TEXTILE TOOLS FROM SITAGROI

A total of 477 objects are recorded in the database (figure 1). Textile tools from the site were first recorded in the CTR database using the information available in the publication *Prehistoric Sitagroi: Excavations in Northeast Greece 1968-1970 Volume 2: The Final Report* (Renfrew, C & Elster, E 2003). Afterwards the database was revised and completed by Professor Ernestine Elster and Tara Carter.[1] Initially, the textile tools from the earlier phases (I-III) were excluded because these are outside the Bronze Age focus of the TTTC research programme. However, for the purposes of this report, it was later decided to compare some of the textile tools from phase III with the tools from the later phases, since we think that these tools add important information to the discussion and thereby the conclusions.

Furthermore, it should be noted that phase III lasts from 4600 until 3500 BC (a period of 1100 years), while phase IV covers 3500 to 3100 BC (400 years) and phase V is dated from 3100 to 2200 BC (900 years). Consequently the tools from the different phases cannot be considered as representative, either with regard to considering the likely nature of the textile production in a certain phase, or in making comparisons between the different phases. On the other hand, an analysis of the recorded tools can give an indication of what types of textiles might have been produced at Sitagroi.

The majority of the recorded tools date to period V – EH II. 250 objects are from household contexts and 227 are from other contexts described as, for example, "Bin Complex". Phase V has been further divided into two phases; Va and Vb. However, in the database the tools are just dated to phase V. In some cases we have therefore tried to separate the objects from Va and Vb, in accordance with the existing publications (Renfrew, C *et. al.* 1986; Renfrew, C & Elster, E 2003).

It should also be noted that impressions of cloth (2), cord (8) and mats (46) have been found on clay. Another two textile impressions have not yet been identified. The majority of the impressions are from phase III (44); 2 are from phase I, only 3 are from phase IV and finally, 14 are from phase V (Renfrew, C & Elster, E 2003: 247). The impressions have also been analysed and discussed in relation to painted and incised designs on pottery (Renfrew, C *et. al.* 1986; Renfrew, C & Elster, E 2003).

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[1] We kindly thank Professor Ernestine Elster and Tara Carter for their collaboration and support.

Context date		spindle whorl	loom weight	spool	pointed bone tool	hook	Anchor	in all
Phase IV - EH I								
	household	42	14		17			73
	other	25	3	2	13			43
Phase V - EH II								
	household	109	14	17	11	8	13	172
	other	89	14	14	9	18	8	152
mixed								
	household	5						5
	other	27	4	1				32
in all		297	49	34	50	26	21	477

Figure 1. Chronological and contextual distribution of the objects from Sitagroi based on context date.

SPINNING AND SPINDLE WHORLS AT SITAGROI

298 objects are recorded as spinning tools in the database. However, due to its very high weight we have reclassified object SIT-2753 as a loom weight or another type of weight, and the object has been excluded from the present analysis. 67 whorls are from phase IV and 198 are from phase V. Another 98 whorls dated to phase III have been recorded from the publication but please note that we have not registered *context type*.

The majority of the spindle whorls are made of clay and have a biconical or conical shape (figure 2).

Type	Clay	stone	in all
biconical	145		145
concave conical	2		2
conical	128		128
convex	9		9
convex?	6		6
cylindrical	1		1
discoid	34	1	35
other	47	3	50
spherical	17	1	18
not available	1		1
In all	390	5	395

Figure 2. The relationship between the type and material of the spindle whorls. Please note that spindle whorls from phase III are also included.

However, as can be seen in figure 3, the majority of the whorls from all contexts in phase III and most of the whorls from phase IV (deriving from both household and

other contexts) are conical. The spindle whorls from phase V are in general biconical (figure 3).

	Phase III, LN	Phase IV, EH I		Phase V, EH II		In all
context		household	other	household	other	
type						
biconical	6	8	5	66	52	137
concave conical	1	1				2
conical	49	27	13	12	15	116
convex?				3	3	6
cylindrical					1	1
discoid	33	3	6	2		44
other	8	3	1	18	16	46
spherical	1			7	2	10
not available				1		1
In all	98	42	25	109	89	363

Figure 3. The relationship between date, context and spindle whorl type.

Working from the published information it is possible to divide 143 of the spindle whorls from phase V contexts into different chronological groups; Va (3100-2700 BC) and Vb (2700-2200 BC). As can be seen in figure 4, 14 spindle whorls are dated to the first phase Va and 129 to phase Vb, but there is no prominent change in type between these two periods.

Date	Type	Va	Vb	In all
Phase Va and Vb, EH II	biconical	11	76	87
	concave conical			
	conical	2	19	21
	convex?		3	3
	cylindrical		1	1
	discoid			
	Other		25	25
	spherical	1	5	6
	In all	14	129	143

Figure 4. The relationship between date and spindle whorl type in Phase Va and Vb.

