

Sumptuary crafts from a technological perspective: Initial observations on Punic ostrich eggshells from Villaricos (South East Iberian peninsula) and Puig des Molins (Ibiza)

*Les arts somptuaires sous l'angle technologique :
premières observations sur des œufs d'autruche d'époque
punique à Villaricos (sud-est de la péninsule Ibérique)
et à Puig des Molins (Ibiza)*

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Abstracts: In the Phoenician-Punic cultural sphere, ostrich eggshells were primarily used as raw material to craft objects with religious or sacred significance. Due to their widespread presence in the Mediterranean, they offer valuable insights into technical processes, cultural traditions, trade routes, and identity-related practices. This study examines the production sequence of Punic decorated ostrich eggshells, focusing on assemblages from Villaricos and Puig des Molins. By analysing manufacturing techniques and decoration methods, we aim to elucidate the technical choices made by artisans and explore potential geographical or cultural distinctions.

Our findings identify two distinct methods for cutting eggshells: peripheral sawing in Villaricos and controlled percussion in Puig des Molins. Surface preparation, including abrasion or acid corrosion, remains a subject of debate, as no clear evidence has been observed in the specimens analysed. SEM analysis has not revealed striations indicative of abrasion or polishing, which may suggest the selection of naturally smoother eggshells from North Africa. Regarding decoration techniques, we document the use of various brush sizes for polychrome designs, ranging from extremely fine (0.1 mm) to very thick (25 mm). Notably, thick brushes were used in Puig des Molins but are absent in Villaricos. These differences in tools and working methods suggest slightly divergent craft traditions. The evidence points to distinct manufacturing traditions, potentially shaped by local preferences or specific regional influences.

Future research will further investigate the relationship between these differences and technical processes, cultural traditions, and trade networks. Through isotope analysis and contextual archaeological study, we aim to uncover broader patterns in the production and circulation of ostrich eggshell artifacts.

Keywords: Ostrich eggshell, Punic, Iberian Peninsula, technology, toolmark, Mediterranean Archaeology, Villaricos, Puig des Molins.

Résumé : Dans la sphère culturelle phénico-punique, les coquilles d'œuf d'autruche ont été principalement employées comme matière première pour la fabrication d'objets à signification religieuse ou sacrée. Leur large diffusion en Méditerranée en fait un sujet d'étude privilégié pour analyser les processus techniques, les traditions culturelles, les routes commerciales et les pratiques identitaires. Cette étude se concentre sur la séquence de production des objets en coquilles d'œuf d'autruche d'époque punique, en prenant pour corpus les ensembles de Villaricos (Almería) et de Puig des Molins (Ibiza). Par l'analyse des techniques de fabrication et des méthodes de décoration, nous cherchons à éclairer les choix techniques des artisans et à identifier d'éventuelles différences géographiques ou culturelles. Nos recherches ont permis d'identifier deux méthodes distinctes pour la découpe des coquilles : le sciage périphérique à Villaricos et la percussion contrôlée à Puig des Molins. La préparation de la surface, incluant l'abrasion ou la corrosion acide, reste discutée, car

aucune preuve tangible n'en a été observée sur les échantillons analysés. L'analyse au microscope électronique à balayage (MEB) n'a révélé aucune strie caractéristique d'abrasion ou de polissage, ce qui pourrait suggérer une sélection de coquilles d'œuf d'autruche naturellement plus lisses en provenance d'Afrique du Nord.

En ce qui concerne les techniques de décoration, nous avons identifié, pour les motifs polychromes, l'usage de pinceaux de tailles variées allant de très fine (0,1 mm) à très épaisse (25 mm). L'utilisation de pinceaux épais a été observée à Puig des Molins, mais pas à Villaricos. Ces différences dans les outils et les méthodes de travail suggèrent des traditions artisanales légèrement différentes, potentiellement influencées par des préférences locales ou des traditions régionales spécifiques.

L'analyse des étapes de production révèle trois phases principales : (1) la vidange initiale de l'œuf, (2) la mise en forme, incluant la préparation des ébauches, et (3) la finition. Les coquilles intactes de Villaricos présentent une seule perforation de vidange, de 2 à 2,5 cm de diamètre, tandis que l'unique spécimen de Puig des Molins qui conserve une perforation présente une ouverture plus petite, de 1,8 cm. Quant aux techniques de coupe, le sciage à Villaricos laisse des stries nettes et non régularisées par abrasion, alors que les spécimens de Puig des Molins présentent des traces de percussion contrôlée, sans indication de l'usage d'une scie.

Concernant la décoration, la présence de pigments rouges, orange-rouge et noirs a été confirmée. Des traces de pigment blanc ont été observées, mais leur nature reste à déterminer. En revanche, aucune décoration bleue n'a été identifiée dans notre étude, contrairement aux observations antérieures. L'existence d'une technique de décoration par corrosion acide reste une hypothèse, nécessitant des études expérimentales supplémentaires.

L'analyse de l'outillage révèle que les artisans de Villaricos et de Puig des Molins employaient des matériaux et des techniques distinctes. Par exemple, la décoration du bord des récipients à Villaricos inclut des entailles réalisées à l'aide de deux types d'outils différents, alors qu'aucun spécimen de Puig des Molins ne présente ce type de finition.

Nos résultats mettent en évidence des traditions artisanales distinctes, suggérant soit une adaptation aux préférences locales, soit un approvisionnement en coquilles travaillées à partir de régions spécifiques. De futures analyses isotopiques et contextuelles permettront de mieux comprendre les schémas de production et de circulation de ces objets. Par ailleurs, l'étude des nécropoles où les coquilles d'œuf ont été découvertes aidera à évaluer le rôle de celles-ci dans les rituels funéraires et leur importance symbolique. En combinant approches technologiques et études archéologiques, nous espérons pouvoir identifier les réseaux d'échanges et les pratiques artisanales liées aux coquilles d'œuf d'autruche puniques. De plus, des analyses approfondies des pigments et des techniques de peinture permettront d'affiner la compréhension des différences esthétiques et des influences artistiques sur ces artefacts. En intégrant ces approches, notre étude contribuera à une meilleure appréhension des dynamiques culturelles et économiques du monde punique.

