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Describing the neolithic cord production process: Raw materials, techniques and experimental archaeology in La Draga (Girona, Spain; 5207–4862 cal BC)

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ABSTRACT

Cordage is related to daily activities and as such has been a basic element for self-suffiency since Prehistory. Due to the lack of their preservation in most archaeological contexts, the knowledge of these technologies in the past is limited. This paper analyses the production process through an experimental program of the cordage assemblage from La Draga (Girona, Spain; 5207–4862 cal BC). The site is an Early Neolithic site from north-eastern Iberia, where a wide vegetal set of fibre-based craft was recovered in waterlogged preservation conditions. First, a systematic identification of raw materials used for cord production is done. Subsequently an experimental approach to these cords, considering both the raw materials used and their properties, has been developed. The study aims to infer raw material selection for producing cords, as well as the importance of raw material and group standards involved in the final objects. The results showed a preferable selection of lime tree bark (*Tilia* sp.) and nettle bast fibre (*Urtica* sp.), which may be obtained from the surroundings of the site. Both were used to produce different types of cords, twisting preferred above braiding, which should be related to cultural standards and traditional learning processes.

1. Introduction

Preservation of perishable material in archaeology limits our knowledge of plant crafts in the past. This is the case of vegetal fibre-based objects; although we know they existed, direct evidence is scarce (Hurcombe, 2014). While their use is well documented since Palaeolithic chronologies (Barber, 1994; Soffer, 2004; Hardy, 2008; Kvavadze et al., 2009), the knowledge of this perishable technology usually comes from fibre imprints in durable materials such as clay or pottery (Soffer et al., 2000; Wigforss, 2014). Although these imprints let an approach to the technique used to make these objects, they do not allow the species of the raw material to be recognised. The identification of plants by the study of indirect evidence is challenging because of the lack of reference material, but also because the features shared between plants do not permit specific differentiation.

A wide diversity of plants offers fibre for crafts production, and they can be both monocotyledon and dicotyledon families. Moreover, both groups are anatomically easy to distinguish observing their cross-section. Monocots present scattered vascular bundles all around the section, while dicots present their bundles arranged in a ring during the secondary growth (Evert, 2006). Fibres from monocot families are usually leaves and stems from grasses, cattails, sedges or palms, while the dicot fibres are extracted from the stems from different herbs such as nettle, hemp, and linen or the bark of trees. The fibres extracted from both types, need different processing to be used. Monocots are dried after gathering the plant and moisturized closer to their use. Dicot families need a more detailed preparation that consists in general terms of extracting the bast fibres which corresponds to the phloem fibres of the vascular system (Evert, 2006). In this paper we refer to "bast fibres" as the fibres obtained from the stems of dicots herbs, and "bark" to cite the materials obtained from trees.

Mesolithic and Neolithic sites from wetlands in northern Europe have provided several examples of braided cords and nets. This is the case of the nets and cords made of lime tree bark (*Tilia* sp.) found at the Friesack-4 site (Germany; 7700 BCE) (Gramsch, 1992), or those made of bark fibres of lime, willow (*Salix* sp.) and nettle (*Urtica dioica*) found at

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the site of Antrea (Finland; 8400–8300 cal BC) (Bender Jørgensen, 1992; Miettinen et al., 2008; Wigforss, 2014). Other sites, such as Dejrø and Skjoldnæs (Denmark; 6500 BCE) provided strands and twisted nettle cords (Bender Jørgensen, 1992; Wigforss, 2014). For Neolithic chronologies, there are noteworthy plant craft remains at the lacustrine settlements in Central Europe, such as those in the Circum-Alpine zone. They have provided cordage materials from sites like Arbon-Bleiche (Switzerland, 3384–3370 BCE) where the materials were made of lime tree bark and flax (*Linum usitatissimum*) (Médard, 2003), and the Wetzikon-Robenhausen site (Switzerland, 3700–3300 BCE), where the lime tree was also used (Altorfer and Médard, 2000). The cordage remains of these sites documented a diversity of plant raw materials used in the production of cordage, mainly bast fibre of dicot families.

In more southern latitudes, archaeological sites in wetlands and lacustrine environments are less common and preservation of the plant crafts is rarer. The earliest direct materials known are three partially charred fragments of a braided cord recovered in the Coves de Santa Maira site (Alacant, Spain; 12,900–10,200 cal BC). The identification of the plant fibres showed that they were made of leaves from a Poaceae species, more specifically from esparto grass (*Stipa tenacissima)* (Aura Tortosa et al., 2019). The few lacustrine sites in the Mediterranean region have also provided evidence of Early Neolithic plant crafts. This is the case of La Marmotta (Italy, 5690–5260 BCE), which has yielded a huge amount of vegetal remains (Bazzanella, 2012; Mineo et al., 2023), and La Draga (Girona, Spain; 5207–4862 cal BC), where charred and waterlogged plant crafts were recovered (Piqué et al., 2018, Romero-Brugués et al., 2021). The present study focuses on the materials from La Draga, and their description is given below. In addition, some other remains had been recovered in specific scattered archaeological sites in the Iberian Peninsula. In chronological order, the archaeological site of Cueva de Los Murciélagos (Granada, Spain; 5200–4600 cal BC) should also be mentioned. In this case, the materials are preserved by dehydration and consist of an extended collection of organic objects, both fibre and wooden based. Regarding the cordage materials, there were ropes themselves, but also parts of sandals made of esparto grass (Alfaro Giner, 1980, 1984; Cacho et al., 1996). Late Neolithic-Chalcolithic esparto grass ropes were also recovered in some archaeological sites in southern Spain, where the preservation was basically by carbonization. Some of these remains were found in the archaeological sites of Campos (Almería), Cueva Sagrada (Murcia) (Papí Rodes, 1992–1994), Cueva de Nerja (Málaga), and Sima de la Curra (Málaga) (Jordà Cerdà et al., 1983), among others.

Although esparto grass was extensively used in southern and eastern Iberia, a greater diversity of raw materials has been documented in the north. An example is the Cueva del Moro site (Huesca; 1530–1423 cal BC) where an indeterminate monocot and willow were identified in fibre-based objects (Alcolea and Rodanés, 2019). Previous studies of La Draga site have documented a wide variety of manufacturing techniques among the cordage remains (Piqué et al., 2018, Herrero-Otal et al., 2021; Romero-Brugués, 2022). Despite the huge diversity of vegetal taxa identified in palynological (Revelles et al., 2014, 2015; Revelles and van Geel, 2016), anthracological (Caruso-Fermé and Piqué, 2014), and carpological studies (Antolín, 2013) and the analysis of wooden objects (López-Bultó and Piqué Huerta, 2018), monocot and dicot families were determined as raw materials for fibre-based cords and baskets (Piqué et al., 2018, Herrero-Otal et al., 2021). Plant availability may be an important factor for taxa selection but the use of specific families with mechanical and physical properties may bear on the technique used in production.

In this work, we present the results of the systematic identification of raw materials used for cord production in La Draga, as well as an experimental reproduction of these cords considering both their use and properties. Through an experimental approach to the manufacturing processes, we aim to understand how raw materials were acquired and transformed to produce the ropes at the La Draga site in the Neolithic, and how the properties of raw materials or cultural preferences were considered in obtaining determined typology of objects. This study will therefore infer the raw material selection for producing different types of cords, previously documented in La Draga, as well as the importance of raw material and group standards involved in resultant cords.