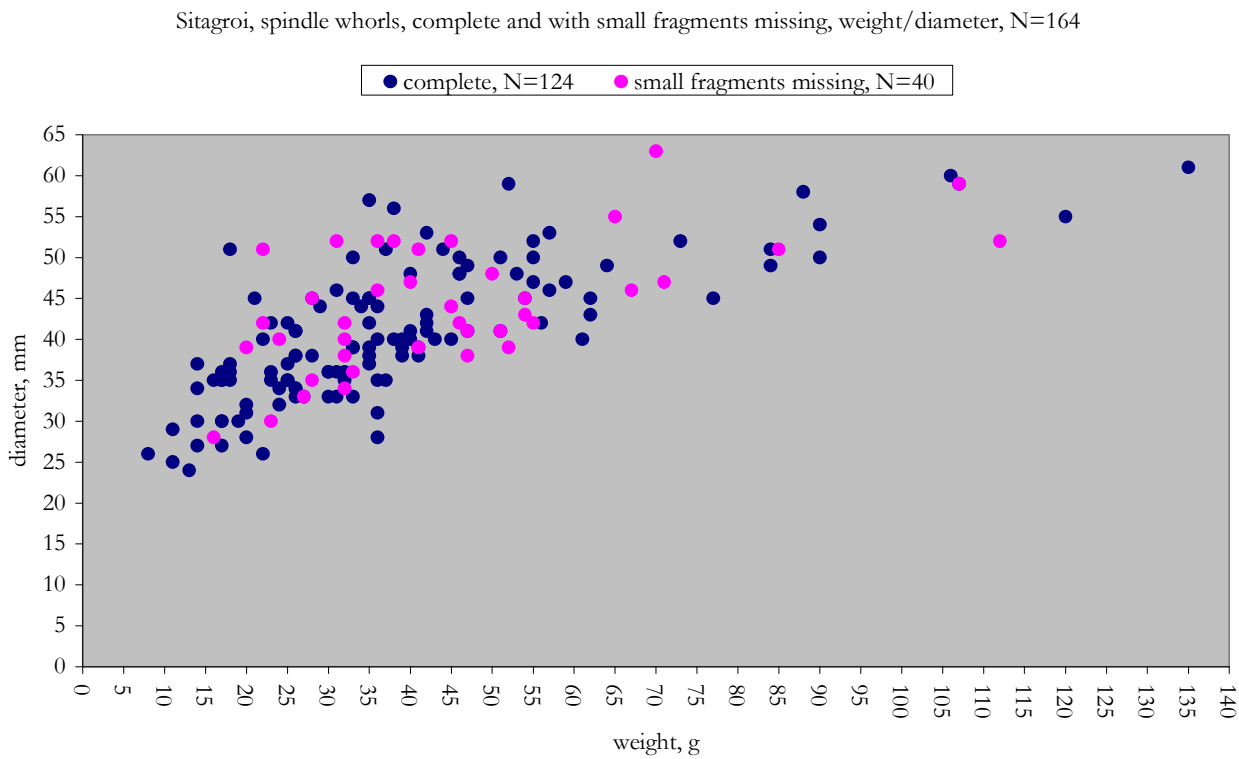


Figure 5. Complete spindle whorls and spindle whorls with small fragments missing, weight/diameter.

Complete spindle whorls and spindle whorls with small fragments missing

A comparison between the complete whorls with a recorded weight (124 objects) and the spindle whorls with small fragments missing (40 objects) demonstrates that they fall within the same weight range (figure 5). We have estimated that the margin of error in the calculation of the whorls with small fragments missing is less than 10% (1g for a whorl weighing ≤ 10g, 2g for a whorl weighing ≤ 20g etc.). This variation would not have affected the finished thread produced by the whorls and we have therefore decided to include the whorls with small fragments missing in this study.

Type and weight-diameter

As can be seen in figure 6, there is no clear relation between spindle whorl type and weight. The weight of the spindle whorls varies from 8g to 135g and the diameter varies from 26 mm to 61 mm. This indicates that several types of yarn spanning from thin to very thick were produced at Sitagroi. Conical spindle whorls and "other types", however, display greater variation in diameter than the biconical spindle whorls.

