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Textile production in Late Bronze Age Khania. Evidence from the Greek-Swedish Excavations at the Agia Aikaterini Square, Kastelli*

In 2005, the Danish National Research Foundation provided substantial funding for an international and interdisciplinary team to conduct cutting-edge research examining textile production in the Bronze Age — both in Scandinavia and in the eastern Mediterranean. This paper presents the initial findings of the Mediterranean research programme *Tools and Textiles – Texts and Contexts*. A description of the research project can be found at <www.hum.ku.dk/ctr> and will be published extensively (Andersson Strand – Nosch forthcoming). The research programme is interdisciplinary, with collabora-

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tion including historians, archaeologists, philologists, hand-weavers, spinners and textile specialists from all over Europe and the United States.[1]

As a tribute to the organisers of the 10th International Cretological conference, we have chosen to elucidate textile production at Khania in the Late Bronze Age in this paper. Although the *Master of Khania* is slightly underdressed, it is important to remember that there was a tremendous need for textiles in a Minoan town like Khania. The population constantly needed to produce thread in order to meet the need for clothing, domestic textiles like beddings and carpets, sacks and sails.

The Bronze Age represents the first time in history when textile production in some areas developed from household production to standardised, industrialised, centralised production, on the basis of a division of labour (Barber 1991). The development of dye industries, colour extraction and the intensive use of colour symbolism in dress demonstrate that the Bronze Age shepherds were using selective breeding in order to obtain a variety of wool colours and qualities.

During this same period, there were other developments occurring, including palace economies, new means of production, inscriptions with extensive records on production management, tools, glyptic, frescoes and relief iconography in which various types of dress are visible. It is thus important to analyse and discuss the parameters of the technology and the development of this intensive, industry-like production of textiles, and its impact on society. The goal is to reveal how tools and technology developed to meet the new demands. In the quasi-absence of the textiles themselves, it is necessary to investigate other remains of textile production, such as depictions, archaeological contexts and textile tools (Andersson – Nosch 2003).

The missions of the research programme *Tools and Textiles – Texts and Contexts* are to:

• understand the technological parameters for textile production

1 We warmly thank Margarita Gleba, Ulla Mannering, Anne Batzer and all our collaborators for their advice and trust.

- elucidate the economic and cultural impact of textiles and textile manufacturing on society
- develop experimental textile archaeology as a scientific method
- disseminate this new knowledge to the academic community in general.

When the technical analyses of tools and archaeological textiles are woven together with the historical, ethnographical, and anthropological knowledge and theoretical frameworks, the result will not only be a stimulating collaboration, but also new knowledge about textile production and its place in Bronze Age societies.

This research programme combines three approaches: textile tool studies, experimental testing and context studies. In order to combine these approaches successfully, we need specialist knowledge from various perspectives. We therefore have composed an international team of archaeologists who are investigating Aegean and Near Eastern textile tools and technology. The team is composed of (as of Autumn 2006): Assaf Yasur-Landau (Tel Kabri, Israel); Luca Peyronel and Elena Felluca (Ebla, Syria); Iris Tzachili and Stella Spantidaki (Akrotiri); Maigorzata Siennicka and Lorenz Rahmstorf (Tiryns); Iphygenia Tournavitou and Mina Nikolovieni (Mycenae); Erik Hallager and Maria Bruun (Khania); Pietro Militello (Hagia Triada, Phaistos); Joanna Smith (Cyprus); Lena Klintberg and Ann-Louise Schallin (Berbati, Midea, Asine); Anna Fahlén (Asine); Vassilis Aravantinos, Maria Emanuela Alberti and John Fappas (Thebes); Rainer Feldbacher and Peter Fischer (Tell el'Ajjul, Gaza Strip, Tell abu al'Kharaz, Jordan); and Marcella Frangipane, Romina Laurito and Emanuela Cristiani (Arslantepe, Turkey).

Bronze Age textile tools

In research on the Mediterranean area, there is a great deal of confusion about the definition of textile tools, as the primary analyses are frequently based on their shape and decoration rather than on their function. A further problem is that analyses of textile tools are rarely discussed or published systematically. The first source group

to investigate is thus the textile tools, but utilising a functional approach: How did they function? What were their qualities and limits? How time consuming were the various stages in the textile production? It has been demonstrated that variations within a tool group determine variations in the final textile product (Andersson 2003). The variations in the tools thus provide information concerning very specific qualities in the cloth or thread, and suggest the type and quality of textile production in a given place. The uniformity of tools, the number of tools and the distribution of tools can provide valuable information on the organisation of production and its role in ancient economies.

