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Approaches to the osseous industry from Cueva de los Murciélagos in Albuñol (Granada, Spain) and its possible relationship with plant-based technologies

L'industrie osseuse de la Cueva de los Murciélagos à Albuñol (Grenade, Espagne) et son possible lien avec les techniques de traitement des végétaux

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Abstract: Plant fibres and skins played an essential role within the daily life of past populations, although in most Mesolithic and Neolithic contexts the preservation of these perishable materials is extremely rare. Analysis of the tools associated with the crafts associated with these materials often yields evidence of manufacturing processes, but rarely do we have the opportunity to examine both types of evidence from the same site allowing us to compare the tools directly with the resulting products. Recent research at the burial site of Cueva de los Murciélagos in southern Iberia, uncovered during 19th century mining activities, has afforded a new insight into Mesolithic and Neolithic basketry production and other organic artifacts. Here, we present a preliminary analysis of the worked osseous assemblage recovered in the 19th century from this site. As is common within southern European Neolithic sites both caprine and probably bovid or red deer long bones were systematically chosen for the manufacture of pointed tools.
The results show that the two main procedures used to obtain the blanks were bipartition by splitting the diaphysis and fracture by direct percussion. Shaping was mainly achieved by abrading the surfaces to obtain the finished objects. The traceological analysis confirms previous experimental work, indicating that at least some of the bone artefacts were involved in the manufacture of the plant-based items documented at the cave.
Keywords: Osseous technology, basketry tool, plant-based technology, Neolithic, Cueva de los Murciélagos, Iberian peninsula.

Résumé : Les fibres végétales et les peaux ont joué un rôle fondamental dans la vie quotidienne des populations anciennes, servant de matière première à l'élaboration d'une grande variété d'objets destinés à des usages domestiques, techniques et parfois même symboliques. Leur transformation a permis la confection de paniers, de cordages, de vêtements, de récipients souples ou encore d'éléments de parure. Cependant, malgré l'importance indéniable de ces matériaux périssables dans les économies et les modes de vie préhistoriques, leur conservation demeure extrêmement rare dans les contextes archéologiques mésolithiques et néolithiques. Leur préservation n'est en effet possible que dans des conditions environnementales très spécifiques, telles qu'une immersion prolongée en milieu humide et anaérobie ou, à l'inverse, un contexte de dessiccation extrême. Le caractère exceptionnel de ces situations réduit considérablement les possibilités de compréhension directe des pratiques artisanales de ces époques, puisque seuls quelques restes fragmentaires nous sont parvenus.
En l'absence de ces témoins matériels, l'étude des outils ayant servi à la fabrication d'objets en fibres végétales revêt une importance capitale. L'analyse fonctionnelle, notamment tracéologique, permet de déceler les indices laissés par l'usage répété de certains artefacts, révélant ainsi indirectement les gestes techniques et les chaînes opératoires mises en œuvre. Toutefois, il est rare que l'archéologue dispose simultanément des outils et des produits finis sur un même site, ce qui rend les comparaisons directes particulièrement précieuses lorsqu'elles sont possibles.

À cet égard, les récentes révisions des découvertes issues du site funéraire de la Cueva de los Murciélagos, situé dans le sud de la péninsule Ibérique, constituent un apport exceptionnel. Découvert au XIXe siècle lors d'activités minières, ce site fut décrit et publié par Manuel de Góngora y Martínez, pionnier de l'archéologie préhistorique espagnole. Les artefacts organiques provenant de ce gisement, longtemps conservés dans des collections muséales, offrent aujourd'hui une nouvelle perspective sur les savoir-faire liés à la vannerie, au tissage et à l'exploitation des fibres végétales au Mésolithique et au Néolithique. La possibilité d'associer des restes d'objets finis en fibres avec les outils en os utilisés pour leur production constitue une opportunité rare et scientifiquement précieuse.

L'étude ici évoquée se concentre sur l'analyse préliminaire de quatre objets en os exhumés dans la grotte. Elle met en lumière le rôle des matières dures d'origine animale dans l'équipement technique des sociétés anciennes. À l'instar de ce qui a été observé sur de nombreux sites néolithiques du sud de l'Europe, les communautés de la Cueva de los Murciélagos privilégiaient l'emploi d'os longs et plats, issus en particulier de caprinés domestiques mais aussi d'ongulés sauvages, pour façonner des instruments. Cette sélection n'est pas aléatoire : elle répond à des critères de solidité, de maniabilité et d'adaptabilité à des fonctions variées. Les catégories d'outils identifiées comprennent majoritairement des pièces à extrémité pointue, suivies par des objets spatulés, plats et allongés, dont l'extrémité active ne présente pas de fonction perforante mais semble plutôt adaptée à la pression ou au frottement.

Sur le plan technique, deux méthodes principales de débitage des supports osseux ont été reconnues : d'une part, la bipartition par fendage longitudinal des diaphyses, et d'autre part, la fracturation par percussion directe. Dans les deux cas, les artisans conservaient intentionnellement les épiphyses, qui jouaient probablement un rôle de zone de préhension facilitant la manipulation des outils. Le façonnage s'effectuait principalement par abrasion, permettant de régulariser les surfaces et d'obtenir les formes recherchées.

