Technical Textile Tools Report

Archontiko

Eva B Andersson

Tools and Textiles – Texts and Contexts research program
The Danish National Research Foundation's
Centre for Textile Research
(CTR)
University of Copenhagen

PREFACE

We thank you for your cooperation in the first part of the Tools and Textiles – Texts and Contexts (TTTC) research programme and we look forward to your reactions to our tool analysis and the technical report. A synthesis of all technical reports will be published in 2009 (Andersson, E. and Nosch, M-L. *Tools, Textiles, and Contexts*, Oxbow Books, Oxford).

This technical report is written for you; it forms the basis of your context description which we look forward to receiving. In future research, you are most welcome to use the results of the report in other publications and articles about your site and textile production. Please remember to quote the Danish National Research Foundation's Centre for Textile Research.

INTRODUCTION

One of the main objectives of the TTTC research program has been to record as many textile tools from as many types of sites as possible within our target area and date, Eastern Mediterranean in the Bronze Age. The majority of the registered tools are spindle whorls and loom weights, but other tools such as needles, shuttles, and spinning bowls have been recorded (a category termed 'uncertain' has been reserved for possible or unidentified textile tools).

The initial goal was to create a database to gather information on such diverse topics as textile tools in the neo-palatial and post-palatial periods; changes in loom weight shapes at a specific site; spindle whorls from different contexts in a particular period, and so on.

We have now processed the data from the sites investigated. The next step will be for all collaborators to incorporate the results in their individual site context description. After that, we will be able to attain the research program's primary aim: to elucidate the economic and cultural impact of textiles and the textile manufactures in Bronze Age Aegean and Near Eastern societies.

It is our hope that this will create new knowledge and also demonstrate the possibilities in this research field and encourage scholars to continue the work. This is the beginning, not the end.

This report is based solely on the information gathered from the textile tools, giving you the results of our analyses, which concern the physical material – its dimensions, material and find context: we have only given our interpretation from a "tool and textile craft perspective". It is up to you how you interpret this information and incorporate it into your context description.

While processing the data we have compiled all functional parameters, i.e. such parameters that affect textile production according to our experiments and knowledge. We have then compiled and compared the results chronologically and contextually. Following the main body of text you will find a short summary and our interpretation of the textile production based on your recordings, on the analyses of the material in the database, and on the site contexts.

As our interpretation is also based on different experiments you will in the beginning of the report find a short summary of the five experimental tests that have been conducted at CTR in the TTTC research program. For more detailed information please refer to the Experimental Archaeological TTTC reports that have been published on our webpage (www.hum.ku.dk/ctr).

In the new database file, which you receive with this report, you will find comments on tools that we have excluded as textile tools (in those cases they are also marked with a question mark in the field *Find Category*. Sometimes the data you provided, e.g. *the maximum length* or *weight,* is not plausible. This is also commented upon, and in those cases we have changed your recordings and written what we have done and why. If you have sent us pictures and/or drawings they are now linked to the database. To open them you have to click on the *Picture*.

The questions we have processed in the database are saved in tables. You will find them under *Table,* but please note that they are not linked with the original tables. In this report you will find several tables and diagrams, and they are also available in the enclosed excel file.

Should there be any questions, please contact Eva, who will be happy to help.

Definitions

Spindle whorls

For the different types of spindle whorls please see the CTR Database Manual. Spindle whorl is abbreviated *SpW* in diagrams and tables. The spindle whorl measurements are presented in graphs. If both weight and diameter are recorded, these parameters are presented in the same diagram. In some cases the parameters are presented in separate diagrams (for example, if just the weight is recorded).

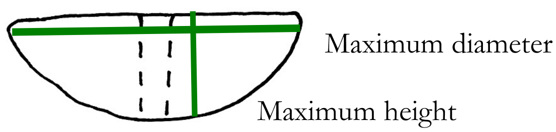

Figure 1. Example of spindle whorl demonstrating maximum diameter and height.

Loom weights

For the different types of loom weights please see CTR Database Manual. Loom weight is abbreviated *LW* in diagrams and tables. The loom weight measurements will be presented in diagrams. If both weight and thickness are recorded, these parameters will be presented in the same diagram. In some cases the parameters could be presented in separate diagrams (for example, if just the weight or the thickness is recorded).

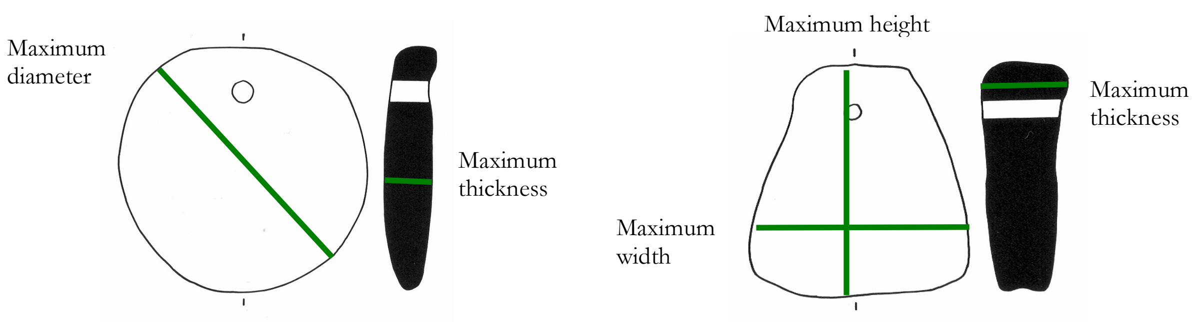

Figure 2. Example of loom weights demonstrating maximum diameter, thickness and width.