2. Materials

The archaeological site of La Draga is located on the eastern shore of Lake Banyoles at 172 m.a.s.l. in northeastern Iberia (Banyoles, Girona, Spain). It has been excavated for more than thirty years and it is considered the only evidence of a Neolithic Lake dwelling in the Iberian Peninsula (Palomo et al., 2014; Terradas et al., 2017). Two occupations are detected at the site: the first one dated in 5309–5247 cal BC related to the use of wooden platforms and their successive repairs, and a second occupation associated with pavements formed by travertine slabs dated in 5207–4862 cal BC (Andreaki et al., 2022). Although it is suggested that the real site covers an area of about 15,000 m^2, 1000 m^2 have been excavated and three different sectors have been identified. Sector A is found above the water table and organic materials are only preserved when they are charred, Sector B/D is located in the water table, and Sector C is currently under water but was exposed in prehistoric times. Sectors B/D and C have preserved organic materials because of the anaerobic conditions (Fig. 1).

The cordage set analyzed in this study was recovered in the archaeological fieldwork from 1998 to 2005 in Sector B, where organic remains were conserved by waterlogged conditions. The remains were recovered directly in the field or in the later wet-sieving, then cleaned and restored by the method of freeze-drying (Piqué et al., 2014).

The cords were previously technologically analysed and an approach to the raw material used was carried out for a few of the remains (Piqué et al., 2018). The total sample has 75 remains, including twisted and braided cord, two single fibres, a knot and three non-processed rolls of liana (Fig. 2). Considering similarities between the individual fragments (morphology and technology) and location in the site, several associations were made, resulting in 22 different registers. Each register corresponds to either a single cord element or a group of fragments of similar characteristics associated. Although small strand fragments may be detached from the larger ones, it was not always possible to relate them to specific cord element. Even in the fragmentary state of conservation, several morphological and technical features of the remains could be observed and measurements were taken (cord and strand size and angle of torsion) to describe the process of cord production and associations between fragments. The results of this study revealed that most of the cords from La Draga were made by twisting, and the dominant pattern was S (S z,z), but also the Z pattern (Z s,s,s) was recorded, as well as a single case of braided cord (Romero-Brugués, 2022). The authors also worked on the raw materials used in four of the registers (references D01 JJ87-22, D02 JI88-15, D04 JF72-1, and D04 JI92-9) using an optical and electronic microscope. They identified the use of bast stem fibres, lime tree bark fibres (*Tilia* sp.), and *Clematis* sp. corresponding to a roll of liana, which was not included in the current study (Piqué et al., 2018).

3. Methods

Twenty-two samples of each reference number corresponding to the cords set from La Draga were taken and analysed in this study. Sampling archaeological materials is a destructive process, but the current technologies need samples for analyses. However, due to the fragility of the materials studied in this paper, it was possible to use fragments detached from the materials during the excavation and conservation processes, or even during their storage, so no further damage was caused to the archaeological objects. Besides, only small fragments are needed for this study.

Although the restoration processes add rigidity to the objects, they change the properties of the organic remains and hamper the sampling

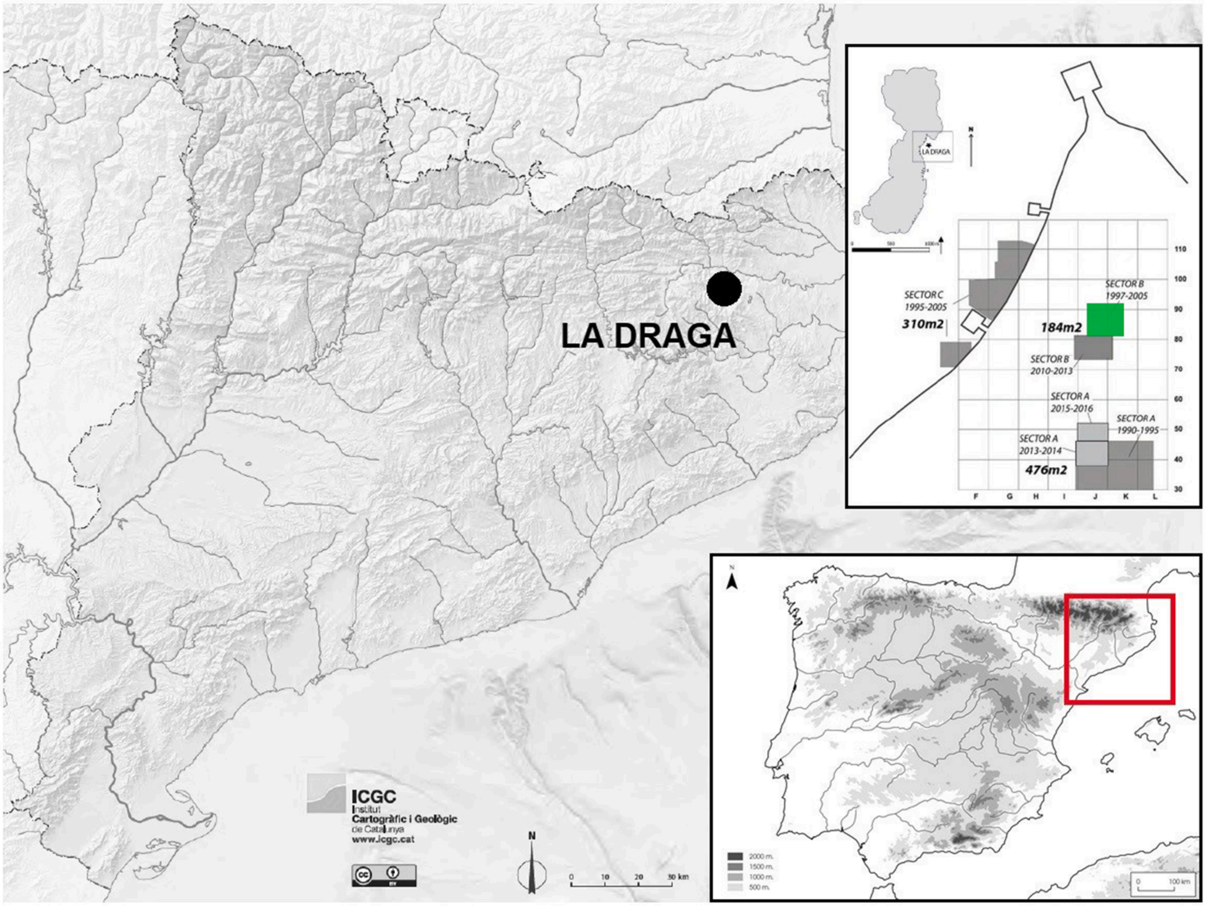

Fig. 1. Location of La Draga archaeological site in the North-East of the Iberian Peninsula. Details of the excavation sectors, Sector B is highlighted in green. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 2. Cordage remains from La Draga: a) roll of S z,z twisted cord (reg. D04 JI92-9); b, c) S z,z twisted cords (regs. D05 JJ92-16 and D05 R-8); d) S z,z twisted cord (reg. D02 KA88-14); f) braided cord (reg. D98 JF86-13); e) Z s,s,s twisted cord (reg. D01 KA87-27) (modified from Piqué et al., 2018).

and the anatomical analysis of the fibres. For this reason, it is preferable to sample the objects before the application of consolidants. The cordage remains from La Draga were excavated many years ago and were consolidated after the excavation; for this reason, sampling for this study was carried out on restored material. Even though Polyethylene Glycol (PEG) treatment was used, a dry cutting method breaking the samples by hand or with a razor blade offered quality surfaces to be observed microscopically both optically (OM) and by scanning electron microscope (SEM) to obtain better-quality images. In this sense, transversal and longitudinal surfaces of the samples were used for identifying the raw materials used. The OM analyses were performed using a reflected optical microscope for the opaque samples, and a transmitted light microscope for samples mounted in slides, at the Archaeobotanical Laboratory of the Department of Prehistory at the *Universitat Autònoma de Barcelona* (UAB). Olympus BX51 and Olympus BX43 microscopes coupled with an Olympus DP26 camera and linked to Olympus cellSens software were used. The SEM analysis was conducted at the Microscopy Services in the same university. The samples were mounted on stubs using double-sided carbon tape and coated with a 15 nm layer of gold using an Emitech K550 Sputter Coater Unit and were examined using a Zeiss EVO® MA 10 SEM.