Les observations tracéologiques effectuées sur ces artefacts révèlent des indices d'utilisation en lien avec le travail des fibres végétales. Certaines pièces présentent des stries courtes, parallèles et peu profondes à leur extrémité distale, traces tout à fait comparables à celles produites expérimentalement lors du traitement de fibres riches en silicates, telles que celles de certaines graminées ou du sparte. Les références bibliographiques disponibles (Griffitts, 2001 ; Soffer, 2004 ; Legrand, 2008 ; Legrand et Radi, 2008 ; Buc, 2011 ; Campana et Crabtree, 2018 ; Bach *et al*., 2023) confirment que ces micro-traces sont caractéristiques du frottement répété contre des végétaux abrasifs. Dans certains cas, un usage prolongé est attesté par la présence d'un lustre brillant couvrant la zone active et par l'adoucissement marqué de l'extrémité, signes d'un polissage dû à la friction continue.

Ainsi, l'analyse conjointe des outils en os et des artefacts en fibres de la Cueva de los Murciélagos éclaire de manière inédite les techniques artisanales des populations préhistoriques ibériques. Elle démontre que la production d'objets en matériaux organiques ne reposait pas uniquement sur l'ingéniosité des savoir-faire de travail des végétaux, mais également sur un outillage spécialisé façonné en matières osseuses. Ce dialogue entre ressources animales et végétales reflète la complexité et la complémentarité des stratégies techniques mises en œuvre par ces communautés, révélant des sociétés attentives à la sélection des matières premières et capables d'optimiser leur transformation en fonction des besoins quotidiens.

Mots-clés : technologie osseuse, outils de vannerie, Néolithique, Cueva de los Murciélagos, péninsule Ibérique.

INTRODUCTION

In most Mesolithic and Neolithic contexts, the preservation of perishable materials such as plant-based artefacts is extremely rare. As a result, our understanding of the past technologies used to produce these items depends largely on indirect evidence, particularly the analysis of tools associated with their production (Soffer, 2004). The study of wear patterns on tool edges and surfaces has proven to be crucial in providing insight into the activities performed with these tools. This approach to understanding the function of bone tools through the analysis of use-wear has a long tradition in archaeological research (Semenov, 1964; Buc, 2011; Wojtczak and Kerdy, 2018; Bofill and Taha, 2013; De Diego, 2023). This includes identifying the types of materials worked on and reconstructing the movements or kinematics involved in their use (Gibaja et al., 2010, Altamirano, 2014, among others). It is also important to highlight the valuable contribution of combining use-wear analysis with ethnographic studies in linking specific use-wear characteristics to particular basketry techniques, especially coiled basketry (Desmond, 2022; Franch et al., 2023). This interdisciplinary approach not only enhances our understanding of how tools were used but also provides a framework for interpreting functional and technological aspects of ancient crafts.

While such analyses of tools have significantly advanced our understanding of ancient plant-based crafts, opportunities to directly compare tools with their associated products within the same archaeological context remain extremely rare. The site of Cueva de los Murciélagos (Albuñol, Spain), used as a burial site between 7500 and 1800 cal. BC, represents an exceptional case as it has provided the oldest and best-preserved plant and animal fibre based objects in southern Europe (Martínez-Sevilla et al., 2023; Bertin et al., 2024). This site offers the possibility of studying the production of plant crafts, both through the tools used and the preserved products themselves.

This paper focuses on a collection of worked bone tools recovered from Cueva de los Murciélagos in the 19th century. These artefacts display both morphological features and use-wear patterns which suggest that they were involved in textile or basket-making activities. The main objective of this study was to characterise the morphological and functional features of these bone tools, using traceological analysis to reconstruct their production processes and assess their role in the manufacture of

plant-based crafts. By integrating this evidence into the wider archaeological context, this research aims to shed light on the technological and cultural practices associated with the production of plant crafting implements in the Neolithic period.

1. THE SITE

Cueva de los Murciélagos is one of the most significant and emblematic prehistoric sites in Europe regarding the preservation of organic materials. Located approximately 7 km from the Mediterranean coast in Albuñol, Granada, Spain, it nestles in the karstic formations of the Sierra de la Contraviesa, situated 450 m above sea level, overlooking the Angosturas Gorge (fig. 1). The region's arid climate and unique geological features, such as fractured limestone, have created ideal conditions for preserving perishable organic materials, rarely found in other archaeological contexts. These factors make the cave a treasure trove of information on the Mesolithic to Bronze Age periods, with evidence spanning from approximately 7500 to 1800 cal. BC (Martínez-Sevilla et al., 2023; Bertin et al., 2024).

The cave was discovered in the 19th century during mining activities. Workers inadvertently uncovered a gallery containing partially mummified human remains, baskets, wooden tools, and other artefacts. Initial exploration and collection efforts were spearheaded by M. de Góngora, a pioneer in Spanish archaeology, who documented the findings (De Góngora, 1868). The objects are currently held in the Museo Arqueológico Nacional (MAN, Madrid) and the Museo Arqueológico y Etnológico (MAEG, Granada). Despite the significant contribution of Góngora's work, the lack of precise documentation

