Technical Report
Experimental Archaeology
Part 2:1 flax, 2006

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Tools and Textiles – Texts and Contexts
Research Programme

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Contents

Introduction

The experimental research programme described in the following is a component of the *Tools and Textiles – Texts and Contexts* (TTTC) project directed by archaeologist Eva B. Andersson, PhD, and historian Marie-Louise Nosch, PhD. The first aim of this programme is to investigate the function of textile tools from the eastern Mediterranean areas that are dated to the Bronze Age using experimental archaeology as a method. The second aim is to explore experimental archaeology as a method, including its potentials and risks. Three stages of research focussing on different questions have been performed during 2005 and 2006. Part one took place in November-December 2005; part two, presented here, took place in March-May 2006; and part three in November 2006. The experiments have been conducted by textile technicians Anne Batzer, a professional weaver working at Lejre Historical-Archaeological Experimental Centre (HAF) in Denmark, and Linda Mårtensson, an archaeologist from Sweden and educated in prehistoric textile technology.

To ensure scientific control over the experiments, they have been conducted according to TTTC's principles for utilizing experimental archaeology as a scientific method:

- The primary parameter to be investigated is function
- Raw materials, such as wool and flax, must be selected according to our knowledge of Bronze Age fibres and work processes
- Tools must be reconstructed as precise copies of archaeological artefacts
- All processes must be performed by at least two skilled craftspeople
- Every new test should be preceded by some practice time
- All processes must be documented and described in writing, photographed and some filmed
- All processes must be analysed individually
- All products must be submitted to external experts on textile analysis

Stage 2:1: flax fibres

During March 2006, the second stage of the research programme with experimental archaeology begun. The initial test in this stage concerned spinning with flax fibres. Flax is known from written sources from the eastern Mediterranean Bronze Age (Ventris & Chadwick 1973). The mission was to get more and specific information about how the textile tools function when working with flax fibres. The main question asked was what type of knowledge we can get concerning the tools' function by using flax fibres. In order to compare the tools' function when spinning wool as opposed to flax fibres, we decided to use the same 8 g whorl on the same spindle rod as was used in an experiment examining the spinning of wool fibres (Mårtensson *et al.* 2005-2006). The aim was also to test if and how the linen threads, spun with the 8 g whorl, work in a warp weighted loom.

Preparing flax

To date, we do not have any information on what kind of flax was used in the Bronze Age eastern Mediterranean area, and how it might have been prepared**.** We decided to use flax that was already worked into fibres, ready to spin when we got it, instead of spending too much time on the flax preparation, a very time consuming process. We got the flax fibres, weighing about 100 g, from HAF (fig. 1). The information we had on the fibres was that they had been stored for many years at HAF, were water retted and that they were prepared in a way that has been employed traditionally in Scandinavia.

Fig. 1. 10 g of about 50-100 cm long flax fibres used in the experiment.

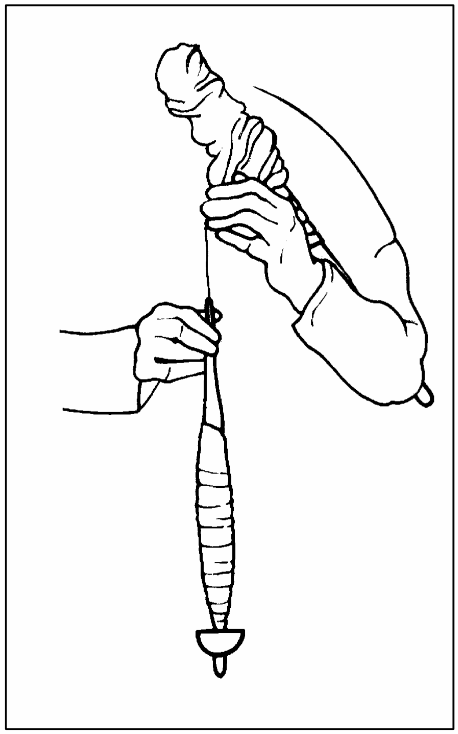

Fig. 2. Spinning with the help of portable distaff and spindle.