To achieve the goals of the research program, we are — in close collaboration with the international team — gathering data on textile production, in order to facilitate the comparison of textiles tools via a common database designed by the Danish National Research Foundation's Centre for Textile Research. The comparison of the contexts of textile productions regarding the individual sites is being undertaken by the collaborators. Meanwhile, at the Danish National Research Foundation's Centre for Textile Research, reconstructed Bronze Age textile tools are being tested systematically in a series of controlled experiments.[2] The experimental testing is being conducted by the Centre's experienced textile technicians handweaver Anne Batzer and archaeologist Linda Mårtensson. The tests were designed according to the Centre's principles for conducting experimental research (Mårtensson 2007). Of relevance here are the systematic tests of wool spinning with an 8 gram spindle whorl and an 18 gram spindle whorl, as well as the weaving tests conducted using the wool yarn spun with the 8 gram whorl (see <www.hum.ku.dk/ctr>).

During the summer of 2006, in collaboration with the Greek-Swedish excavation team at Khania, Eva Andersson and Maria Bruun examined the textile tools from this excavation. Approximately 400

2 The tools were reconstructed at the Lejre Experimental Centre, Denmark, and we are greatful for this collaboration.

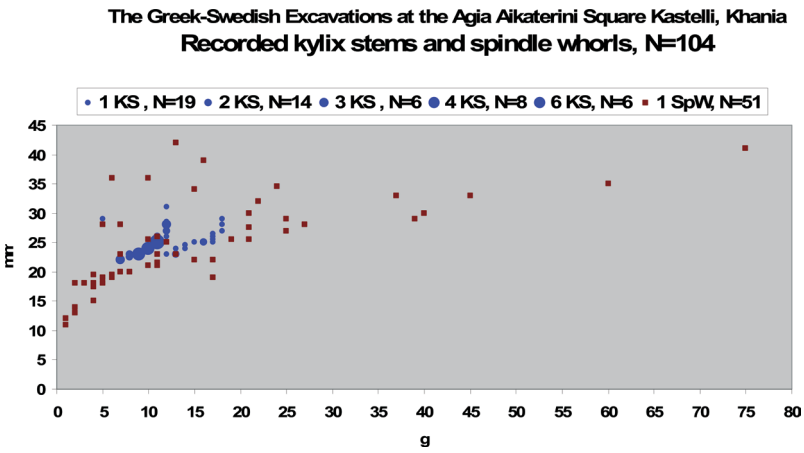

Diagram 1 : *Kylix stems and spindle whorls from all periods.*

textile tools, mainly spindle whorls and loom weights, have been recorded so far from the Greek-Swedish excavation at Agia Aikaterini Square in Khania. The analysis is not yet complete, thus in the following we report the results to date. We have chosen to present a general overview of spinning and weaving in Khania and tools dated from LM IIIA:2 to LM IIIC (Hallager – Hallager 1997; 2000; 2003; forthcoming).

Spinning at *ku-do-ni-ja*

The possible spinning tools are the spindle whorls (SpW), the so-called bead/buttons, and the kylix stems (KS). Naturally, we cannot say whether they were all used as tools for spinning, but balanced kylix stems and bead/buttons with a centred hole certainly function well as spindle whorls.

The data were recorded in the CTR database and classified according to the possible function of the tools. Diagram 1 presents the distribution of all the recorded spindle whorls from all the periods of study, though generally from Late Minoan. The data in Diagram 1 indicate

that the people who lived in the Minoan houses in the Agia Aikaterini Square produced several qualities of thread. Textile experience and the systematic spinning tests carried our by our textile specialists at the Centre for Textile Research suggest at least four different qualities of yarn. Diagram 1 illustrates a concentration of spindle whorls weighing between 8 grams and 12 grams. According to our results, yarn spun on a spindle with a whorl weighing between 8 grams and 12 grams is quite thin, but still strong enough to hold in a warp, and with this quality of yarn, a weaver makes a cloth of fine quality.

Only 40 dated whorls with preserved weight and diameter have been recorded from the Late Minoan III period. This does not provide an adequate basis for any statistics or interpretation. However, no major changes in the textile production during Late Minoan III are apparent from the data. The observed concentration of whorls weighing between 8 grams and 12 grams is also present in this smaller Late Minoan III set of data.

Weaving at *ku-do-ni-ja*

We now turn to the weaving equipment, loom weights, preserved from all periods, though generally from Late Minoan. The number of recorded loom weights is 189. Most of these are discoid or spool shaped. The loom weights excavated in Khania weigh from 50 grams up to 1.2 kilograms and are between 15-100 mm thick (see Diagram 2). According to our experience, different types of loom weights can be used to weave different types of fabric. Generally, when weaving with a high thread count, that is, many threads per cm, and with thin threads, it is preferable to use thin and light loom weights. When weaving a coarser fabric with thicker threads, it is better to use heavier and thicker loom weights.