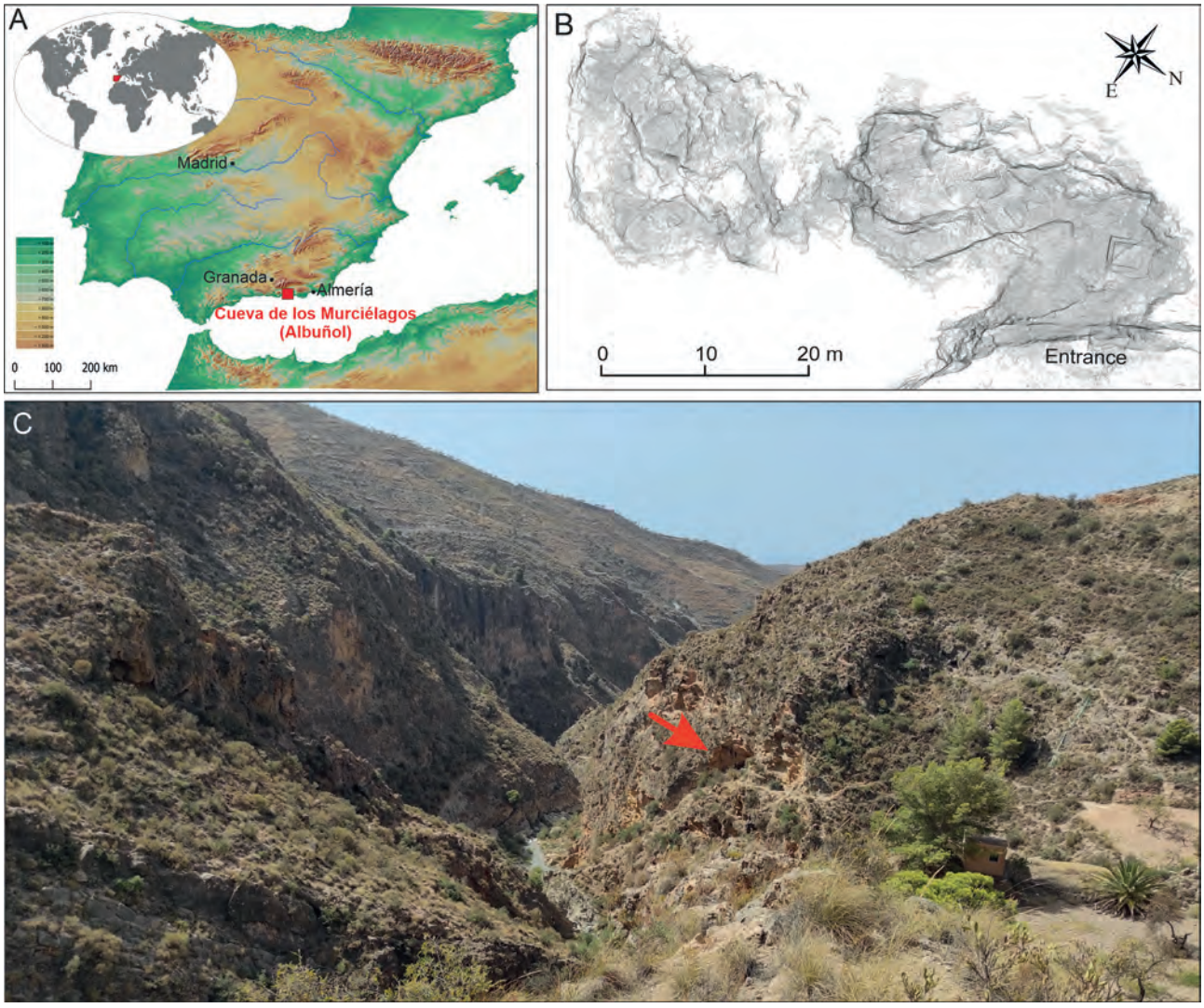

Fig. 1 – The site of Cueva de los Murciélagos: A) Location of Cueva de los Murciélagos in southeast Spain (Andalucía, Albuñol); B) Plan of the cave made with the 3D model; C) View from the north toward the Angosturas gorge and cave entrance.

Fig. 1 – Le site de la Cueva de los Murciélagos: *A) localisation de la Cueva de los Murciélagos dans le sud-est de l'Espagne (Andalousie, Albuñol) ; B) plan de la grotte réalisé selon un modèle 3D ; C) vue depuis le nord vers le ravin des Angosturas et de l'entrée de la grotte.*

of artefact contexts during this early period has created challenges for modern archaeological interpretation (Martínez-Sevilla et al., 2023).

Recent investigations, particularly the interdisciplinary efforts of the MUTERMUR project, have employed advanced archaeometry techniques to provide a more comprehensive understanding of the site. These include high-precision radiocarbon dating, Bayesian modelling, and microscopic analysis of plant-based materials. These studies have refined the chronological framework of the site, revealing a 2000-year gap between the Mesolithic and Neolithic occupations (Martínez-Sevilla et al., 2023).

Radiocarbon dating has established so far three distinct occupational phases within the cave. The first, associated with Mesolithic hunter-gatherer populations, is dated to approximately 7500–7000 cal. BC. This period is characterised by the production of simple twined baskets, often decorated with geometric motifs using dyed plant fibres, more specifically the leaves of esparto grass (*Stipa tenacissima*). These items represent some of the oldest and best-preserved examples of basketry in Europe, highlighting the advanced technological capabilities of early Holocene societies.