Vegetal identifications were based on anatomical and histological descriptions of the archaeological samples compared with contemporary species identified around the site by other archaeobotanical and ecological studies. This also implies the use of a local and specific reference collection of modern plants, the consideration of historical and popular knowledge, and the use of specific microanatomical atlases of plant histology and physiology, and other accessible reference collections.

Experimental archaeology is a basic methodological tool that enables quantitative and qualitative variables to be recorded and provides empirical data. It has an important role in understanding the technological parameters involved in the diversity of activities and makes it possible to connect the past and the present. The research group working on La Draga site has a long tradition and expertise of working on experimental archaeology regarding the materials recovered on the site (Palomo, 2012; Palomo et al., 2021). The experimentation followed in this paper was focused on testing the ways that archaeological materials were produced and assessing the function of the tools. In this sense, ethnography is essential to formulate a hypothesis of the ways of production and functionality of cordage. Regarding vegetal fibre use, experimental archaeology includes the raw material selection, the preparation of the fibres and, the production of the final objects, as well as the use of other elements. The diversity of production processes followed by each artisan, who may not use the same tools, techniques and materials, is quite challenging for applying experimentation. In the current paper, an experimental approach was applied to reproduce the fabrication of the cords, measuring different aspects such as the raw material, the replicated product (measurements and twist typology), the time devoted to their production, the tools needed, and the number of people necessary to produce the cord.

4. Results

4.1. Raw material identification

Regarding the 22 samples, 18 were identified as dicotyledon families, and in a single case, both types (dicotyledon and monocotyledon) were used. Features were not clearly visible to identify 3 of the remains (Table 1). Two types of dicot fibres were identified in cordage production in La Draga. Tree bark strips were identified in 16 remains, whereas bast fibres were identified in 2 of the remains.

Through OM, the second phloem is visible in the transversal section of bark strips. Alternate layers of fibres with the sieve tubes and parenchymatic tissue with expanding cells are visible (Fig. 3a). The longitudinal section permits the observation of different rays immersed in the parenchyma tissue (Fig. 3b). Fig. 3c and 3d show the same features but observed in an electron microscope. The features observed are similar to those lime tree fibres (*Tilia* sp.) The only monocot identified in the current study was identified by the isolated vascular bundles visible in the transversal section of the sample (Fig. 3e). It corresponds to a leaf of Poaceae, which is also confirmed on its surface where round epidermal cells are visible (Fig. 3f).

In two cases, bast fibres were identified. They present long and thin fibres with cross-sections inside (Fig. 3g). These cross marks are easier to observe under polarization (Fig. 3h). These are distinctive features of

Table 1
Cords typology and raw material used.

Register	Typology (Piqué et al., 2018)	Technology	Raw material	
D98 JF83-4	-	-	Dicotyledon	*Tilia* sp.
D98 JF86-13	Cord	Braided	Dicotyledon	*Tilia* sp.
D98 JG85-29	–	–	Non-identified	Non-identified
D01 JJ87-22	String	S	Dicotyledon*	*Tilia* sp.*
D01 JJ87-7	String	Z and S	Dicotyledon	*Tilia* sp.
D01 KA87-13	String	S	Dicotyledon	*Tilia* sp.
D01 KA87-22	String	S	Dicotyledon	*Tilia* sp.
D01 KA87-27	Cord String	Z s,s,s S	Dicotyledon Dicotyledon	*Tilia* sp. *Tilia* sp.
D01 KA87-32	–	–	Non-identified	Non-identified
D01 KB87-15	String S	S	Dicotyledon	*Tilia* sp.
D02 JI88-15	Fibre	–	Dicotyledon*	Bast fibre*
D02 KA88-14	Cord	S z,z	Dicotyledon	*Tilia* sp.
D02 KA88-15	String	S	Dicotyledon	*Tilia* sp.
D02 KA89-21	String	S	Dicotyledon	*Tilia* sp.
D02 KA89-5	String	S	Dicotyledon	*Tilia* sp.
D02 KA89-8	String	S	Non-identified	Non-identified
D02 KB90-7	String	S	Dicotyledon	*Tilia* sp.
D03 JH85-6	String	S	Dicotyledon Monocotyledon	*Tilia* sp. Poaceae
D04 JI92-9	Roll of cord Knot	S z,z -	Dicotyledon* -	Probably *Urtica* sp.* -
D05 JJ92-16	Cord	S z,z	Dicotyledon	*Tilia* sp.

* Samples identified in Piqué et al. (2018).

bast fibres: the fibrous material from the stem of dicotyledons such as flax (*Linum* sp.), hemp (*Cannabis sativa*), nettle (*Urtica* sp.), jute (*Corchorus capsularis*) and ramie (*Boehmeria nivea*), among others. Some of these species are out of the context studied in the present paper, so they have not been taken into consideration. In this sense, hemp, flax, and nettle are difficult to distinguish because of their similarity in appearance, but several researchers have focused their studies on bast fibres differentiation (Bergfjord and Holst, 2010; Haugan and Holst, 2014; Lukešová et al., 2017; Suomela et al., 2017; among others). Regarding the materials in this study, one of the remains (D02 JI88-15) was identified as bast fibre in previous studies (Piqué et al., 2018), but no more information could be described. Even so, visible features in fibres from sample D04 JI92-9, such as the cross marks, their measurements, and the direction of the microfibrillar structure, suggest this remain was made of nettle.

Unfortunately, anatomical features were not clearly visible to identify three of the samples. This may be related to taphonomic processes which acted on the materials for thousands of years, as well as the