Mots-clés : coquille d'œuf d'autruche, punique, péninsule Ibérique, technologie, marque d'outils, archéologie méditerranéenne, Villaricos, Puig des Molins.

INTRODUCTION

Ostrich eggs have served as modified and decorated luxury items since prehistory, and were traded among different Mediterranean cultures from the Bronze Age onwards. The Phoenicians highly valued worked ostrich eggshells and facilitated their distribution across the western Mediterranean through various trade routes (Le Meaux, 2013). Within the Phoenician-Punic cultural sphere, ostrich eggshells served as a raw material for crafting a range of objects, primarily those of religious or sacred significance. Both complete, undecorated ostrich eggshells and modified specimens—often transformed into vessels but also into masks—decorated with vibrant colors are frequently found as grave goods throughout the Mediterranean region (Savio, 2004). Their presence in funerary contexts suggests a sacred function, commonly linked to apotropaic beliefs and interpreted as symbols of rebirth, the seed of life, and regeneration (Fantar, 1970; Moscati, 1988, p. 456; Ruiz Cabrero, 2004 and 2021).

A considerable number of ostrich eggshells have been identified across the western Mediterranean, notably in Carthage, the Iberian Peninsula and the Balearic Islands (Astruc, 1951 and 1957; Botto, 1996, p. 155; San Nicolás Pedraz, 1975; Le Meaux 2013; Jiménez Barrero, 2021). In the Iberian Peninsula, decorated ostrich eggshells were

commonly found in Punic necropolises in the 4th and 5th centuries BCE. Their presence in earlier periods is less frequent. However, their discovery in some Tartesian so-called princely tombs in southwestern Andalusia suggests that local populations adopted or adapted Phoenician funerary rites (Torres Ortiz, 1999, p. 157; Le Meaux, 2013; Mederos Martín, 2023, p. 490). In other non-ritual contexts, the presence of ostrich eggshell fragments has also been documented, such as in habitation contexts in Ibiza (Illa Plana, Sa Caleta, etc.; Jiménez Barrero, 2021, p. 7) or in deposits which, due to their quantity, have been interpreted as possible production waste in Huelva (González de Canales Cerisola et al., 2004, pp. 170–171), as well as in La Fonteta (Guirguis and Pla Orquín, 2014, p. 750).

The tombs from the necropolises of Villaricos (Almería) and Puig des Molins (Ibiza) have yielded two of the most significant collections in Spain, and arguably in the Mediterranean. The most extensive archaeological assemblage identified to date comes from Villaricos, where over 700 ostrich eggshells have been recovered.

Villaricos is a site of great significance for the Phoenician-Punic period in the Iberian Peninsula and has been designated a Site of Cultural Interest in Spain. It has been the focus of archaeological research since the early 20th century (López Castro, 2000). The first excavations were conducted by L. Siret and later continued

by M. J. Almagro Gorbea (Siret, 1906; Almagro Gorbea, 1984). Findings from the site were partially published by M. Astruc and subsequently revised by M. E. Aubet Semmler (Astruc, 1951 and 1957; Aubet Semmler, 1986).

The site is a funerary complex containing nearly two thousand tombs (Rodero Rianza et al., 1996). The necropolis is associated with the neighboring settlement identified as the Phoenician city of Baria, founded in the 7th century BCE (Ramos Linaza, 2020). The documented Punic tombs date from the 6th century BCE, a period when Baria is believed to have developed into a city-state. The necropolis exhibits a wide variety of tomb types, including monumental hypogea carved into the rock, displaying diverse construction techniques and decorative elements. The earliest documented burial practice was inhumation, later replaced by cremation (Astruc, 1951; Rodero Rianza et al., 1996). Several Punic tombs from the 6th–4th centuries BCE have yielded exceptionally rich grave goods, including imported Greek pottery and decorated ostrich eggshells (Astruc, 1951; Aubet Semmler, 1986). This material wealth suggests a period of prosperity for the city during these centuries.

At the current stage of our project and based on the published literature (Astruc, 1951; San Nicolás Pedraz, 1975; Rodero Rianza et al., 1996), our database indicates that 735 ostrich eggs have been recovered from 374 graves at Villaricos. As previously mentioned, funerary rituals at the site include both inhumation and cremation, with ostrich eggshells present in both practices. These eggshells constitute a significant element in understanding the symbolic aspects of the rituals and the selection criteria for specific grave goods, possibly related to age, family affiliation, identity, or social status. According to M. Astruc two types of ostrich eggshells have been identified at Villaricos: (1) whole eggs with a small extraction hole and no decoration, and (2) decorated vessels, cut at two-thirds of their height and adorned with painted motifs (Astruc, 1951, p. 123). Other artifact typologies documented in the central Mediterranean, for instance masks (Moscati, 1988, fig. 457), are not found in the necropolises of the Iberian Peninsula or the Balearic Islands.

Along with the ostrich eggshells from Villaricos, the collection from the necropolis of Puig des Molins in Ibiza has also been considered in this study to compare the technological processes involved in eggshell manufacture in both cases. At the necropolis of Puig des Molins (Mezquida and Fernández, 2010), approximately 90 ostrich eggshell vessels have been recovered from tombs dating between the 6th and 4th centuries BCE (see e.g. the catalogue in Savio, 2004, as well as Astruc, 1957; Jiménez Barrero, 2021).

