Research Article

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The Loom Weight, the Spindle Whorl, and the Sword Beater – Evidence of Textile Activity in the Early Neolithic?

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Abstract: After the development of an experimental protocol concerning an enigmatic tool rarely recognized archaeologically and potentially used as a sword beater, that is, blades in bone or wood, we were able to establish certain diagnostic criteria. These tools recur in sites in the south of France and Italy, for example, dated to 3023 BC. If our experimental reference work is extended, we may be able to determine which fibers were used for textile production during the Neolithic. This could reveal a virtually unknown field in the prehistoric economy and shed light upon the procurement and the use of plant and animal resources developed by populations living in a period when domestication was just beginning.

Keywords: fibers, textile tools, polish, use-wear, experimentation

1 Introduction

The study of textile production is an effective approach to study the technical systems of the past. This domain of production is strongly linked to the exploitation of environmental resources and relates strongly to the link between societies and their environment.

During neolithization, when habits and strategies to acquire resources changed drastically, textile production is of great interest in investigating the relation to animal or vegetal resources involved in different stages of production such as fibers, colorants, and tools.

Paradoxically, our knowledge of Neolithic European textile industries is poorly developed despite a new dynamic initiated a dozen years ago (Stone, 2010; Van Gijn, 2005, 2007).

One of the specific features of textile production is the perishable nature of both their products and the waste resulting from the different phases of production. Consequently, the information must be sought out almost exclusively through the study of the tools involved in the different stages of this production, from the acquisition of fibers up to the finished fabric (Barber, 1991, 2003; Breniquet, 2008; Carington Smith, 1992; Levyand & Gilead, 2012).

The use of warp-weighted looms has been attested in Europe since the Early Neolithic, notably on the Tiszajeno site (in the Körös culture) where a set of pyramidal loom weights and two separate post-holes 185 cm apart have been discovered, revealing a set of loom weights and post-holes (Barber, 1991). The Early

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Neolithic shows a great variety of types of loom weights: pebbles with notches, bobbins, cylinders, spheres, pyramids, and cones (Carington Smith, 1975).

Pyramid loom weights are essentially found in the Balkans (Tizsa Valley) and bobbin scales mainly in the Aegean area. This distribution includes some exceptions: Corinth revealed pyramidal and conical loom weights and cubic loom weights were found in Crete (Carington Smith, 1977, 1992, 2000; Cheval, 2011a).

This diffuse evidence of textile productions in the Early Neolithic, mainly found in the Aegean and the Middle East, should lead us to re-examine existing archeological collections in the hope of finding other possible tools related to textile production.

While spindle whorls are systematically identified in later phases, some publications deny their existence before the Middle Neolithic even if several artifacts that morphologically could be whorls have been discovered (Ayobi Arroq, 2013). Even if this is probably due to a circular argument: “there were no spindle whorls before the Middle Neolithic, so this cannot be.” It is still difficult to argue the identification of a spindle-whorl convincingly.

Other tools made from bone or antler could be of greater interest in looking for testimonies of textile production. Unlike spindle whorls, several tools directly in contact with fibers are more likely to show use-wear and give information about textile activities and also the nature of the fibers.

During our research on weaving tools from the Neolithic of the Northern Mediterranean, various artifacts made of bones or antlers have drawn our attention by their morphology: “awls” on metapods, bovine ribs, antler tools, and so on.

Some of these tools could be compared to sword beaters as represented in later context iconography. The Terracotta Lekythos, attributed to the Amasis painter (Metropolitan Museum of New York) and dated 550–530 BC, is one of the oldest representations and seems to depict sword beaters (Breniquet & Mints, 2000). It shows a warp-weighted loom with two women weaving. The one on the right passes the shuttle through the loom shed, while a kind of large stick is placed at the top; the other woman seems to be packing the loom picks with a similar stick. Another representation, the stele of Genetiva in Gaul, shows a woman holding a small object with a cylindrical section (Roche-Bernard, 1993). These objects are well known in later antiquity and called “pin beaters” (Wild, 2002). Medieval illuminated manuscripts often represent the same object: a kind of large flat wooden spatula with a handle: a sword beater (e.g., *Education of the Blessed Virgin/Liber Floridus*-/XV^{es}).