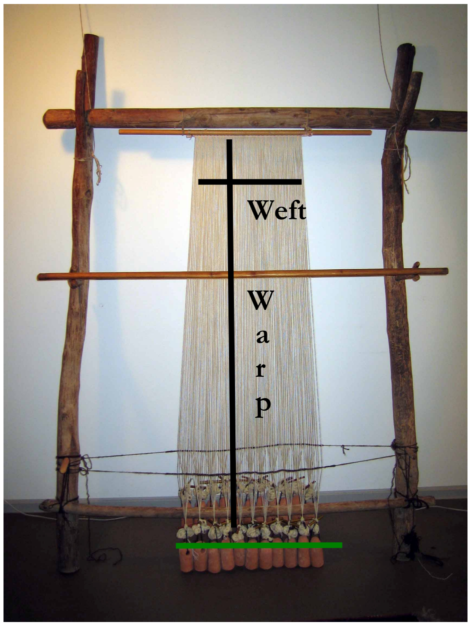

Figure 3. Warp weighted loom with the total width of loom weights in one setup.

Weaving Techniques

Different types of weaving techniques will also be discussed. The figures below demonstrate different technical expressions and techniques mentioned in the text. Evidence of tabby weaving exists from Bronze Age Crete. Since tabby weaving is considered the most common weaving technique during the Bronze Age, we have based our calculations on this type of fabric. A balanced tabby has more or less the same number of threads and the same type of threads in both warp and weft (figure 4a, 4c, 4d and 4e). A weft faced tabby is when the weft is covering the warp threads and there are more weft threads than warp threads (figure 4b). A fabric can also be open (figure 4a) or closed (figure 4d). However, one must bear in mind that there is an infinite amount of different types of tabbies. To our knowledge, the only preserved examples of twill (see figure 4f) are fragments from Alishar in Turkey dated to the late 4th millennium (Fogelberg and Kendall, 1937, 334-35; Barber 1991, 167-168).

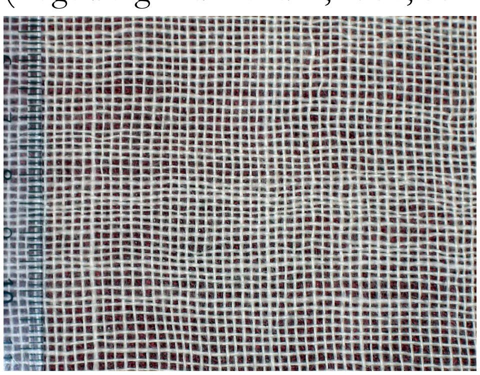

Figure 4a. Balanced open tabby, with an average of 6.1 warp threads and 7.4 weft threads per cm (wool fabric).

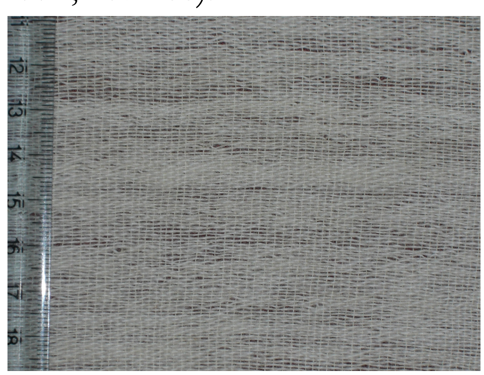

Figure 4b. Weft faced tabby, with an average of 5.8 warp threads and 14.8 weft threads per cm (wool fabric).

Figure 4c. Balanced tabby, 9 warp and 9 weft threads per cm (wool fabric).

Figure 4d. Balanced tabby, 14 warp and 14 weft threads per cm (linen fabric).

Figure 4e. Balanced tabby, 10 warp and 8 weft threads per cm (nettle fabric).

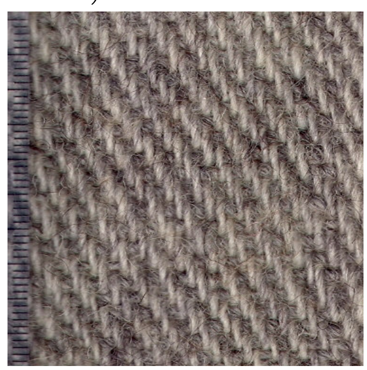

Figure 4f. 2/1 twill, 8 warp and 5 weft threads per cm (wool fabric). Note that this figure is only an example of a twill fabric; it is not a reconstruction of the fragment found in Turkey.

SPINNING[1]

The most common archaeological evidence for spinning consists of spindle whorls[2] and by analysing them one can gain knowledge of what types of yarn could be produced. Spindle whorls are generally used when working with a suspended spindle (figure 5).

The spinning experiments with suspended spindles conducted in the TTTC program have confirmed that it is primarily the quality of fibres and the weight of the spindle whorl that affect the finished product, i.e. the spun yarn.

The spindle whorls tested in the TTTC experiments weighed 4g, 8g and 18g. The tests confirmed that when spinning with a suspended spindle and a similar type of fibres, the

[1] For more information, see also Mårtensson *et al.* 2006a; 2006b; 2006c.

[2] It is of course also possible to spin without a whorl, and whorls can be made of perishable materials. The absence of spindle whorls in the archaeological record is thus not an indication of the lack of spinning activity.

lighter the spindle whorl, the thinner thread will be (Mårtensson *et al.* 2006a; Mårtensson *et al.* 2006b; Mårtensson *et al.* 2006c). Previous tests with heavier spindle whorls have also demonstrated that the heavier the spindle whorl the thicker the thread will be (Holm 1996; Andersson 2003; Andersson and Batzer 1999; Mårtensson 2006).