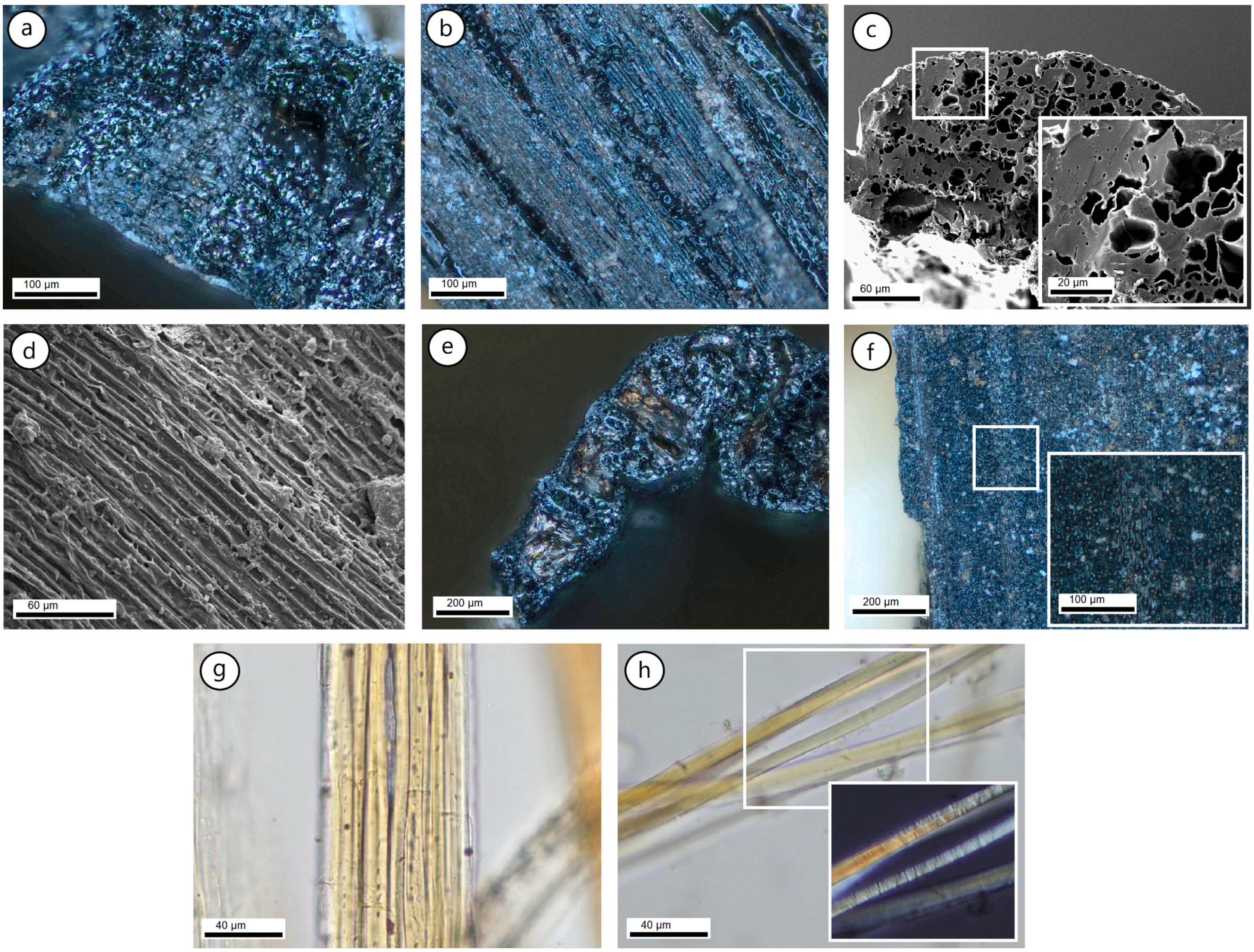

Fig. 3. Archaeological samples from La Draga: (a, b) transversal and longitudinal view of *Tilia* sp. bark with OM; (c, d) transversal and longitudinal view of *Tilia* sp. bark with SEM; (e, f) probably *Urtica* sp. fibres with OM and polarised the light; (g, h) transversal and epidermal view of a Poaceae leaf with OM.

consolidation processes they were subjected to. As mentioned above, sampling the materials before the restoration processes is essential for the following analyses, and this should be highlighted. The use of consolidants, such as PEG or Paraloid®, makes the identification more difficult. They affect the surface of the samples and produce a bright layer hiding anatomical features which must be visible for the identification of raw materials (Fig. 4).

4.2. Experimental cordage production with the bark of Tilia sp.

Since most of the cords from La Draga were made using lime tree bark, we selected this raw material for the experimental approach. *Tilia cordata* was used because it is the lime tree species available in the surroundings of the site. The experimentation consisted in producing a 2-ply cord with S-twist (two-strand cord S z,z) which is represented in almost four individualized cords from the site. Characteristics of remain D02 KA88-14 were the ones replicated during the experimental approach. It presents a Z-spun twisting of each strand, and a final S-twist, 5 mm thickness and 3 twists per centimetre (approximately). A rope-making tool, similar to the bone tools recovered at the site, was used for the production process. This is a fragment of a cow long-bone shaft with two holes. Use-wear analysis on it has been carried out and is part of another research line and will not be developed in the current paper.

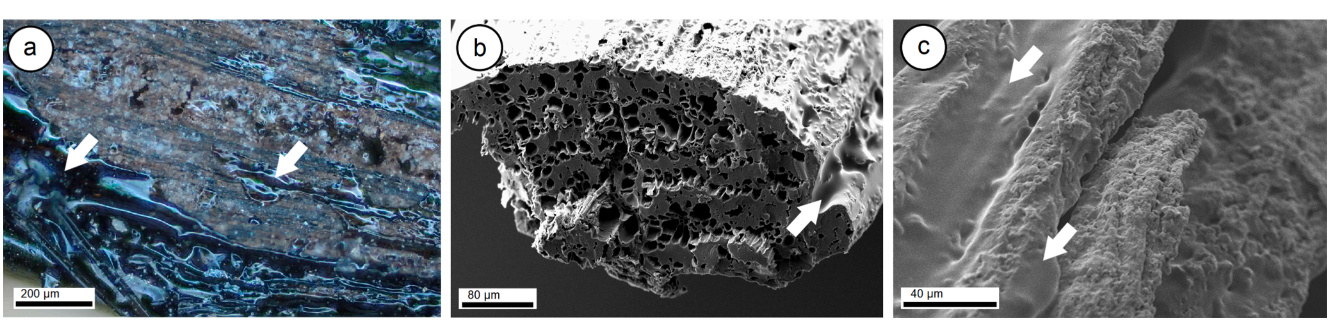

Fig. 4. Microscopy images showing consolidants affectating the observation of the samples. Arrows show where the products are present: (a) OM; (b, c) SEM.

The raw material used in the experimentation was gathered during the early summer (month of June) from branches of *Tilia cordata* tree. The bark was stored and let dry until the cord was produced during the month of September. The raw material was submerged in water for approximately 12 h until it was soft enough to be manipulated. A piece of 130x4 cm of bark was stripped into thin threads by the hand and by using a sharp tool which allowed to obtain thinner strips (Fig. 5a, 5b). The preparation of the threads involved four people. Finally, the strips obtained were used to produce an S z,z cord with a rope-making tool, which needed the participation of three people. Two of them carried out the manual twisting of each strand (Z-spun) while the third person made, at the same time, the torsion of the two strands creating the cord (S-twist) (Fig. 5c). The function of the holed tool was to tighten the cord after each twisting movement which helps in the final cord production.

The resultant cord measured 6 m long and 6–7 mm thick (Fig. 5d, 5e). The cord production lasted approximately an hour and a half from the very beginning of stripping the fibres in small units. This first part was about 25 min, and one hour to twist 6 m of cord.

5. Discussion

5.1. The raw materials

The palaeoenvironment at La Draga is one of the best-known in the Iberian Peninsula because of the preservation of organic materials at the site. The identification of plants used for craft productions provides new data about the past landscape and complements previous archaeobotanical studies. The vegetal species identified in the current study are compatible with the results of previous data regarding the past vegetation that surrounded the settlement and the evidence of plant use for fibre-based craft production by the population of the site.

