the tooth more securely. In prolonged use, it may also have served to prevent the thread from fraying. When the experimental pieces were attached to leather and worn for 6 months (Fig. 18a), it was observed that the paste dried out quite quickly, which not only made for a more secure fixing, it had also lost its esthetic qualities (the colors being less vibrant than before), which reinforces our view that the paste had a primarily functional (rather than esthetic) purpose. Use-wear tended to be more developed on the archeological specimens than on the experimental pieces that were used for 6 months (Fig. 18b–g), which suggests the archeological pieces had been worn over a longer period, possibly several years.

Fig. 18

Evolution of wear traces on experimental cyprinid teeth appliqués (after 6 months). **a** The experimental pieces. **b**–**c** Residue and use-wear traces at the fracture edge. **d**–**e** Use-wear traces on the globular body. **f**–**g** Use-wear traces on the neck


a
200x
b
150x
c
150x
d
200x
e
150x
f
200x
g

AQ5

Mammalian teeth

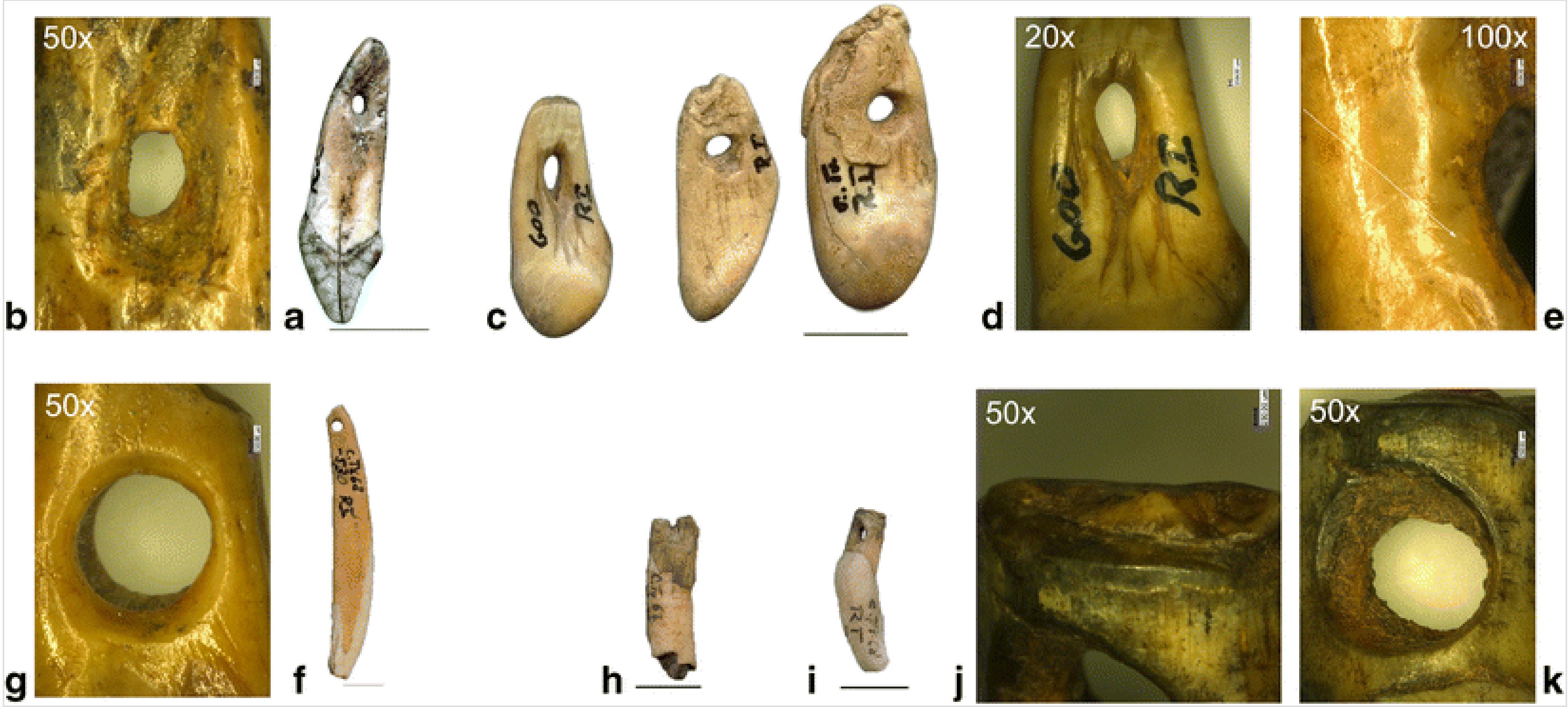
With no modern samples at our disposal (in contrast to the gastropod shells and cyprinid teeth), we were not able to conduct experiments on mammalian teeth. The following technological observations, therefore, relate only to the archeological specimens.

