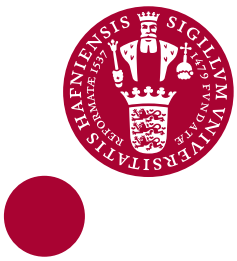

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SPINNING AND WEAVING WOOL IN UR III ADMINISTRATIVE TEXTS

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In his book *Untersuchungen zur Neusumerischen Textilindustrie* (*UNT*), Hartmut Waetzoldt[1] has written extensively on the interpretation of Ur III textile texts. His emphasis in that work was directed towards the difficult task of understanding the cryptic texts that served to log the administration of the work of the textile industry.

The aim of this paper is to bring together the information from the administrative texts that describe the tasks of spinning and weaving wool and to interpret these in the practical terms of textile making in order to gain a better understanding of the nature of these textiles. This will use the knowledge base gained by the Danish National Research Foundation's Centre for Textile Research in Copenhagen (CTR). In particular, it will use the results of spinning and weaving experiments that were designed by CTR. The interpretation of the texts used here will closely follow that given by Waetzoldt in *UNT*.[2]

In a discussion on the manufacture of woollen textiles it is natural to start by considering wool quality before going on to consider the spinning of the yarn and the weaving of the textiles. The textile tablets list many different types of fabrics and garments. However, the intention here is to concentrate on four of the main types of textile, namely, ^{túg}guz-za, ^{túg}níg-lám, ^{túg}uš-bar and ^{túg}bar-dul$_5$ (which, for convenience, will be written in this paper without the determinatives). It will be shown that the eventual type of fabric produced was determined by both the selection of the wool and the spinning of the yarn.

Wool Quality

The wool and textiles listed in the administrative texts are very frequently listed according to their specified quality. The wool quality in the records was determined by the breed of sheep and the part of the sheep from which the wool is taken. Waetzoldt's findings are neatly summarized by Potts (1997, 92),

> Five classes, ranging from first (royal) to fifth (normal), in addition to coarse, unclassed wool, were recognized in the Ur III period (*UNT* 47–48). Judging by the economic texts the overwhelming majority of wool produced in Mesopotamia was of the poorer quality but the percentage of wool belonging to each of the qualitative classes varied

1. We thank Hartmut Waetzoldt and Eva Andersson Strand for their useful suggestions and comments.

2. It should be noted that there are occasional references to textiles in literary texts. However, it is not considered appropriate to examine those in detail here for two reasons. First, the descriptions of textile production in literary texts are not as detailed as the information that can be gleaned from the administrative texts considered in this paper. Second, textiles in literary texts are usually associated with divinities or royalty and are therefore of a much higher quality than the overwhelming majority of the garments manufactured in the Ur III period, even though they might be described using some of the same terms.

Table 1. An example of wool provided by a shepherd from Umma.

Quantity of wool (mana)	Wool Quality
17.5	for níg-lám fabric of 3rd quality
132.5	for guz-za fabric of 3rd quality
45.5	for níg-lám fabric of 4th quality
25.5	for níg-lám fabric of 5th quality
209	for guz-za fabric of 4th quality
220.67	for guz-za fabric of 5th quality
75	for uš-bar fabric
Total = 725.67	

> greatly within a flock of sheep and between different cities (*UNT* 62–63). Moreover, wool quality varied according to sheep breed, as did the quantity of wool produced per animal. Thus, the fat-tailed sheep (*udu-gukkal*) produced wool of high quality (first and second classes) … In contrast, the 'highland/mountain sheep' (*udu-kur-ra*), … only rarely produced third-class and yielded mainly fourth- and fifth-class wool. The most common sheep of the Ur III period, called *udu-uli-gi*, … produced gi-wool … Gi-wool was coarse and only rarely entered the fourth and fifth classes. More often it was unclassed and used for general wool rations and the manufacture of coarse garments.

In an example from a tablet from Umma (Jursa and Payne 2005: no. 5, i 1–9) information is given about the wool from mountain sheep provided by Urru the shepherd, summarized here in table 1.

This clearly demonstrates that the quality of fabrics was determined by the quality of the wool. The convention was for scribes to list types of wool and fabrics in the order of their quality. Thus the information in table 1 would imply, for example, that the 3rd-quality wool for níg-lám fabrics is of a higher quality than the 3rd-quality wool for guz-za because it precedes the latter in the list. It would also imply that the 5th-quality wool for guz-za fabrics is of a higher quality than the wool for uš-bar. It will become clear that this is consistent with the finding below that the yarn used for níg-lám is finer that that used for guz-za, which is in turn finer that the yarn used for uš-bar fabric.

Spinning

The tablets that record details about the spinning of wool distinguish between whether the yarn is to be used for the warp or the weft of the fabric.[3]

UNT 125 lists six examples that set out the task of spinning wool for warp threads (denoted by ŠID), which are all taken from the Girsu tablets *ITT* II 909 and *ITT* V 9996.[4] These texts provide information on the total weight of wool and the number of days required to spin that wool.[5] In addition, there are five equivalent examples for spinning weft threads (denoted by šà), again from *ITT* II 909 and *ITT* V 9996 (*UNT* 127).

3. The ancient Mesopotamians probably used horizontal ground looms (Waetzoldt 1972: 130–32). Warp threads are the threads that are fixed onto the wooden beams of the loom and serve as the basis for the weave into which the weft is inserted. The warp yarn must thus be spun with a greater level of tightness since it plays an important part in determining the strength of the fabric. See Waetzoldt (*UNT* 130–31) and Breniquet 2009. On the identification of workplaces for weavers, see the critical analyses by Breniquet 2006.

4. *ITT* V 9996 is listed by Waetzoldt as *UNT* 32.

5. Since there is inevitably some wastage, the weight of the wool spun is somewhat smaller than the weight of the yarn produced.