Like iconography, ethnography displays a large variety of sword and pin beaters. These, observed in many cultures, adopt different shapes and types. Wood, antlers, and bone are used. In some cases, we may observe very simple objects, like a simple wood blade (culture Li, China, or Navajo in North America) (Mc Manis & Jeffries, 2009). In other cases, tools can be much more elaborate, for example, Lappish in Scandinavia with highly decorated antler tools. Finally, some tools are simpler; just metapodial bone carved into a point as in the Chipaya region in Peru (Métraux, 1936) or simple bones blades in Bolivia (Textile Collection from Museo Nacional de Etnografía y Folklore, La Paz, Bolivia). Thus, sword beaters present a great morphological diversity, but they all share the following characteristics: a worn, rounded working edge, a variable extension of polish on this edge, and a more or less flat section. These morphological criteria enable us to identify several “candidates” among Neolithic artifacts.

However, this parallel is limited because the shape alone does not determine the function, and several pointed metapods “with pulleys” are often interpreted as awls or basketry tools (Buc, 2010). Other tools with a worn, rounded working edge are interpreted as smoothers for ceramics (Martineau & Maigrot, 2004) or as instruments having worked on leather (Legrand & Sidéra, 2006; Lompre & Negroni, 2006).

Only use-wear analysis will allow us to determine the function of this type of artifact. Therefore, after an initial approach concerning the work on plants, we implemented a systematic experimental database on the use of these artifacts as swords or pin beaters. The implementation of this experimental protocol concerning a potential use as sword beaters completed the referential for other uses proposed in the literature, particularly as scrapers, spoons, or end scrapers (Bofill Martínez & Taha, 2013; Legrand & Radi, 2011; Sidéra & Legrand, 2006). Based on this experimental referential, we examined a series of artifacts from two Early Neolithic sites in Central Italy: Catignano and Colle Cera. Central Italy is well documented regarding chronology and cultures (Binder, Lepère, & Maggi, 2008; Colombo, Serradimigni, & Tozzi, 2008; Grifoni Cremonesi, 2001, 2012; Radi, 2006; Tozzi & Zamagni, 2003).

2 Material and Methods

2.1 Use-Wear Approach and Production of a Collection for a Comparison

Analyses of both experimental and archaeological pieces were initially observed with the naked eye (observation of polish) and with a microscope ($\times 10$ to $\times 200$). Use-wear was described using a metallographic stereomicroscope (Leica DMLM) with reflected light ($\times 50$ to $\times 500$). Archeological artifacts were cleaned under the stereomicroscope using a wooden toothpick and distilled water to remove the sediment when necessary.

Finally, a selection of tools was observed with SEM to describe the topography of striations.

Considering osseous material tools, we paid particular attention to certain criteria. The polish is interpreted according to two criteria: its extent, position, and degree of shine (sheen, gloss, gleaming to varnished). Striations are fine grooves on the surface of the tool resulting from rubbing fine abrasive particles.

We analyzed archeological artifacts through comparison with a reference collection and bibliographical data. On the basis of an experiment on a corpus of 15 blades used as sword beaters and a comparison with use-wear highlighted from other functions (Legrand, 2003; Martineau & Maigrot, 2004; Sénépart, 1992), we established the diagnostic stigmata of this function (Cheval, 2011b; Cheval & Radi, 2013).

The reference collection was produced from seven sheep metapods, two from deer, two from cow rib, two deer antler tools, and finally two pine-wood blades. Other wooden sword beaters were used (two buxux and one oak).

We reproduced the gesture of a sword beater, knowing that whatever the type of loom, it is always a launched percussion and the contact zones vary only according to the section of the tools (Figure 1). It results in characteristic use-wear: often bifacial covering, glossy to varnished polish, with homogeneous parallel striations, more or less perpendicular to the strike angle. On bone, marks of wear formed more quickly and are more contrasted. Antler is marked less quickly although use-wear is similar though noticeably more diffuse.