Figure 5. Textile technician Linda Mårtensson is spinning with an 8g suspended spindle.

If one tries to spin a thin thread with few fibres per metre with a heavy spindle, the thread will break because of the weight of the spindle. On the other hand, if one spins a thick thread on a light spindle, the spindle will only rotate with much effort, and the yarn will not be strong enough to be used in a weave. It should, however, be noted that it is also of greatest importance how the fibres were prepared before spinning.

Sometimes the differences between types of yarn are not visible to the eye. One possibility, though, is to record how many meters of yarn can be produced when spinning identical fibres with different spindle whorls. The TTTC spinning tests clearly demonstrated that the lighter the whorl, the more yarn can be produced (figure 6). In general, a thin thread contains a smaller amount of fibre.

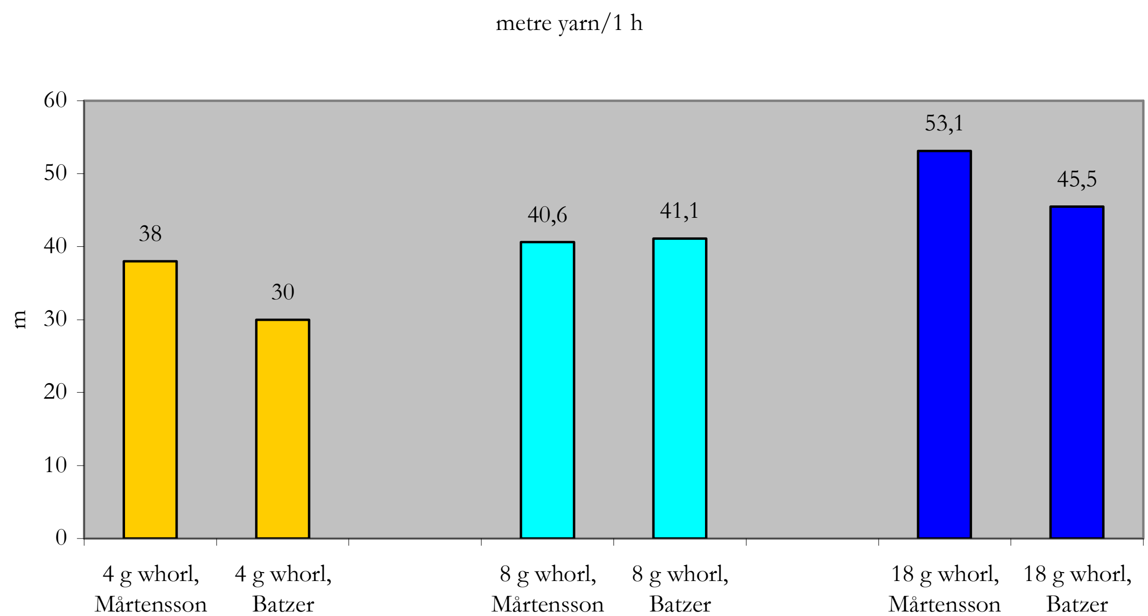

Figure 6. Length of spun yarn obtained from 100g wool, spun on 4g, 8g and 18g whorls respectively. The difference in yarn length can be explained by the fact that there is less fibre per meter in the thread spun with the 4g spindle than the 8g and the 18g spindle. The graph also demonstrates the relatively similar results obtained by the two spinners when using identical tools.

A yarn can be described in far more detailed ways than just as a thin or a coarse thread: as for example: hard or loosely twisted. This can be measured in the yarn twist angle. The twist angle is the angle at which the fibres are positioned in the spun thread, and is a measurement of how hard twisted the yarn is (figure 7). Previous tests have demonstrated that the relation between the weight and the diameter of the spindle whorl can affect the twist angle. If one is working with a light spindle whorl with a large diameter, the thread will be more hard twisted than if the whorl had a smaller diameter. The reason is that the whorl will rotate longer in the first case than in the second. It should, however, be noticed that it is possible to rotate the whorl additionally by hand, although this would take considerably more time (Holm 1996, 113-116). If the thread is loosely twisted, the fabric in general feels soft, and if the thread is very hard twisted the fabric can feel harder. These parameters do of course affect the quality of a fabric but without any textile finds it is difficult to estimate a specific twist angle just by analysing the diameter of the spindle whorls.

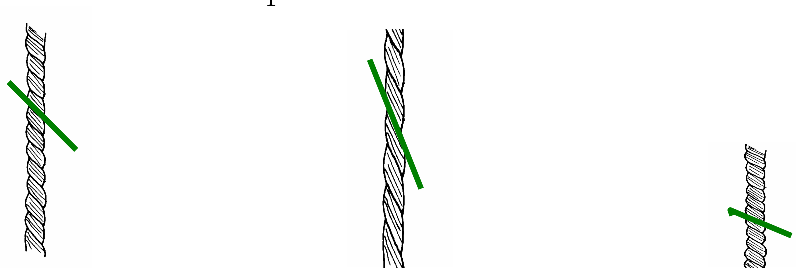

Figure 7. Twist angles.