As for the methodological state of the art, the types of ostrich egg artifacts in Phoenician-Punic culture and their decorative motifs have been catalogued previously (Astruc, 1951; San Nicolás Pedraz, 1975; Savio, 2004). However, these studies focus exclusively on formal and iconographic descriptions, without addressing technical aspects. In only a few instances is there any discussion of

the techniques, tools, or methods used for their transformation, or about other factors affecting surface modification (e.g. Evely, 1993; Poplin, 1995 and 2000; Kandel, 2004; Koehl, 2006; Brysbaert, 2013; Le Meaux, 2013; Hodos et al., 2020; Ramos Sainz, 2021; Pastorelli et al., 2023). Some hypotheses have also been proposed regarding whether the eggs were emptied before transportation (e.g. Phillips, 2000, p. 333; Brysbaert, 2013, p. 250). Several scholars have pointed out that many aspects remain unknown, such as the tools and abrasive materials used to work and decorate the eggs (Martín Ruiz, 2018). Our research aims to provide further insight into some of these technical aspects within the framework of a broader research project that will investigate the provenance, dating, and other aspects related to the composition of the decoration on the eggshells, as well as the analysis of the skeletal remains of the individuals associated with them.

The objective of this study is to analyse a large sample of ostrich eggshells in order to: 1) characterize the tools, techniques and methods employed in the working of these eggshells; 2) examine potential differences or standardization within the same assemblage (Villaricos); and 3) investigate similarities or differences between necropolises of similar cultural context and chronology (Villaricos vs. Puig des Molins). While the ostrich eggshells from different sites appear to show variations in decorative style, there is limited evidence regarding potential differences in terms of their technical treatment. Therefore, the primary focus of this study is to determine the techniques and tools used in their production and decoration, as well as to explore whether specific cultural or identity-based factors underlie this diversity.

1. MATERIAL AND METHODS

Our project focuses on the study of ostrich eggshells from the collections of the National Archaeological Museum in Madrid. To date, we have analysed 36 ostrich eggshells from Villaricos and six from the necropolis of Puig des Molins (table 1).

The state of conservation of the collection is highly heterogeneous. Some eggs remain nearly intact, with only slight fragmentation and reassembled fragments (e.g. 1935/4/VILL/T590/5). Others preserve only a few fragments (e.g. 1935/4/VILL/T596/1; 1935/4/VILL/T31/1; 1935/4/VILL/T115/1). Additionally, some eggs were completely fragmented and have undergone conservation-restoration treatments, primarily involving the reassembly of fragments through adhesion (e.g. 1935/4/VILL/T87/1; 1935/4/VILL/T88/1; 1935/4/VILL/T460/1; 1935/4/VILL/T780/1). In these cases, adhesive residues are visible along the edges, along with the addition of reinforcing materials, such as cardboard placed inside the egg. Traces and annotations, made in pencil or graphite, from previous studies are also present, possibly attributed to L. Siret and P. Flores, the foreman during L. Siret's excavations.

Id	Museum Id	Site	Grave No.	OES type	Decoration type
1	1935/4/VILL/T31/1	Villaricos	31	Vessel, decorated	VIII
2	1935/4/VILL/T87/1	Villaricos	87	Whole, undecorated	E
3	1935/4/VILL/T88/1	Villaricos	88	Vessel, decorated	IID
4	1935/4/VILL/T89/1	Villaricos	89	Undecorated fragments	-
5	1935/4/VILL/T115/1	Villaricos	115	Vessel, decorated	VIII
6	1935/4/VILL/T127/1	Villaricos	127	Whole, undecorated	E
7	1935/4/VILL/T129/1	Villaricos	129	Vessel, decorated	IIB
8	1935/4/VILL/T445/1	Villaricos	445	Vessel, decorated	IC
9	1935/4/VILL/T460/1	Villaricos	460	Vessel, decorated	V
10	1935/4/VILL/T461/1	Villaricos	461	Vessel, decorated	IIB
11	1935/4/VILL/T500/1	Villaricos	500	Vessel, decorated	IIV
12	1935/4/VILL/T500/2	Villaricos	500	Vessel, decorated	V
13	1935/4/VILL/T502/1	Villaricos	502	Whole, undecorated	E
14	1935/4/VILL/T505/2	Villaricos	505	Vessel, decorated	IIB
15	1935/4/VILL/T590/5	Villaricos	590	Vessel, decorated	III
16	1935/4/VILL/T593/1	Villaricos	593	Whole, undecorated	E
17	1935/4/VILL/T596/1	Villaricos	596	Vessel, decorated	VIII
18	1935/4/VILL/T598/1	Villaricos	598	Vessel, decorated	V
19	1935/4/VILL/T599/1	Villaricos	599	Undecorated fragments	-
20	1935/4/VILL/T600/1	Villaricos	600	Vessel, decorated	VIII
21	1935/4/VILL/T610/1	Villaricos	610	Whole, undecorated	E
22	1935/4/VILL/T611/1	Villaricos	611	Undecorated fragments	-
23	1935/4/VILL/T611/2	Villaricos	611	Undecorated fragments	-
24	1935/4/VILL/T619/1	Villaricos	619	Vessel, decorated	IC
25	1935/4/VILL/T622/1	Villaricos	622	Vessel, decorated	IIC
26	1935/4/VILL/T624/1	Villaricos	624	Undecorated fragments	-
27	1935/4/VILL/T679/1	Villaricos	679	Whole, undecorated	E
28	1935/4/VILL/T680/1	Villaricos	680	Whole, undecorated	E
29	1935/4/VILL/T684/1	Villaricos	684	Vessel, decorated	IV
30	1935/4/VILL/T702/1	Villaricos	702	Vessel, decorated	IIC
31	1935/4/VILL/T706/1	Villaricos	706	Whole, undecorated	E
32	1935/4/VILL/T780/1	Villaricos	780	Vessel, decorated	IID
33	1935/4/VILL/T820/1	Villaricos	820	Vessel, decorated	IB
34	1935/4/VILL/T824/1	Villaricos	824	Vessel, decorated	IC
35	1935/4/VILL/T825/1	Villaricos	825	Vessel, decorated	III
36	1935/4/VILL/T829/1	Villaricos	829	Vessel, decorated	IA
37	1935/4/VILL/T830/1	Villaricos	830	Vessel, decorated	IB
38	1923/60/249	Puig des Molins	249	Vessel, decorated	-
39	1923/60/250	Puig des Molins	250	Vessel, decorated	-
40	1923/60/252	Puig des Molins	252	Vessel, decorated	-
41	1923/60/304	Puig des Molins	304	Cup, decorated	-
42	1923/60/306	Puig des Molins	306	Vessel, decorated	-
43	1923/60/308	Puig des Molins	308	Vessel, decorated	-

Table 1 – List of ostrich eggshells studied at the National Archaeological Museum in Madrid, including object descriptions and decoration classification according to M. Astruc (1951).