For the fox canine, the perforation and its preparation were bifacial, with a thinning of the area to be perforated—the area was first prepared by small-scale chipping, followed by sawing. The perforation was then produced by bifacial rotation.

In the case of the red deer canines (Fig. 19c), the perforation was made through the root of the tooth. Both unifacial (3 cases) and bifacial (10 cases) rotation were employed. In four of these 13 cases, the site of the perforation was first prepared by scraping. For the last specimen, bifacial longitudinal scraping was applied, with the purpose of thinning the surface, and that operation was continued until the perforation was achieved. ~~Perforation~~ has an elongated morphology and intensely polished edges (Fig. 19d). The location of the use-wear indicates the canines were suspended in such a way as to produce the most intense wear along the lateral edges (Fig. 19e).

Fig. 19

Perforated teeth. **a** Wolf incisor (Cuina Turcului). **b** Perforation detail. **c** Red deer canines (Cuina Turcului). **d** Perforation detail. **e** Intense wear along the perforation. **f** Wild boar incisor (Cuina Turcului). **g** Perforation detail. **h** Beaver incisor (Cuina Turcului). **i** Herbivore incisor (Cuina Turcului). **j** Segmentation side. **k** Perforation detail



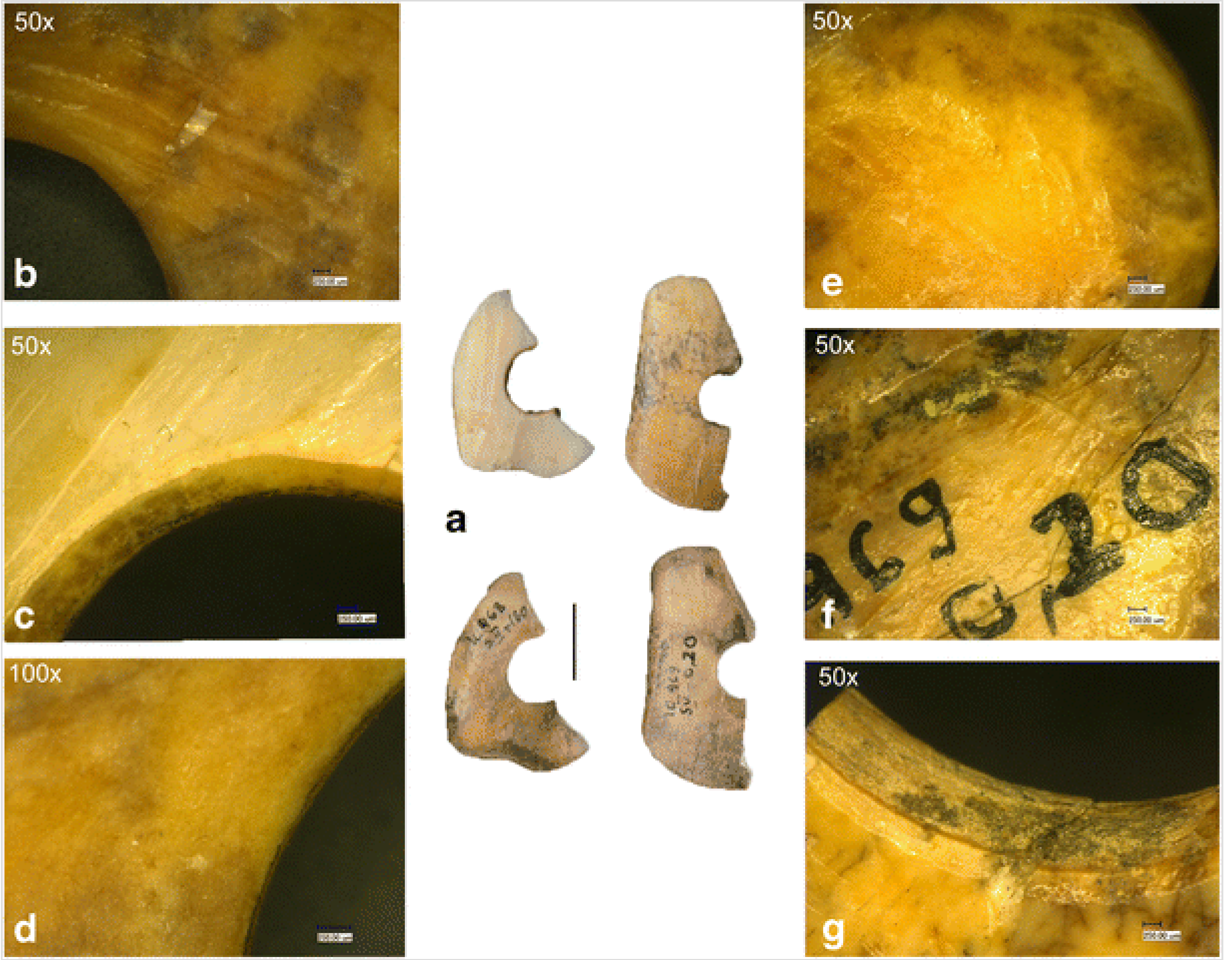
The wild boar lower incisor (Fig. 19f) was perforated by bifacial rotation (Fig. 19g), while for the wolf incisor (Fig. 19a), a more complex procedure was applied: first thinning of the surface by slightly oblique scraping, thus creating a depression with a small oval perforation, then the perforation was finished by bifacial rotation (Fig. 19b).