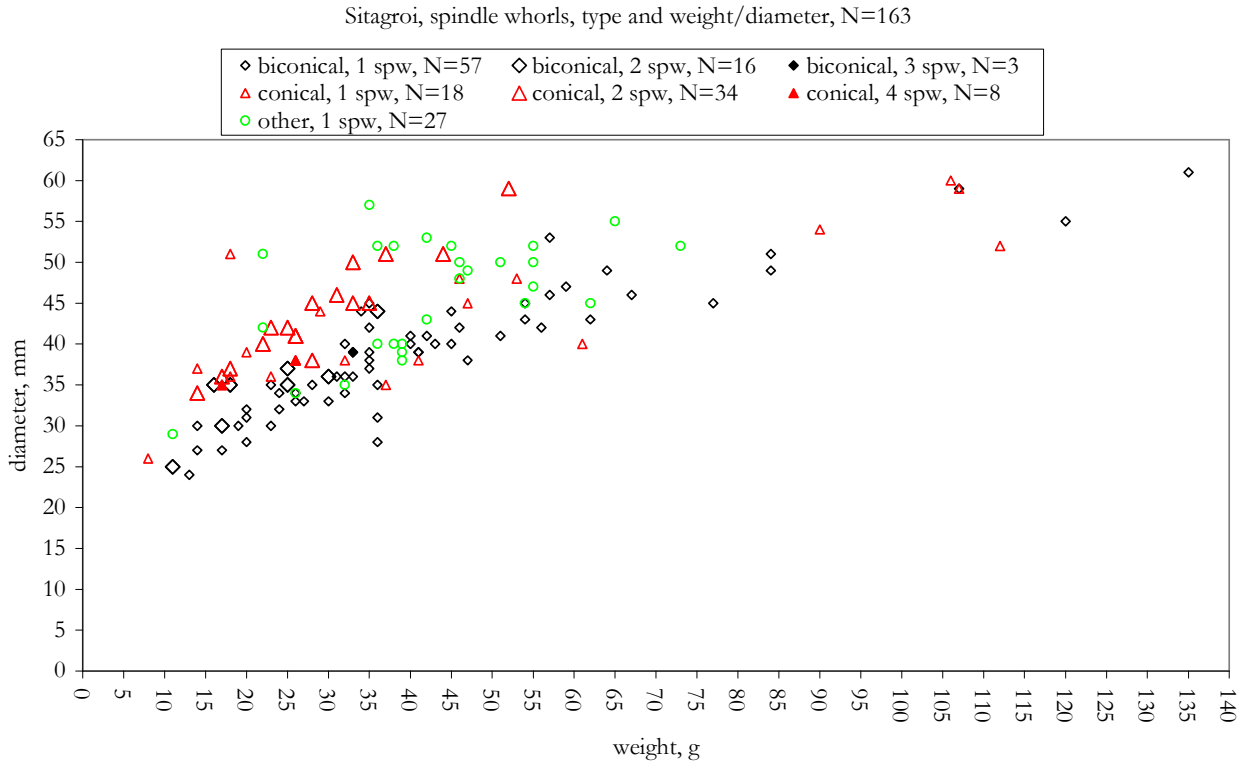


Figure 6. The relation between type and weight/diameter. Please note that types that are represented by < 5 spindle whorls are excluded from this figure.

As can be seen in figure 7 the variation in whorl weight is considerably larger during phase V, indicating a larger range of different types of thread, with an emphasis on thicker thread. However, it should be noted that spindle whorls are less numerous during phase III and IV (35 and 15 objects respectively) compared to phase V (112 objects). What is also interesting is that the diameter of the whorl in relation to the whorl's weight is in general larger in phase IV than in phase V. When the spindle whorls from phase III are included, the analysis demonstrates the same tendency; the spindle whorls in phase III also have a larger diameter in relation to the weight (figure 7). This could of course be due to the change in shape of the whorls, but this change could also affect the outcome with regard to the spun yarn. The conical whorls are very suitable for spinning hard spun threads while the thread spun with the biconical spindle whorls with the same weight would become more loosely spun (please see introduction). Furthermore, the analysis clearly demonstrates that the spinners at Sitagroi were already spinning different types of thread from thin to very thick in the LN period.