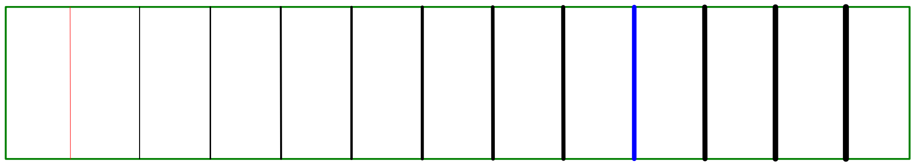

Figure 8. Variations from thinner to thicker "threads". The first line (red left) corresponds to a thread spun with the 4g spindle whorl, while the ninth line (blue) corresponds to a thread spun with a 44g spindle whorl.

According to our experience the height of the spindle whorl is of minor importance for the finished product.

As it is practically impossible to determine which types of yarn have been produced, we will just refer to thinner or thicker yarn (figure 8).

Different degrees of yarn coarseness also require different weight tension when the yarn is used as a warp on a warp weighted loom. If the tension on the warp threads is too low it will be difficult to change the shed. On the other hand, if the tension is too high the warp threads will break. According to our results a thread spun with a 4g spindle whorl requires a tension of 10g per warp thread and a thread spun with the 8g requires 20g. No weaving test was made in the TTTC program on the thread spun on an 18g spindle whorl, but previous tests confirm that the thicker the thread the more tension is needed. A yarn spun with a 44g spindle whorl needs approximately 40g tension (Batzer pers. com.).

WEAVING[3]

In the Aegean and Central Turkey, the most common archaeological evidence for weaving consists of loom weights used on a warp weighted loom. Since most parts of the vertical warp weighted loom were made of perishable materials they do not usually survive in the archaeological record. It is also possible that other types of looms were used, such as the vertical two beam loom, the back strap loom, or the horizontal loom - but since these types of loom are of completely perishable materials, it is hard to find any archaeological remains. The conclusion is that one cannot *exclude* weaving, when no loom weights are found.

[3] For more information see Mårtensson *et al.* 2006a; 2006b; 2006c; 2007a; 2007b.

Figure 9. Two rows of loom weights.

When producing a tabby weave, the loom weights are hanging from two thread layers (front and back). Every other warp thread is attached to a loom weight in the front layer, and every other warp thread to a loom weight in the back layer.[4] The loom weights in each row are positioned side by side (figure 9).

It is important that the warp threads are hanging vertically and evenly distributed. It is preferable that the row of loom weights has a total width which is identical or slightly larger than the width of the fabric to be produced (figure 10a). If the warp threads are slanting outwards (figure 10b), or inwards (figure 10c), the warp threads will not be evenly distributed, and this will affect the weaving and the resulting fabric negatively (Mårtensson *et al.* 2007a).

In previous tests (Batzer pers.com.), different scholars have established that the weight of loom weights influences weaving on a warp weighted loom. Different types of yarn need different tension and this limits how many warp threads can be attached to one loom weight. If the yarn needs 20g tension per warp thread, and the loom weight weighs 500g, one can attach approximately 25 warp threads to this loom weight. If, however, one uses a yarn that requires 50g tension, one can only attach 10 warp threads to the loom weight. Likewise, if one uses a loom weight with a weight of 300g, and a yarn that needs a tension of 20g per warp thread, one can attach only 15 warp threads to each

[4] The warp weighted loom can be operated in several ways, depending on for example which weaving technique is employed, such as tabby or twill. The construction of the loom encourages creativity and personal ways of operating. Our assumption is that weaving was well-planned. By this we mean that planning and preparing of weaving as well as the selection of equipment was done consciously. Furthermore, that the weaver was experienced and knew what decisions should be taken in order to facilitate optimal production of textiles and to reach a desired result.

loom weight, but if the required tension is 10g per warp thread, then the weaver can attach 30 warp threads.

The experiments conducted in the TTTC program have also clearly demonstrated that the thickness of a loom weight does play an important role when weaving, and hence that the choice of loom weights affects the fabric (Mårtensson *et al.* 2007a; Mårtensson *et al.* 2007b).

Figure 10a. The warp threads are hanging vertically and are evenly distributed.

Figure 10b. The warp threads are slanting outwards.

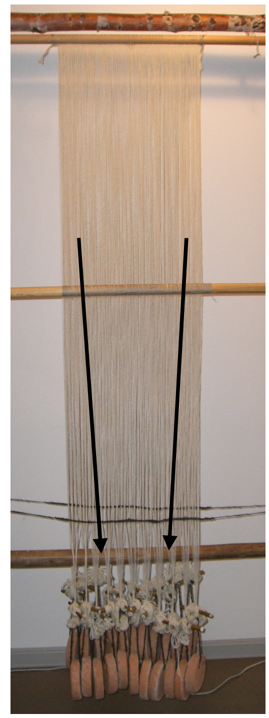

Figure 10c. The warp threads are slanting inwards.

The distribution of warp threads depends on the weight and the thickness of the loom weights. The experiments demonstrate that there is no advantage in attaching more than 30 threads to one loom weight. If more threads are attached, it will create problems during the set up and weaving, thereby affecting the final product. On the other hand, if just a couple of threads are attached to one loom weight, considerably more loom weights will be needed, thus also creating problems.

The weaving tests have confirmed that if the weaver wants to produce an open fabric using thick yarn, (s)he would have to choose heavy and thicker loom weights; if (s)he wants to weave a coarse and dense fabric, (s)he would have to choose heavy but thinner loom weights. On the other hand, if (s)he wanted to produce an open fabric or a weft faced fabric using thin yarn, (s)he would have to choose light and thick loom weights. Finally, if (s)he would like to weave a dense fabric using fine yarn with many threads per cm, she would prefer light and thin loom weights (Mårtensson *et al.* 2007a; Mårtensson *et al.* 2007b).