Texts for Spinning Wool

The readings of the texts concerned with the spinning of wool are as follows,

ITT II 909 i:

a) 7. ⅓ ma-na ŠID ^{túg}níg-lám 3-kam-ús
8. á-bi 60 u_4 1-šè
["⅓ mana warping thread (for) 3rd class níg-lám material,
work for 60 (spinners) for one day"]

b) 12. 1 gú 15 ma-na 10 gín šà ^{túg}uš-bar
13. á-bi 300⅔ u_4 1-šè

c) 14. ⅔ ma-na ŠID ^{túg}uš-bar
15. á-bi 8 u_4 1-šè

ITT V 9996 ii:

d) [ŠID-bi ⅔? ma-na]
1. [gemé 1-e u_4 1]-a igi-3-[gál] ˹ì˺-U.NU

e) 2. [šà]-bi 1⅔ ma-na
3. gemé-1-e u_4 1-a 1 gín ì-ak-ke_4

ITT V 9996 iii:

f) 8. ŠID-bi ⅔ ma-na
9. gemé 1-e u_4 1-a 1 gín ì-U.NU

g) 10. šà-bi 3⅓ ma-na
11. gemé 1-e u_4 1-a 7½ gín ì-ak-ke_4

ITT V 9996 Rev. i:

h) 11. [ŠI]D-bi 1⅓ ma-na
12. [gemé 1]-e $u_4$1-a 2 gín [ì]-U.NU

i) 13. [šà -bi]˹1˺⅔ ma-na
14. [gemé 1-e $u_4$1]-˹a˺ ˹6?˺ (or ˹3˺) ˹gín˺ [ì-ak-ke_4]

ITT V 9996 Rev. ii:

j) 3. [ŠID-bi x] ma-na
4. [gemé 1-e u_4 1]-a 5 gín [ì-U].NU

k) 5. [šà -bi] 6 ma-na
6. [gemé 1-e]˹u_4 1-a˺ ⅓ ma-<na> ì-ak-ke_4

It is useful to include here some discussion about the interpretation of these texts. Text (g) can be interpreted as "3⅓ mana of weft threads, one woman spinning 7½ gín per day" or in terms of modern units, "1.67 kg of weft

threads, spinning 62.5 g per day."[6] The texts (b) and (e) to (k) fall into this pattern. Text (d) is slightly different because the number is given as a reciprocal (igi … gál). Thus, the reading of (d) is that ⅓ gín of fiber is spun each day.

There is a complication with text (i) where the number of gín per day is variously given in *UNT* as 6? or 3 (p. 127) and +3 or 5 (p. 233).

Texts (a) to (c) take a different form since they give a total weight of wool and state how many days it would take to spin it. Text (c) is the most straightforward since it states that ⅔ mana (40 gín) of wool are spun in 8 days, that is, 5 gín per day (cf. text [j]).

Table 2. A summary of the rates of spinning wool from the above texts.[7]

fabric	**Rate of spinning (gín per day)**	**Warp or weft threads**	**Text**
níg-lám (3rd quality)	⅓	warp	(a), (d)
	1	weft	(e)
guz-za (4th quality)	1	warp	(f)
	7½	weft	(g)
bar-dul$_5$ (5th quality)	2	warp	(h)
	3, 5, or 6?	weft	(i)
uš-bar	5	warp	(c)
	15	weft	(b)
?	5	warp	(j)
	20	weft	(k)

Results of CTR Experiments

The next step is to try to relate these spinning rates to the types of thread that might have been produced. The following is a brief summary of the results of spinning experiments conducted by CTR under "laboratory conditions" but also includes a conversion into quantities with Neo-Sumerian units.[8]

1. Using an 18g whorl, a spinner can spin 56.5 g of woollen thread in 7.2 hours with a length of 350.6 m (0.16 g/m), i.e., 62.8 g (7.5 gín) per 8-hour day with a length of 390 m. This thread has a mean diameter of 0.46 mm.
2. Using an 8 g whorl, a spinner can spin 76.5 g of woollen thread in 19.3 hours with a length of 786.1 m (0.10 g/m), i.e., 31.7 g (3.8 gín) per 8-hour day with a length of 326 m. This thread has a mean diameter of 0.37 mm.

6. 1 mana is approximately equal to 500 g and 1 gín is one sixtieth of a mana (i.e., 8.33 g). For the present analysis, it is often convenient to use mana and gín as the units of weight in this paper because the original calculations take advantage of the sexagesimal number system.

7. In this paper, it is assumed that Waetzoldt (*UNT* 125, 127) is correct in suggesting that (d) and (e) correspond to níg-lám fabric.

8. Experiments (1)–(3) are described by Mårtensson et al. (2009) and in web reports on http://ctr.hum.ku.dk/research/tools/. See also Andersson et al. 2008; Nosch 2012. All the experiments are described by Andersson Strand and Nosch (2013). We should note that the times quoted do not include an allowance for winding the thread from the spindle into balls of yarn.

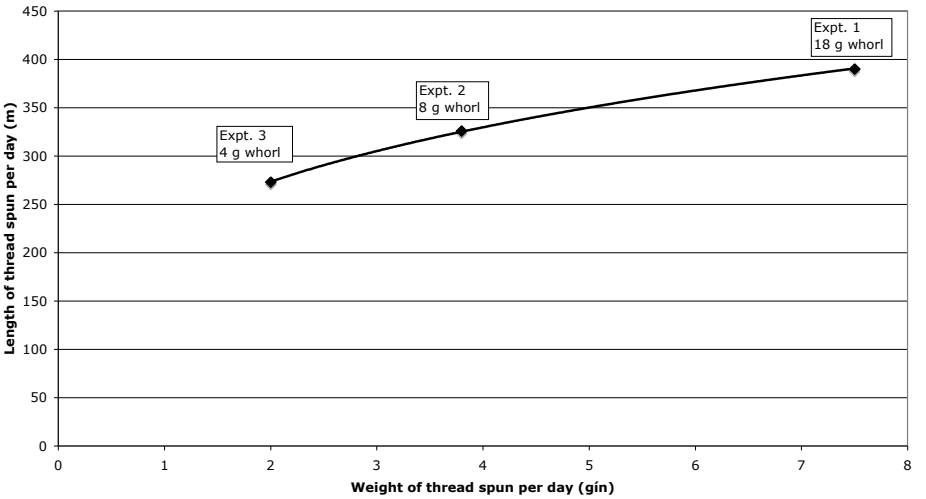

Fig. 1. Rates of spinning woolen thread in CTR experiments expressed in gín.

3. Using a 4 g whorl, a spinner can spin 31.1 g of woollen thread in 15.1 hours with a length of 515.3 m (0.06 g/m), i.e., 16.5 g (2 gín) per 8 hour day with a length of 273 m. This thread has a mean diameter of 0.29 mm.

The spinning rates for wool in the CTR experiments are sufficiently comparable to allow them to be used to interpret the practical implications of the work described in the texts. It is useful to express the above three results for the spinning of wool yarn in graphical form so that they are easier to interpolate and extrapolate (fig. 1).