Tabl. 1 – Liste des coquilles d'œuf d'autruche étudiées au Musée archéologique national de Madrid, avec description des objets et classification de la décoration selon M. Astruc (1951).

Our research aims to reconstruct the entire life cycle of these ostrich eggshells, from their acquisition to their use and cultural significance, including the production process and its various stages. In this article, we focus exclusively on the technical aspects of the production sequence. To identify and analyse the work traces and their sequence, all specimens were examined under low magnification. The classification of observed traces, as well as the identification of techniques and tools used, follows established terminologies and methodologies from previous research. The description of surface modifications and general technological vocabulary is based on A. Averbouh and N. Provenzano (1998–1999) and the *Multilingual Lexicon of Bone Industries* (Averbouh, 2010). More specific techniques and observations related to ostrich eggshells are drawn from the works of M. Astruc, M. P. San Nicolás Pedraz, F. Poplin, and H. Le Meaux (Astruc, 1951; San Nicolás Pedraz, 1975; Poplin, 1995 and 2000; Le Meaux, 2013). Additionally, technological studies and observations made on other hard osseous materials (e.g. Le Meaux, 2013; Luciañez-Triviño, 2023) have contributed to the description of certain techniques.

2. RESULTS

To date, we have identified three main stages in the production of objects made from ostrich eggshells: (1) an initial processing stage, which begins with the emptying of the egg; (2) the shaping of blanks and pre-forms, occurring only when a specific type of vessel is

being produced; and (3) the finishing stage. In the following sections, we will describe the observations made at each stage of this production sequence (fig. 1).

2.1. Emptying of the ostrich eggshells

All complete ostrich eggshell specimens from Villaricos exhibit a single emptying hole. However, for incomplete eggs, it is not possible to determine whether one or more holes were originally used for emptying. None of the ostrich eggs from Villaricos that were transformed into vessels retain the emptying hole, indicating that artisans removed the section of the eggshell where the hole had been made. As a result, only the undecorated, complete eggshells preserve a visible hole, which is a single small opening measuring approximately between 2 cm and 2.5 cm in diameter.

On the other hand, all the six eggshells from Puig des Molins that we have studied are vessels, and none of them were complete eggshells. However, unlike those from Villaricos, one of them does retain the emptying hole. This is a “cup” (1923/60/304), which features a hole measuring 1.8 cm in diameter at its base.

The technique used to create the holes remains unclear, as there is little visible evidence along the edges. We suggest that these holes may have been made using indirect percussion with an intermediary tool, such as an awl or a small chisel. In all specimens—both those from Villaricos and the cup from Puig des Molins—small scars and notches have been observed primarily on the inner edges of the holes. This suggests that the holes were likely made through highly controlled percussion rather than by sawing or abrasion (fig. 2).

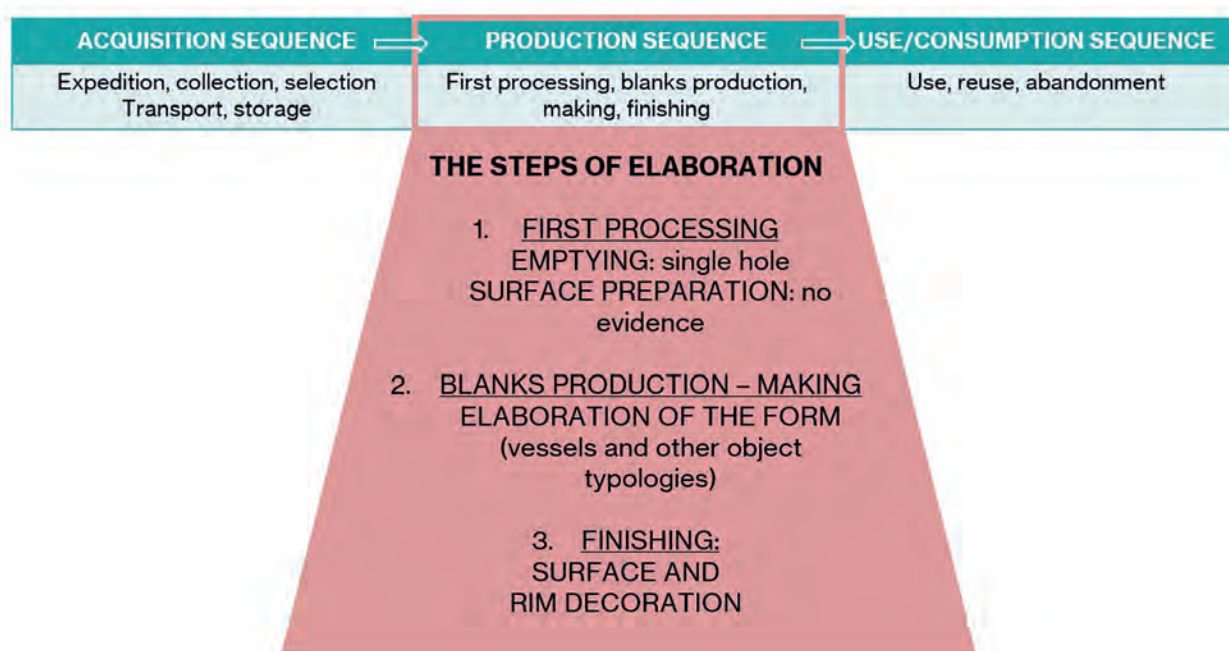


Fig. 1 – Production sequence of ostrich eggshell objects from the Punic necropolis of Villaricos.