In conclusion, recording weight and maximum thickness of loom weights and combining this data with the results of experimental weaving, makes it possible to suggest the kind of textiles that could have been produced with a given yarn quality.

FROM LOOM WEIGHT RESEARCH TO INTERPRETATIONS OF FABRICS.

In this report, we will give some examples of what types of fabric could have been produced with your recorded loom weights. Based on the calculations we have made an evaluation of what we interpret as the most likely choice of tool in relation to fabric. Please note that these suggestions are based on our experience and experiments but are on the other hand conjectural as to what is optimal.

With the loom weights from your site, we have made an assessment of the various types of loom setups and possible resulting fabrics, dividing them into the *TTTC choice*, *Possible*, and *Unlikely*.

- The *TTTC choice* means that 5-30 warp threads per loom weight would be the most functional choice for an optimal production

- *Possible* means that 30-40 or 4 warp threads per loom weight could be possible but not optimal. More than 30 warp threads will create problems during the set up and during weaving. Too many warp threads on one loom weight will make it difficult to distribute the warp threads evenly in the fabric. Less than 4 warp threads per loom weight require very many loom weights in the set up, and here the thickness becomes essential in that consequently only thin loom weights can be accommodated in a row corresponding to the total width of the fabric. Although such scenarios are possible, they remain impractical and hence not optimal.

- *Unlikely* means that attaching more than 40 or less than 4 warp threads to one single loom weight is not functional and even counterproductive; we consider these setups unlikely on a loom.

We will show the results in tables and you will also find a calculation of the fabric, which we consider the most likely to produce with the specific loom weights. We have based our calculations on a warp length of 2 m and a width of 1 m. There is also an estimate of how many loom weights and how many metres of yarn would be needed for such a loom setup. The calculations will illustrate the specific textile production on the site.

However, please note that several loom weights could be used for various types of fabrics and that consequently there can be more than just one *TTTC choice*.

The example below is not based on any archaeological loom weight, but demonstrates how the calculations are made. There is also an estimate of how many loom weights and how many metres of yarn would be needed for such a loom setup. The calculations will illustrate the specific textile production on the site.

To elucidate our interpretation of loom weights and our suggestions of TTTC choice of tools for a fabric you will find an example below.

The following is our interpretation of the fabrics resulting from the use of a loom weight with a weight of 150g and a thickness of 20 mm. The example demonstrates how such a loom weight functions with various types of warp yarn. The weight of the 150g loom weight defines how many warp threads can be attached to it.

If a thread requires 10g warp tension (A), the weaver must attach 15 threads to each loom weight. On the other hand, if a warp thread requires 30g tension (C), the weaver can only attach 5 warp threads to each loom weight.

The loom weight has a thickness of 20 mm. In case A, the 15 warp threads from the loom weight in the front layer and the 15 warp threads from the back layer must be packed in the space of 20 mm. The result is a dense fabric with 15 warp threads per cm. In case C, the 5 warp threads in the front layer and the 5 warp threads in the back layer will be packed in the space of 20 mm. The result is an open weave with 5 warp threads per cm.

Loom weight TTTC-XXX: weight 150g, thickness 20 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	15	7.5	5	3
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	30	15	10	6
Warp threads per cm	15	7.5	5	3
TTTCs' evaluation of suitability of the tool	TTTC choice	TTTC choice	TTTC choice	Unlikely

Figure 11. Calculations of loom setups with a loom weight weighing 150g and with a thickness of 20 mm.

As suggested in figure 11 this type of loom weight is suitable when weaving with thin yarn requiring little tension. Both a warp thread with 10g tension (A) and 20g tension (B) would function well but the fabric with the 20g tension will become more open (or weft faced). If the warp thread of 30g tension (C) is used, the weaver can just attach 5 warp threads per loom weight and the fabric will become quite open (or weft faced). Finally, if the weaver chooses a thread with a 40g (D) warp tension, (s)he can only attach 3-4 threads per loom weight and the fabric will be very open. In case D it would have been much easier to choose a heavier and thicker loom weight.

If we focus on the best choice A, we can hypothesise the following loom setup:

Loom setup (calculated on 10g warp tension)
Starting border (width of the fabric): 100 cm
Number of loom weights needed: 100
Numbers of warp threads: 1500 threads, 2 m each = 3000 m
Weft 1: if a balanced tabby = 3000 m
Weft 2: if a weft faced tabby = 6000 m
Total amount of yarn with weft 1 (+ 2%) = 6120 m
Total amount of yarn with weft 2 (+2%) = 9180 m

It is possible to calculate the necessary yarn for producing specific fabrics. The required amount of yarn depends on the number of threads per square cm.

The calculations are all based on a fabric with a length of 2 m and a width of 1 m. If the fabric contains 15 warp threads and 15 weft threads per cm, 3000 m warp threads and 3000 m weft threads is needed, in total 6000 m. However if it is weft faced, the double amount of weft thread is needed, in thus a total 9000 m

A tabby is the result of two thread systems crossing each other at right angels. Even if both the warp and weft threads are taut, the threads will never be fully stretched or lie completely straight since they cross over and under each other. Furthermore, it is not technically possible to weave the last part of the warp, meaning that there will always be some waste warp yarn. For these reasons, one has to add approximately 2-5% more yarn when calculating the need of yarn for one setup. In our calculations, we have chosen to add 2% more yarn for the calculated setups.