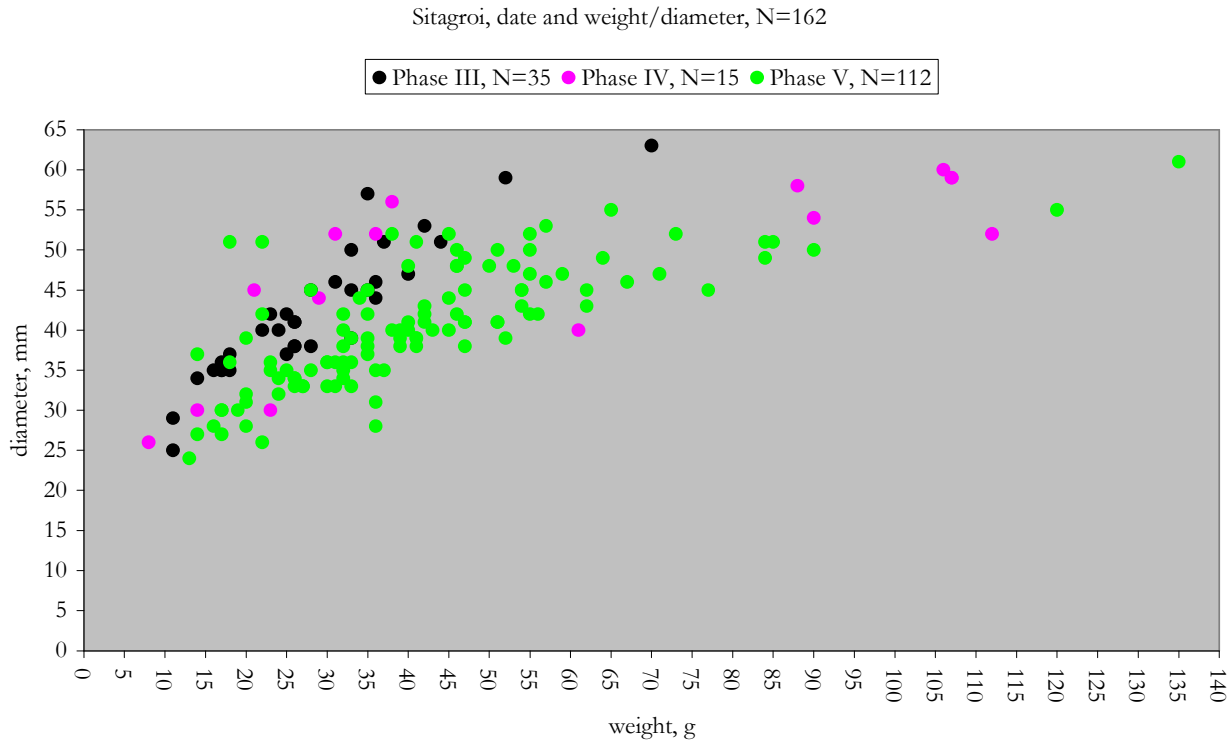


Figure 7. The relation between spindle whorl date and weight/diameter.

There is a difference between the phase IV spindle whorls from households and "other contexts" (figure 8). The phase IV spindle whorls from households vary in weight from 88g to 135g and in diameter from 52 mm to 60 mm, while the spindle whorls from "other contexts" vary in weight from 8g to 61g and in diameter from 26 mm to 56 mm. This indicates an emphasis on the production of very thick yarn in the households and thin to thick yarn in "other contexts". However, because of the spindle whorl weight the household spindle whorls could also have been used as loom weights.

During phase V there is no significant difference between spindle whorls from household and "other contexts" (figure 8). However, two larger whorls are from household contexts and like the whorls from phase IV they may have been used as loom weights.

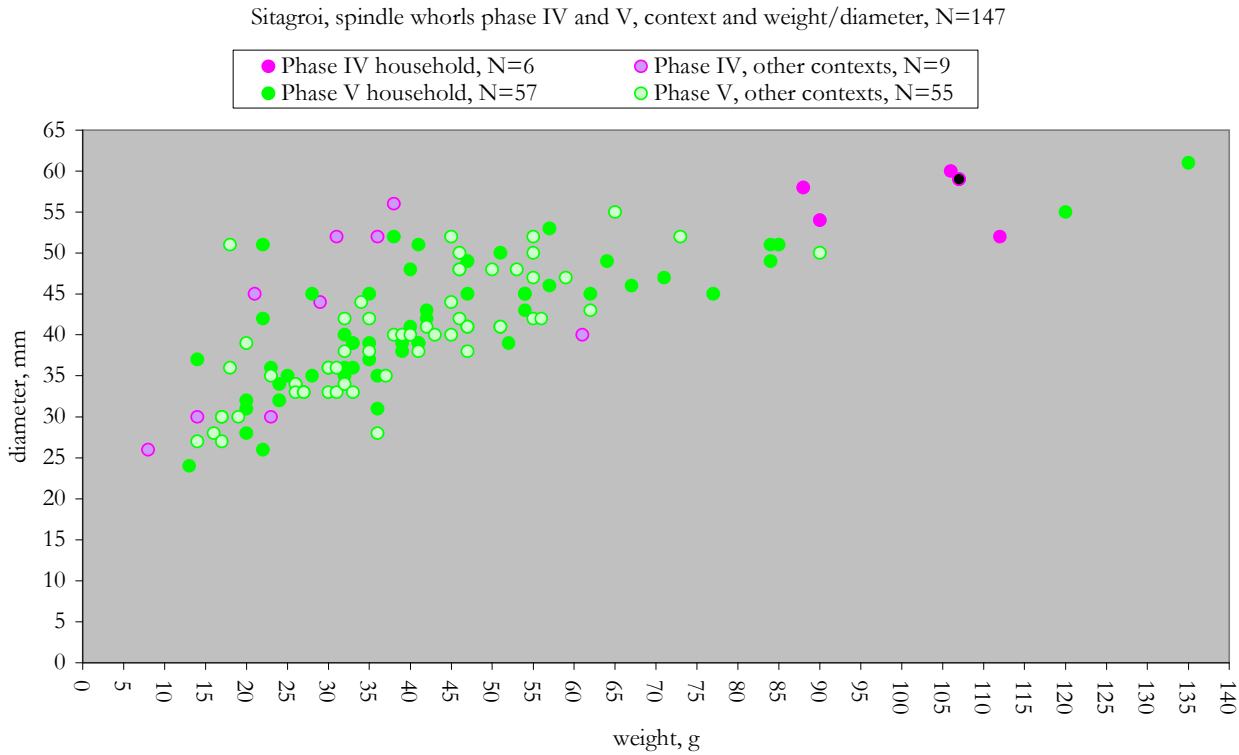


Figure 8. The relation between spindle whorl date, context and weight/diameter.

Spinning at Sitagroi – a summary

The results from phases III, IV and V indicate a larger range of types of yarn during phase V. It is also interesting to note the emphasis on thicker yarn during phase V, while the emphasis during phase III and IV is, with few exceptions, on thinner yarn. The analysis also demonstrates that the Sitagroi spinners were producing a harder spun yarn in phase III and IV than in phase V. This could be due to a change in the type of fibres being spun.