The equation that will be used to interpolate and extrapolate these data is also shown in fig. 1 (see appendix A):

$$\text{Length of thread per day (m)} = 226.3 \times (\text{weight of thread per day in gín})^{0.27}$$

It must be emphasized that extrapolations are particularly subject to uncertainty and the interpolations and extrapolations given here are based on a limited amount of data. Nevertheless, these data are coherent and, in the absence of other data, it is judged that they form a sufficient basis to continue with this analysis.[9]

In the sections that follow, consideration will be given to the four different fabrics in turn and the information that is deduced will be related to our knowledge of the textiles from the texts.

As already noted, in Ur III texts, fabrics are conventionally listed in the order of their value, with higher-quality fine fabrics listed before lower-quality coarser fabrics. The order given in table 2a, that is, níg-lám (3rd quality), guz-za (4th quality), bar-dul$_5$ (5th quality), uš-bar, reflects not only a steady reduction of quality of the wool used, but also an increasing coarseness of the fabric. It is convenient to begin by considering the guz-za fabric because we have the most knowledge about that type of textile from the texts.

9. The rates of spinning found in the CTR experiments might have been increased if the spinners had been given more time and the experiments had been extended over many months. As part of a description of making a Medieval broadcloth, Reurink and Pedersen (2009) state that after four months of intensive spinning using a drop spindle, it was possible to increase the spinning rate. The rate given is ~27% higher than that described in the first CTR experiment for a thread with the same weight per length, although the spinning of wool for the broadcloth used carded wool and so these two trials are not directly comparable. Nevertheless, as a sensitivity study, the calculations were repeated using rates of spinning that were ~27% higher than those achieved in the CTR experiments. This resulted in thread counts that were ~20% higher than those given below.

guz-za Fabric

The full description of the manufacture of a 4th-quality guz-za fabric is given in *ITT* V 9996 iii 4–r. i 4, from which passages (f) and (g) were extracted (Waetzoldt 2010).

A guz-za fabric from 4th class wool,
The (roughly) cleaned wool for it (weighs) 8 mana (4 kg),[10]
1 woman cleans and combs 15 gín (125 g) in a day (and)
1 woman "mingles" (hi-hi) 2 mana in a day;
the warp threads for it (weigh) ⅔ mana (333 g and)
1 woman spins 1 gín (8.3 g) strongly twisted threads [in a day] (for the warp);
the weft threads for it (weigh) 3⅓ mana (1.66 kg and)
1 woman produces 7½ gín (62.5 g of them) in a day (for the weft);
(the) length (of the guz-za fabric is) 3.5 m (and)
(the) width (is) 3.5 m;
3 women warp in 3 days (and)
2 women weave 50 cm in a day.

For the weft of a guz-za fabric, 7.5 gín of wool were spun a day. If it is assumed that a working day lasts 8 hours, then it is possible to use the results of the CTR experiments for spinning yarn on an 18 g spindle from well-prepared and sorted wool. If 7.5 gín corresponds to what can be spun in 8 hours on such a spindle, then it can be estimated that ~390 m of thread could be produced with a mean diameter of ~0.46 mm (~0.16 g/m). It follows that the 3⅓ mana of wool allocated for the weft would result in ~10,400 m of thread. The fabric is 3.5 m square. Therefore, ~10,400 m of weft thread is equivalent to a thread count of ~8.5 weft threads per cm.[11]

For the warp of this fabric only 1 gín of wool was spun in a day. Using the equation above, based on the data from the CTR experiments, it can be estimated that ~226 m of thread would be produced per day. It is possible to go further and suggest that this thread would have a mean diameter less than 0.3 mm (~0.037 g/m) because it would be finer than the thread produced in experiment (3) above. If one gín of wool gives ~226 m of thread, it follows that the 40 gín of wool that is allocated for the warp threads would result in ~9,040 m of thread. Since the fabric is 3.5 m square, the thread count is ~7.4 warp threads per cm.

Although the total weight of the warp threads is only 20 percent of the weight of the weft threads, this calculation suggests that the total length of the warp threads is similar to the total length of the weft thread. This probably reflects an underlying intent that the warp and weft thread counts should be almost equal, as in a balanced fabric, even though, for this fabric, the warp thread is much thinner than the weft thread and so contains less fiber per unit length of thread.

In this example, there is five times more wool in the weft than in the warp. *UNT* 124 quotes two other examples where data are available for guz-za fabrics and these have similar warp to weft ratios of 1:4 and 1:4.2.[12] This would suggest that this ratio could be a defining feature of guz-za fabric. It is therefore suggested that guz-za is

10. We have chosen here to follow the translation of this line in *UNT* 111–12. For a slightly different translation, as "mixed wool," see Waetzoldt 2010: 205). This is in agreement with the following line where the wool is further cleansed (ì-šu-peš$_5$-e).

11. The calculations in this paper do not make the small allowances that are strictly required for the crimp in the threads caused by weaving and the thrums that are left on the loom when the woven fabric is removed. Furthermore, all results should be regarded as approximate because there are variations between the work of individual spinners and weavers.

12. These examples in *UNT* 124 are based on *UET* III 1547 ii 3–4 and BM 13875 1–2, respectively. In view of the disparity between the warp and the weft threads, it is possible that the fabric could have been woven as a gauze rather than as a tabby. For a tabby fabric the warp threads are evenly spaced and the weft threads are woven through them in a straightforward manner. For a gauze, successive pairs of adjacent warp threads are twisted together after each weft insertion, with the weft threads remaining relatively straight. See Andersson Strand, and Cybulska 2012.

a balanced fabric in terms of thread count alone but with a strong weft-faced character with coarse or thick wefts as the dominant feature.

It is possible to calculate that this guz-za fabric would have had a percentage openness of ~48 percent.[13] This is a

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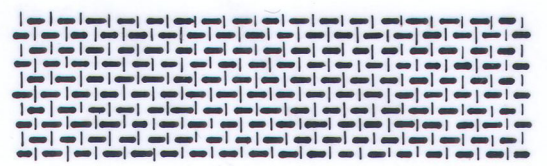

relatively high degree of openness for a fabric and this emphasizes the importance of fulling, which causes shrinkage and a felting of the woven textile, serving to reduce this openness (Firth in press).