The never-ending work with textile production

The time needed to spin a specific amount of yarn is difficult to calculate and it depends on a variety of parameters such as the spinner's skill, the quality of the fibres, and the tool. The TTTC experiments demonstrated that our two technical technicians spun a similar length of wool yarn when using identical tools and fibres. Furthermore, they spun at a similar speed. In average they spun:

- 35 m yarn per hour when spinning with a 4g spindle whorl,
- 40 m yarn per hour when spinning with an 8g spindle whorl, and
- 50 m yarn when spinning with an 18g spindle whorl.

To this the time for sorting wool and preparation of fibres must be added.

The example above (A) demonstrates the substantial requirements of yarn. According to the TTTC experiments, the production of thread for a balanced tabby would take approximately 175 hours to spin on a 4g spindle whorl, and 262 hours to spin the thread on a 4g spindle whorl for a weft faced tabby (Mårtensson *et al.* 2006a; 2006c).

No time study of the weaving process was conducted in the TTTC experiments but earlier experiments state that about 70 cm could be woven per day on a warp weighted loom (pers.com. Anne Batzer). To this must be added time for setting up the loom and for finishing.

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Textile tools from Archontiko, Greece

A total number of 33 objects, 27 loom weights and 6 spindle whorls, were recorded in the database. All objects have been found in House A and are dated to EBA (figure 1).

	SpW	LW	In all
Trench IG, house A	4	8	12
Trench IG-ID, house A		1	1
Trench IG-P, house A	2	2	4
Trench ID, house A		4	4
Trench ID-Y, house A		12	12
In all	6	27	33

Figure 1. All recorded textile tools.

SPINNING AND SPINDLE WHORLS

Six objects are spindle whorls. As can be seen in the diagram below (figure 2), the whorls vary in weight from 25g to 68g, demonstrating that the spinners in Archontiko could have spun different types of yarn by choosing different whorls. The yarn spun with the 25g spindle whorl would have been thinner than the yarn spun with a spindle whorl weighing 70g if the same type of fibre were used. The yarn spun with the three heaviest whorls (55g-68g) must have been quite thick compared with the yarn spun with the lighter whorls, and suitable for coarser fabrics. There is no clear relation between the spindle whorl diameters and the whorl weight: the six whorls have more or less the same diameter. This suggests that the yarn spun with the lightest spindle whorl could be harder twisted than the yarn spun with the heavier whorls.

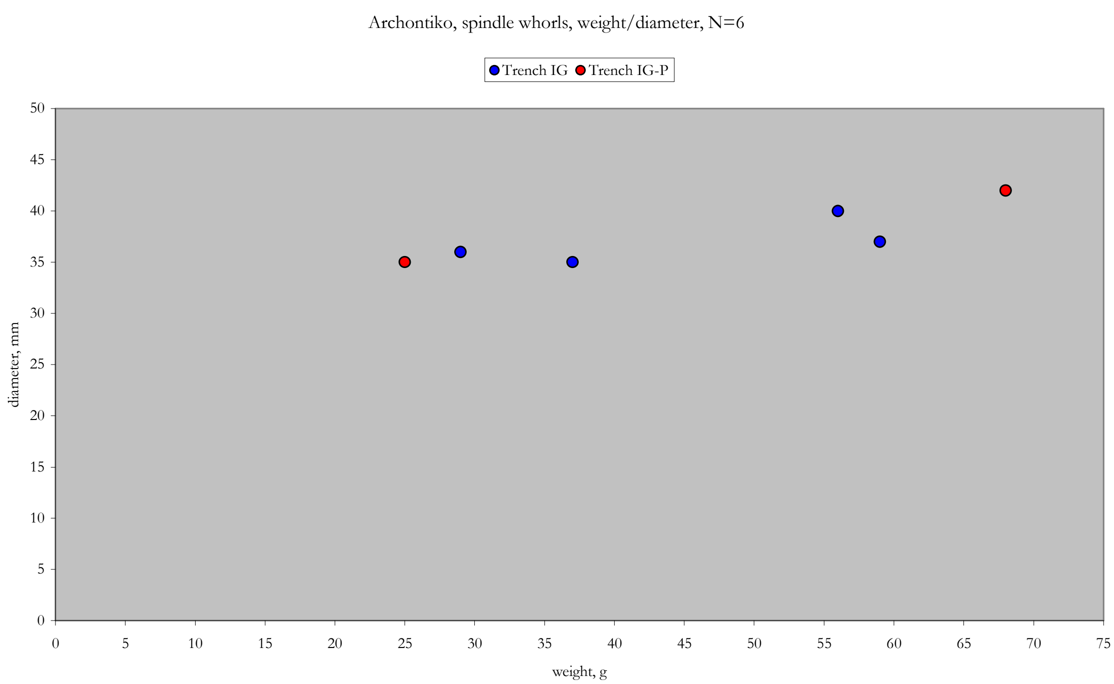

Figure 2. Spindle whorls, weight and diameter.

WEAVING AND LOOM WEIGHTS

22 of 23 loom weights are made of clay and have a pyramidal truncated shape. One is made of stone and has an irregular shape. 17 weights are made of fired clay and five of unfired clay. On two loom weights the information is not available. The weight has been calculated on 24 objects, and it varies from 154g to more than 1100g. The thickness is recorded on 25 loom weights and varies from 41 mm to 88 mm (figure 3).