Fig. 1 – Séquence de production des objets en coquille d’œuf d’autruche provenant de la nécropole punique de Villaricos.

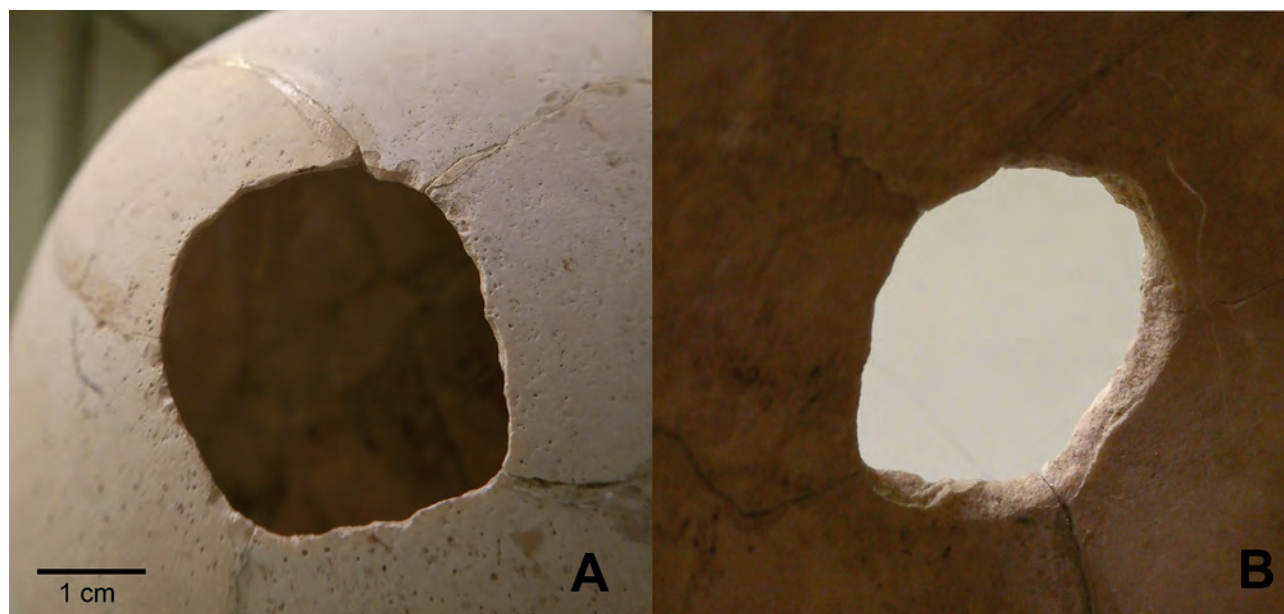


Fig. 2 – Emptying hole in whole ostrich eggshell from Villaricos (1935/4/VILL/T593/1). A: Exterior view; B: Interior view.

Fig. 2 – Orifice de vidange sur une coquille d’œuf d’autruche entière de Villaricos (1935/4/VILL/T593/1). A : vue extérieure ; B : vue intérieure.

2.2. Shaping – blanks production

A diverse range of eggshell artifact types have been documented, generally categorized based on the height at which the egg has been cut (fig. 3). According to M. Astruc and M. P. San Nicolás Pedraz, the studied specimens from Villaricos correspond to Form I (a complete, undecorated egg with a single hole; $N = 8$) and Form II (a bowl-shaped vessel with a wide opening, cut at two-thirds of the egg’s height, $N = 16$; (Astruc, 1951; San Nicolás Pedraz, 1975, Lam. II). Twelve of the eggshells have been typologically classified as “undefined” due to their fragmentary state. Five specimens from Puig des Molins correspond to Form II, while another falls into Form IV (a spherical rhyton-shaped vessel, where the eggshell is cut at its midpoint and retains the hole originally used for extracting the egg’s contents). G. Savio’s typology classifies these eggshell vessels differently (Savio, 2004): one specimen from Puig des Molins would be identified as a cup, while the other studied specimens fall under the description “container cut at the calotte” (without the upper section) or “eggshell with emptying hole”.

In the case of vessels made from ostrich eggshells, the step of production of the blanks is the same as the shaping process, as removing a portion of the eggshell directly results in the desired shape. This happens in the production of the previously mentioned Form II and Form IV. Two distinct techniques have been identified for this process of removing a portion of the eggshell: peripheral sawing (16 cases in Villaricos, none in Puig) and controlled percussion (five cases in Puig dels Molins, none in Villaricos).

The sawing technique is clearly identifiable by the presence of characteristic striations and “slips” caused by the saw during the cutting process (fig. 4a). Additionally,

the edge was not regularized—neither through abrasion nor any other technique—allowing the saw marks and their direction to remain intact. In contrast, none of the six examined specimens from Puig des Molins show evidence of sawing. Five specimens retain a “rough” surface with marks that may correspond to highly controlled percussion around the eggshell (fig. 4b). Only two cases have the edge regularized by abrasion: the “cup” from Puig (1926/60/304, Form IV), and one Form II eggshell from Villaricos (1939/4/VILL/T505/2).