For the beaver incisor (Fig. 19h), preparation of the perforation was initiated through longitudinal scraping, followed by perforation by rotation. A transverse break across the perforation indicates the latter operation was not finished. The herbivore incisor (Fig. 19i) was processed in a unique manner: the root was removed by sawing (Fig. 19j), followed by bending, and the perforation made by bifacial rotation (Fig. 19k). The last (indeterminate) tooth is heavily fractured, preserving only a part of a perforation, accomplished most likely, through rotation.

The two beads from Icoana made from pig canines are unusual in that the blanks were obtained by longitudinal splitting of the tooth (Fig. 20a). The debitage edges were regularized by abrasion (Fig. 20e) and thus the precise procedures could not be identified. The beads exhibit a central perforation, performed by bifacial rotation (Fig. 20c, g). The area to be perforated had been prepared by scraping (Fig. 20b, f), to thin the area, followed by the actual rotation. One bead exhibits heavy use-wear, resulting in the obliteration of the rotation striations and a smooth perforation wall (Fig. 20d). In the case of the second bead, the striations are still visible (Fig. 20g), suggesting less intense use/wear.

Fig. 20

Flat beads made from *Sus scrofa* canines. **a** Archeological pieces (Icoana). **b** Scraping. **c** Perforation detail. **d** Use-wear adjacent to the perforation. **e** Abrasion of the sides. **f** Scraping. **g** Perforation detail