The repeated contact with fibers shows up differently depending not only on the nature of the fiber and how it has been treated but also on the raw material of the tool itself. To the naked eye, there is polishing of variable intensity; this variability lends itself to a diagnosis.

We tested several fibers actually or potentially used during the Neolithic in the Mediterranean area, especially flax, tilia (lime tree liber), nettle, and animal fibers, though this latter feature requires further investigation.

Figure 1: Functioning of a sword beater, and zones of the tool's contact with the warp threads.

Some mineral-rich taxa mark faster on bone, as in the case of lime tree (*Tilia* genus) (15 min) and flax (60 min for large threads, and 110 for fine). Wool marks less rapidly (150 min). The case of the nettle is more complex: depending on whether it is scraped or retted, it will react differently. This is the case of fresh scraped nettle: the fiber is stronger, it marks the support faster than when it is obtained by rotting the pulp, when it is much thinner and more delicate.

Bone shows better marks. Nevertheless, the stigmata are quite similar whether bovines, sheep, and goats have been used, whereas deer is slightly denser. In contrast, antler seems less dense and usage wear takes longer to appear.

Through SEM, we can see the difference very well between the striations left by wool threads on bone (Figure 2) and those left by flax threads. The traces left by wool are fainter, while those made by flax are strongly marked. However, flax threads previously worked on antler do not show up in the same way on bone, where they show up in the same way as wool.

Figure 2: Experimental uses wear on bone tools (flax and wool).

We tried to see if chemical residue analysis could give us some clues as to the type of fibers in contact with our tools. However, the first attempts were unsuccessful. Indeed, animal fibers leave the same

chemical residues as hard animal materials do (bone, antler), like plant fibers having undergone various treatments before being transformed into thread, nothing is detectable. Currently, we are working on new reproductions of tools and wool with lanolin left on: that is to say, we just rinsed it with water and some saponaria (*Saponaria officinalis* L.).

A topographic surface (tribology) analysis was attempted on experimental tools (with R. Vargiolu at the Ecole Centrale of Lyon).

The spectral analysis of the surface wavelets might well reveal the signature of the materials, which were in contact with the tools. This methodology is under experimentation. Before being able to exploit these data, analyses will have to be multiplied.

Our experimental collection was compared to available data for other functions (Table 1). We will then dispose of criteria we can use for archeological artifacts.

2.2 Residue Analysis

Microscopic examination of both longitudinal and cross-sectional samples is typically used to determine the nature of fibers. The distinction between plant and animal fibers (e.g., hairs) results from a topographic observation in SEM in longitudinal and transversal views.

Samples are prepared in two phases. A few unprepared fibers were laid on brass studs, previously covered with adhesive patches. In parallel, other fibers were covered with a thin layer of gold to make the surface conductive.

After a first observation showing a mineral concretion, sampling was carried out to try to dissolve the calcareous residues with hydrochloric acid (HCl) diluted at 10%.

2.3 Archeological Corpus

In this article, we focus on two sites from central Italy: Catignano and Colle Cera, both located in Abruzzo.

Catignano is a Neolithic settlement in the Province of Pescara in Abruzzo. It gave its name to a culture characterized by pottery with an exceptionally fine paste very well kilned,¹ with red painted stripes. The village of Catignano was composed of a wide variety of structures, most of them circular. Some rectangular ones with an apse at one end are interpreted as shacks.

In an environment dominated by forests, the presence of several types of gramineae and leguminosae: einkorn wheat (*Triticum monococcum*), emmer (*T. dicoccum*), barley (*Hordeum vulgare* L.), lentil (*Lens culinaris*), and broad bean (*Vicia faba* L.) reflects a well-established agriculture. Wild fruit picking is also attested (apples, hazelnuts, and pears.).

Sheep, goats, bovineae, and suidae were bred. Hunting was practiced but had a secondary role.

Colle Cera, near Loreto Aprutino (Pescara, Abruzzo), is a large Neolithic settlement on a hill-top. The settlement belongs to the cultural setting known as Cultura di Catignano.