Before spinning, the fibres had to be arranged in a way that made them easy to work with. Since there is no evidence in archaeological records of tools connected to this process, as far as we know, we decided primarily to derive the procedure from iconography, experience and traditions. In Classical Greek art, one can see spinners using distaffs (Barber 1991: 69, 70), but it is hard to tell what fibres they are using. Traditionally, for example in Sweden, the way to arrange the fibres is to separate them according to whether they are long or short. Short fibres and tow are often seen arranged in a bunch, sometimes fastened in a fork on top of a wooden distaff. Long fibres, on the other hand, are seen spread out and hanging down on or fastened around a distaff. Since we were planning to spin long flax fibres, measuring approximately 50-100 cm, we decided to use the method in which the fibres are spread out on the distaff. As we already had two modern wooden reels fastened on a table in the experimental workshop, which could work well as distaffs, we decided to use them. Distaffs more often are portable, fastened to a belt around the waist or held in the hand (fig. 2), but fixed distaffs are also known (Stockenström 1990: 13). We also decided to use the method in which the fibres are fastened around the distaff, predicting that the fibres would turn out more separated from each other, which is important if the threads to be spun are thin. We also decided to arrange 10 g of fibre at a time, which was the amount of fibre we felt would fit on our improvised distaffs.

Fig. 3. Arranging the flax fibres.

The fibres were spread out on a table and formed into a U-shape (fig. 3). Some tows and woody parts of the fibres were discarded. Since the discarded amount was so small, it was collected and measured together with the fibres discarded while spinning. With the lower part of the U as a start, the fibres were smoothly wound around the distaff. A woollen ribbon was wrapped around the fibres to hold them in place. The distaff was fastened on the table and the fibres were ready to be spun (fig. 4).

Fig. 4. The fibres were wound around the distaff, which was fastened on the table.

Spinning

In the first part of the project, which used wool fibres, it was decided that the spinners should not try to spin similarly. As a result, some differences were seen in Batzer's and Mårtensson's ways of spinning and in the final threads. In the current experiment, it was decided that the spinners should try to work in the same way and try to spin similar threads, according to what the spinners could recognize only by looking at and feeling the threads. We chose this procedure because we wanted to see how the individual spinners might affect the spun threads when the aim was to spin similarly. It was also decided that the threads should be spun in a Z direction, as they were to be compared with the Z spun woollen threads from the earlier experiment.

Linseed water

Flax fibres need to be moistened during spinning to make them flexible. This can be done by putting saliva or water on the thread while spinning. Using saliva was not considered in the experiment because this is rather unpleasant when one is spinning many meters of thread. Instead, we decided to use water. Since the threads were supposed to work as a warp, we also decided to put some linseed in the water. Because of the pectin, linseed water is assumed to have a gluing effect on the threads. This procedure may reduce fibres sticking out of the finished thread. One tablespoon of linseed was mixed with 12 centilitres of water. When the linseed water felt too slippery, we added some more water.

Fig. 5. Working position, spinning flax fibres.

Initial test spinning

Since both spinners had spun wool fibres recently, it was of great importance that they spend some time getting a feeling for how to spin the flax fibres in a relaxed way. Each spinner did some initial test spinning before the actual experimental test. Some observations were made regarding these tests.[1]

Both spinners spun in the same way concerning, for example, how to pull out the fibres while spinning (fig. 5). One exception was apparent: Batzer turned her spindle with the left hand and Mårtensson turned hers with the right hand. It was decided that the spinners should continue using different hands, but, besides this, employ the same way of spinning.

Outstanding tows and woody parts were discarded while spinning. When a spindle was filled, the thread was wound onto a reel and treated similarly to what was done in the earlier experiment with wool fibres. The exception was that it was not necessary to moisten the threads on the reel since they became wet while spinning. The threads were weighted when they had dried and then wound onto small bobbins.