Regarding the use of lime tree bark, its regional availability was detected by palynological (Revelles et al., 2014, 2015; Revelles and van Geel, 2016) and carpological (Antolín and Buxó, 2011) studies at the site. Moreover, the study of the baskets found in the site in very similar conditions to the materials analyzed in this paper also detected the use of lime tree bark for stitching three of the eight identified coiled baskets (Herrero-Otal et al., 2021). In addition, an unshaped fragment of wood of *Tilia* sp. was also identified. Thus, the archaeobotanical data confirms the availability of *Tilia* sp. in the settlement surroundings during the Neolithic. Today, the lime tree family is represented by *Tilia platyphyllos* and *Tilia cordata* in the proximities of Lake Banyoles. The fact that lime tree bark appear in a large part among the fibre-based crafts suggests a selection and particular use of this natural resource in the archaeological site of La Draga.

Due to the volume, strength, and pliability of its fibres, lime has been one of the most important material sources in Europe. The selection of this material has been usually determined by practical factors such as suitability and availability similar to other plants like oak (*Quercus* sp.), juniper (*Juniperus* sp.), and willow, which have also been used since antiquity. The use of lime as fibres supplier has been detected in several locations since Mesolithic chronologies as in the Antrea site (Finland, 8400–8300 cal BC), where net fragments made with twisted cords and other typologies were found (Bender Jørgensen, 1992; Miettinen et al., 2008; Wigforss, 2014). Similar examples of twisted cords forming fishing nets and braided cords were recovered in the Friesack-4 site (Germany, 7700 BCE) (Gramsch, 1992) made with the same material, or the fishing nets and string at the site of Zamostje-2 (Russia, 7000–5400 cal BC) made of dicot families (Berihuete-Azorín et al., 2023). Nonetheless, some of the elements found in these two sites have also been identified as the bark of other trees, such as willow, or bast fibres like nettle. Examples of twisted cords made with lime fibres are those S-twisted from Wetzikon-Robenhausen (Switzerland, 3700–3300 BCE), the Z-twisted from Arbon Bleiche (Switzerland, 3385–3370 BCE) (Altorfer and Médard, 2000), and the ones associated with the Tisenjoch Iceman (Junkmanns et al., 2019).

Considering that bast fibre use is well documented since Palaeolithic chronologies, flax is not documented until the second half of the 6th millennium cal BC in the Iberian Peninsula (Peña-Chocarro, 1999; Pérez-Jordà and Carrión-Marco, 2011; Rovira, 2007; Stika, 2005); thus there was no evidence of flax cultivation in La Draga. Regarding the use of bast fibres in La Draga, nettle was available in the palaeoenvironment around the site (Antolín, 2013; Antolín and Buxó, 2011). There are different ways to obtain the fibres from stems of plants. The traditional way of extraction may differ depending on the specialization of the artisans. However, they are similar and consist of harvesting them manually and defoliating the stems (by dehydration or by hand), which makes the stem touchable and workable. But the material can be rinsed

Fig. 5. Experimental approach: (a) wide strips of lime tree bark; (b) lime tree bark after stripping; (c) S z,z cord making with a rope-twisting tool; (d, e) the final rope.

and ret for the same purpose. Then, the fibres can be manually extracted by breaking the bark parts from the stem by barking with different objects such as a wooden mallet and schutching the fibres. The resultant soft and resistant fibres are ready to be used for making different objects (Andersson Strand, 2012; Viotti et al., 2022).

Although we have no archaeological evidence, ethnographical and experimental data reveal that raw materials used for crafting with fibres can be dried from harvesting to the moment of manufacturing the objects. This is a way to prevent materials from shrinking as they dry out, avoid loss of quality, and facilitate their handling. This dehydration of the materials means that the time of harvesting and procurement of the material is not necessarily related to the moment when the implements are manufactured. The bark strips can be stored for long periods, and just need to be slightly rehydrated before manufacture. This allows a delay in manufacturing the implements, after harvesting and gathering the plants when they have reached the optimal quality (Wendrich and Ryan, 2012).

The availability of raw materials in the immediacies of the site and the functional analysis of objects found suggest a local production fibre crafting in La Draga. Use-wear studies detected that awls, needles, spindles and combs were used for processing fibres in La Draga (De Diego et al., 2017, 2018; De Diego, 2023), and *Mytilus galloprovincialis* seemed to be used for similar purposes (Clemente and Cuenca, 2011), as well as some other lithic pieces (Gibaja, 2011). Moreover, several bone tools recovered at the site could act as thread tensioners. They are fragments of bone shafts with two holes similar to those used in our experimentation.

The twisting technique is predominant in the cordage set from La Draga, where a single piece of braided cord was recorded. Moreover, S-twist is more common than Z-twist (Piqué et al., 2018, Romero-Brugués, 2022). S z,z is the predominant twisting pattern and lime is used in most of the cords examples from La Draga. The only cord that does not present this pattern is the only 3-ply cord with Z s,s,s torsion. There are no differences between S-twist and Z-twist cords regarding their size and type. Table 1 shows the non-selection of the raw materials used for each type of cord, either two or three strands, twisted or braided. Lime tree seems to be used indistinctively regarding the typology of the technologies used for cords and their thickness. Lime was the main raw material and the most versatile according to the variability of cords made with this material.

Although the presence of a preferable torsion pattern could be related to the raw material used in cord production and the direction the fibres adopt when they are twisted, several researchers demonstrated ropes twist direction is directly related to cultural influence (Carr and Moslowski, 1995; Johnson and Speedy, 1992; Petersen and Wolford, 2000). As an example, Minar (2001) demonstrated a wide range of factors are involved in the final cord considering cultural material factors as learning processes, so the transmission of specific attributes. Three different hypotheses to explain the final direction of twist in cordage remains from the Alachua culture (north-central Florida). These scenarios consider the spinning method, the type of fibre, and the handedness. After the pertinent observations, the three scenarios were rejected, and the study concluded with the premise that it exists a preferable twisting related to community practice and learning processes within a community related to a common learning origin in the different individuals. Thus, cordage production processes may be conservative within a group because of cultural preferences (Minar, 2001). We assumed this is what happened in La Draga. There should be culturally preferred standards that made most of the cords of the site were made with the same technique and pattern.

The single object which presents a different raw material, probably *Urtica* sp., is the case of the roll of cord which had been related to a bowstring function. This register was found near three fragments of bows on the site, and although it was not tied to the wooden weapon, authors suggested it could be used as a bowstring (Piqué et al., 2015; 2018). The measurements of the length and thickness enhance this possibility, as well as its similarity to the twisted bowstring of the Tisenjoch Iceman, although it was made of different raw materials. The use of nettle has been documented in other Neolithic contexts, like the Sweet Track site (England; 4000–3500 BCE), where nettle was used without much pre-treatment (Edom, 2019).

5.2. Cord production

The experimental approach to cord production allowed us to determine the amount of raw material needed to produce the cord, the time involved in the different steps, and the technique needed to obtain a cord with homogeneous thickness.

The acquisition of strips from lime tree is complex (Médard, 2008; Myking et al., 2005). It generally consists of cutting the branches in the spring or early summer, when the tree has reached its maturity, leaves have grown to full size and the bark is easily removable thanks to the sap which has risen. The material is usually obtained from young lime trees or new straight shots resulting in thicker branches of old pollarded or coppiced trees because this influences the fibres quality. The bark is stripped or removed from the wood and submerged in freshwater or seawater for several weeks for retting: soaking to make it softer by bacterial decay and pectin and lignin degradation. This induces the natural fibres separation in layers. Nevertheless, some experimental archaeology works suggest the use of inner bark without retting for craft purposes.