The spindle whorls could have been used to spin the yarn for all fabrics with warp threads needing a tension of 20g or more. Note, however, that the type of fibre and the fibre quality can also have a significant influence on the type of fabric produced. If, for example, the Sitagroi sheep had wool with very thin and long fibres, it would be possible to spin a fine thread with the lightest whorls. Also, if they were spinning plant fibres like flax or nettle, this type of light spindle whorl would be suitable to spin a fine thin yarn. For example, one test in the TTTC programme demonstrated that it was possible to spin a thin but strong thread with a 8g spindle whorl, that on the loom needed 20g tension per thread. The yarn spun with the heaviest whorls would have been very thick and would have been used for coarser textiles.

WEAVING AND LOOM WEIGHTS AT SITAGROI

A total number of 83 objects were recorded as loom weights in the database.

Context date	Type	Household	other	In all
Phase IV EH I	Conical	1		1
	cylindrical long	8	3	11
	Discoid	3		3
	Other	2		2
	pyramidal			
	Spool		2	2
	in all	14	5	19
Context date	Type	Household	other	In all
PhaseV EH II	Anchor	13	8	21
	cylindrical long	1		1
	Discoid	1	1	2
	Hook	8	19	27
	Other	2		2
	pyramidal	10	11	21
	Spool	17	14	31
	Torus		2	2
	in all	52	55	107

Figure 9. The relationship between loom weights, anchors and hooks: context, date and type. Please note that objects from mixed contexts are excluded.

As can be seen in figure 9, the majority of the loom weights are dated to Phase V – EH II. 14 of the loom weights from phase IV are from household contexts and 5 are from "other contexts". 11 of these weights have a cylindrical long shape. In this figure we have chose to include the anchors and hooks from phase V, since it has been suggested that they could have had a function as loom weights. This will be discussed later in the text.

31 of the loom weights from phase V derive from household contexts and 28 are from "other contexts". 31 weights, from both household and other contexts, are spool shaped. 21 loom weights have a pyramidal shape (figure 9).

31 loom weights are completely preserved and 20 weights have small fragments missing. However, for phase IV, the weight and thickness measurements are only available for 7 loom weights, all cylindrical long. For phase V, the weight and thickness are available for 21 weights, all spools. Another 2 loom weights from mixed phases are recorded with thickness and weight. The weight and thickness for the loom weights from phase III are not available.

The weight of the loom weights from phase IV varies from 600g to 1170g and the weight of the spools from phase V varies from 21g to 68g. Furthermore, the weight of two broken pyramidal loom weights from phase V is recorded, their weight being 1510g and 1285g respectively. This observation clearly demonstrates that very heavy loom weights were also used during phase V.

To conclude, since the number of loom weights with both weight and thickness recorded is small, the following analysis cannot be considered as representative of the overall textile production at Sitagori during phases IV and V, but it can, on the other hand, give an indication of what types of fabric may have been produced with the preserved tools.

Loom weights and weaving at Sitagroi during phase IV.

7 of the loom weights from phase IV vary in weight from 600g to 1170g, with a width varying from 57-98 mm. These loom weights would have been suitable for producing coarser fabrics with thick threads. To elucidate our interpretation of these weights and how different variables affect a fabric we have calculated a possible loom setup based on the loom weight measurements. We have chosen loom weight SIT-3057 and SIT-476. Please note that the suggestions are based on our experience and experiments, but are on the other hand conjectural as to what is optimal.

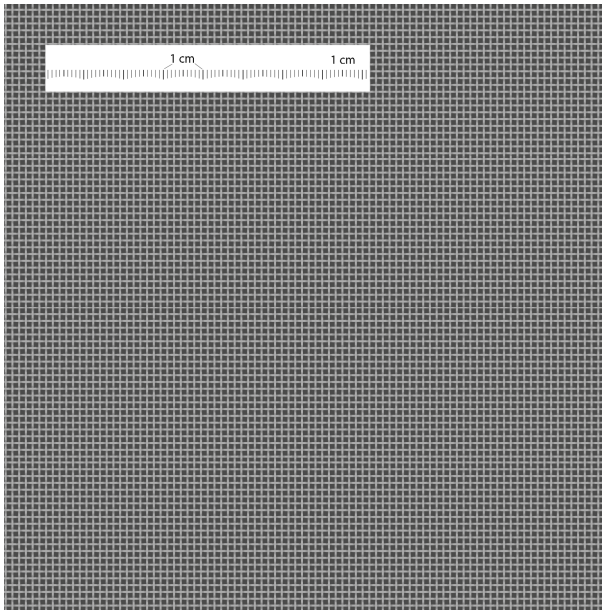
Warp thread tension	10 g warp tension	20 g warp tension	30 g warp tension	40 g warp tension
Number of warp threads/loom weight	600 divided by 10=60	600 divided by 20=30	600 divided by 30=20	600 divided by 40=15
Number of warp threads/ 2 loom weights	60x2=120	30x2=60	20x2=40	15x2=30
Warp threads/cm	120 divided by 6,3=19	60 divided by 6,3=10	40 divided by 6,3=6	30 divided by 6,3=5
Number of loom weights	32	32	32	32
Number of warp threads	1900	1000	600	500
Amount of warp yarn	1900 m	1000 m	600 m	500 m
Amount of weft yarn	1900 m	1000 m	600 m	500 m
Yarn consumption for 1 m^2 cloth (including 2% waste)	3876 m	2040 m	1224 m	1020 m
Time consumption for spinning the yarn	111 h	51 h	24,5 h	20,5 h
Technical evaluation of the tool's suitability	Unlikely: too many threads per loom weight	Optimal, but a large number of threads per loom weight	Optimal	Optimal