Experimental test spinning

Twenty tests were made with the 8 g whorl (fig. 6). Both spinners conducted 10 tests each. Each test was documented in a log. Each number in the schedule represents one spindleful. The weight and length of the threads and the time it took to spin a full spindle were measured for each test (Appendix).

	yarn weight g	yarn length m	spinning time h
Batzer, 10 tests	23	226.4	9.3
Mårtensson, 10 tests	21.8	289.6	8.7
Tot. 20 tests	44.8	516	18

Fig. 6. Total result, 8 g whorl, flax.

Figures 7-9 illustrate the maximum, minimum and the mean result of the total outcome of all filled spindles, according to spinning time, yarn length and yarn weight. The maximum and minimum results show that there was a significant difference between the two spinners in terms of when the spindle was regarded as filled. The relationship between the two spinners is clear when comparing the mean

[1] In one of these tests, Mårtensson spun the thread in an S direction, since flax fibres naturally turn in this direction. The practice in spinning in an S direction indicated that there was an obvious difference between Z and S when spinning with the 8 g whorl. The S spun thread was much more lively, meaning that the thread twisted and curled more than did the Z spun thread, especially while winding the thread on the spindle rod. But when the thread finally was in place on the spindle, it embraced the rod very tightly. When spinning in a Z direction, both spinners felt that the threads were rather balanced, meaning that the thread was straight and calm while spinning and winding it on the spindle. But when the thread was on the spindle, the spinners could feel some movements in the thread that made the thread embrace the spindle rod in a loose way. This was probably caused by the fibres' natural S twist.

results. In regards to time and weight, the results are quite similar (figs. 7 & 9). But, in relation to length, Mårtensson spun about 22 % longer threads (fig. 8), even though, the threads weighed about 5% less than did Batzer's threads. This means that Mårtensson's threads generally were longer and thinner. This result is interesting, since both spinners were trying to spin similar threads. The matter may be clarified by some observations made while spinning.

While spinning the 10 tests, both spinners reacted to how difficult it was to produce a thread that felt similar to the previous ones. Since it was difficult to spin similar threads within an individual spinning, it was even harder to adjust the spinning in a way that the threads were similar with the other spinner's threads. These differences may have something to do with the fibres. For example, woody fibres were found in some tufts of fibres and in other tufts there were none. Another reason why it was so hard to spin similarly also could have been the lack of experience and routine.

One important factor that might have affected the differences in the two spinners' threads was observed while adding linseed water. This process was not discussed in detail during the spinning experiment. It was reported later that Batzer used much more linseed water while spinning the thread than did Mårtensson. Could this have had an effect on the final thread? One guess is that the water helped to connect more fibres.