There is no evidence for the bark strip acquisition process in La Draga, where only final products have been recovered. The absence of *Tilia* sp. in the charcoal remains and its scarce presence among the wooden remains suggest that inhabitants from of La Draga transported just the strips to the site. Even so, stored bark strips have not been found at La Draga.

The results of our experimentation demonstrate the amount of raw material needed and the time invested in producing a S z,z cord 6 m long. A piece of lime bark130x4 cm in size was necessary, previously immersed in water. In this way, the preparation of the threads can be done easily by hand, although the use of a sharp tool can help to obtain thinner threads. The use of the bone rope-making tool for tightening the cord allowed us to obtain a homogeneous thickness and maintain the torsion angle and rigidity. Similar items are known since Palaeolithic chronologies, such as the one found in a cave in Swabian Jura in Germany (Conard and Malina, 2016).

Although a cord can be made by a single person, the use of this sort of tool required the cooperation of three people, but less time is consumed. The presence of a perforated diaphysis at La Draga, suggests that cord production could have been carried out with this item. This hypothesis is confirmed by use-wear observed on the tools, demonstrating their efficiency (De Diego, 2023). The time required to produce a cord from the very beginning of the process (excluding the acquisition of fibres), was approximately an hour and a half. However, three or four people were involved in the process.

6. Conclusions

The Early Neolithic site of La Draga, an archaeological settlement in the Iberian Peninsula, has provided one of the oldest fibre-based assemblages thanks to the preservation conditions at the site. The raw material used for cordage production has been identified systematically here. The importance of sampling the vegetal-based materials after their recovery and before their consolidation should be emphasised, to improve and facilitate the identification of their nature, as well as the performance of other studies.

The results showed an almost total selection of lime bark (*Tilia* sp.) and nettle stem fibre (*Urtica* sp.) to produce different types of cords, both twisted and braided. In a single case, a fragment of Poaceae was detected but it seems to be a fortuitous case. Previous archaeobotanical studies have identified the presence of these plants in the immediacies of Lake

Banyoles in Neolithic chronology, so they were available raw materials from the surroundings of the site. This, together with other use-wear analysis, suggests a local production of the cords in La Draga. Cultural standards related to traditional or common learning processes should be involved in a predominant S-twist typology of cord examples.

Moreover, contextualization with other Neolithic cord remains, which is limited by the scarcity of known examples, shows that the variability in the materials is similar to that at other sites in Europe, but different from southern latitudes, as it also occurs with basketry remains. Regarding the functionality of the cords in relation to the raw material used, no specific pattern was detected, except for the use of nettle to make what is considered a bowstring.

The experimental approach was performed to replicate the elaboration of cords regarding the raw material selection, their processing and the final cord production. This aimed to replicate cord-making at La Draga by measuring such aspects as the time consumed, the tools needed, and the number of people necessary to produce a cord, among others. These experimental programmes may help to understand crafts production processes which took place in the past and give us an overview about which aspects may be considered.

Authors' contribution

Authors contributions are as follows: MHO, collection, raw materials analysis, experimental approach, and data interpretation, writing, revision of the paper and decision to submit; SRB, technological analysis, experimental approach, writing, revision, and decision to submit; RP and AH, collection, experimental approach, writing, revision and decision to submit; MDD and AP; experimental approach, revision and decision to submit.

Declaration of Competing Interest

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

Data availability

No data was used for the research described in the article.

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References

Alcolea, M., Rodanés, J.M., 2019. Ephemeral Archaeology South of the Central Pyrenees (Huesca, NE Iberia): The Exceptional Preservation of Woody Objects in Moro de Alins Cave-site. Environ. Archaeol. doi: 10.1080/14614103.2019.1654642.

Alfaro Giner, C., 1980. Estudio de los materiales de cestería procedentes de la cueva de los Murciélagos (Albuñol, Granada). Trabajos de Prehistoria 37, 109–139.

Alfaro Giner, C., 1984. Tejido y cestería en la Península Ibérica. Historia de su técnica e industrias desde la prehistoria hasta, la romanización. Bibliotheca Praehistorica Hispana 21. CSIC Instituto Español de Prehistoria, Madrid.

Altorfer, K., Médard, F., 2000. Nouvelles découvertes textiles sur le site de Wetzickon-Robenhausen (Zürich, Suisse). Sondages 1999. Montagnac. Mergoil, pp. 35–75.

Andersson Strand, E., 2012. The textile chaîne opératoire: Using a multidisciplinary approach to textile archaeology with a focus on the Ancient Near East. Paléorient 38 (1-1), 21–40. https://doi.org/10.3406/paleo.2012.5456.

Andreaki, V., Barceló, J.A., Antolín, F., Gassmann, P., Hajdas, I., López-Bultó, O., Martínez-Grau, H., Morera, N., Palomo, A., Piqué, R., Revelles, J., Rosillo, R., Terradas, X., 2022. Absolute chronology at the waterlogged site of La Draga (Lake Banyoles, NE Iberia): Bayesian chronological models integrating tree-ring measurement, radiocarbon dates and microstratigraphical data. Radiocarbon 64 (5), 907–948.

Antolín, F., 2013. Of cereals, poppy, acorns and hazelnuts. Plant economy among early farmers (5500–2300 cal BC) in the NE of the Iberian Peninsula. An archaeobotanical approach. Universitat Autònoma de Barcelona, Barcelona. PhD Dissertation.

Antolín, F., Buxó, R., 2011. L'explotació de les plantes al jaciment de La Draga: contribució a la historia de l'agricultura i de l'alimentació de l'agricultura i de l'alimentació vegetal del Neolític a Catalunya. In: Bosch, A., Chinchilla, J., Tarrús, J. (Eds.), El PobLat Lacustre DEl Neolític Antic De La Draga: Excavacions De 2005–2005. CASC Museu d'Arqueologia de Catalunya, Girona, pp. 147–174.

Aura Tortosa, J.E., Pérez-Jordà, G., Carrión Marco, Y., Seguí Seguí, J.R., Jordá Pardo, J. F., Miret i Estruch, C., Verdasco Cebrián, C.C., 2019. Cordage, basketry and containers at the Pleistocene-Holocene boundary in southwest Europe. Evidence from Coves de Santa Maira (Valencian region, Spain). Veg Hist Archaeobot 29 (5), 581–594.

Barber, E.W., 1994. Women's work: the first 20.000 years. Women, Cloth and Society in Early Times. Norton & Company, New York.

Bazzanella, M., 2012. Italy: Bronze Age. In: Gleba, M., Mannering, U. (Eds.), Textiles and Textile Production in Europe. From Prehistory to AD 400. Ancient Textiles Series 11. 203–214, Oxford. Oakville.

Bender Jørgensen, L., 1992. North European textiles until AD 1000. Aarhus University Press, Aarhus.

Bergfjord, C., Holst, B., 2010. A procedure for identifying textile bast fibres using microscopy: Flax, nettle/ramie, hemp and jute. Ultramicroscopy 110 (9), 1192–1197. https://doi.org/10.1016/j.ultramic.2010.04.014.

Berihuete-Azorín, M., Lozovskaya, O., Herrero-Otal, M., Piqué i Huerta, R. (2023) Fishing nets and strign at the Final Mesolithic and Early Neolithic Site of Zamostje 2, Sergiev Posad (Russia). Open Archaeol. 9(1), 20220283. doi: 10.1515/opar-2022-0283.