Figure 10. Calculation of various loom setups with a loom weight of 600g and a thickness of 63 mm. SIT-3057

Warp thread tension	10 g warp tension	20 g warp tension	30 g warp tension	40 g warp tension
Number of warp threads/loom weight	880 divided by 10=88	880 divided by 20=44	880 divided by 30=29	880 divided by 40=22
Number of warp threads/ 2 loom weights	88x2=176	44x2=88	29x2=58	22x2=44
Warp threads/cm	176 divided by 5,7=31	88 divided by 5,7=15	58 divided by 5,7 =10	30 divided by 5,7=8
Number of loom weights	34	34	34	34
Number of warp threads	3100	1500	1000	800
Amount of warp yarn	3100 m	1500 m	1000 m	800 m
Amount of weft yarn	3100 m	1500 m	1000 m	800 m
Yarn consumption for 1 m^2 cloth (including 2% extra yarn)	6324 m	3060 m	2040 m	1632 m
Time consumption for spinning the yarn	181 h	76,5 h	49 h	33 h
Technical evaluation of the tool's suitability	Unlikely: too many threads per loom weight	Unlikely: too many threads per loom weight	Optimal	Optimal

Figure 11. Calculation of various loom setups with a loom weight of 880g and a thickness of 57 mm. SIT-476

As can be seen in figures 10 and 11 these loom weights would function very well as loom weights for producing fabrics with 5 to 10 threads per cm in warp and weft. The calculations are based on a balanced tabby (please see introduction page 6) but the fabrics could also have been weft faced, which results in a more dense fabric (figure 12a-c).



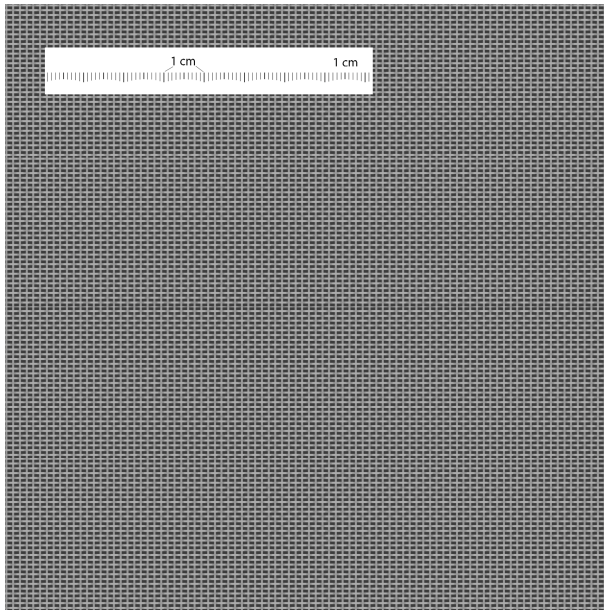


Figure 12a. **Left:** a balanced tabby with 0.5 mm thick threads and 5-6 threads per cm in warp and weft.
Figure 12b. **Right:** a slightly weft faced tabby with 0.5 mm thick threads and 5-6 threads per cm in warp and 7.5 threads per cm in weft.

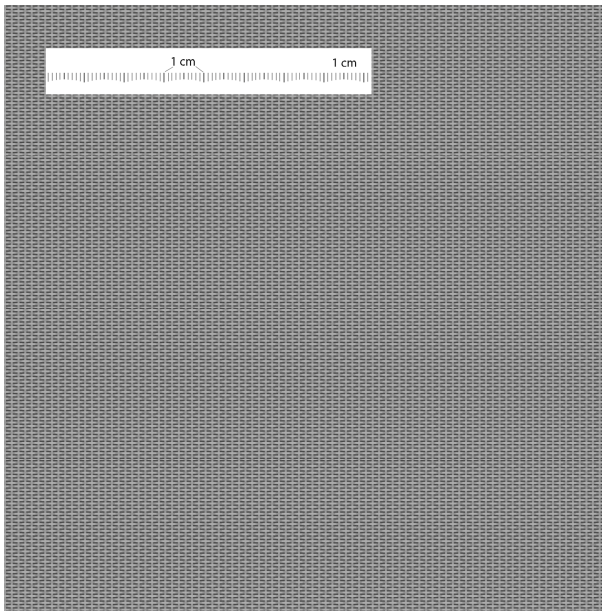


Figure 12c. A weft faced tabby with 0.5 mm thick threads and 5-6 threads per cm in warp and 10-12 threads per cm in weft.

To conclude: the analysis suggests that it is possible, with these loom weights, to produce many different types of fabric, both fine and coarse, with thin to very thick threads.

Weaving at Sitagroi during phase V

58 loom weights come from period V. 30 are from household contexts and 28 are from other contexts.

Weaving with spools?