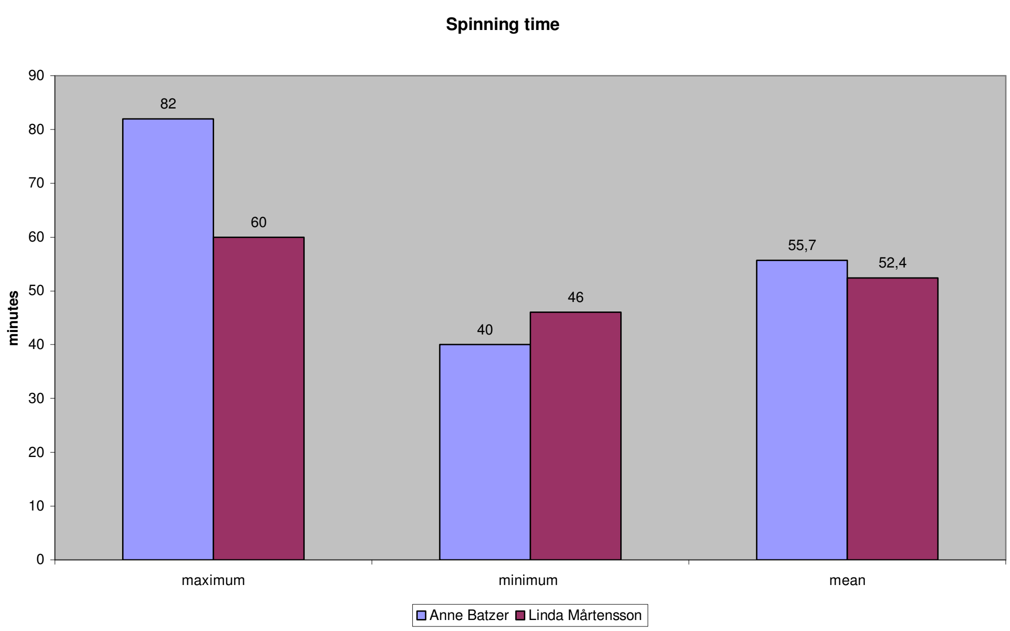

Fig. 7. Spinning time for a full spindle, 8 g whorl, flax, Batzer & Mårtensson.

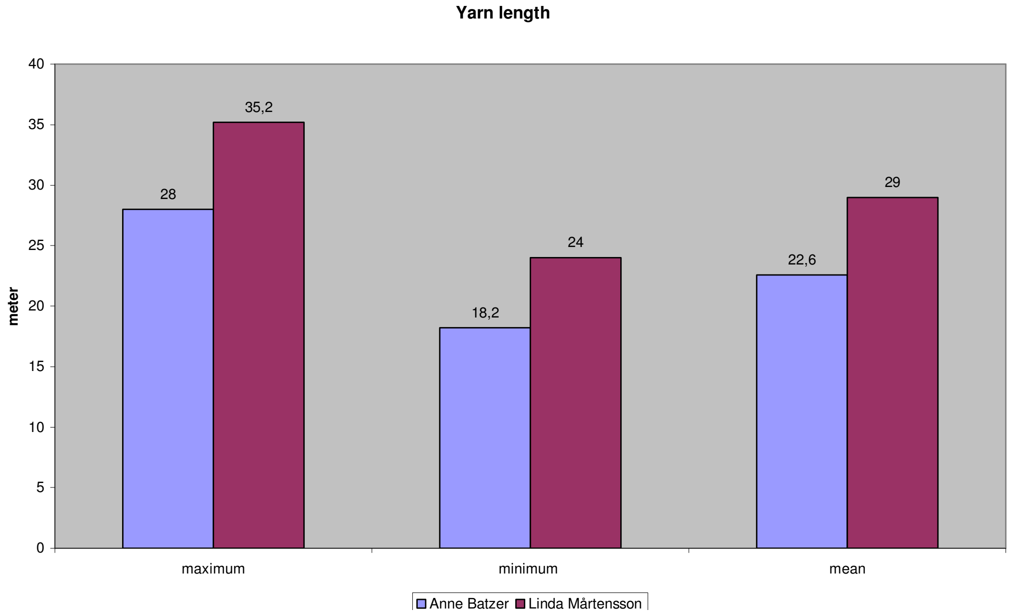

Fig. 8. Yarn length for a full spindle, 8 g whorl, flax, Batzer & Mårtensson.