The second phase, spanning roughly 5400–4200 cal. BC, corresponds to Neolithic farming communities. This period saw a diversification of artefacts, including more complex basketry techniques such as coiling, braiding, pseudobraiding/cofín, and diagonal twining all using esparto grass. Notable discoveries include sandals made from crushed esparto grass, a wooden mallet made from olive tree wood (*Olea europaea*), digging sticks made from strawberry tree wood (*Arbutus unedo*), as well as a recently published assemblage of archery-related artefacts that includes the remains of bowstrings made of sinew (Bertin et al., 2024). These items reflect a shift toward agricultural practices and suggest a high degree of specialisation in plant-based technologies and sinew processing.

Finally, the third phase documented corresponds to the Bronze Age (1900–1700 cal. BC). The cave's desiccating conditions played a crucial role in preserving these organic materials, offering a rare glimpse into technologies and daily life from these periods. Research has already shed light on the technological innovations of the cave's inhabitants, such as the selection and processing of esparto grass for various technological and functional applications (Martínez-Sevilla et al., 2023).

2. MATERIAL AND METHODS

A total of four bone objects (fig. 2) were recovered by Manuel de Góngora in the 19th century (De Góngora, 1868), and have been partially described in previous publications (López, 1980). While not numerous, these finds provide valuable insights into the use of hard animal tissues as a key raw material during the prehistoric occupation of the site. Analysis revealed a clear selection of long and flat bones from medium and large ruminants, mainly caprid and bovid or red deer.

Most of these objects lack precise stratigraphic context but several lines of evidence suggest that they date to the Neolithic period. These include the use of domesticated raw material, the typological characteristics, their features and the chronological framework established for other materials recovered from the cave. Together, these factors provide a strong basis for attributing the bone items to the Neolithic period.

The artefacts have previously been grouped based on their general morphology and the features of their active ends (Camps-Fabrer, 1966; Stordeur, 1988; Altamirano, 2013); their function was determined by microwear analysis, according to a scheme proposed by I. Sidéra and A. Legrand (2007).

The possible use of prehistoric bone tools can be determined by studying the macroscopis traces and microscopic abrasive changes that appears on their surface due to repeated use, producing wear patterns (Campana, 1989). For our analysis, we observed surface traces with the naked eye and with 5× and 60× magnification provided by a stereoscopic microscope. Further traceological analysis to identify the possible function of the tools was carried out by taking more detailed images using a portable digital microscope (Dino-Lite Edge Digital Microscope AM7915MZT) with a magnification of ×20 to ×220.

The observed traces were compared with previously published experimental reference works (Campana, 1989; Maigrot, 2005 and 2010; Beugnier and Maigrot, 2005; Campana and Crabtree, 2018; Legrand and Radi, 2018), which allow the association of specific use-traves with certain activities, such as textile production.

3. TYPOLOGICAL AND TECHNICAL APPROACHES

The four bone objects can be classified into three types based on the shape of their active ends: pointed tools, tools with a flat working surface (smoothers) and toothed tools. This classification may be redefined as the study progresses and incorporates new data on artefact use and production.

The two pointed tools can be further subdivided based on their blanks and anatomical features. The awl preserves the distal epiphysis as a handle with a complete shaft circumference in portion to its length (fig. 2a). The bone shaft was opened in the future distal portion by direct percussion and subsequently abraded to create a pointed active end (fig. 3a). The tool is made from caprid tibiae and its dimensions are 125,7×56,2×18,1 mm (max. length, width and thickness).

The second pointed tool type (94×13,5×10,7 mm) is formed by long bone splinters, probably worked from a large mammal metapodial (possibly bovid or red deer)

Fig. 2 – Bone tool assemblage from the site of Cueva de los Murciélagos discovered in the XIXth century: a) Awl on caprine tibia (No. 465); b) Spatula on bovid or red deer rib (No. 468); c) Pointed bone splinter on big-sized mammal long bone (No. 467); d) Toothed flat artefact on bovid or red deer rib (No. 469).

***Fig. 2** – Ensemble d'outils en os provenant du site de la Cueva de los Murciélagos, découvert au XIX^e siècle: a) poinçon sur tibia de capriné (n° 465) ; b) spatule sur côte de bovidé ou de cerf élaphe (n° 468) ; c) éclat appointé sur fragment d'os long de grand mammifère (n° 467) ; d) artefact plat dentelé sur côte de bovidé ou de cerf élaphe (no 469).*

using a bone shaft fragment and shaped by abrasion to create a pointed end (fig. 2c).

The spatula (109×21,6×14,1 mm) with a flat working surface, is made from a rib shaft from a large ruminant, probably split longitudinally by double parallel grooving based on evidence from other Iberian and European Neolithic and early Chalcolithic sites (Vitezović and Bulatović, 2013 and 285; Altamirano, 2014). It is heavily worn and has a straight proximal end displaying a single bipolar perforation, probably used to suspend it or to be tidied up, and extensive use-wear with shallow longitudinal traces on its active end (cf. fig. 2b and fig. 3b).

Finally, the flat, toothed artefact (59,6×18×18,9 mm) has two perforations on its mesial and distal portions and 21 aligned triangular or trapezoidal teeth on its active end that give it a serrated appearance, although the tool is broken and half is missing (fig. 2d and fig. 3c). The teeth display significant wear, with longitudinal striations and potentially having resin residues that require further analysis. Its lower portion features engraved motifs, possibly decorative in nature (fig. 3d). Although it exhibits a morphology similar to objects referred to as "gradinas" (elongated osseous tools with a serrated active end) and despite it being incomplete, its overall form, the higher number of teeth, and their "U"-shaped profile suggest that it is a different type of object. Ethnographic parallels indicate a use more closely related to textile or basketry activities, such as objects used as weaving battens (Stone, 2011, p. 33, fig. 3 a, b; Mineo et al. 2023, p. 325, fig. 9).