The diversity of the forms certified by ethnography and iconography initially led us to retain a broad spectrum of objects: round sticks pointed at both ends, sword beaters (blades with a haft or not). These objects display the following characteristics: a blunted edge; a more or less-extended polished edge and a more or less flat section. This morphological preselection of artifacts included 19 pieces. The microscopic analysis allowed us to exclude a number of items, and we finally identified 12 items as probable pin beaters (Figure 3).

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¹ It's called ceramic *figuline*.

Table 1: Summary of diagnostic criteria for distinguishing different working materials

	Clay working		Fiber working		Leather working	
	Fresh clay: Scraper	Dry clay: Spoon	Basketry	Weaving sword or pin beater	End-scraper	“queueuse” Stake
Polish/glossy or brightness	Moderate	Invasive polish	Invasive	Moderate to invasive	Moderate to invasive	Invasive
Striations	Unobtrusive	Dull	Gleaming to varnished		Sheen	Gloss
	Curved and parallel secant striations	Narrow, deep, untidy, intertwined	Short, thin, numerous, intertwined	Numerous, parallel between them and at right angles to the edge (Cheval & Radi, 2013)	At right angles to the sharp edge	Gleaming to varnished
Bibliography	(Maigrot, 1997) (Sénépart, 1992)		(Legrand, 2003) (Stone, 2010)		(Van Gijn, 2005, 2007)	

Figure 3: Map of sites.

3 Results

3.1 Catignano

The artifact Ca-12 shows a characteristic varnished appearance: polished, homogeneous, smooth; micro-topography: parallel, narrow, straight, and shallow striations, which are oriented perpendicularly to the long axis of the tool. These use-wear traces are similar to those on pin-beater tools.

On contact areas of the tool, we can observe a series of parallel striations, slightly oblique relative to the perpendicular from the axis of the object. This arrangement of striations is characteristic and reflects the movement during the thrashing of the weft perfectly. We can observe similar use-wear on the experimental tools used with thin flax threads (Figure 4).

3.2 Colle Cerra

Object CC-11 shows not only use-wear but also a crisscross concretion on its surface (Figure 5). Therefore, this artifact interests us for two reasons.

CC-11 is composed of three fragments of a little incomplete tool: two matching together for a total length of 60 mm and a third detached fragment 20 mm long.

The maximum width reaches 17 mm (fragments a + b) and 20 mm (fragment c). The minimum total length can thus be assessed at 106 mm. The object is completely manufactured; however, it is impossible to identify the bone. Presumably, the tool required a bone bigger than a metapodia, and as its shape does not suggest a rib, it may have come from a diaphysis of a long bone such as a tibia or femur.

Figure 4: Drawing of Ca-12 with localization of polishes and microscopic views.

The thin blade has a constant thickness of 3 mm and a single edge. It is a carefully shaped tool: even if grooving traces are still visible on the upper part, the end was perfectly worked, round, and beveled.

Macroscopically, this object shows an intensive polish, invasive, and glossy on the edge of the “bottom” of the blade. The break occurred after the polishing and striation and was therefore posterior to use.

Under the microscope, at low magnification ($\times 10$), fine striations parallel to each other and perpendicular to the cutting edge can be observed. They are narrow and straight, shallower, and smoother than flax striations.

With SEM, we can distinguish two sorts of striation: (1) shallow but clearly marked on the surface, with a V-shaped section; (2) much lighter and with a shallow dished section.

Such types of use-wear could indicate work with unretted nettle fibers as well as an animal fiber. Because wool is not attested in Early Neolithic contexts, we can exclude this hypothesis, but several other animal fibers could have been used: horse hair, goat, and so on, and we know that many types of hair were employed, like badger in Hochdorf (Banck-Burgess, Raeder Knudsen, Walton Rogers, & Hübner, 1999) (Figure 6).

The very weathered residual concretions are located at three separate points on both sides. This position indicates that the object was wrapped, voluntarily or not, in the substance or had even slipped between two layers of it.

A microscope observation was carried out ($\times 100$ and $\times 200$). This preliminary observation enabled us to note fibers emerging the concretion: remnants of the mineralized cloth. As the concretions are limestone, the fibers have been included in the concretion.