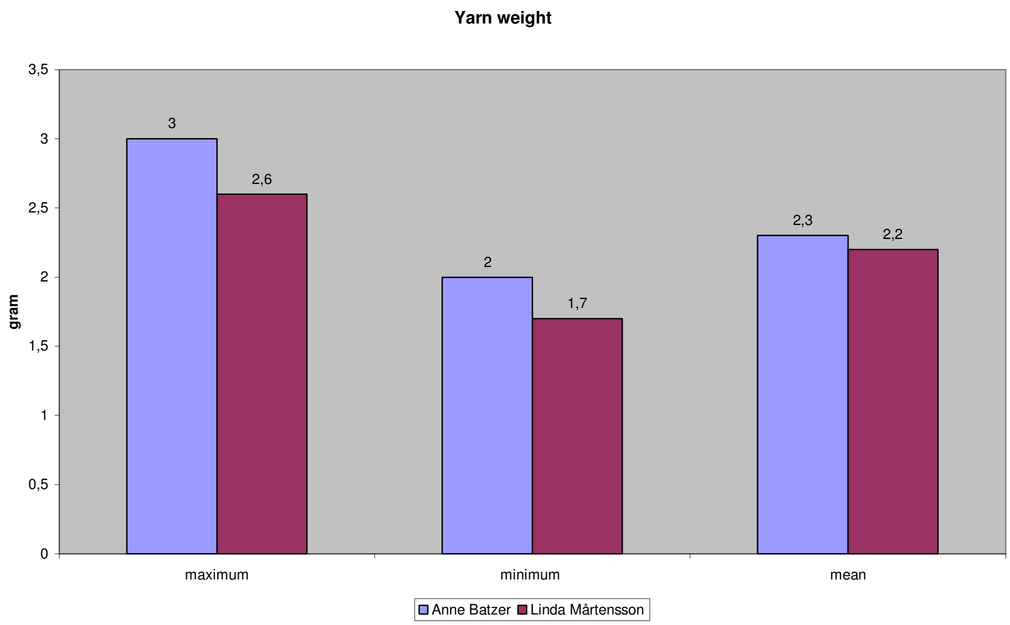

Fig. 9. Yarn weight for a full spindle, 8 g whorl, flax, Batzer & Mårtensson.

Flax consumption

The fibre (raw material) was already prepared when it was received from HAF. Because of this reason, it is not possible to describe the preparation process. Some of the fibres were discarded when arranging the fibres on the distaff and some were discarded while spinning. Only around 6 g was lost from overlooked spill and dust. All together, approximately 10-12% was discarded as too woody or messy (fig. 10).

	Batzer	Mårtensson
Raw material	27.9	26.7
Yarn weight	23	21.8
Discarded	3.4	2.8
Discarded %	12	10

Fig. 10. Consumption of raw material.

Comparison of flax fibres and wool fibres spun with the same 8 g whorl

The comparison of working with flax fibres and wool fibres indicates two main differences according to the tools' function while spinning. When the spindle was almost full of thread, it started to wobble in a more extreme way while spinning with flax than it did with wool. There are three possible explanations for this. It could be that the whorl may have managed to twist the flax fibres in a more balanced way if the rod was thinner in width, to expand the whorl's diameter in relation to the rod. It should also be remembered that the wooden spindle rod and the threads absorbed some of the linseed water, which may have affected the spindle's weight above the whorl. A third possible explanation could be that the linseed water made the top of the spindle slippery, which made the spindle hard to twist. It felt more extreme, overall, when the spindle was full. The spindle changed quite abruptly to being hard to twist, it stopped and ran the other way around.

Fig. 11. Thread slipping off the whorl.

The second notable difference compared to spinning wool was that the threads easily slipped off the whorl when the spindle was almost full of thread (fig. 11). We tried to wind the threads higher up on the spindle rod, instead of on the width, but the spindle started to wobble and spun the other way around. It has been assumed that a whorl with a large diameter is needed to spin plant fibres. This assumption was corrected in an earlier experiment, where it was shown that a whorl with a small diameter works well for spinning flax (Andersson & Batzer 1999: 18, 19). One reason a whorl with a large diameter could be especially suitable for spinning flax also could be that it stops the threads from slipping off the spindle. It would be interesting to test, in a more systematic way, if it is only the Z spun threads that glide off the whorl. If that is the case, would a whorl with a small diameter be considered unsuitable for Z spun flax threads?

A calculation was made concerning how many metres of thread we got per 100 g of fibre (fig. 12). A comparison of these results indicates that the outcomes produced from working with wool and flax fibres are quite similar. No difference is apparent between the various fibres, but there are differences between the two spinners.

Thread samples sent for external analysis

In the earlier test of spinning wool fibres, an estimate was made to determine to what extent the samples sent for external analysis were representative for all the spun threads. It was clear that overall the samples of approximately 2 metres of thread were representative of the spun thread. In the current experiment, it was decided that every sample should contain approximately 7 metres of thread. A longer thread sample provides an even better picture of the total result when examining the threads. Samples were taken from Batzer's and Mårtensson's spinning tests 3, 6 and 9.