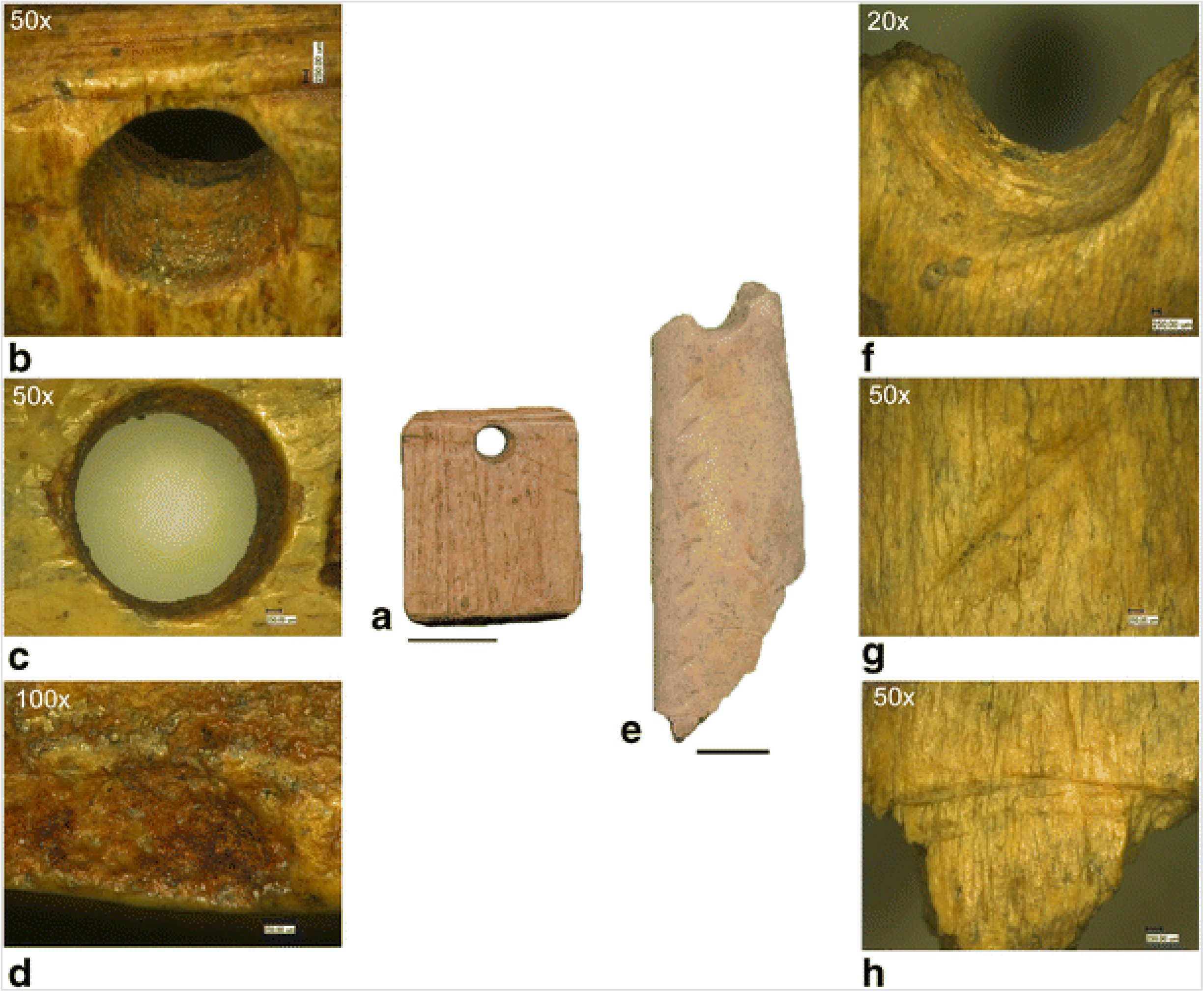
Bone and antler

In the case of the two fish vertebrae (Fig. 13e), the vertebral spines were detached by bending the bone. The central perforation was produced by bifacial rotation.

The bone pendant (Fig. 21a) was made on a flat blank (from a long bone shaft), seemingly obtained by sawing (Fig. 21b) followed by bending, with the segmentation marks still visible at the proximal and distal extremities. The superior surface preserves the original bone morphology. The inferior surface was regularized by longitudinal scraping. The perforation was obtained through rotation (Fig. 21c), starting on the inferior surface, resulting in a hole with a conical profile. Specks of red ~~ochre~~ are visible on the edges of the perforation and toward the distal extremity (Fig. 21d).

Fig. 21

Pendants. **a** Bone pendant (Cuina Turcului). **b**–**c** Perforation details. **d** Red ~~ochre~~ specks. **e** Antler pendant (Cuina Turcului). **f** Perforation detail. **g** Decoration details. **h** Proximal end decoration



The debitage procedure used in the case of the flat antler blank (Fig. 21e) could not be determined as all manufacturing traces were erased when the inferior surface was scraped to make it more regular. At the distal end, the piece has a perforation (Fig. 21f) made by rotation only, started from the superior surface. Also on this surface is a series of nine parallel oblique lines (Fig. 21g) produced by sawing. The piece is broken at the proximal end, but four transverse saw marks (Fig. ~~21f~~) are still visible.

Discussion

The research presented in this paper both complements and extends that undertaken by Cristiani and Borić (2012) on the production and use of ornaments at Mesolithic Vlasac, in the Serbian part of the Iron Gates. There are many similarities in approach and methodology between the two studies, but there are also differences in emphasis and scope. Cristiani and Borić looked in detail at the finds from a single site, and especially those recovered in their own excavations where the contexts of the ornaments (including their placement with respect to the body in a grave) were recorded in considerable detail. In contrast, our study has examined the ornaments from four different sites, excavated between 1964 and 1990, for which detailed contextual information is often lacking and post-excavation treatment of the finds unknown. For example, burial M38 at Schela Cladovei (excavated in 1990) is not closely dated, there is no precise information on the distribution of the ornaments with respect to the skeleton, and surface residues are poorly preserved possibly due to post-excavation cleaning of the material. Consequently, the emphasis in our research has been on use-wear analysis and experimentation, rather than residue analysis. In addition, while the finds from Vlasac relate mainly or wholly to the Late Mesolithic, those examined in our study span virtually the whole of the Mesolithic time range, from *c*. 14,300 to 8000 cal BP. Although our experiments so far have been limited in scope (using only vegetal fiber and leather as mounting materials), we believe the findings nevertheless contribute to knowledge of several aspects of the production and use of personal ornaments during the Mesolithic in Southeast Europe.

Choice and acquisition of raw materials

Many of the raw materials used to produce small ornaments in the Iron Gates Mesolithic were available locally. The freshwater gastropods, *Lithoglyphus* sp. and *Theodoxus danubialis*, and the land snail, *Zebrina detrita*, are all native to the Iron Gates reach of the Danube, although this does not prove they were obtained and processed locally rather than acquired through exchange networks. The same applies to the pierced mammal teeth, which could have derived from animals hunted close to the sites given that bones of the same species were present in the archeological deposits (A. Boroneanț 2011). In all these cases, the absence of preforms and finished but unused ornaments argues against on-site production, although unmodified shells of *Theodoxus danubialis* and *Zebrina detrita* were recovered in excavations at Schela Cladovei (Pickard et al. 2017). All the archeological beads studied are finished items and with such heavy wear that all manufacturing traces (perforation marks) have been erased. Most of the ornaments found outside burials were still functional and not broken at the perforation, which suggests they were *either* lost or abandoned pieces *or* derived from disturbed burials.