4. FUNCTIONAL APPROACHES

Considering the morphology of their active ends we have mainly focused on three tools (465, 468 and 469).

In terms of macroscopic traces, the pointed tool (465) has a broken tip displaying smooth edges as a result of continued use despite the breakage (fig. 4a). All three analysed tools display bright, smooth surfaces, especially in the distal and mesial areas as is especially clear on the spatula (fig. 4b).

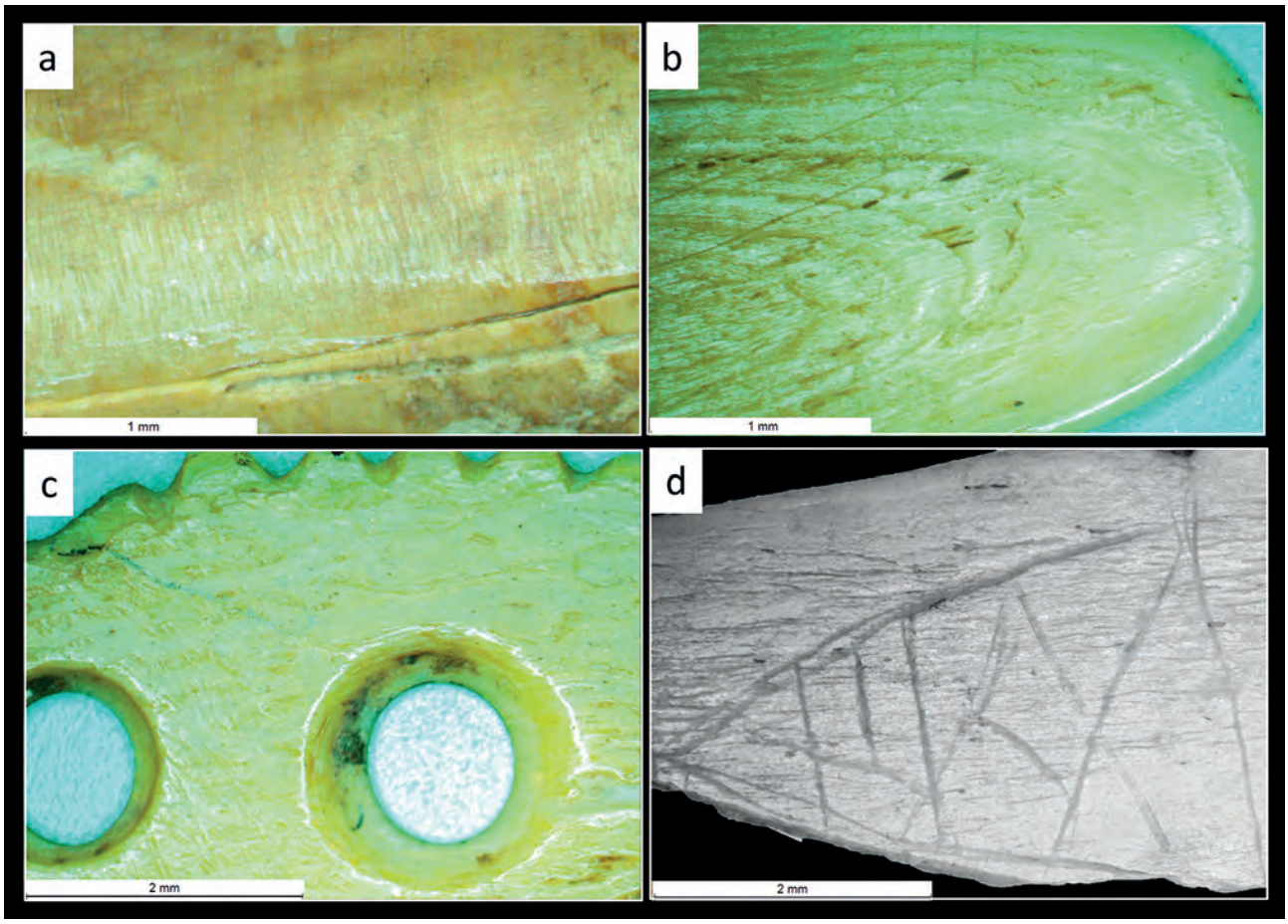

Fig. 3 – Manufacturing traces: a) Oblique abrasion marks on the distal area of the bone awl (No. 465); b) Distal portion of the bone spatula displaying a shiny and heavily worn surface partially covering the manufacturing traces (No. 468); c) Detail of the trapezoidal teeth on the active end displaying a double pierced surface (No. 469); d) Detail of the possible engraved abstract decoration on the distal portion of the toothed artefact.