Conclusion: spinning

The aim was to get more and specific information about how the textile tools function when working with flax fibres. The tool used was the same 8 g whorl used in the earlier wool experiment. Overall, the 8 g whorl worked well as a spindle whorl for spinning flax fibres. It was possible to spin a thread with this tool in a relaxed way, without giving the spindle much force from the spinners' hands. It was hard to spin a homogenous thread that was perfectly similar within all 10 spinning tests.

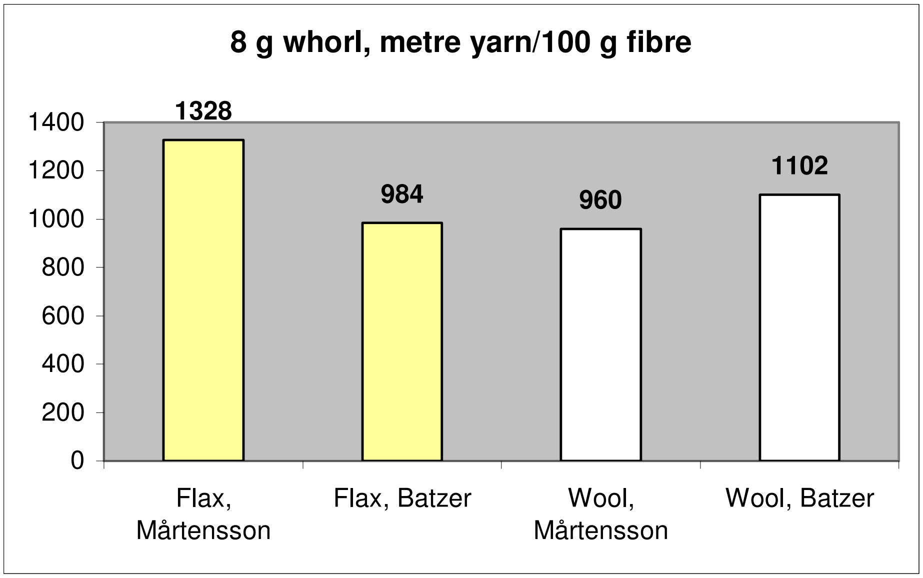

Fig. 12. Calculation of metre yarn/100 g spun fibres.

Moreover, it was even harder to spin threads that were similar to the other spinner's threads. Some differences were seen in the tools' function in comparison to the experiment on spinning wool fibres with the same spindle. When the spindle was almost full of thread, it started to wobble in a more extreme way while spinning with flax than it did with wool. The Z-spun linen threads also easily slipped off the spindle while spinning, which was a rather disturbing interruption. Perhaps the spindle would be more suitable in its function, for spinning Z-spun linen threads, if the whorl had a larger diameter. Thus, the calculation concerning how many metres of threads we got on 100 g spun fibres showed no clear difference between spinning with wool or flax fibres.

Weaving

The aim was also to test if and how the linen threads, spun with the 8 g whorl, work in a warp weighted loom. This was done by weaving a small sample.

To be able to compare the process and the results with the results from weaving with wool threads, spun with the 8 g whorl in the first stage of the experiment, the linen threads were arranged on the loom in the same way. One half of the warp consisted of only Batzer's threads and one half only Mårtensson's, altogether a 19.5 cm wide warp with 226 warp threads (11 threads/cm). We did not do any calculations on the nature of the threads before the weaving test. Thus, we expected the threads to function together and assumed that it would be appropriate to warp 11 threads per cm to produce a tabby in balance.

Loom weights

We assumed that each thread would need approximately 18 – 20 g tension. The same discoid, rounded loom weights, as in the earlier weaving test were used. The loom weights weighed 180-187 g and had a thickness of 2 cm and a diameter of 10 cm (fig. 13). Every loom weight was attached to 11 threads, approximately 18.5 g/thread.

Fig. 13. Reconstructed discoid, rounded loom weight.

Fig. 14. Arranging the warp threads. The wet handkerchief is seen in the background.

The weaving process

The linen threads spun with the 8 g whorl worked well for weaving. The threads were strong and did not break. The shed was easily changed without any problems, with threads from different layers sticking together. The threads were continuously moistened while weaving to obtain a more flexible yarn. Cups with water were placed on top of the radiator and underneath the loom. The threads were also carefully moistened with a wet handkerchief (fig. 14).