As mentioned above, spools are the most common type of loom weight recorded in the database but the weight and the thickness varies within this group. 17 spools with preserved weight and thickness have been recorded. The spools vary in weight from 21g to 68g and in thickness from 26 mm to 38 mm (figure 13). In the TTTC research program two weaving tests have demonstrated that it is possible to use spools as loom weights (Mårtensson et al. 2007). The spools tested in these experiments weighed 100g and 285g, and so the experiments still leave the important question whether spools weighing less than 100g could function as loom weights in a warp weighted loom. All spools from Sitagroi weigh less than 100g.

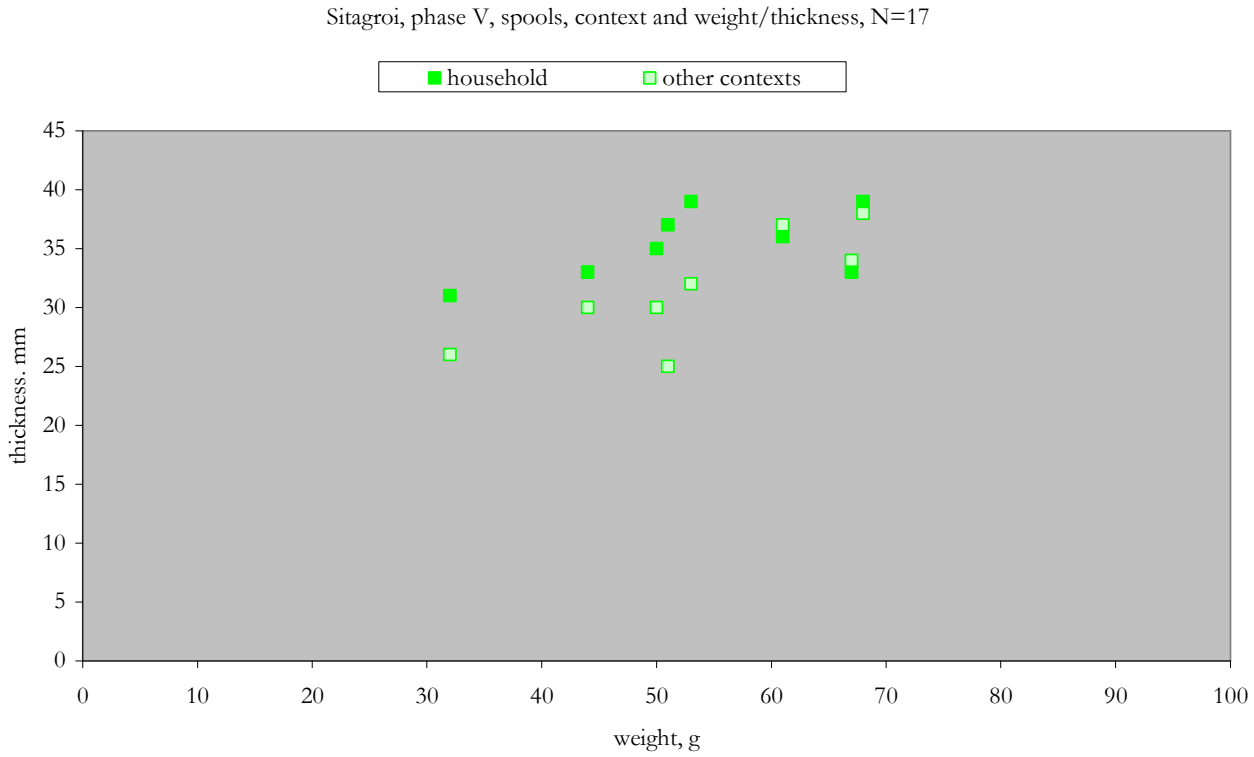


Figure 13. The relation between the spools' contexts and weight/thickness.

To elucidate our interpretation of the spools' function as loom weights we have calculated possible loom setups on the basis of one spool from the Sitagroi settlement area.

Warp thread tension	10 g warp tension	20 g warp tension	30 g warp tension	40 g warp tension
Number of warp threads/loom weight	44 divided by 10=4	44 divided by 20=2	44 divided by 30=1	44 divided by 40=1
Number of warp threads/ 2 loom weights	4 x=8	2x2=4	1x2=2	1x2=2
Warp threads/cm	8 divided by 3,3 cm=2	2 divided by 3,3 cm ≤1	2 divided by 3,3 cm <1	2 divided by 3,3 cm <1
Number of loom weights	60	60	60	60
Number of warp threads	200	< 100	<100	<100
Amount of warp yarn	200 m	X	X	X
Amount of weft yarn	200 m	X	X	X
Yarn consumption for 1 m^2 cloth	408 m	X	X	X
Time consumption for spinning the yarn	12 h	X	X	X
Technical evaluation of the tool's suitability	Unlikely: too few threads per cm	Unlikely: too few threads per cm	Unlikely: too few threads per cm	Unlikely: too few threads per cm

Figure 13. Calculation of various loom setups with a spool of 44g and a thickness of 33 mm. SIT-1565