***Fig. 3** – Traces de fabrication: a) stries d'abrasion obliques sur la partie distale du poinçon en os (n° 465) ; b) extrémité distale de la spatule en os montrant une surface brillante et fortement usée, couvrant partiellement les traces de fabrication (n° 468) ; c) détail des dents triangulaires à l'extrémité active présentant une surface doublement perforée (n° 469) ; d) détail de la probable gravure géométrique sur la partie distale de l'artefact dentelé.*

Microscopic traces were observed, with a pattern of short, shallow and parallel striations in the distal areas (fig. 4a). Previous experimental and archaeological work suggests this type of polishing to be the result of continuous contact with the vegetal fibres, the smooth and bright surfaces being a consequence of conctact with rich-silicate plant fibres as well as a long-term use (Griffitts, 2001; Soffer, 2004; Legrand, 2008; Legrand and Radi, 2008; Buc, 2011; Campana and Crabtree, 2018; Bach et al., 2023). Moreover, a recent study of a North African bone tool assemblage (Desmond, 2022) suggests these traces might have been produced by working plant fibres that were rich in silicates, such as those of esparto grass.

Evidence of the curation of the active area was also observed for tool 465 with abrasion striations slightly shorter and more perpendicular to the longitudinal axis of the tools over the intense superficial lustre. These striations are extremely faint due to a more continuous use over time, with a high degree of polishing and complete smoothing of the surface, resulting in a slightly rounded tip and a high degree of lustre and bright surface, extending along the shaft of the artefact.

The toothed flat tool (469) might also have been involved in crafting vegetal fibres, perhaps as a "weaving" tool used to prepare and firmly pack the weft of fibres (fig. 4c). Its surface is shiny and well well smoothed by use, and the teeth display distinct rounding and striations that are mainly perpendicular.

5. DISCUSSION

Analysis of the set of manufactured bone objects found in the Cueva de los Murciélagos site in Albuñol, provides an insight into how these hard animal materials were utilised by prehistoric people who occupied the site particularly during the Neolithic.

The careful selection of long bones of medium- and large mammals to produce different types of tools, linked

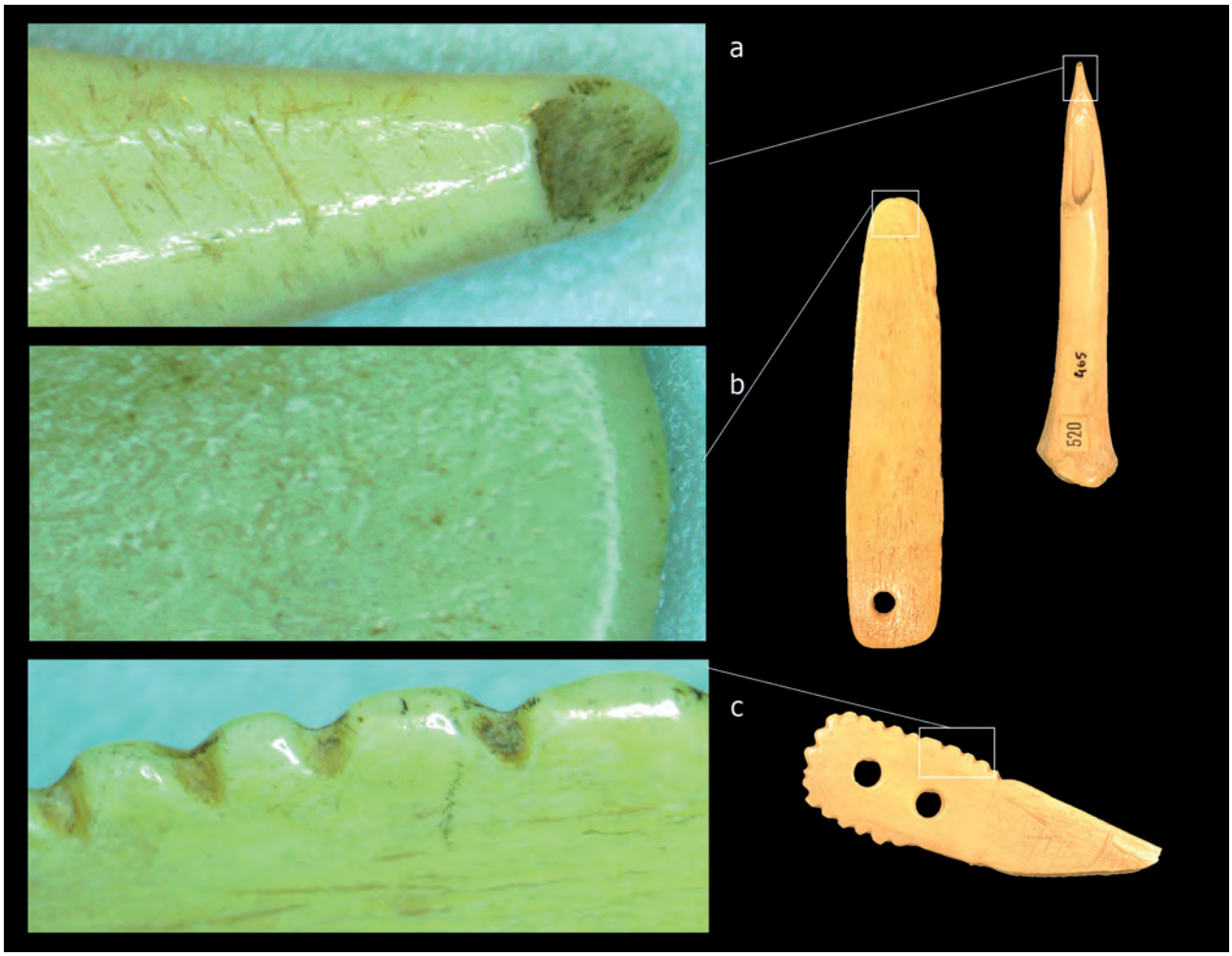

Fig. 4 – Use wear traces result of continuous contact with the vegetal fibers: a) Short, shallow and parallel striations in the distal area, displaying smooth and bright surfaces as a consequence of a long-term use and contact with rich-silicate plant fibers (No. 465); b) Smooth texture on the spatula active end surface (No. 467); c) Detail picture of the toothed artefact displaying shiny surface heavily smooth by use (No. 469).