Only 35 dated loom weights with preserved weight and maximum thickness have been recorded from Late Minoan III. Again, this does not provide an adequate basis for any statistics or interpretation. However, compared to previous periods the textile production during LM III seems more standardised or at least less varying.

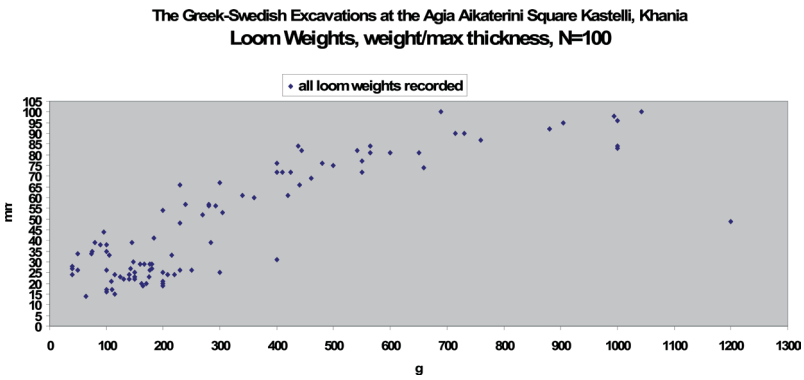

Diagram 2 : *Loom weights from all periods.*

Written evidence of textile production at *ku-do-ni-ja*

In the Mycenaean Linear B administration, one of the major concerns of the palace scribes was the organisation of textile production. Actually, this concern was also evident in most Near Eastern palaces. The Mycenaean bureaucrats followed the textiles from the first wool on the lambs to the flock of castrated sheep, to the textile workers and their children and their food rations, to the finished cloth and its quality and colour.

For some administrative reason, the Knossian scribes divided Crete into territories, and one of these was western Crete with *ku-do-ni-ja* (Godart – Tzedakis 1992). The special task of some scribes was to record the western Cretan sheep, and others the western Cretan wool and textiles (Godart 1971-1972; Killen 1976: 121). Thus, we actually are quite well informed about the Late Bronze Age administration of textile production in *ku-do-ni-ja* and in western Crete. An example is tablet Lc(2) 481, found in Magazine VII in the Palace of Knossos. This room corresponds to F6 in the find-spot classification by Olivier 1967. The writing on the front side was done by palace scribe 113, while the writing on the back side was done by another palace scribe known as scribe 115.

Knossos Lc(2) 481 (113)
.A] ‘pa-we-a’ TELA[3] 30[
.B] , ku-do-ni-ja LANA[

verso (115)
to-]u-ka LANA[

The tablet concerns Khania / *ku-do-ni-ja*. It records 30 pieces of the common type of cloth called *pa-we-a*. This cloth type is also known from records in Pylos. We know that ca. 5 kilos of raw wool are needed to make 1 *pa-wo*, and thus 150 kilos of wool are needed to make 30 *pa-we-a* (Killen 1966). After cleaning, this would leave about 50% for spinning, that is, 75 kilos of wool (Andersson – Nosch 2003). On the back of the tablet, wool recorded by scribe 115 is ‘for finishing’, *to-u-ka*.

This fragment provides a glimpse of the organisation of textile work in western Crete. Generally, in Mycenaean palace-organised textile production, it appears that each woman working for the palace-monitored textiles industry had the assignment to produce one piece of textile for the palace (Killen 1968, no. 11; Killen 1984, no. 10, 12). Combining data from the Linear B inscriptions with data from experimental archaeology makes it possible to evaluate the time consumption and work of these women when manufacturing their piece of textile (Andersson – Nosch 2003). A *pa-wo* textile requires 5 kilograms of raw wool. The cleaning and preparation process reduces the wool to a weight of about 2.5 kilograms of clean, prepared wool available for textile work. If all this wool is used, and nothing is discarded during spinning, then 2.5 kilograms of wool yield ca. 15 kilometres of yarn when spun on a spindle with an 18 gram whorl.[3] If the wool was spun instead on a spindle with an 8 gram whorl, then 2.5 kilograms of clean sorted wool would yield ca. 25 kilometres of yarn.[4] These calculations are based on a series

3 A spinner spins an average of ca. 625 metres yarn per 100 grams of spun wool fibres on an 18 gram spindle whorl (Mårtensson *et al.* 2006, fig. 6).