Figure 5: Drawing and photo of CC-11 showing localization of use-wear.

The fibers are impregnated with mineral concretions. An extreme thinness of the fibers (5–6 μm) can be noted. An HCl cleaned-up sample enables us to see fibers freed in the longitudinal sight/view (Figure 7).

The reticulated appearance of the concretions suggests a weave. Fibers are not randomly disposed but organized. Individual strands of twisted sets can be seen at first sight (Figure 6). This twisting is noticeably light, and the degree of deterioration does not allow us to identify the type of twisting resulting from spinning.

Microscopic examination of both longitudinal and cross-sectional samples is typically used to determine the nature of fibers. The distinction between plant and animal fibers (e.g., hairs) results from a topographic observation in SEM in longitudinal and transversal views (Janaway, 1987).

Animal hair fibers are covered with layers of overlapping scales, while vegetable fibers appear as smooth cylindrical bundles with flexural nodes (Cheval, 2011a). Stem fibers (e.g., linen, nettle) have a more or less polygonal section with a lumen in the center also called the medullary canal (Moulerat, 2000).

As we said, the fibers being impregnated with mineral concretions, their reading was impossible, except that the extreme thinness of these fibers (5–6 μm) was to be noted.

Figure 6: Threads on CC-11 observations with naked eye and microscope.

Figure 7: Fibers without concretions (a) and (b).

In a second stage, a sampling was made after a moderate attempt to dissolve the calcareous residues with HCl diluted to 10%. It was a delicate operation with a risk of dissolving the fibers.

Nevertheless, this new sample allowed us to see fibers freed from their calcareous gangue.

In a longitudinal view, we can see smooth fibers perfectly with folds of flexion characterizing vegetable fibers of Liber origin (such as flax and hemp).

The closer examination of the sample enabled us to see the transverse section of these fibers, a determining element for the identification of our taxons. Given the cultural context, which eliminates the possibility of hemp (no credential note) and the thinness of the fibers, we could assume linen. However, linen fibers are faceted, and as they have a polygonal section, the folds of flexion mark an obvious characteristic X, and the lumen, that is the internal conductive canal, is very fine (Moulherat, 2000).

Our fibers are not faceted and are slightly oval. The lumen seems rather wide, reducing the fiber walls. It is possible that these fibers are nettle (genus *Urtica*), and this taxon is attested during the Neolithic in the Abruzzo region (Shelton, 2001; Spiteri, 2012). Nevertheless, a better state of conservation would have allowed a more precise determination.

4 Discussion: A Better Understanding of Textile Production

4.1 Identification of Textile Production Tools in Early Neolithic Sites

Traditionally, it is affirmed that the mastery of textile techniques dates from Middle Neolithic. This assumption derives from the multiplication of spindle whorls during this period. While whorls are direct evidence of the production of threads and therefore of textiles, and their absence cannot be interpreted as the absence of textile production. However, not only can threads be generated without whorls but also these could have been made of some perishable material. In addition, we stress that possible whorls are not identified in early Neolithic sites. For example, in Catignano, numerous perforated shards could have been used as spinning tools (Tozzi & Zamagni, 2003). Moreover, there are also spindle whorls from Ripa Tetta (Tozzi, 2002) or Rendina (Cipolloni, 2002).

4.2 Early Neolithic Fibers Used

As concerns fibers, it is classically considered that only vegetable fibers were exploited during the Neolithic (Médard, 2002). This relies on the direct determination of fibers in several archeological contexts. Whatever the case, difficulties of preservation must be taken into account in this domain. Therefore, the analysis of blades that keep the signature of these fibers can help us to have a glimpse of the types of fibers used in the north of the Mediterranean basin.

Also, ropes and cords found in Paleolithic sites like Lascaux (Glory, 1958; Leroi-Gourhan et al., 1979) or early Neolithic sites (Piqué et al., 2018) confirm a real knowledge of work with plant fibers.

More indirectly, the study of lithic tools on the scraping of flexible plants gives the same indications (Caspar, Feray, & Martial, 2005; Gassin et al., n.d.; Gassin, Marchand, Claud, Guéret, & Philibert, 2013).