***Fig. 4** – Traces d'usure résultant d'un contact continu avec les fibres végétales : a) stries courtes, peu profondes et parallèles dans la partie distale, présentant une surface lisse et brillante en raison d'un usage prolongé (n° 465) ; b) surface lisse et émoussé sur la partie active de l'outil spatulé (n° 468) ; c) détail de l'artefact dentelé montrant une surface brillante et fortement polie par l'utilisation (n° 469).*

to both domestic and symbolic spheres, is particularly notable. In terms of manufacturing methods, the dominant technique is fracturing by percussion and splitting, possibly by longitudinal grooving. At least one of the tools (465) shows an initial phase of modification to the original material through scraping followed by oblique and transverse abrasion to achieve the final shape (fig. 3a). Bone assemblages, including tools with comparable morphology, showing similar techniques of manufacture, have been documented in Neolithic contexts in the southern Iberian Peninsula, such as in the Cueva del Toro in Antequera (Meneses, 1991; Rodríguez, 2015), the site of Cueva de la Carigüela de Píñar in Granada (Salvatierra, 1980 and 1982), as well as at other Levantine sites such as Cova de l'Or and Cova de la Sarsa (Pascual, 2011 and 2016). Studies of these (and other) assemblages has highlighted the importance of abrasion, longitudinal grooving, and direct percussion for fracturing bone, especially metapodials from medium- and large mammals, during the Neolithic.

The presence of heavily worn surfaces on the analysed tools suggests long-term use, possibly even indicating that the items were of significant value for their owners. The worn surfaces and the use-wear traces might also indicate that the tools were involved in the manufacture of the plant-based objects. The extremely worn and bright surfaces, mainly on the active ends but also on the mesial and proximal portions, of at least three of the four bone tools might have been in contact with silicate-rich plant fibres.

Similar use-wear patterns are observed on artefacts from the Italian site of La Marmotta, where tools such as spatulas, awls, and caprine bone needles were used to work with a range of raw materials (Mozota and Gibaja, 2015), or from La Draga (Banyoles, Spain) where an in-depth analysis of the worked osseous assemblage has linked some of these artefacts to the working of textiles and animal skins (De Diego, 2023). These publications both report that the active ends of the artefacts studied

show a shiny, smoothed surface, connected to use-wear resulting from prolonged contact with plant fibres.

Artefacts from Taforalt (Morocco) display similar use patterns. Use-traces diagnostic of basketry production occur in the form of small, short, shallow, parallel, clustered transverse striations, generally originating on or below the point tip (Griffitts, 2001; Soffer, 2004; Legrand and Radi, 2008; Buc, 2011; Campana and Crabtree, 2018).

The serrated object displays a morphology that differs from those items traditionally referred to as "gradinas" (López, 1980, p. 171). Examples of these serrated elements with pierced proximal portions have been documented in several Iberian Neolithic sites, such as the Cova de l'Or (Alicante; Vento, 1985, fig. 1, 3) or the Cueva de los Murciélagos site in Zuheros (Córdoba) (Vicent and Muñoz, 1973, fig. 30). These "gradinas" have an elongated morphology with a serrated active end with around 6 to 11 teeth. A similar toothed item with a proximal perforation has also been found at the La Draga site (Tarrús et al*.,* 1992, fig. 4; Palomo et al*.,* 2017, 143, no. 100), and was also linked to textile production or animal skin processing (Legrand 2011, p. 118; De Diego, 2023, p. 131, fig. 68). These serrated tools are similar to other ethnographic items for textile or basket production from various parts of the world (Stone, 2011).

Overall, this study provides an initial understanding of the exploitation of bone in the Cueva de los Murciélagos in Albuñol, particularly during the Neolithic phase. The results are partial, given the small sample size, but ongoing excavations at the site are providing a broader and more complete view of the relevance of these raw materials and their use in the manufacture of both domestic and symbolic objects. A more in-depth functional study, along with an experimental programme focused on basketry production, will be undertaken in the near future.

As mentioned above, several plant and sinew-based items have been documented at the site. These include various types of baskets, cords and sandals made from esparto grass (Alfaro, 1980; Martínez-Sevilla et al*.,* 2023), as well as sinew cords (Bertin et al*.,* 2024) and fragments of textile. The evidence highlights significant differences in basket making techniques and raw material processing between Mesolithic and Neolithic contexts. In the Mesolithic, esparto leaves were used whole, whereas in the Neolithic they were crushed to make them malleable before use (Martínez-Sevilla et al*.,* 2023). Similarly, while twisting was the only basketry technique identified in the Mesolithic, the Neolithic period saw the introduction of braiding and sewing of esparto fibres to make sandals (fig. 5). The awls analysed in the present study may have played a key role in the production of coiled basketry, particularly for sewing and securing the stitches between the fibre bundles of the coils. These tools may also have been used for similar purposes in the production of sandals. The identification of esparto grass as the primary raw material helps to explain the distinctive wear marks observed on these tools, which are very similar to those produced when working with other silicate-rich plant fibres (Desmond, 2022). Esparto leaves are particularly hard due to their high silica composition with abundant silica hairs present on the axial surface visible under the microscope.