AQ6

In contrast, the fish teeth were almost certainly processed in situ. The main evidence for this at Schela Cladovei is the presence of teeth already detached from the pharyngeal arch but showing no traces of use around the neck, suggesting they had not yet been fastened or sewn to anything. They were probably kept in reserve, destined to replace lost or broken pieces. An important question is why these ornaments were made only from the pharyngeal teeth of *Rutilus*, and no other cyprinid genus from the Danube. The fact that most of the pieces show use-wear traces suggests they were worn for a large part of an individual's lifetime and were not purposely created for inclusion in burials. Moreover, they exhibit varying degrees of use-wear, indicating that broken or missing pieces were replaced. Yet, it seems clear that such ornaments had a special significance. Embroidering of the teeth onto a cloak or fitted garment may have been designed to imitate the fish during the breeding period, when along the body of male *Rutilus* there appear numerous pearly nodules known as "breeding tubercles" (outgrowths of the epidermis), which are particularly well developed on the head and along the lateral and dorsal parts of the fish's body (Schmall and Ratschan 2010). These milky white nodules give the fish a distinctive appearance, which may have had esthetic appeal for humans. The apparently deliberate selection of teeth of similar dimensions, with a well-formed undamaged globular body, for use as *appliqués* (only 13 [4%] of the cyprinid teeth from burial M38 at Schela Cladovei were naturally rotted—during the fish's lifetime) may have been for esthetic reasons.

Not all Late Mesolithic graves at Schela Cladovei and Vlasac contained cyprinid pharyngeal teeth. The graves in which they do occur comprise those of men, women, and children (Cristiani et al. 2014a). This implies that their use did not depend on affiliation to a gender or age group, but perhaps on the bloodline within a particular social group or ancestral ties that gave certain individuals the right to wear garments embroidered with *Rutilus* teeth, in life and death. This is speculation, but in principle is capable of being tested by aDNA analysis.

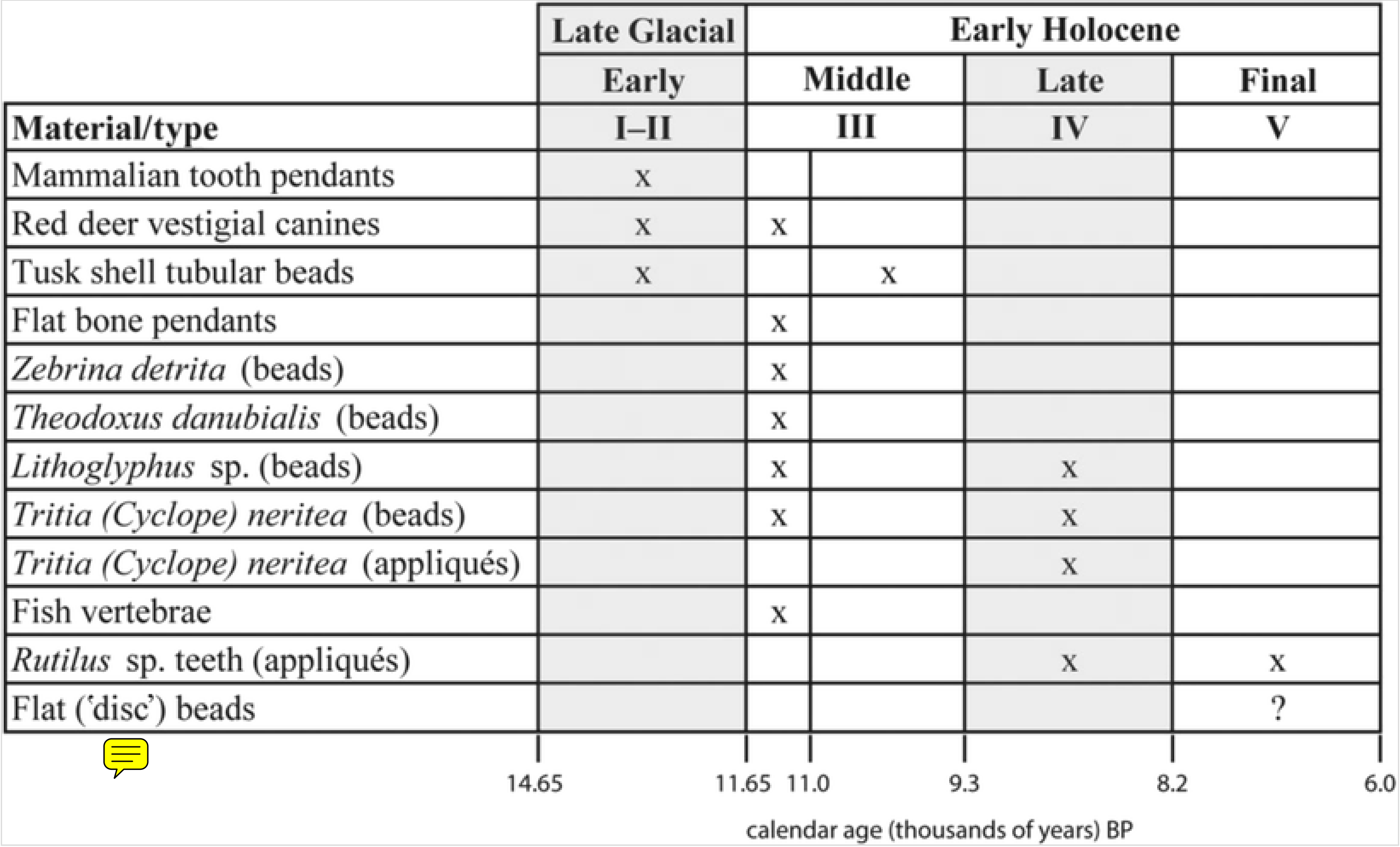
The scaphopod shells also pose interesting questions. Scaphopods are marine mollusks and most species live offshore beyond the tidal zone, but their empty shells can be found washed up on beaches. The tusk shells from Cuina Turcului, Climente II, and Icoana could have originated on beaches along the Adriatic, Aegean, or Black Sea coasts; alternatively, they could have been collected from fossiliferous deposits in or near the Iron Gates region. At Late Neolithic Vinča–Belo