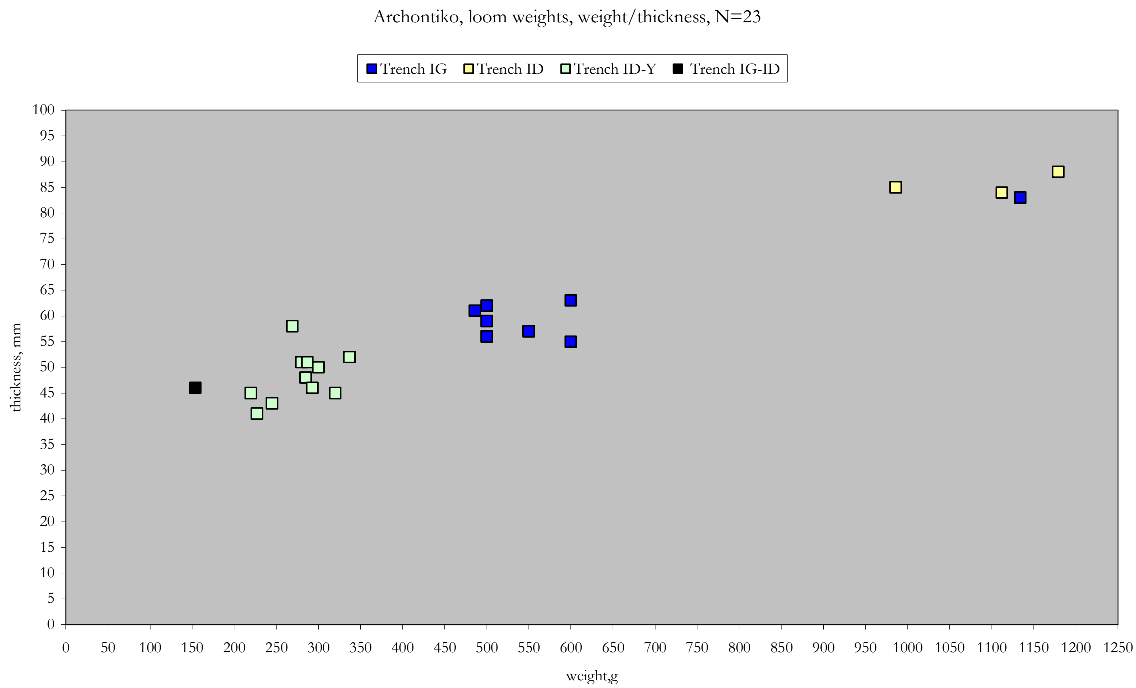

Figure 3. Loom weights, weight and thickness.

To elucidate our interpretation of the loom weights and to suggest the types of fabrics which we consider the most likely to have been produced with these specific loom weights we have chosen three loom weights with different weight and thickness from Archontiko. Please note that these suggestions are based on our experience and experiments but are on the other hand purely conjectural as to what is optimally possible.

Loom weight ARC-58: weight 280g, thickness 51 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30 g warp tension	40g warp tension
Numbers of threads per loom weight	28	14	9	7
Number of threads per two loom weights (one in front layer, one in back layer)	56	28	18	14
Warp threads per cm	11	5-6	3-4	2-3
TTTC's evaluation of suitability of the tool	TTTC choice	TTTC choice	Unlikely	Unlikely

Figure 4. Calculation of possible loom setups with loom weight ARC-58

12 loom weights were found in trench ID-Y. 11 are made of clay and one is made of stone. The weight of the clay loom weights varies from 220g to 337g and the thickness from 41 mm to 58 mm. These loom weights could have been used in the same setup as they all are within the same range of weight and diameter. ARC-58, analysed in figure 4, represents the average of the 11 clay loom weights (see figure 3).

The TTTC choice suggests a fabric with 5-11 warp threads per cm with 10g-20g tension on each warp thread.

The loom weight made of stone is considerably heavier (578g) than the other weights, and it would not be functional in the same loom setup as the other loom weights found in trench ID-Y. It is also the only loom weight made of stone from Archontiko. After examining the photo of it, we cannot exclude that this weight could have been used as a loom weight, although perhaps it is more likely to have been used in other functions, e.g. as a net sinker.

If we focus on the TTTC choice A in figure 4, we can hypothesise the following loom setup:

Loom setup (ARC-58) calculated with 10g warp tension:

Starting border (width of the fabric): 1 m

Number of loom weights needed: 40

Numbers of warp threads: 1100 threads, 2 m each= 2200 m

Weft 1: if a balanced tabby = 2200 m

Weft 2: if a weft faced tabby = 4400 m

Total amount of yarn with weft 1 (+ 2%) = 4488 m

Total amount of yarn with weft 2 (+ 2%) = 6732 m

The calculations demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately hours 128-192 just to spin the thread needed to produce the fabric for this setup. Time for sorting and preparing the fibres is not included, nor time for preparing the setup, weaving and finishing.

Seven of eight loom weights from trench IG have a weight between 486g - 600g and their thickness varies from 55 mm to 63 mm. ARC-10 represents the average of the seven loom weights' weight and thickness (figure 3). The eighth loom weight is much heavier (1134g) than the other weights and it would not be functional in the same loom setup as the other loom weights found in trench IG.

Loom weight ARC-10: weight 550g, thickness 57 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of threads per loom weights	55	28	18	14
Numbers of threads per two loom weight (one in front layer one in back layer)	110	56	36	28
Warp threads per cm	19	10	6	5
TTTC's evaluation of suitability of the tool	unlikely	TTTC choice	TTTC choice	TTTC choice

Figure 5. Calculation of possible loom setups with loom weight ARC-10.