The text implies that 50 cm of fabric were woven in a day. If there were ~8.5 weft threads per cm, then ~425 weft threads were woven each day or (for an 8 hour day) ~53 weft threads per hour.[14]

This leads to a discussion about whether the fabric was woven as a single large piece or whether it was woven as two widths and sewn together. It is argued in *UNT* 131 that it must have been woven in two pieces because the effective maximum width for two women weaving would be about 160 to 180 cm (based on ancient Egyptian information). However, Barber (1991: 81) quotes an example of very wide sheets of ancient Egyptian linen up to 2.8 m wide woven on a ground loom. In principle, if it were possible to weave fabric that was 2.8 m wide then it would be possible to extend that a little to 3.5 m. However, it would not be easy to weave such large widths if there were only two weavers (as on the above extract from *ITT* V 9996) because the width of fabric associated with each weaver would be much wider than her natural reach. Furthermore, the rate of weaving expected, of approximately one warp thread woven every minute, would argue in favor of a readily achievable weaving width, rather than one for which each weft thread required considerable effort.

Thus, this discussion favors the implication in *UNT* that the guz-za fabric in *ITT* V 9996 was woven in two or more strips and sewn together. It could be suggested that since two women were engaged in weaving, then there were two looms and so the cloth was woven in two strips. However, these strips would still be relatively wide (1.75 m). An alternative suggestion is that the cloth was woven on three separate looms, each weaving strips of 1.17 m, with two women weaving on each loom. In this case, the total time taken for weaving each strip would be seven days and the total time for the whole fabric would be twenty-one days.

It is now possible to consider the time taken for each of the different tasks listed in the text given above. A comparison will also be given with the findings from the CTR experiments wherever appropriate.

- For a guz-za fabric made from 4th-class wool, the (roughly) washed wool weighs 8 mana (4 kg),
- 1 woman cleans and combs 15 gín (125 g) in a day. Thus, it would take her thirty-two days to clean and comb all the 4 kg. This compares closely with the finding in the CTR experiments, where each person prepared ~14.2 g of wool per hour, corresponding to 114 g per eight-hour day.
- The warp threads for the guz-za fabric weigh ⅔ mana and the weft threads weigh 3⅓ mana. Therefore, this guz-za fabric would weigh 4 mana (2 kg).

13. Percentage openness = {1 – [(n1 x t1)/10 + (n2 x t2)/10 – (n1 x n2) x (t1 x t2)/100]} x 100, where the warp thread has a diameter of t1 mm and with n1 warp threads per cm; and the weft thread has a diameter of t2 mm with n2 weft threads per cm (Firth 2013).

14. The weaving rate for a tabby in CTR experiments is 45 weft threads per hour using two weavers working together. Therefore, a weaving rate of 53 weft threads per hour seems highly plausible.

- The implication is that when the 4 kg of (roughly) washed wool was cleaned, sorted, and combed, 2 kg (50%) was discarded. It is difficult to make a direct comparison here with the CTR experiments because it is dependent on how much washing and sorting of the wool was done prior to the start of the measurements. However, a loss rate of 50 percent is very plausible.
- In the text, one woman "mingles" (HI.HI) 2 mana in a day, thus the "mingling" takes two days. It is not clear what this process was because if it was simply mixing wool to obtain a uniform color then the time required seems excessive.
- Thus, in the text thirty-four days are recorded as being required for one woman to prepare 4 kg of (roughly) washed wool. In the CTR experiments, each craftswoman could prepare and comb 114 g per day (8 hours work) and this was wool that had already been presorted from a 2.7 kg fleece into a quantity of 1.1 kg of selected wool.
- The fabric was 3.5 x 3.5 metres and weighed 2 kg, therefore it had a density of 163 g per square meter.
- The warp threads for the guz-za fabric weigh ⅔ mana (333 g) and one woman spins 1 gín (8.3 g) strongly twisted threads in a day. This implies forty days for one woman to spin the warp.
- The weft threads for the guz-za fabric weigh 3⅓ mana (1.66 kg) and one woman produces 7½ gín (62.5 g) of them in a day. This implies 26⅔ days for one woman to spin the weft.
- Thus, the total time for spinning the yarn for this guz-za fabric is 66⅔ days. In 66⅔ days (with 8 hours per day), a CTR spinner could have spun 4.2 kg on an 18 g spindle, 2.1 kg on an 8 g spindle, and 1.1 kg on a 4 g spindle (assuming that the spinner continued to spin at the same rate as during the experiment).
- In the text, it takes three women three days to warp the loom(s) for a fabric of width 3.5 m.
- In the text, two women weave 50 cm in a day. The average weaving rate at CTR was 45 wefts per hour equivalent to 3–4 cm for two women weaving together.

In summary, the total time to make a guz-za fabric from 4th-class wool for one woman:

- 32 days to clean and comb all the 4 kg.
- 2 days for the "mingling"
- 40 days to spin the warp.
- 26⅔ days to spin the weft.
- 9 days to set up the warp of the fabric of a width of 3.5 m.
- 21 days to weave 3.5 m cloth (with the assumptions set out above that the cloth was woven in three strips and with 50 cm being woven on each strip per day)
- Total=130⅔ days

Thus, 26 percent of the time is taken up in fiber preparation, 51 percent in spinning and 23 percent in weaving. It should be emphasised that these times do not include the finishing and fulling of the fabric.

Dalley (1980) notes "^{túg}sig$_4$.za : *CAD*, s.v. *i'lu*, suggests that sig$_4$.za is a variant of guz.za, found at Amarna, Ugarit and Assur … Since guz.za means "having wiry hair" (*CAD*, s.v. *apparrû*), and since sig$_4$.za is used for the feet, for chairs (see *CAD*, s.v. *i'lu*) and for burial in this text, the meaning rug or blanket seems fairly certain." Durand (2009, 35) describes guz-za as a hairy or rough fabric. Waetzoldt (2010: 205) states that "the almost square guz-za fabric was doubled and used as a wrap-around garment (*Wickelgewand*)." Guz-za fabrics are also sometimes described as shaggy (Waetzoldt 2010: 204–5). There is nothing in the above calculations that would indicate a knotted or looped fabric. Therefore, if the description is correct, it might possibly imply that the level of fulling, which was required to compensate for the openness of the fabric, created a "fuzziness" of the fabric.

In Waetzoldt's (2010) brief description, he states that guz-za fabrics "have a weight of between 1.7 and 3.35 kg and they were 3.5 to 4 m in length and up to 4.5 m in width. A piece of guz-za fabric, however, could have a

length of 6.8 m." At first sight this seems to be a wide range of characteristics and so it would appear that guz-za is not standardized in terms of its size or weight.