In contrast, the other two tools seem to be linked with textile production. While the study of the textile remains from the site is ongoing, initial results confirm that the primary technique to be plain weaving, typically linked to the use of a loom, which requires special tools to separate the threads.

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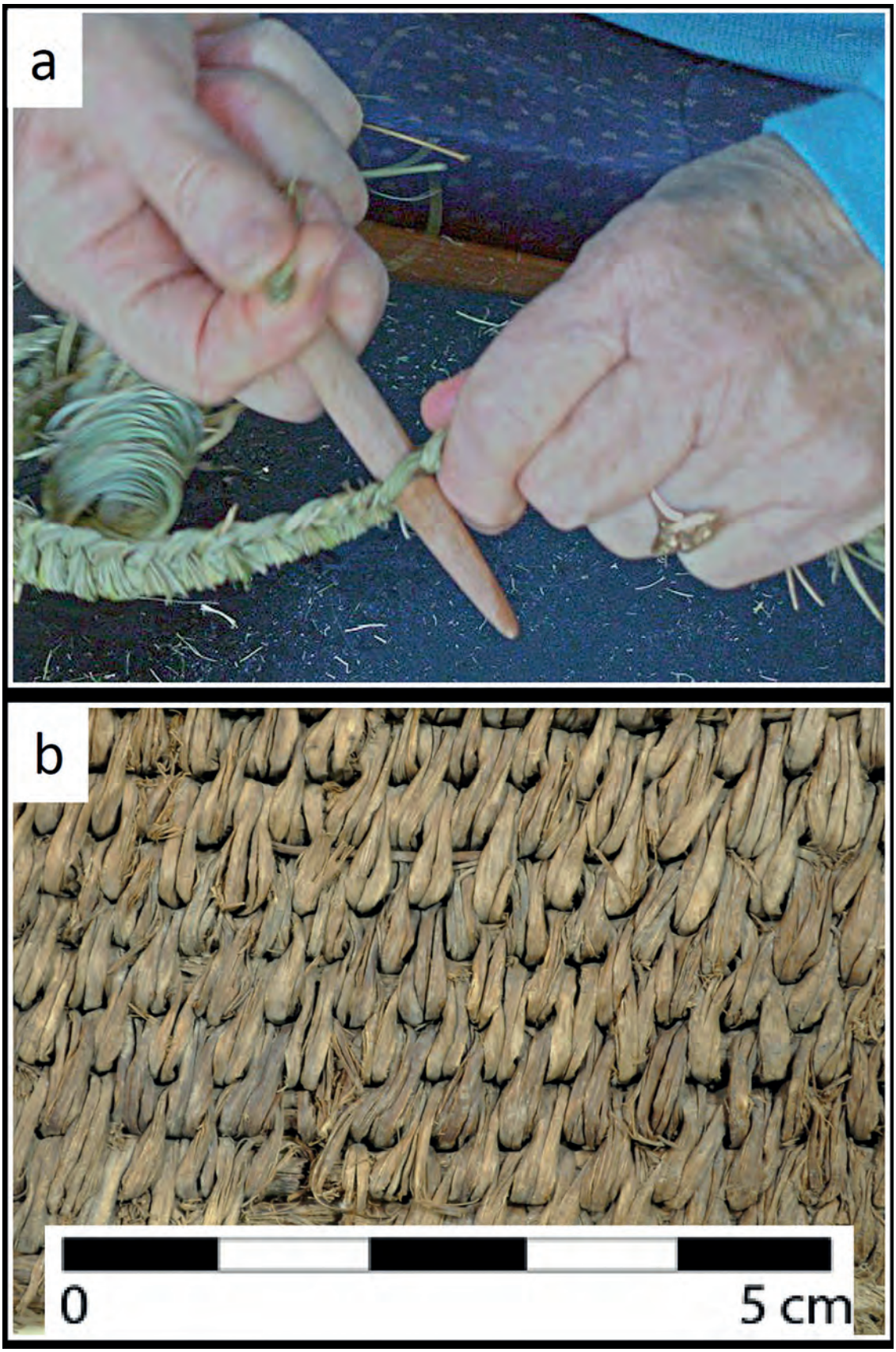

Fig. 5 – a) Example of use by A. Homs of pointed bone tool to perforate esparto fibers; b) Basket fragment 615 (Beta-627241: 5580 ±30 BP, Martinez-Sevilla et al., 2023) made by close coiling with esparto grass that involves the use of bone industry for separating the stands.

***Fig. 5** – a) Exemple d'utilisation par A. Homs d'un outil en os pointu pour écarter des fibres d'esparto ; b) fragment de panier 615 (Beta-627241 : 5580 ± 30 BP, Martinez-Sevilla et al., 2023) fabriqué par enroulement serré avec des fibres d'esparto, ce qui implique l'utilisation d'outils en os pour l'écartement des brins.*

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