2.3. Finishing: surface and rim decoration

Only ostrich eggshells that have been transformed into vessels show any form of decoration; no evidence of ornamentation has been found on complete eggs. Two possible decorative techniques have been identified: one which could have involved “corrosion” (similar to an acid etching; Villaricos: $N = 2$; Puig: $N = 0$) and the other involving the application of pigments (Villaricos: $N = 10$; Puig: $N = 5$). Apparently, in some cases (Villaricos: $N = 7$; Puig: $N = 0$), both techniques are present on the same egg. However, the origin of this potential “acidic” decoration requires further investigation, building upon the line of research initially proposed by M. L. Ramos Sainz for surface treatments (Ramos Sainz, 2021). Engraved decoration is a documented decorative technique in ostrich eggshell craftsmanship (Moscati, 1988, Caubet, 1995), although in this case the evidence does not allow us to confirm that this technique was employed. As part of an experimental program in progress, we will explore the materials that may have been used for this “corrosive” decoration, compare with the traces on eggshells from Villaricos and explicitly rule out the possibility that it resulted from a post-depositional differential alteration

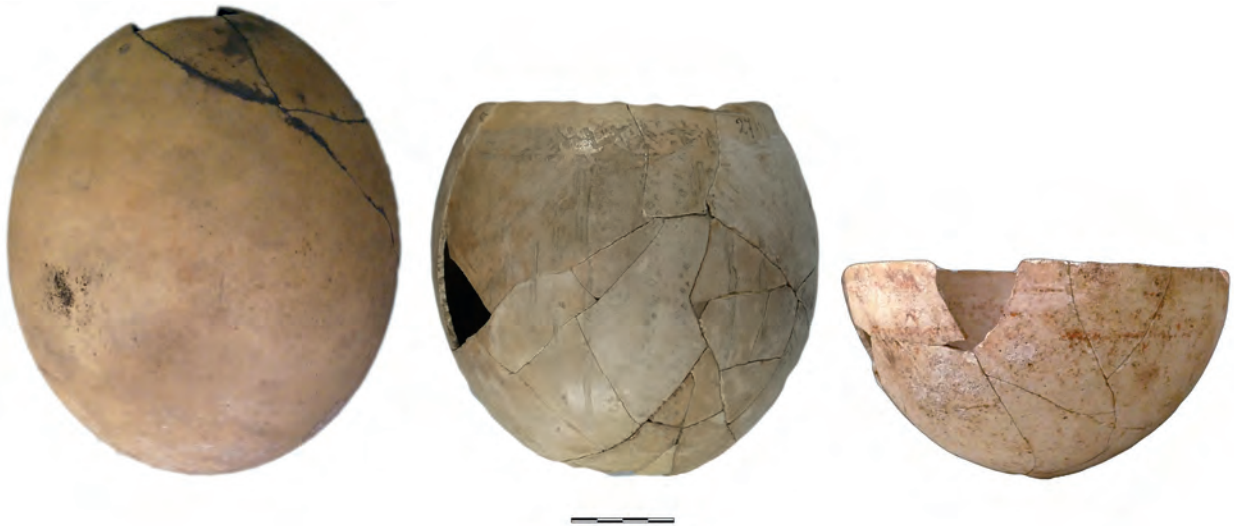


Fig. 3 – Eggshell artifact types that have been documented. Left: Complete, undecorated eggshell with emptying hole. Centre: Bowl-shaped vessel with a wide opening, cut at two-thirds of the egg's height. Right: "Cup" from Puig des Molins.

Fig. 3 – Types d'artefacts en coquille d'œuf d'autruche documentés. À gauche : coquille d'œuf entière, non décorée, avec orifice de vidange. Au centre : récipient en forme de bol à large ouverture, sectionné aux deux tiers de la hauteur de l'œuf. À droite : récipient (« coupe ») de Puig des Molins.



Fig. 4 – Evidence of techniques for upper section removal and rim decoration in ostrich eggshells. A: Sawing striations (Villaricos, 1935/4/VILL/T590/5); B: Controlled percussion marks (Puig des Molins, 1923/60/252); C: Parallel-walled, flat-bottomed gorges (Villaricos, 1935/4/VILL/T598/1); D: Convergent-walled gorges (Villaricos, 1935/4/VILL/T598/1).

Fig. 4 – Stigmates techniques de retrait de la section supérieure et de décoration du bord des coquilles d'œuf d'autruche. A : pan de sciage, avec stries visibles (Villaricos, 1935/4/VILL/T590/5) ; B : stigmates de percussion contrôlée (Puig des Molins, 1923/60/252) ; C : sillons de rainurage à parois parallèles et fond plat (Villaricos, 1935/4/VILL/T598/1) ; D : rainures à parois convergentes (Villaricos, 1935/4/VILL/T598/1).

of the surface, a doubt that L. Siret had already raised in his initial observations about these eggs (Siret, 1906 and 1908, pp. 197–198).

The rim is sometimes decorated with notches (13 Form II eggshells). In the Villaricos collection, we observe different types of gorges: parallel-walled and flat-bottomed ($N = 1$) (fig 4c), and convergent-walled ($N = 13$) (fig 4d), indicating the use of two different tools with distinct active edges. One specimen has both types of notches (1935/4/VILL/T598/1). However, none of the ostrich eggshell vessels from Puig des Molins that were studied have rims decorated with notches.

Regarding painted decorations, we have identified pigments in shades of red, orange-red, and black. The possible use of a white pigment has also been noted, although the existing traces remain inconclusive. M. Astruc reported the presence of blue decorations; however, none have been identified in the eggs examined in our study so far (Astruc, 1951, p. 123). The characterization of the pigments is currently under study.

Some ostrich eggshells feature decorative motifs painted with a thick, grainy pigment. However, in many cases where the paint has worn away, it has left behind a sort of imprint or mark that appears as a faint relief. M. Astruc previously noted that if the surface of the egg is not closely examined, this effect could be mistaken for an engraving—although it is not (Astruc, 1951, p. 125).