In order to examine the weight of guz-za further, an analysis was made of a sample of over one thousand guz-za textiles that are described simply as 1st, 2nd, 3rd, 4th, or 5th quality within the cdli database.[15] The summary of the findings based on this sample are given in table 3.

Table 3. Survey of 1079 examples of guz-za fabrics.

Quality	1st	2nd	3rd	4th	5th	All
Number	7	4	100	544	424	1079
Min. wt. (kg)	1.56	2.68	2.53	1.65	1.93	1.56
Max. wt. (kg)	2.86	4.12	3.54	3.70	4.17	4.17
Average (kg)	1.83	3.04	3.06	2.51	2.28	2.47

Table 3 suggests that the majority of guz-za textiles were of 4th or 5th quality, with relatively few such textiles of 1st or 2nd quality. There is a clear indication that the weight of guz-za textiles was generally heavier as the quality increased from 5th to 4th to 3rd quality, while 1st-quality guz-za seems to have its own weight class.[16]

Many of the guz-za fabrics summarized in table 3 were weighed in batches rather than individually. This would have the effect of averaging out the individual weights, so if these guz-za had been weighed individually a small number could have been outside the range defined by the maximum and minimum shown in the table (i.e., less than 1.56 kg or more than 4.17 kg). Nevertheless, on the basis of the data available, it would appear that most of the guz-za fabrics were closer to the average weights than to the maxima or minima quoted.

Table 4. Summary of the information that is available on the size of guz-za fabrics (*UNT* 144–48).

Quality	Weight	Width (m)	Length (m)	Tablet
4	4 kg	3.5	3½	*ITT* V 9996 iii 4–Rev. i 4
3			4	*TMH* NF 1–2, 233 1–2
3			$3\frac{5}{6}$	*TMH* NF 1–2, 233 3–4
1	1.8 kg		$4\frac{1}{6}$	*HLC* 68 (p. 43) 3-4
1	2.9 kg		4½	*HLC* 68 (p. 43) 7–8
5	2.8 kg		$6\frac{5}{6}$	*UNT* 92 Rev. 7–9
4	2.5 kg		2	*UET* III 1547 ii 3ff. (*)
1			$\frac{5}{6}$	*UNT* 34 ii 2
1			$\frac{5}{6}$	*UNT* 34 ii 4
1			3½	*UNT* 34 Rev. ii 13
2			3½	*UNT* 34 iii 7
su_3-a lugal			3½	*UNT* 34 iii 11

15. Cdli database (www.cdli.ucla.edu; searched on 4 January 2010). As there are a limited number of examples of 1st and 2nd quality, this sample includes all of the instances found by searching for weights specifically of guz-za šà and guz-za ús fabrics.

16. There was already some indication of this found by Veenhof (1972: 209) on the basis of *SET* 274 vi 15–20 (Jones and Snyder 1961: 200).

1			$^{5}/_{6}$	*UNT* 34 Rev. ii 9
2			3½	*UNT* 34 Rev. ii 23
1			1½	*UNT* 34 iii 9
4			3¼	*UNT* 34 Rev. ii 7
4			$1^{5}/_{6}$	*UNT* 34 Rev. ii 11
2			⅔	*UNT* 34 Rev. ii 15
1			1½	*UNT* 34 Rev. ii 19

* weaving not completed

The impression obtained from table 4 is somewhat different from the impression gained from considering the fabric weights. The comparison of the weights of guz-za fabric seemed to show that there was a small set of target weights, with a few outlying exceptions. However Table 4 shows a very wide range of fabric lengths, which vary from ⅔ to $6^{5}/_{6}$ m. Many of these examples are from first- and second-quality guz-za and these qualities were not the most typical. On this basis, more emphasis should be placed on the general and better documented weights of guz-za fabrics in table 3 than on the measurements in table 4.

Unfortunately, guz-za is the only fabric for which there is a complete and unambiguous set of data. For the other fabrics there are some data together with partial readings and/or suggestions (from *UNT*) and so we will progress on that basis.

níg-lám *Fabric*

It is already evident from the spinning rates, considered above, that níg-lám is a finer fabric than guz-za. Therefore, níg-lám fabrics should always precede guz-za fabrics of the same quality when they are listed together.

Details of the spinning and weaving of a 3rd-quality níg-lám fabric are included in *ITT* V 9996 i 1–ii 9.[17] The following interpretation of the text relies on Waetzoldt's translation for guz-za (given above) as a basis for constructing a parallel translation for níg-lám:

the warp threads for it (weigh) ⅔? mana (333 g? and)
1 woman spins ⅓ gín (2.8 g) strongly twisted threads [in a day] (for the warp);
the weft threads for it (weigh) 1⅔ mana (0.833 kg and)
1 woman produces 1 gín (8.3 g of them) in a day (for the weft);
(the) length (of the níg-lám fabric is) 4 m (and)
(the) width (is) 3.5 m;
3 women warp in 2 days (and)
3 women weave 25 cm in a day.

17. In this section, it is assumed that Waetzoldt is correct in his suggestion that this part of the text refers to níg-lám fabric (cf. the spinning rate for the warp given in *ITT* II 909 7–8 and *ITT* V 9996 ii 1). The above interpretation is based on the readings given in *UNT* 125 and 232. In particular, the estimate for the weight of the warp threads is given by *UNT* 125. This is probably based on Waetzoldt's finding that the total weight of a níg-lám fabric is, typically, 2.2 mana (*UNT* 159, n. 51).

The weft threads are spun at a rate of 1 gín per day. Using the equation above based on CTR experiments, it is possible to estimate that ~226 m of thread were produced per day. The total weight of the weft threads is 1⅔ mana (833 g), therefore the total length of the weft threads would amount to ~22,600 m. This is equivalent to a weft thread count of ~16.1 threads per cm (see graph above).

The warp threads are spun at the significantly slower rate of ⅓ gín per day. Again, extrapolating the CTR results, it can be estimated that this produced ~168 m per day. If Waetzoldt's estimate for the total weight of the warp threads is correct, then there would have been 40 gín of warp threads, implying a total length of ~20,190 m. This is equivalent to a warp thread count of ~14.4 threads per cm.

Thus, although the weight of the warp threads is only 40 percent of the weight of the weft threads, the length of the warp threads is approximately equal to the length of the weft threads. This probably reflects an underlying intent that the warp and weft thread counts should be almost equal, even though the warp thread is much thinner than the weft thread (cf. the conclusion reached for the guz-za fabric above).