4 A spinner spins an average of ca. 1000 metres yarn per 100 grams of spun wool

of experiments conducted by two modern, skilled spinners at the Danish National Research Foundation's Centre for Textile Research.

How long would it take to spin the wool for one piece of cloth? The spinners who conducted this spinning test recorded the time needed for spinning on an 8 gram spindle whorl and an 18 gram spindle whorl. The following represents the average amount of time:

- It took 20 hours to spin 1 kilometre of yarn on an 18 gram whorl;[5] thus it would take 300 hours to spin 15 kilometres of yarn from 2.5 kilograms of wool on the 18 gram whorl.
- It took 25 hours to spin 1 kilometre of yarn on an 8 gram whorl;[6] thus it would take 625 hours to spin 25 kilometres from 2.5 kilograms of wool on the 8 gram whorl.

Thus, if a woman spun 10 hours every day, she would have to spin for one month on a spindle with an 18 gram whorl in order to spin all the wool assigned for one *pa-wo*. If she spun the yarn on a spindle with an 8 gram whorl, she would need more than two months of constant spinning to fulfil the target. The time consume is impressive. Even if a Bronze Age spinner could spin faster than our experts, the time that would be consumed is still impressive. On the other hand, we know from the Linear B inscriptions that children were involved to a great degree in the palace monitored textile production. The children probably would have spun slower, simply because their spinning would have been interrupted much more frequently for winding up the thread because of their smaller stature. Finally, one should not forget that spinning is only one of several production processes in the textile manufacturing.

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fibres on an 8 gram spindle whorl (Mårtensson *et al*. 2006, fig. 6).

5 One spinner spins ca. 50 metres of yarn per hour on an 18 gram whorl (Mårtensson *et al*. 2006, fig. 7).
Thus: 100 metres per 2 hours
1 kilometre per 20 hours.

6 One spinner spins ca. 40 metres of yarn per hour on an 8 gram whorl (Mårtensson *et al*. 2006, fig. 7).
Thus: 100 metres per 2.5 hours
1 kilometre per 25 hours.

In Scandinavia, we can investigate Bronze Age textile production by studying real archaeological textile finds. Although this is not possible in the Aegean, textiles are occasionally found in Greece, and even in Khania. In the Greek-Swedish excavations at the Agia Aikaterini Square, 22 small pieces of textile were found, of which 20 pieces belong to a narrow band. We are grateful to the Greek-Swedish excavations and to the Director of the Archaeological Museum in Khania for giving us the opportunity to study these items. The following findings are from an analysis conducted by textile specialist and archaeologist Susan Möller-Wiering, Centre for Textile Research.

The narrow band is 6 mm wide and is composed of only 3 warp threads of plant fibre — perhaps of linen. Parallel to the warp is another thread stitched into the band, perhaps already integrated during the manufacture of the band. There are about 10 weft threads per centimetre. The weft threads are short bundles of animal hair. Thanks to the generous support of the Institute of Aegean Prehistory, in 2007, the band is undergoing fibre and dye analyses.

Conclusion

The goal of the Danish National Research Foundation's Centre for Textile Research is to accumulate new knowledge about Bronze Age textile production. This is done through international collaboration with many different specialists. We approach the topic from different perspectives: from epigraphical, historical, archaeological and experimental angles. Each discipline represents its own qualities and assemblages of sources, but when these disciplines are joined, they shed light on each other's findings, resulting in innovative knowledge. Through this international and interdisciplinary investigation, we can achieve a better understanding of textile production in the Bronze Age society.

The analysis of archaeological textile tools in the Late Bronze Age in Khania does not suggest that there were any major changes in the textile production during the period. The textile tools, however, demonstrate that the people in Khania produced many types of textiles. In the settlement excavated by the Greek-Swedish excava-

tion team, a concentration of spindle whorls weighing 8-12 grams is evident. The experimental tests indicate that such spinning tools yield thin but strong threads and fabrics of quite a fine quality, suitable for clothing. The range of spinning tools from 2 grams to 40 grams shows that the inhabitants also produced both finer and coarser threads for other types of fabrics. This interpretation is also supported by the inhabitants' weaving equipment, i.e., the loom weights. The varying thickness and weight of the loom weights suggest that the weavers produced many different types of fabrics. The overall picture from the archaeological textile tools in the settlement testifies to a rich and sophisticated textile production ranging from coarse fabrics to finer fabrics. The refinement of the technology was demonstrated in the small textile band preserved at the site. The sophistication and variety in fabric types contrast with the written Linear B evidence in which a much more standardised and controlled textile production is described.

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