Fig. 15. Weaving sample.
The sewing threads indicate parts of the sample with only Batzer's or Mårtensson's threads (Mårtensson: red and orange; Batzer: green and blue).

Separating the warp threads
There was an obvious imbalance between the two halves of the weave. Mårtensson's half tended to be more packed together than was Batzer's. This was already noticed in the starting border during warping. The resulting asymmetrical effect could be regulated by arranging the single weft threads with a small pin beater. But treating the weave in this very delicate way felt unreasonable. Instead, the decision was taken to separate the warp into two samples. How would the different spinners' threads work in the loom separated? In this way we could work with Batzer's and Mårtensson's threads independent of each other. Weaving a small sample with the two halves separated was performed without any problems. It was obvious that Mårtensson's threads were suitable for a more closely warped fabric. Perhaps the threads from the two different spinners would work better together if the threads were warped alternating between Batzer's threads and Mårtensson's.

Generally, it took about 50 minutes to weave 4 cm. The weight of the loom weights, 18.5 g/thread, worked well with these threads. The final sample (fig. 15) was sent for external analysis.

Conclusion, stage 2:1: Flax fibres

The aim was to get more and specific information on how the textile tools function when working with flax fibres. What can we learn about the tools' function by using flax fibres? The aim was also to test if and how the linen thread worked in a warp weighted loom. The 8 g whorl spindle worked well as a spindle whorl when using flax fibres. When examining how many metres of thread were spun on 100 g spun fibres, the results of spinning with wool and flax fibres were quite similar. The greatest difference was between the spinners and not between the fibres. This result was also significant in the weaving test. The threads spun by the two spinners did not work well together in the loom. Separated, they were suited for two different types of fabrics, one with a higher thread count than the other. Overall, the linen threads worked well in a warp weighted loom. An important finding indicated that both wool and linen threads spun with the same 8 g whorl require identical weight tension in a warp, 18.5 g per thread.

References

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Appendix

	Batzer								
	flax, 8 g whorl, Z								
nr	**date**	**whorl**	**spindle**	**fibre before (g)**	**fibre left (g)**	**discarded fibre (g)**	**yarn weight (g)**	**yarn length (m)**	**spinning time (min)**
1	09-03-2006	IIb	b	10			2.7	23.1	75
2	09-03-2006	IIb	b				2.4	22.4	55
3	10-03-2006	IIb	b				2.3	28	82
4	10-03-2006	IIb	b	42 min:10g		42min: 1.3	2	22.4	64
5	10-03-2006	IIb	b			0.4	2.1	28	57
6	16-03-2006	IIa	a				2.1	18.2	40
7	16-03-2006	IIa	a				2.1	21	44
8	16-03-2006	IIa	a	12 min:10g		12min:1.1g	3	25.5	51
9	17-03-2006	IIa	a				2.3	19.6	46
10	17-03-2006	IIa	a		2.1	0.6	2	18.2	43
	Mårtensson								
	flax, 8 g whorl, Z								
nr	**date**	**whorl**	**spindle**	**fibre before (g)**	**fibre left (g)**	**discarded fibre (g)**	**yarn weight (g)**	**yarn length (m)**	**spinning time (min)**
1	09-03-2006	IIa	a	10g			2.6	28.8	60
2	09-03-2006	IIa	a				2.1	24	50
3	10-03-2006	IIa	a				1.9	27.2	53
4	10-03-2006	IIa	a	41min: 10g		41min: 0.7g	2	28.8	51
5	10-03-2006	IIa	a				2.6	35.2	55
6	17-03-2006	IIb	b				1.7	32	55
7	17-03-2006	IIb	b				2.3	33.6	52
8	17-03-2006	IIb	b	32min: 10g		32min: 1.3 g	2.5	30.4	54
9	21-03-2006	IIb	b				2	24	46
10	21-03-2006	IIb	b		3.3	0.8	2.1	25.6	48