Animal and vegetal fibers do not have the same mechanical properties. Animal fibers are more fragile than fibers from plant stalks (flax, hemp) and even more than phloem fibers (obtained from under the bark of certain trees such as oaks or lime trees). In fact, the traces left on the bone surface when switching from animal fiber yarns to plant fibers appear to be smoother than those left by the latter. For the time being, from the cardial material I have observed, only the Colle Cera artifact (CC-11) shows this type of trace. However, it should be noted that one vegetable fiber seems to yield relatively equivalent stigmata: the nettle wire. Nevertheless, the repository of nettle fibers must be reconsidered because the wires that were used in the experiment were obtained by retting, which gives a fragile and delicate fiber. However, it is very likely

that nettle fibers were obtained by scraping with checkmark blades (ongoing experimentation by B. Gassin & C. Cheval). Indeed, the recovery of fibers by scraping is much more effective than by retting, and fibers whose texture remains silky appear altogether more robust and more resistant. Therefore, the experimentation for this category of fibers will have to be renewed.

Whether the fibers employed were from the wild or domesticated species has still to be investigated. With nettle, the question hardly arises because it is a ruderal species. However, direct evidence of the use of the dioecious nettle (*Urtica dioica*) in the Neolithic and Bronze age is well attested (Bergfjord & Holst, 2010; Bergfjord et al., 2012; Ryder & Graba-Sanders, 1987; Trolldoft Andresen & Karg, 2011). On the other hand, there are traces that seem rather to be linked to the work of vegetable fibers although doubt is permitted concerning some artifacts: most fragile fibers in the form of thin threads were in contact with some tools like CC-11. Therefore, one can think of animal fibers that can be quite thin; however, the remnants of fibers on the tool of the CC11 plead for a possible exploitation of urticacea fibers that have a reputation for being very fine and delicate (Hurcombe, 2008).

In the case of traces from animal fibers, it would be interesting to multiply these identifications. Indeed, sheep wool as we know it nowadays did not yet exist since these modern fibers have been developed through the selection of animal breeds. Wool was really developed in the Bronze Age, and the animals resembled Soay sheep. Furthermore, other taxa were used for textiles, sometimes as unexpected as dog, cat, horse, and even badger (site of Hochdorf Banck-Burgess et al., 1999). Indeed, the exploitation of animal fibers is not necessarily related to their domestication: some hunter-gatherer societies harvested molting hairs in the wild (horsehair, wild goats among the Amerindians, and Thar), or spider's webs in Vanuatu, New-Guinea, and French Polynesia.

5 Conclusion

The results of this study show the efficiency of applying a systemic approach to textile production by treating the entire *chaîne opératoire* of perishable production through the study of production-associated tools.

The use-wear examination of a series of tools from two Early Neolithic sites allows us to identify two pin beaters. These results clearly attest the textile production in these two sites and help to confirm the diffuse evidence of textile production during the Early Neolithic. Other objects of similar shapes and dimensions come from Cardial sites like La Balance, the Baudinard cave, Fontbrégoua other objects rise question about their functions although we know that homology does not always lead to a similar way of functioning.

Also, the postulate generally accepted that textile productions were only developed from the Middle Neolithic, is simplistic, and therefore merits a review of the analysis of certain artifacts. These should even be the subject of systematic analysis, site by site, aimed at highlighting these use-wears on these types of objects or on other forms of tools.

The interest of working on this type of tool allows us to approach ancient periods, for which direct testimony is lost.

The possibility of identifying the fibers used opens up new prospects for the knowledge of animal or plant resources used in textile production.

The identification of diverse plants used for threads and textile production leads us to a better understanding of the relationship prehistoric societies had with their vegetable resources.

With this problem, this research allows us to throw new light on the current issues of the Neolithic economy in pastoral societies. Prehistoric societies are often approached today through nonperishable productions or types of objects. Here, we have developed a panel from the technical system as a whole.

This approach provides a very powerful tool to understand how to identify the raw materials that were used and so to detect textile activity in early prehistoric periods.

We hope this new study will lead to a better understanding of the history of textile production in prehistoric societies.

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