There are interesting differences between the weaving times required for the níg-lám and guz-za fabrics. For the guz-za it takes three women three days to set up the looms and two women weave 50 cm of fabric per day. For níg-lám it takes three women two days to set up the loom and three women weave 25 cm of fabric per day. There are clearly underlying assumptions implicit within these figures concerning the width of the strips of fabric that were being woven. On the basis of the evidence available, the most likely suggestion is that the níg-lám fabric was woven in three strips, each 1.17 meters wide.

The text implies that 25 cm of fabric were woven in a day. If there were ~16.1 weft threads per cm, then ~403 weft threads were woven each day or (for an 8 hour day) ~50 weft threads per hour.[18] The fact that the weaving rate of níg-lám is only 25 cm a day compared to 50 cm per day for guz-za clearly implies that work on níg-lám was more demanding. This is consistent with níg-lám being regarded as a more valuable fabric that is consistently listed above guz-za fabrics of the same quality.

The number of worker-days required to produce this níg-lám fabric is:

- 120 days to spin the warp
- 100 days to spin the weft
- 6 days to set-up the warp
- 48 days to weave (assuming that the fabric was woven in 3 strips)
- =254 days

This does not include the time taken for the preparation of the wool before spinning or the time for finishing. However, even with these omissions, the amount of time taken for the níg-lám fabric is double that required to manufacture the guz-za fabric considered above. The other point to note is that the time required for spinning is four times that needed for the weaving. It is worth noting that the weight of the fabric would have been 0.08 kg per square meter, that is, approximately half the density for the guz-za fabric.

Thus, níg-lám is a very thin fabric, which takes a considerable time to make. There is 2.5 times more wool in the weft than in the warp but it takes about the same time to spin warp and weft. A níg-lám fabric would appear visually as weft-faced since it incorporated much more weft yarn.

According to the *Chicago Assyrian Dictionary*, ^{túg}níg-lám corresponds to the Akkadian *lamaḫuššu*, where *lamahuššu* was a precious garment made from wool (*CAD* L, 59).[19] Michel and Veenhof identify *lamaḫuššûm* as an equivalent of *namaššuḫum* (Michel and Veenhof 2010: 264).

18. The weaving rate for guz-za was calculated to be ~53 weft threads per hour and in CTR experiments it was 45 weft threads per hour. Therefore, a weaving rate of ~50 weft threads per hour for níg-lám seems highly plausible.

19. Waetzoldt 1980–1983: 22 suggests that the Akkadian term *lamaḫuššu* is probably built up from the second element of ^{túg}níg-lám together with huš-a "red."

For níg-lám fabrics a similar survey was done to that for guz-za fabrics, to determine average weights. In this case, since níg-lám fabrics are not so numerous as guz-za, the survey included most of the níg-lám fabrics that were listed as 1st, 2nd, 3rd, 4th, or 5th quality within the cdli database. Following Pomponio 2010, níg-lám fabrics described as ensi ("governor's"), lugal ("royal"), or of the kings Šu-sin or Ibbi-Sin were included as 1st class. The results of the survey are given in table 5.

Table 5. Survey of 476 examples of níg-lám fabrics.[20]

Quality	1st	2nd	3rd	4th	5th	All
Number	16	17	226	138	79	476
Min. wt. (kg)	0.42	0.83	0.62	0.64	0.70	0.42
Max. wt. (kg)	1.28	1.45	1.46	1.16	1.09	1.46
Average (kg)	0.85	1.16	0.98	0.86	0.89	0.93

Table 5 shows that the majority of níg-lám fabrics were 3rd, 4th, or 5th class, with relatively few 1st- and 2nd-class examples. Whereas the most common quality for guz-za fabrics was 4th or 5th class, the most common níg-lám qualities are 3rd and 4th class. This undoubtedly reflects the finding that níg-lám fabrics were manufactured from thinner thread (and have a higher thread count) and so are typically of a higher quality than the guz-za fabrics, which were generally made from a coarser wool (and typically have a lower thread count).

There is no significant variation in weight between the average 4th- and 5th-class níg-lám. However, the average 2nd-class níg-lám fabric is heavier than the average 3rd-class fabric, which, in turn, is heavier than the average 4th- or 5th-class níg-lám fabrics. The average weight of 1st-class níg-lám fabrics does not follow this trend (cf. guz-za fabrics). This reflects the suggestion that 1st-class fabrics were not mass-produced and so do not fit in with overall weight statistics.

The information from the texts on the size of níg-lám (see *UNT* 144–48) shows an analogous picture to that for guz-za in table 4. It is from a limited number of tablets and the lengths of fabric given vary widely. As for guz-za, this presents a different picture to that gained from examining the weights and it seems reasonable to draw the same conclusion, that such information was probably given because these fabrics were atypical. Thus, for typical níg-lám fabrics, emphasis should be placed on the weights of fabrics summarized in table 5.

bar-dul$_5$ *(5th quality) Fabric*

The text for bar-dul$_5$ on *ITT* V 9996 rev. i 7–14 is more fragmentary than that for guz-za and níg-lám and there is some uncertainty on the spinning rate for the weft threads (see table 1). In addition, the size of the fabric has not been preserved.

For the warp threads 1⅓ mana of wool is spun at the rate of 2 gín per day. From the CTR experimental data, this corresponds to the production of ~273 m per day, which for forty days would result in ~10,920 m of thread.

The weight of the weft threads is 1⅔ mana. However, there are three suggested readings for the rate of spinning the weft thread, 3, 5 or 6 gín per day. They would produce about 10,130 m, 6990 m or 6120 m per day. If we assume that the length of the warp and weft threads is approximately equal (cf. the analysis of guz-za and níg-lám above), then this would imply that the weft is spun at a rate of 3 gín per day.

The ratio of the weight of warp to weft thread is 1:1.25.

20. The table excludes the 2nd-quality níg-lám weighing 3.28 kg listed on *UET* 3 1696 1–2 because it was so far from the norm that it distorted the results.

It is possible to provide a rough estimate of the area of the fabric. If it is assumed that the percentage openness of the fabric was approximately equal to 48 percent (as for the guz-za fabric above) and using an average thread diameter of 0.32 mm, then it is possible to estimate the warp and weft thread count to have been ~9.6 per cm. Then, using an average thread length of ~10,520m, it can be calculated that the fabric area would have been about 11 square meters. The density of the fabric would have therefore been roughly 0.14 kg per square meter. Eleven square metres is surprisingly large for a garment, and this could suggest that bar-dul$_5$ in this case is fabric for more then one garment.