In the eggs we have studied so far, traces of the brushes used are clearly visible. As a result, we have confirmed that polychromy was applied with different brushes on the same egg. In Villaricos, fine brushes, from 1 to 3 mm in thickness, were used, creating irregular and sinuous lines in many cases (fig. 5a). Thus, 16 eggs from Villaricos were painted with fine brushes. The overlapping of brushstrokes has also been documented (fig. 5b). In contrast, at Puig des Molins, we identified as well the use of much thicker brushes ($N = 2$) (fig. 5c), up to 2.5 cm thick (fig. 5d), which were not observed in any of the specimens from Villaricos.

3. DISCUSSION

In this study, we have focused on the production sequence of ostrich eggshells, while questions related to raw material acquisition—specifically, the supply and selection of eggs—are currently being investigated using other methodologies as part of our broader research project. Laboratory techniques, primarily isotope analysis, will be employed to clarify trade routes and contacts. However, it is reasonable to assume that artisans would have selected eggs with superior aesthetic qualities whenever possible, as suggested by some authors (Ramos Sainz, 2021, pp. 30–31).

Further insights can be provided regarding the manufacturing stages of the production sequence.

Considering the initial processing stage, as previously mentioned, emptying holes have been documented. In the

case of Villaricos, only whole, undecorated eggs feature such holes, which have a diameter between 2 cm and 2.5 cm. At Puig des Molins, only one specimen exhibits an emptying hole, as the others are vessels, which typically do not retain it. The opening of the Puig des Molins “cup” is smaller (1.8 cm) than those from Villaricos, aligning with the range of hole sizes observed in eggshell “cups” in Ibiza by M. L. Ramos Sainz (Ramos Sainz, 2021, p. 33). The position of the holes, the consistency of their diameter, and their association with this low bowl or “cup” type support the idea that the hole was intended for the insertion of a foot, allowing for the creation of an ostrich eggshell cup, already suggested by M. P. San Nicolás Pedraz (1975, p. 95). This type of artifact is not documented in Villaricos, which may suggest either a lack of demand among the population of Baria or a different chronological or geographical context for the supply of manufactured eggshells.

From a technological perspective, two clearly distinct procedures for removing the top section and manufacturing different types of vessels have been documented in the assemblages we studied. In Villaricos, only peripheral sawing was used, whereas in five of the specimens from Puig des Molins analysed in this study, controlled peripheral percussion was applied. These latter cases, with unsawn and unregularized edges, are particularly interesting. It would be valuable to study additional examples to identify breakage patterns that might indicate a deliberate technical action or, alternatively, to determine whether these unregularized rims could result from the reuse of naturally hatched eggshells.

M. L. Ramos Sainz proposes a different method for removing the top section of the Puig des Molins eggshells, suggesting that a tool similar to a hand drill may have been used, with the egg cut by making adjacent holes (Ramos Sainz, 2021, p. 33). However, while this partitioning technique proved effective in her experimental study, it does not align with the archaeological evidence. None of the published specimens from Puig des Molins, nor those we directly examined at the National Archaeological Museum of Madrid, show indications of perforation use. The gorges identified as edge decoration cannot be interpreted as repairs of the perforation holes, since they are too widely spaced to correspond to the distance required for an even break of the eggshell. Moreover, they extend below the fracture line, and thus cannot be related to any trace that might have remained flush with the edge. Likewise, the marks identified on specimen MAEF 10002/24 as evidence of abrasion striations for edge regularization (Ramos Sainz, 2021, pp. 36–37, fig. 7) could instead be interpreted as sawing marks based on the published photographs. However, we remain cautious in our assessment until a direct examination can be conducted.

Various authors have suggested the need to prepare the surface of the eggshells. According to some authors, the cuticle, or the greasy and shiny outer layer, had to be removed either through abrasion (Poplin, 1995; Poplin, 2000, p. 129; Le Meaux, 2013) or through acid corro-