As can be seen in figure 13 these light spools cannot be considered functional as loom weights in a warp weighted loom as such. Attaching so few warp threads to one single spool is not functional and even counterproductive. The thickness of the spools is also a vital factor, because if using a light but thick weight the fabric will become very open and consequently not functional as a fabric. As can be seen in figure 14, a fabric with 5 threads per cm woven with thin threads also becomes very open and a fabric with even fewer threads would therefore be even more open. On the basis of the same inferences we do not consider that the other spools from Sitagroi were functional as loom weights in a warp weighted loom We also strongly support the earlier interpretation (Renfrew, C & Elster, E 2003, 239) that these spools can be very useful as weights for tablet weaving, where one adds two to four threads per tablet, or for other types of band weaving and braiding (Gleba 2008). These spools could also have been very useful when setting up a warp in a loom (Mårtensson *et. al.* 2006).

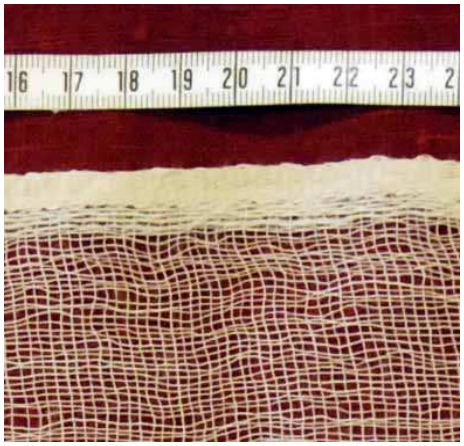


Figure 14. A fabric, woven with threads requiring 10g warp tension, ca. 5 warp threads per cm and 8 weft threads per cm (Mårtensson et al. 2006).

Anchors and hooks

In the publication it is suggested that the anchors and hooks could have had a function as loom weights (Renfrew, C & Elster, E 2003, 242-245). The weight is not recorded, but according to their thickness (hooks 8mm to 21 mm and anchors 14 mm to 21 mm) we consider that, if they are not too light, they may have functioned as loom weights. It is not yet possible to make any calculations on potential loom setups using these objects, but one would expect the fabric woven to be quite dense.

Pyramidal shaped loom weights

Finally, the pyramidal loom weights must be discussed. According to the publication (Renfrew, C & Elster, E 2003, 241; see also Plate 6.11 and 6.12) these loom weights vary greatly in size, which suggests that the pyramidal loom weights could have been used to produce many different types of fabric from fine to coarse, with thin to very thick threads. Actually, with some of these loom weights it would probably be possible to produce the same types of fabric as with the cylindrical long weights from phase IV. The heavy weights would be most suitable for coarser textiles with thick threads.

Weaving at Sitagroi during phase V

It is difficult to make any conclusions regarding what types of fabric could have been produced during this phase. The spools could have functioned as weights in a tablet weave or may have been used when setting up a warp on a loom. Even if the loom weight material is very sparse, the pyramidal shaped loom weights give an impression of a quite varied production of different qualities of fabric.

OTHER TEXTILE TOOLS

Pointed bone tools have also been found at Sitagroi. We have recorded 30 from phase IV and 20 from phase V that, in our opinion, could have been used as pin beaters - a multifunctional weaving tool. The pin beaters could for example have been used to distribute the weft thread in the weave, and some (for example the pointed tools on ribs), could have been used as weft beaters for band weaving. These types of tools are

also suitable for use in association with different types of looms, both the warp weighted loom and the two beam vertical loom.

TEXTILE PRODUCTION AT SITAGROI

The analysis suggests a production of many different types of yarn, from thin to very thick. During phase V the results indicate a larger range of different types of thread with an emphasis on thicker threads. The spindle whorls are from both *household contexts* and *other contexts* but it is only during phase IV that a clear difference in production between the two contexts can be seen. It has also been noted that the majority of the phase IV spindle whorls in general have a larger diameter in relation to the weight than the whorls from period V. This could indicate a change in fibre material or just a change from the use of a hard spun to a more loosely spun yarn. It is interesting that there is evidence for wool (or at least sheep) during all the three phases (Renfrew, C *et. al.* 1986, 69). The indications of flax and other plant fibres are rare, but are present (Renfrew, C & Elster, E 2003, 230). This indicates that all whorls from Sitagroi could have been used for spinning both wool and plant fibres.

Only a limited analysis of the loom weights and weaving has been possible, because all the necessary parameters are not available, and the results therefore cannot be considered as representative. However, there are very few loom weights and even if the analyses of the spindle whorls and the loom weights suggest different types of threads and fabrics, the possibility must be considered that other types of loom than the warp weighted loom may also have been in use during all phases.

It is also notable that in phase V the variation in the weight range and the diameter/thickness range of both the spindle whorls and the loom weights is larger than in phase IV, demonstrating a larger variation in the textile production.

The evidence provided by the mat and textile impressions suggests a well developed textile production at Sitagroi and the recorded tools support this. Unfortunately, there are no cloth impressions from phase IV or V, but the elaborate mat techniques clearly indicate that the textile producers at Sitagroi had a good knowledge of fibres and textile techniques. The textile impression dated to phase I is also very interesting, since it demonstrates a long textile tradition at Sitagroi.