The *Chicago Assyrian Dictionary* equates ^{túg}bar-dul$_5$ with *kusîtu*, which is described as "an elaborate garment" (*CAD* K, 585). It is evident that such garments could be used in a sacred context (though presumably these were better than the 5th-quality bar-dul$_5$ being considered here).

Waetzoldt (2010: 206) draws attention to the combination ^{túg}níg-lám šà (^{túg})bar-dul$_5$, which he suggests means "níg-lám fabric with weft from the bar-dul$_5$ type. This means that weft threads originally produced for the bar-dul$_5$ fabric were woven into a níg-lám fabric." This would suggest that the administrators could distinguish between various types of yarn and that the fabrics are partly identified by the yarn used to produce them. Thus, the combination of yarns in this fabric appears to imply that this fabric is a combination of the warp threads of a níg-lám fabric and the weft threads of a bar-dul$_5$ fabric. If it is assumed that the warp and weft thread counts are approximately equal (as for níg-lám and guz-za fabrics) then, using the spinning rates of ⅓ gín per day for níg-lám warp threads and 3 gín per day for bar-dul$_5$ weft threads, it can be calculated that warp to weft ratio for this fabric would be 1:5. This would align plausibly with the previous results.[21]

An attempt to survey the weights of bar-dul$_5$ fabrics had limited success because the number of fabrics given with weights was relatively low and many of these had descriptors that showed that they were not standard pieces of fabric.

uš-bar *Fabric*

The details for spinning the wool for uš-bar fabrics are found on *ITT* II 909 i 12–15. In this case, the weights of wool are so clearly disproportionate that they are evidently not preparing wool of particular pieces of fabric. Therefore, we do not have direct information about how much warp and weft wool there is in the uš-bar fabric.

However, table 1 shows that 5 and 15 gín of wool are used per day spinning the warp and weft threads, respectively. From this it can be calculated that the warp to weft ratio was probably 1:2.2 (using the equation given in appendix A), that is, the warp weighed (1/3.2) times the weight of the fabric. We also know from *UNT* 160, n. 60 that the weight of uš-bar fabric was typically 3.9 mana. Thus, it can be estimated that the weight of the warp was 1.2 mana and the weft 2.7 mana.

The warp takes one day to spin 5 gín and so, from the CTR experiments, it can be estimated that the length of yarn produced would have been ~350 m. To spin 1.2 mana would have taken 14.4 days and the total length of yarn would have been ~5050 m (see graph above)

The rate of spinning the weft yarn was 15 gín per day and it is possible to estimate that the length of yarn produced each day would have been ~470 m. To spin 2.7 mana of wool would have taken ~10.8 days.

In order to make rough estimates about uš-bar fabric it will be assumed that the length of the warp and weft yarns were equal. If the openness of the fabric were about the same as that for the guz-za fabric, and given an average thread thickness of 0.45 mm, then it can be estimated that the warp and weft thread counts would be ~6.8

21. It is worth noting that the warp to weft ratio for this new fabric would be 1:7.2 or 1:8.2 if the rate of spinning for bar-dul$_5$ weft threads was 5 or 6 gín per day. These ratios are less plausible and so again support the reading of 3 gín per day for the rate of spinning this weft threads.

per cm. This would imply that the area of the fabric was roughly (5050/6.8*100) = 7.4 square metres, that is, the density of the fabric would have been about 0.26 kg per square meter.

There have clearly been a number of assumptions made in the course of this discussion on uš-bar and so the results should only be regarded as rough estimates. Nevertheless, they give some indication of the sort of fabric that is being described by the term uš-bar. A survey of 1355 uš-bar fabrics produced the results in Table 6.

Table 6.

Number	1355
Min. wt. (kg)	0.51
Max. wt. (kg)	4.38
Average (kg)	1.95

Time to Weave a Fabric

The amount of cloth to be woven each day is set out in table 7 (based on *ITT* V 9996).

Table 7. The amount of cloth to be woven each day.

Text	Fabric	No. of weavers	Length per day
l) ii 7	níg-lám (3rd quality)	3	25 cm
m) iii 1	níg-lám (4th quality)	3?	33.3 cm
n) rev. i 4	guz-za (4th quality)	2	50 cm

It has been shown above that texts (l) and (n) imply weaving rates of about 50 and 53 wefts per hour and that this rate of weaving is consistent with the CTR experiments. In broad terms, the amount of fabric produced for the 4th-quality guz-za fabric is double that produced for the 3rd-quality níg-lám fabric because the weft thread for the 3rd-quality níg-lám fabric is approximately double that used in the 4th-quality guz-za fabric described on *ITT* V 9996. It is therefore reasonable to assume that the rate of weaving, in terms of weft threads per hour, implied by text (m) is similar to that for (l) and (n). However, since a greater length of fabric is woven each day for 4th-quality níg-lám fabrics than for 3rd-quality níg-lám, this implies that the weft threads are approximately 50 percent larger in diameter for the 4th-quality níg-lám than for the 3rd-quality níg-lám.

Thus, at least in this case, the quality of the fabric did not simply reflect the quality of the wool that was used to make it. There is some evidence here that the higher quality níg-lám fabrics were woven with thinner weft threads. This would not only imply that higher quality fabrics took longer to weave but also, because the weft thread was thinner, it would have taken longer to spin. Thus, the overall time taken to produce a higher-quality níg-lám fabric would have been substantially longer. This demonstrates that the quality of a fabric is related to the time consumed to manufacture it.

It is worthwhile comparing the overall times (in days) implied for the textiles included on *ITT* V 9996. In practice, there is only a complete set of times for guz-za and so a number of the times taken for other fabrics are our estimates. Nevertheless, table 8 draws attention to the number of days allocated for the various tasks.

Table 8. The number of days of work allocated to individual tasks.

Task	níg-lám (3rd)	guz-za (4th)	bar-dul$_5$ (5th)
Cleaning and combing	[16?]	32	16
HI.HI	[1?]	2	1
Spinning warp	120	40	40
Spinning weft	100	26⅔	33⅓?
Warping	6	9	[6?]
Weaving	48	21	[28?]
Total time	291(?)	130⅔	124⅓(?)