Brdo (*c*. 150 km upriver from Cuina Turcului and Climente II), tusk shell ornaments are thought to have been made from fossil shells that were collected from Miocene outcrops near to the site (Dimitrijević et al. 2010).

The only raw material that was certainly imported into the Iron Gates is shells of marine gastropods, primarily *Tritia neritea*. Whether these shells originated in the Black Sea or the Mediterranean, the considerable distance involved (at least 400 km) argues against gathering expeditions organized by the Iron Gates communities. Ethnographic studies suggest that members of hunter-gatherer groups rarely traveled distances of more than 300 km from a base camp (Hewlett and Cavalli-Sforza 1986; Kelly 1995). Arguably, therefore, the occurrence of marine shells on sites in the Iron Gates is more likely the result of social exchanges, although ~~in~~ present evidence, the structure of the networks and the directions of movement can only be guessed at.

Temporal and geographical patterns

Any discussion of the temporal spans of ornament types, materials, and technologies in the Iron Gates Mesolithic is constrained by uncertainties over dating, compounded by small sample sizes and uneven archeological recovery methods. Table 2 summarizes the occurrence of ornament types and materials from the Iron Gates sites according to the chronological framework outlined in Fig. 2, while Table 3 presents the Iron Gates data in relation to those from the wider Balkan region. In creating these tables, we have made several assumptions, which as research progresses may need rethinking: (i) the “Tardigravettian I and II” horizons at Cuina Turcului date to the Late Glacial and the very early Holocene, respectively; (ii) the mammalian tooth ornaments from Icoana are either Final Mesolithic or Early Neolithic in date; and (iii) the *T. neritea* shell ornaments from Ostrovul Banului are of roughly the same age as those from Schela Cladovei. No ornament type or material can be shown to have been used *throughout* the Mesolithic in the Iron Gates.



	Late Glacial	Early Holocene			
	Early	Middle		Late	Final
Material/type	I–II	III		IV	V
Mammalian tooth pendants	x				
Red deer vestigial canines	x	x			
Tusk shell tubular beads	x		x		
Flat bone pendants		x			
Zebrina detrita (beads)		x			
Theodoxus danubialis (beads)		x			
Lithoglyphus sp. (beads)		x		x	
Tritia (Cyclope) neritea (beads)		x		x	
Tritia (Cyclope) neritea (appliqués)				x	
Fish vertebrae		x			
Rutilus sp. teeth (appliqués)				x	x
Flat ('disc') beads					?

14.65 11.65 11.0 9.3 8.2 6.0

calendar age (thousands of years) BP

Table 2

Chronology of ornament use in the Iron Gates Mesolithic

Table 3

Occurrence of raw materials used for producing ornaments by Mesolithic hunter-gatherers in SE Europe Data from: Cannarella 1961; Andre Radić 2005; Komšo 2008; Komšo and Vukosavljević 2011; Cristiani et al. 2014b; Borić and Cristiani 2016