Cacho, C., Papí, C., Sánchez-Barriga, A., Alonso, F., 1996. La cestería decorada de la Cueva de Los Murciélagos (Albuñol, Granada). Complutum 6 (1), 105–122.

Carr, C., Maslowski, R.F., 1995. Cordage and fabrics: relating form, technology and social processes. In Carr, C., Neitzel, J. E. (Eds.), Style, Society and Person. Archaeological and Ethnological Perspectives. Plenum Press, Nova York, pp. 297–343.

Caruso-Fermé, L., Piqué, R., 2014. Landscape and forest exploitation at the ancient Neolithic site of La Draga (Banyoles, Spain). Holocene 24 (3), 266–273. https://doi.org/10.1177/0959683613517400.

Clemente, I., Cuenca, D., 2011. Instrumentos de trabajo de concha en el yacimiento neolítico de La Draga. In: Bosch, A.; Chinchilla, J., Tarrús, J. (coords.) El poblat lacustre del neolíticantic de La Draga. Les campanyes dels anys 2000-2005. Museud'Arqueologia de Catalunya-CASC (Monografies del CASC, 9), pp. 137–145.

Conard, N.J., Malina, M., 2016. Außergewöhnlicheneue Funde aus den aurignacienzeitlichen Schichtenvom Hohle Felsbei Schelklingen. Archäologische Ausgrabungen Baden-Württemberg 2015, 60–66.

De Diego, M., 2023. Tecnología textil y del trabajo de la piel en el Neolítico Antiguo de La Draga, Banyoles (España) (5.300-4.900 cal BC). Aproximación funcional y experimental a los instrumentos óseos y de madera. Universitat Autònoma de Barcelona, Barcelona. PhD Dissertation.

De Diego, M., Piqué, R., Palomo, A., Terradas, X., Saña, M., Clemente, I., Mazota, M. (2018) Evidence of textile technology in the Early Neolithic site of La Draga (Banyoles, Spain). Some hypotheses. In First Textiles. The beginnings of textile manufacture in Europe and the Mediterranean: 69-80. ISBN: 978-1-78570-798-8.

De Diego, M., Piqué, R., Palomo, A., Terradas, X., Clemente, I., Mozota, M., 2017. Traces of textile technology in the Early Neolithic lakeside settlement of La Draga (Banyoles, Catalonia) from an experimental perspective. In: In Universidad Autónoma De Madrid (Ed). PlayIng With the Time. Experimental Archaeology and the Study of the Past, pp. 139–144.

Edom, G., 2019. From Sting to Spin: A History of Nettle Fibre. Urtica Books.

Evert, R.F., 2006. Esau's plant anatomy: meristems, cells and tissues of the plant body: their structure, function, and development, 3rdedn. Wiley, Hoboken.

Gibaja, J.F., 2011. La función de los instrumentos líticos tallados. In: Bosch, A., Chinchilla, J., Tarrús, J. (coord.), El poblat lacustre del neolític antic de La Draga: excavacions 2000-2005, Monografies del CASC, Vol. 9, Girona, pp. 91–100.

Gramsch, B. (1992). Friesack Mesolithic wetlands. In: Coles, B. (Ed.), The Wetland revolution in prehistory: proceedings of a conference held by the Prehistoric Society and WARP at the University of Exeter. London, pp. 65–72.

Hardy, K., 2008. Prehistoric string theory. How twisted fibers helped to shape the world. Antiquity 82 (316), 271–280. https://doi.org/10.1017/S0003598X00096794.

Haugan, E., Holst, B., 2014. Flax look-alikes: pitfalls of ancient plant fibre identification. Archaeometry 56 (6), 951–960. https://doi.org/10.1111/arcm.12054.

Herrero-Otal, M., Romero-Brugués, S., Piqué Huerta, R., 2021. Plants used in basketry production during the Early Neolithic in the north-eastern Iberian Peninsula. Veg. Hist. Archaeobotany 30 (6), 729–742.