UNT 139–40 gives a lengthy list of times associated with specific fabrics. Waetzoldt suggests that these are the total times include cleaning, spinning, and weaving, based on the guz-za fabric on *ITT* V 9996. However, while all of the times clearly include the time required for spinning and weaving, it is not clear that they include the time for cleaning and combing the wool and finishing the fabric. This is particularly apparent for the uš-bar fabric, which is the heaviest fabric we are considering. The total time of twenty-seven days quoted on *ITT* II 909 i 9f for the production of an uš-bar fabric weighing 4.5 mana would not give sufficient time just to clean and comb enough wool for this fabric.[22] On this basis, it is more likely that the total times quoted by *UNT* are only for the spinning and weaving phases of production.

Using this assumption, table 9 now gives a summary of the times quoted by *UNT* 139–40, restricting the list to níg-lám, guz-za, bar-dul$_5$, and uš-bar, based on the above discussion. The data for *ITT* V 9996 are taken from table 8 (excluding the cleaning and combing phase) and are included in table 9 for completeness.

Table 9. Number of work days required to make fabrics.

Fabric	Quality and description	Time (days)	Text
níg-lám	1st (2 mana)	335	*ITT* II 909 i 1–2
	2nd tab-ba ús-AB ^{d}Šūsîn	960	*ITT* V 6858 ii 8–9
	2nd ús-GUG$_4$	300	*ITT* V 6855 iii 4–5
	3rd (2 mana)	150 each	*ITT* II 909 i 4–5
	3rd (2⅓ mana)	275(?)	*ITT* V 9996
guz-za	1st	1200	*ITT* V 6606 i 3–4
	1st	360	*ITT* V 6606 ii 9–10
	4th	98⅔	*ITT* V 9996
	5th	90 each	*TCL* V 5565 rev. 4–5

22. If we assumed that a 4.5 mana fabric required 9 mana of roughly washed wool, which was cleaned and combed at a rate of 15 gín per day, this would take thirty-six days.

bar-dul$_5$	1st gada (linen)	1080	*ITT* III 6605 i 4–5
	an-dùl-gin	780	*UET* III 1750 1–2
	5th	108⅓(?)	*ITT* V 9996
uš-bar	bar-si-sá-bi (4.5 mana, 2.5 m)	27	*ITT* II 909 i 9–10

On the basis of the limited data available, there would seem to be a relatively small variation between spinning and weaving times between the 4th- and 5th-quality guz-za shown in table 9. Therefore, it would seem to follow that the average lower quality guz-za fabrics were lighter because they were generally smaller in size.[23] First and second quality guz-za fabrics were exceptional items that were not mass-produced and are likely to have varied according to particular specifications.

While table 9 provides evidence that higher quality fabrics tended to require more time to manufacture, it is clear that this was not standardized. Thus, two fabrics, with nominally the same description (e.g., 1st-quality guz-za), could have taken substantially different times to make. The two most likely reasons for this are that the cloth that took the longer time could be larger or it could have been made with thinner thread. Since these are higher-class fabrics (and there is a limit to the useful size of a fabric), it is more likely to be the latter. However, this would be somewhat puzzling since guz-za is clearly intended to be a heavy fabric and it seems contradictory to have a thinner version of a thicker fabric type nominated by the same term.

Conclusions

The objective of this paper has been to analyze the information available on the manufacture of ^{túg}guz-za, ^{túg}níg-lám, ^{túg}uš-bar, and ^{túg}bar-dul$_5$ based on the experimental data from the Danish National Research Foundation's Centre for Textile Research in Copenhagen. This has shown that it is possible to provide plausible reconstructions of some of the key parameters of these textiles.

The results from the analysis shows that Ur III textiles under investigation were rather open fabrics constructed with thinner warp threads and thicker weft threads. Much more wool is allocated for weft threads than for warp threads but the times consumed for spinning both yarn types are not very different. This means that the weft is not significantly longer than the warp but is significantly thicker than the warp. The resulting fabric would be visually dominated by the weft yarn. The degree of openness is consistent with texts that show that these woollen textiles underwent fulling in order to tighten the surface and render the fabrics more resistant. Despite the fact that ^{túg}guz-za, ^{túg}níg-lám, ^{túg}uš-bar, and ^{túg}bar-dul$_5$ are well attested in Ur III records, and seem to have been standardized products, their physical characteristics can vary considerably. The standardization thus seems related to the thread count, yarn types and weave rather than to the size of the fabrics or their use.

23. We do not have enough data here to be entirely consistent because, if a 5th-quality guz-za was smaller than one of 4th-quality then it would have taken less time to make. However, we know that if the 5th-quality guz-za was the same size but thinner then the weft thread would be thinner and it would take longer to spin and weave and would result in a finer quality fabric and that would be contradictory.

Appendix A: Summary of the Mathematical Equations

The form of the curve,

$$\text{Length of thread per day (m)} = 226.3 \times (\text{weight of thread in gín})^{0.27}$$

that was used for interpolating and extrapolating the data in fig. 1 was chosen on the basis that it fitted closely to the data points. However, the simplicity of this form also allows us to develop some equations.

Let x_1 be the number of gín of wool spun per day for the warp, spinning y_1 meters of wool, and let N_1 be the number of days required for spinning. Similarly, let x_2, y_2 and N_2 be the equivalent terms for the weft thread. Then, from the fit to the CTR data,

$$y_1 = 226.3\, x_1^{0.27} \text{ and } y_2 = 226.3\, x_2^{0.27}$$

$$\text{i.e., } (y_1/y_2) = (x_1/x_2)^{0.27}$$

Now, if we make the assumption that the warp and weft thread counts are equal, then the length of yarn in the warp threads is equal to the length of yarn in the weft threads. Thus,

$$N_1 y_1 = N_2 y_2$$

The ratio of the weights of warp thread to weft thread is $[N_1 x_1 / N_2 x_2]$ and so,

$$\text{ratio} = [N_1 x_1 / N_2 x_2] = [y_2 x_1 / y_1 x_2] = [x_1 / x_2]^{(1-0.27)}$$

The percentage of openness of a fabric (prior to fulling) can be calculated using the formula,

$$\%\ \text{openness} = \{1 - [(n_1 \times t_1)/10 + (n_2 \times t_2)/10 - (n_1 \times n_2) \times (t_1 \times t_2)/100]\} \times 100$$

If we were to try to make estimates based on the openness, then this could be done approximately by assuming that the thread counts were the same and using an average thread thickness, then it is possible to simplify the formula as,

$$\%\ \text{openness} = \{1 - (n \times t)/10\}^2 \times 100$$

which makes it easier to manipulate.

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which of these is cited on p. 73? The other is not cited and has to be deleted.