Late Glacial

Genneral classification	Species	Adriatic								
		Biarzo	Šandalja	Pupićina	Vlakno Cave	Kopačina Cave	Vela Spila (Korčula)	Crvena Stijena	Boïla	Klithi
Terrestrial mammals	Red deer canines	X	X				X	X	X	
	Fox canines									
	Wolf incisors									
	Beaver incisors									
	Wild boar incisors									
	Other									
Marine gastropods and bivalves	*Tritia (Cyclope)* spp.	X					?		X	X
	Columbella rustica	X		X	X	X	?			
	~~*Antalis*~~ *(Dentalium)* spp.									X
	Nassarius circumcintus						?			
	Nassarius incrassatus									
	Glycymeris spp.						?	X		

	Homolopoma sanguineum								X	X
	Aphorrais sp.									
	Buccinum undatum									
	Other gastropod						X			
	Other bivalve						X			
Freshwater gastropods	*Lythogliphus* spp.	X		X						
	Theodoxus spp.	X		X					X	X
Terrestrial gastropod	*Zebrina detrita*									
Early Holocene										
General classification	Species	Adriatic								
		Riparo Biarzo	Cavernetta della Trincea	Grotta Azzurra	Grotta dell'Edera	Caverna dei Ciclami	Grotta Benussi	Ovčja Cave	Nugljanska Cave	Pupićina peć
Terrestrial mammal	Red deer canines		X						X	X
	Other spp.			X Neo?						
Marine gastropods and bivalves	*Tritia (Cyclope)* spp.	X								X
	Columbella rustica	X			X	X	X	X		X

	Cerithium vulgatum									X
	Antalis (Dentalium) spp.									
	Nassarius circumcintus									
	Nassarius incrassatus									
	Nassarius cf. *nitidus*									X
	Glycymeris spp.									
	Aphorrais sp.									
	Buccinum unidatum									
Freshwater gastropods	*Lythogliphus* spp.	X								X
	Theodoxus danubialis	X								X
Terrestrial gastropod	*Zebrina detrita*									
Fish remains	Vertebrae									
	Cyprinid pharyngeal teeth									

Beads or pendants made from whole mammalian teeth seem to have been confined to the earlier part of the time range (stages I–III). The flat “beads” from Icoana, made from split tooth fragments, differ in form and technique. They are of uncertain date and cultural context, but may belong to the Early Neolithic or to the very end of the Mesolithic (8200–7900 cal BP) when the impact of farming and Neolithic culture was starting to be felt across the region.

Gastropod shell beads, with a hole made through the last (body) whorl near the peripheral flange, are found throughout the Holocene portion of the Mesolithic time range. Throughout this period, the technique of perforation of the shell was more or less the same, regardless of chronological or archeological context or shell type. Beads made from shells of *Lithoglyphus* sp. and *Tritia neritea* were the most popular and have been found at several sites across the time range. Beads made from shells of other gastropod species are more restricted in their occurrence. *Zebrina detrita* and *Theodoxus danubialis* beads were only found at Cuina Turcului, and *Columbella rustica* beads only at Vlasac. Only three species, *Tritia neritea*, *Columbella rustica* and *Lithoglyphus naticoides*, were certainly found with burials. Only in one case (a *Tritia neritea* shell bead from Cuina Turcului) did we observe traces of a reddish pigment or residue.

The only clear temporal change among the shell ornaments was the appearance in the Late Mesolithic (after 9300 cal BP) of *Tritia neritea* shells that were processed in a very particular way, which involved removal of the spire and upper part of the body whorl to facilitate attachment of the shells to clothing in the manner of *appliqués* (Cristiani and Borić 2012). So far, *T. neritea* appliqués are only clearly documented in the Iron Gates.[1] However, they may not have replaced *T. neritea* beads entirely, as suggested by Borić and Cristiani (2016), since at least one example of the latter was found at Schela Cladovei (Table 1).

Another important change associated with the Late Mesolithic in the Iron Gates is the appearance of cyprinid (*Rutilus* sp.) pharyngeal teeth used as ornaments. They occur in burials either on their own or in association with *T. neritea* appliqués, and in one burial at Vlasac with *Columbella rustica* beads (Cristiani et al. 2014a). About half of the cyprinid teeth from Vlasac had perforations made in the neck of the tooth by V-shaped cuts, although this modification has not been observed on any of the cyprinid teeth from Late Mesolithic burials at Schela Cladovei or Icoana in the Romanian sector of the Iron Gates, which appear to have been attached by threads secured around the neck of the tooth and covered by a pasty compound fixative.

Unlike *T. neritea* appliqués, evidence for the use of cyprinid teeth as ornaments is not confined to the Iron Gates. They have also been found in several sites in the Upper Danube catchment in southwest Germany. At Hohlenstein-Stadel, they were found with a secondary burial deposit of detached human skulls dated to *c*. 8650 cal BP (Haas 1991), while detached *Rutilus* teeth (some modified with drilled perforations) were also found in Mesolithic layers of other caves and rock shelters in the region (Lepiksaar 1978; Grünberg 2000; Rigaud 2011). Use-wear and residue traces on the Hohlenstein-Stadel ornaments, together with the absence of signs of secondary modification (Rigaud et al. 2014), highlight their close similarity to the cyprinid teeth ornaments from the Iron Gates Mesolithic and Schela Cladovei in particular. However, three cyprinid teeth with drilled perforations from Burghöhle Dietfurt (Taute 1990) have no parallels in the Iron Gates.