The TTTC choice suggests a fabric with 5-10 warp threads per cm with 20-40g tension on each thread, which is quite a large span. The calculations thereby demonstrate that a loom weight of this particular size is flexible and can be used for several different qualities of fabrics and with a variation of yarn. It is possible to use all loom weights from this context in the same setup.

If we focus on the TTTC choice B in this example we can hypothesise the following loom setup:

Loom setup (ARC-10) calculated with a 10g warp tension:

Starting border (width of the fabric): 1 m

Number of loom weights needed: 36

Numbers of warp threads: 1000 threads, 2 m each= 2000 m

Weft 1: if a balanced tabby = 2000 m

Weft 2: if a weft faced tabby = 4000 m

Total amount of yarn with weft 1 (+ 2%) = 4080 m

Total amount of yarn with weft 2 (+ 2%) = 6120 m

The calculations demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 102-153 hours just to spin the thread needed to produce the fabric in this set up. Time for sorting and preparing the fibres is not included, nor time for preparing the set up, weaving and finishing.

Four of the loom weights from Archontiko are very heavy. Three of them are found in trench ID. When calculating a possibly loom setup with the heaviest loom weight from Archontiko, ARC-36, the TTTC choice demonstrates a coarse fabric with 5 warp threads per cm with 40g tension on each warp thread (figure 6).

Loom weight ARC-36: weight 1179g, thickness 88 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of threads per loom weights	118	59	40	29
Numbers of threads per two loom weight (one in front layer one in back layer)	236	118	80	58
Warp threads per cm	27	13	9	7
TTTC's evaluation of suitability of the tool	unlikely	unlikely	unlikely	TTTC choice

Figure 6. Calculation of possible loom setups with loom weight ARC-36.

If we focus on the TTTC choice D in this example we can hypothesise the following loom setup:

Loom setup (ARC-36) calculated with 40 g warp tension.

Starting border (width of the fabric): 1 m

Number of loom weights needed: 22

Numbers of warp threads: 700 threads, 2 m each= 1400 m

Weft 1: if a balanced tabby = 1400 m

Weft 2: if a weft faced tabby = 2800 m

Total amount of yarn with weft 1 (+ 2%) = 2856 m

Total amount of yarn with weft 2 (+ 2%) = 4284 m

The calculations demonstrate that the amount of yarn needed is substantial even for this coarse fabric. According to the TTTC experiments it would take approximately 57-86 hours just to spin the thread needed to produce the fabric in this set up. Time for sorting and preparing the fibres is not included, nor time for preparing the set up, weaving and finishing.

These three examples (figure 4, 5 and 6) suggest great variation in the types of fabrics that could have been produced with the loom weights from Archontiko. It is clear that these loom weights have been used for different qualities, from rather fine to coarse fabrics. Note that the textiles that can be produced with ARC-58 (figure 4) and ARC-10 (figure 5) have the same number of warp threads per cm, 5-10. The difference in the weight of the loom weights, however, suggests that the fabrics made with the two loom weights are visually quite different. ARC-58 weighs just 280g and needs no more than fine threads to hold its weight. The fabric will thus be light and fine, whereas ARC-10 requires a stronger thread, and the resulting textile will seem denser and coarser.

The number of finds does not correspond to the number of loom weights needed for these loom setups. Even if the width of a given fabric was considerably narrower, e.g. 50 cm, the number of loom weights is still too small. This means that the excavated loom weights make up only a fragment of the number of loom weights that must have existed in the Early Bronze Age in Archontiko.

Summary

Even if the number of tools from Archontiko is quite small, 33 objects, the analyses reveal considerable diversity in the production. The yarns produced with the spindle whorls would be suitable for several types of fabrics as suggested by the analyses of the loom weights.

An example: the thread spun with the whorls weighing 55g or more would probably function very well in the weaves with the heavy loom weights of more than 900g. The result would be a coarse textile with few but thick threads per cm.

The spindle whorls weighing between 25-40g could have been used for all fabrics produced with a warp thread with a tension of 20g or more. Note, however, that the type of fibre and fibre quality also can yield a great influence on the fabrics. If e.g. the Archontiko sheep had wool with very thin and long fibres, it would be possible to spin a relatively fine thread with the 25g spindle whorl. Also, if they were spinning plant fibres like flax or nettle, this spindle whorl would be suitable to spin a fine thin yarn.

As demonstrated above, the loom weights of less than 338g could also be used when producing a dense fabric with thin warp threads. It is, however, unlikely that such a warp thread could have been spun with any of the recorded spindle whorls since one probably needs a whorl with a weight of less than 10g (if spinning on a suspended spindle).

Production quality	Fired clay	Unfired clay	Stone	Not available
good	12			2
medium	5	4		
poor		1		
Not available			1	2

Figure 7. Evaluation of the textile tools production quality.

The majority of the tools are considered to have been made in a *good production quality* (figure 7). All the loom weights (except the stone weight) and four of the six spindle whorls are of the same type regarding shape and material. This fact does not seem coincidental, and suggests, perhaps, that great care was also taken in the production of the textiles.

To conclude: the textile production in Archontiko appears to have been well developed. The spinners and weavers knew how different types of tools affected the final products and also the tools themselves were well made. The analysis of the spindle whorls demonstrates that the spinners have spun different types of yarn from thin to thick qualities. The variation within the loom weights and the variation within the spindle whorls indicate that the people of Archontiko produced many different types of textiles from dense to coarse fabrics that could have been open, dense, weft faced and coarse.