Hurcombe, L.M., 2014. Perishable Material Culture in Prehistory. Investigating the Missing Majority. Routledge, London.
Johnson, W.C., Speedy, D.C., 1992. Cultural continuity and Change in Middle and Lade Woodlant Periods in the Upper James Estuary, Prince George County, Virginia. J. Middle Atlant. Archaeol. 8, 91–106.
Jordà Cerdà, F., Jordá Pardo, J., González-Tablas, F.J., Aura, J.E., Sanchidrián, J.L., 1983. La cueva de Nerja. Revista de Arqueología 29, 58–65.
Junkmanns, J., Klügl, J., Schoch, W., Di Pietro, G., Hafner, A., 2019. Neolithic and Bronze Age archery equipment from Alpine Ice-Patches: a review on components, construction techniques and functionality. J. Neolithic Archaeol. 283–314. https://doi.org/10.12766/jna.2019.10.
Kvavadze, E., Bar-Yosef, O., Belfer-Cohen, A., Boaretto, E., Jakeli, N., Matskevich, Z., Meshveliani, T., 2009. 30 000-year-old wild flax fibers. Science 325 (5946), 1359. https://doi.org/10.1126/science.1175404.
López-Bultó, O., Piqué Huerta, R., 2018. Wood Procurement at the Early Neolithic site of La Draga (Banyoles, Barcelona). J. Wetland Archaeol. 18 (1), 56–76.
Lukešová, H., Salvador Palau, A., Holst, B., 2017. Identifying plant fibre textiles from Norwegian Merovingian Period and Viking Age graves: The Late Iron Age Collection of the University Museum of Bergen. J. Archaeol. Sci. Rep. 13, 281–285. https://doi.org/10.1016/j.jasrep.2017.03.051.
Médard, F., 2003. Vestiges textiles et activités de filage sur le site néolithique d'Arbon-Bleiche 3 (TG Suisse). Bull Soc préhistfr 100 (2), 375–391. https://doi.org/10.3406/bspf.2003.12874.
Médard, F., 2008. L'acquisition des matières textiles d'origine végétale en préhistoire. L'apport des données expérimentales et ethnographiques. Les nouvelles de l'archéologie. https://doi.org/10.4000/nda.602.
Miettinen, A., Sarmaja-Korjonen, K., Sonninen, E., Junger, H., Lempiäinen, T., Ylikoski, K., Mäkiaho, J.P., Carpelan, C., Jungner, H., 2008. The palaeoenvironment of the Antrea Net Find. Karelian Isthmus. Finn. Antiquarian Soc. 16, 71–87.
Minar, C.J., 2001. Motor Skills and the Learning Process: The Conservation of Cordage Final Twist Direction in Communities of Practice. J. Anthropol. Res. 57 (4), 381–405.
Mineo, M., Mazzucco, N., Rottoli, M., Remolins, G., Caruso-Ferme, L., Gibaja, J.F., 2023. Textiles, basketry and cordage from the Early Neolithic settlement of La Marmotta, Lazio. Antiquity 97 (392), 314–330.
Myking, T., Hertzberg, A., Skrøppa, T., 2005. History, manufacture and properties of lime bast cordage in northern Europe. Forestry 78 (1). https://doi.org/10.1093/forestry/cpi006.
Palomo, A., Piqué, R., Terradas, X., Bosch, A., Buxó, R., Chinchilla, J., Saña, M., Tarrús, J., 2014. Prehistoric occupation of Banyoles lakeshore: results of recent excavations at La Draga site, Girona, Spain. J. Wetl. Archaeol. 14, 58–73. https://doi.org/10.1179/1473297114Z.00000000010.
Palomo, A., Terradas-Batlle, X., Piqué, R., López-Bultó, O., De Diego, M., Clemente-Conte, I., 2021. Experimentación en torno al proyecto de investigación sobre el yacimiento neolítico de la Draga (Banyoles-Girona). Boletín de Arqueología Experimental 14, 85–101. https://doi.org/10.15366/baexuam2020.14.005.
Palomo, A. (2012) Tecnologia lítica i de la fusta de la prehistòria recent al nord-est peninsular. Anàlisi tecnomorfològica i experimental. PhD Dissertation. Barcelona, Universitat Autònoma de Barcelona.
Papí Rodes, C., 1992–1994. Improntas de esterillas en cerámicas del Bronce Final de la Peña Negra (Crevillente, Alicante). Campañas de 1983 y 1984. Lvcentvm 11–13, 39–49.
Peña-Chocarro, L., 1999. Prehistoric agriculture In Southern Spain during the Neolithic and the Bronze Age. The application of ethnographic models. BAR International Series S818, Oxford.
Pérez-Jordà, G., Carrión-Marco, Y., 2011. Los recursos vegetales. In: Pérez Jordà, G., Bernabeu Aubán, J., Carrión Marco, Y., García Puchol, O., Molina Balaguer, L., Gómez Puche, M. (Eds.). La Vital (Gandía, València). Vida y muerte en la desembocadura del Serpis durante el III y el I Milenio a.C. Serie Trabajos Varios del SIP. Servei d'Investigacions Prehistòriques. Diputació de València. València.
Petersen, J.B., Wolford, J.A., 2000. Spin and Twist as Cultural Markers: A New England Perspective on Native Fiber Industries. In: Drooker, P.B., Webster, L.D. (Eds.), Beyond Cloth and Cordage: Archaeological Testile Research in the Americas, pp. 101–1017. University of Utah Press, Salt Lake City.
Piqué, R., Palomo, A., Terradas, X., Aguer, C., Bogdanovic, I., Chinchilla, J., García, I., Jover, A., López, O., Moitinho, V., Buxó, R., Bosch, A., Tarrús, J., Saña, M., Vivar, G., 2014. Registro, análisis y conservación de los objetos de madera del yacimiento neolítico de La Draga Banyoles, Catalunya. AA.VV. Arqueología subacuática española: actas del I Congreso de Arqueología Náutica y Subacuática Español. Cartagena, marzo de 2013. Ed. Cartagena. ARQUA Museo Nacional de Arqueología Subacuática. Universidad de Cádiz, 978-84-9828-472-0, pp. 1141–1151.
Piqué, R., Palomo, A., Terradas, X., Tarrús, J., Buxó, R., Bosch, À., Chinchilla, J., Bogdanovic, I., López, O., Saña, M., 2015. Characterizing prehistoric archery: technical and functional analyses of the Neolithic bows from La Draga (NE Iberian Peninsula). J. Archaeol. Sci. 55, 166–173. https://doi.org/10.1016/j.jas.2015.01.005.
Piqué, R., Romero, S., Palomo, A., Tarrús, J., Terradas, X., Bogdanovic, I., 2018. The production and use of cordage at the early Neolithic site of La Draga (Banyoles, Spain). Quat. Int. 468, 262–270. https://doi.org/10.1016/j.quain t.2016.05.024.
Revelles, J., Antolín, F., Berihuete, M., Burjachs, F., Buxó, R., Caruso, L., López, O., Palomo, A., Piqué, R., Terradas, X., 2014. Landscape transformation and economic practices among the first farming societies in Lake Banyoles (Girona, Spain). Environ. Archaeol. 19 (3), 298–310. https://doi.org/10.1179/1749631414Y.0000000033.
Revelles, J., Cho, S., Eriarte, E., Burjachs, F., van Geel, B., Palomo, A., Piqué, R., Peña-Chocarro, L., Terradas, X., 2015. Mid-Holocene vegetation history and Neolithic land-use in the Lake Banyoles area (Girona, Spain). Palaeogeogr. Palaeoclimatol. Palaeoecol. 435, 70–85. https://doi.org/10.1016/j.palaeo.2015.06.002.
Revelles, J., van Geel, B., 2016. Human impact and ecological changes in lakeshore environments. The contribution of non-pollen palynomorphs in Lake Banyoles (NE Iberia). Rev Palaeobot Palyno 232, 81–97. https://doi.org/10.1016/j.revpalbo.2016.05.004.
Romero-Brugués, S., 2022. Cordes i cistells elaborats amb fibres vegetals entre el 2300–800 cal BC al Nord-Est peninsular i Balears: Tecnología, materia prima i funció. Universitat Autònoma de Barcelona, Barcelona. PhD Dissertation.
Romero-Brugués, S., Piqué Huerta, R., Herrero-Otal, M., 2021. The basketry at the early neolithic site of La Draga (Banyoles). J. Archaeol. Sci.: Rep. 35, 102692 https://doi.org/10.1016/j.jasrep.2020.102692.
Rovira, N., 2007. Agricultura y gestión de los recursos vegetales en el sureste de la Península Ibérica durante la Prehistoria reciente. Universitat Pompeu Fabra, Barcelona. PhD Dissertation.
Soffer, O., 2004. Recovering Perishable Technologies Through Use Wear on Tools: Preliminary Evidence for Upper Paleolithic Weaving and Net Making. Curr. Anthropol. 54 (3), 407–413.
Soffer, O., Adovasio, J.M., Hyland, D.C., 2000. The "Venus" figurines: textiles, basketry, gender and status in the Upper Paleolithic. Curr. Anthropol. 41 (4), 511–537.
Stika, H.P., 2005. Early Neolithic agriculture in Ambrona, Prov. Soria, central Spain. Veg. Hist. Archaeobotany 14, 189–197.
Suomela, J.A., Vajanto, K., Räisänen, R., 2017. Seeking nettle textiles – Utilizing a combination of microscopic methods for fibre identification. Stud. Conserv. 63 (7), 412–422. https://doi.org/10.1080/00393630.2017.1410956.
Terradas, X., Piqué, R., Palomo, A., Antolín, F., López, O., Revelles, J., Buxó, R., 2017. Farming Practices in the Early Neolithic According to Agricultural Tools: Evidence from La Draga Site (Northeastern Iberia). In: García-Puchol, O., Salazar-García, D.C. (Eds.), Times of Neolithic transition along the Western Mediterranean. Fundamental issues in archaeology. Springer, Cham, pp. 199-220. doi: 10.1007/978-3-319-52939-4_8.
Viotti, C., Albrecht, K., Amaducci, S., Bardos, P., Bertheau, C., Blaudez, D., Bothe, L., Cazaux, D., Ferrarini, A., Govilas, J., Gusovius, H.J., Jeannin, T., Lühr, C., Müssig, J., Pilla, M., Placet, V., Puschenreiter, M., Tognacchini, A., Yung, L., Chalot, M., 2022. Nettle, a long-known fiber plant with new perspectives. Materials 15, 4288. https://doi.org/10.3390/ma15124288.
Wendrich, W., Ryan, P., 2012. Phytoliths and Basketry Materials at Çatalhöyük (Turkey): timelines of growth, harvest and objects life histories. Paléorient 38 (1–2), 55–63. https://doi.org/10.3406/paleo.2012.5458.
Wigforss, E., 2014. Perished Material-Vanished People. Understanding Variation in Upper Paleolithic/Mesolithic Textiles Technologies. Department of Archaeology and Ancient History, Lund Universitet.