Cristiani and Borić (2012) suggested the tradition of using cyprinid teeth as ornaments originated in the Iron Gates and correlated their introduction with the disappearance of beads made from red deer canines. Several lines of evidence argue against the latter interpretation. The use of cyprinid tooth ornaments in the Iron Gates is not evident until at least 9300 cal BP, while red deer canine beads probably disappeared from the cultural inventory much earlier (even supposing the latest examples at Cuina Turcului to date to the first few centuries of the Holocene), since they are not known from ^{14}C dated contexts between 11,000 and 9300 cal BP (at, e.g., Icoana, Lepenski Vir, Padina, and Vlasac), even though there is ample evidence of red deer hunting in the Iron Gates during that period. Moreover, although red deer canines continued to be used into the later stages of the Mesolithic (and beyond) in parts of Central, Northern, and Western Europe (Rigaud 2011) and in the Dnieper Valley in southern Ukraine (Telegin and Potekhina 1987; Lillie et al. 2012), in the Balkans, they are rare or absent after the beginning of the Holocene except in the Adriatic coastal zone (Table 3).

Finds of cyprinid tooth ornaments from Mesolithic contexts in sites outside the Danube catchment—including Vrbčka Cave in Montenegro (Borić and Cristiani 2016), the Dnieper Valley in Ukraine (Lillie and Jacobs 2006), and Zamil-Koba I in the Crimean Peninsula (Kraynov 1940, cited in Borić and Cristiani 2016)—caution against assuming an origin for this ornamental tradition within the Iron Gates or elsewhere in the Danube catchment. It is conceivable the tradition originated further east, where large (anadromous or semi-anadromous) species of *Rutilus*, notably *R. frisii*, were once abundant in rivers draining into the Black Sea and Caspian Sea basins.

Whatever its origins, the use of cyprinid teeth as ornaments seems to have persisted into the Neolithic in Central, Eastern, and Southeastern Europe, evidenced by finds from an LBK burial at Eichendorf-Aufhausen in southeast Germany (Kreiner and Pscheidl 2005), the Dnieper Basin in the Ukraine (Telegin and Potekhina 1987), and the presence of detached *Rutilus* teeth among Early Neolithic settlement debris at Schela Cladovei.

Conclusions

The data and interpretations presented in this paper build upon previous studies of Mesolithic ornamental traditions in Southeast Europe by Rigaud (2011), Cristiani and Borić (2012), Grünberg (2013), and others. There remain unanswered questions and gaps in knowledge, not least the apparent chronological “gap” in the ornament record of the Iron Gates Mesolithic between *c*. 11,000 and 9300 cal BP, and the question of the geographical and chronological origins of the use of cyprinid pharyngeal teeth ornaments. While most of the Iron Gates sites discussed in this paper are now submerged due to dam construction in the 1960s and 1980s, some further research is possible. A thorough re-examination of finds from “old” excavations may reveal ornaments that have not been reported in the archeological literature. This, combined with direct AMS ^{14}C dating of ornaments preserved in museum collections (or of the human remains with which they were associated), may go some way toward resolving issues of chronology and will form part of the next phase in our research. However, the relationship between the Iron Gates sites and those in the Dnieper valley—which, arguably, is critical to understanding the origin of the cyprinid teeth ornamental tradition—is unlikely to be resolved until systematic archeological exploration of the intervening region has been undertaken, especially along the Lower Danube between the Iron Gates II dam and the delta and the now drowned Mesolithic–Early Neolithic coastline around the western side of the Black Sea. This leads in to bigger questions; as emphasized by Gurova and Bonsall (2014), the Lower Danube–Black Sea archeological “void” remains a major impediment to our understanding of the final stages of the Mesolithic and the transition from foraging to farming in the Balkan Peninsula.

Acknowledgements

MM, VR, and AB’s work was supported by a grant of the Romanian National Authority for Scientific Research, CNCS–UEFISCDI, project number PNII-RU-TE-2014-4-0519. CB thanks Paolo Biagi for information on the cave sites of the Trieste Karst.

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[1] Borić and Cristiani (2016: Fig. 9, no. 3) illustrate a possible *T. neritea* appliqué from Vela Spila on Korčula island, in Dalmatia, although this is not mentioned in the site report by Čečuk and Radić (2005), nor is it referred to by Cristiani et al. (2014b) in their consideration of the shell ornaments from Vela Spila.