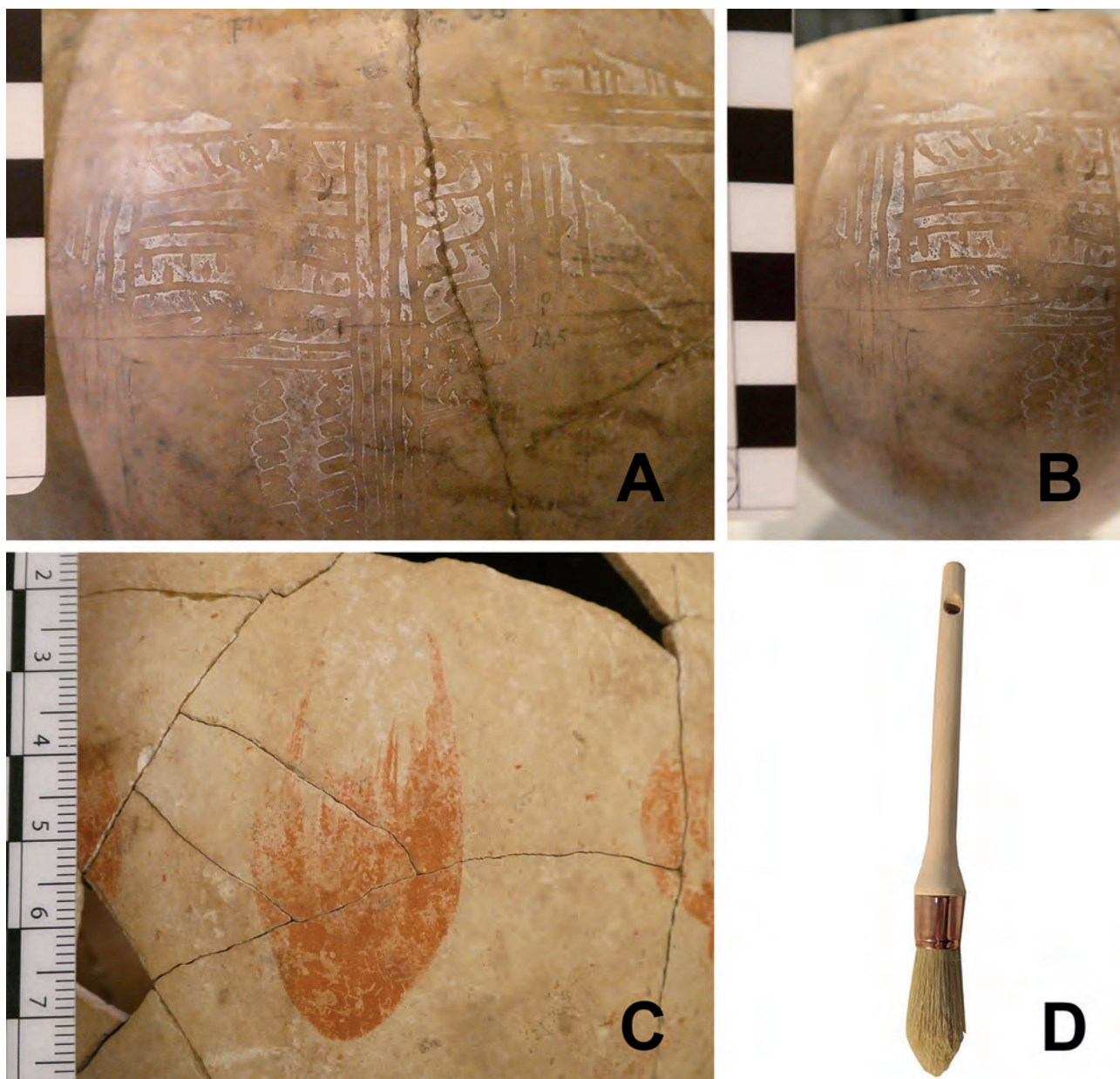


Fig. 5 – Traces of surface decoration techniques (polychromy application). A: Paint application with fine brushes (1–3 mm; Villaricos, 1935/4/VILL/T88/1); B: Detail of overlapping brushstrokes (Villaricos, 1935/4/VILL/T88/1); C: Paint application with thick brushes (25 mm; Puig des Molins, 1923/60/252); D: Example of modern brush with tip shape similar to the brushstrokes observed on the eggshells from Puig des Molins.

Fig. 5 – Stigmates techniques de décoration de la surface (application de polychromie). A : application de peinture avec des pinceaux fins (1 à 3 mm ; Villaricos, 1935/4/VILL/T88/1) ; B : détail de coups de pinceau superposés (Villaricos, 1935/4/VILL/T88/1) ; C : application de peinture avec des pinceaux épais (25 mm ; Puig des Molins, 1923/60/252) ; D : exemple d'un pinceau moderne dont la forme de la pointe est similaire aux coups de pinceau observés sur les coquilles de Puig des Molins.

sion (Ramos Sainz, 2021, pp. 35–36) for better adherence of the polychromy or because the surface of the eggshell used was too rough (Poplin, 1995; Ramos Sainz, 2021). Deep scratching has been clearly documented in eggshells from Puig des Molins, in specific areas of the surface of the egg, possibly with metal files, for better paint adhesion (Ramos Sainz, 2021, p. 39). In our study, we have found no evidence of prior surface preparation, consistent with H. Le Meaux's observations in Villaricos (Le Meaux, 2013). The effects and traces that acid-based

surface preparation would leave are not yet sufficiently documented, making their identification challenging. However, if the eggshells we examined had undergone preparation through abrasion, we believe that, despite their current state of preservation, we would have detected the characteristic striations associated with this technique in at least some specimens. We have also conducted observation of the surface of ostrich eggshell fragments from Villaricos through Scanning Electron Microscope (SEM)¹, which resulted in the lack of identification of any

striations characteristic of abrasion or polishing actions. The absence of polishing could be related to the selection of eggshells with naturally smoother surfaces, which are characteristic of North Africa, in contrast to the rougher eggshells of ostriches from more southern latitudes (Poplin, 1995, p. 126). The latter are the ostrich variety most commonly available for modern experimental studies.

Regarding the finishing steps, in the Central-Western Mediterranean, ostrich eggshells can be decorated using distinct techniques (Poplin, 2000, p. 129; Le Meaux, 2013). Painting is the most common technique in Punic contexts. However, it is also important to highlight the “Gouraya technique” described by F. Poplin, which involves acid engraving using wax or resin resist (Poplin, 2000, p. 130). This method is particularly prevalent at the Punic site of Gunugu in Algeria. F. Poplin suggests that this technique was likely carried out in the original area where the eggs were sourced, prior to emptying the eggshells.

In the Villaricos assemblage, the evidence confirms the application of paint. However, further experimental studies are necessary to evaluate the role of different acidic substances in the creation of the decorations, considering their current state of preservation and assessing the impact of various post-depositional processes of differential alteration.

From a technical perspective, regarding the differences found in the painting techniques between Villaricos and Puig des Molins, while the difference in brush sizes is evident between the specimens we studied in both assemblages, it is important to note that M. L. Ramos Sainz observed the use of brushes of varying thicknesses, ranging from 0.1 mm to 25 mm in width, in the Puig des Molins specimens she studied (Ramos Sainz, 2021, p. 40). This suggests a high variety of painting tools, and further research is needed to identify patterns and associations with other technical features.

In conclusion, the Villaricos assemblage reflects a distinct craft tradition, which may suggest either an adaptation to local preferences or a supply from a specific production area, linked to a tradition tied to a particular geographical location. In contrast, the differences observed

with the Ibiza assemblage (and the internal variations within Puig des Molins) reveal distinct craft traditions, characterized by unique techniques, tools, and decorative motifs. Our future research will focus on investigating whether these differences correspond to varying areas of influence, technical processes, or cultural traditions, by intensifying the technical analysis and by contrasting criteria such as provenance, dating, and archaeological context.

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NOTE

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