VIKING AGE WOOL FIBRES

Irene Skals, Charlotte Rimstad &
Ulla Mannering

Fashioning the Viking Age 4

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This publication is the fourth of the volumes, describing the process and results of the research and outreach project Fashioning the Viking Age

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Content

1. Introduction

In the Viking Age, much of the population lived and worked as farmers, fishermen and craftsmen in small scale communities that depended on self-sustainability. In these small groups, clothing, textiles and skin production were an integrated part of agriculture and an important outcome of food production. It is exactly these materials, related to the cloth culture, that are in focus in the project Fashioning the Viking Age.

Viking Age society was divided into different hierarchical segments defined by family structure, gender, status and profession and this structure is also visible in textile and skin production (Andersson Strand 2015). Textiles were needed and produced in many different qualities and for different purposes: clothing, the household, for warfare, transport and trade. Glass beads, gold, silver and silk played an important part in the construction of clothing as well as in the display of status and wealth. Such commodities were traded from the south, most likely in exchange for slaves and fur from wild animals like beaver, fox and sable that were hunted in the northern regions of Scandinavia and Russia (Kovalev 2001; Vedeler 2014; Mannering 2015). The Fashioning the Viking Age project has used its analysis of all such data to create a new and clearer perception of Viking Age clothing production.

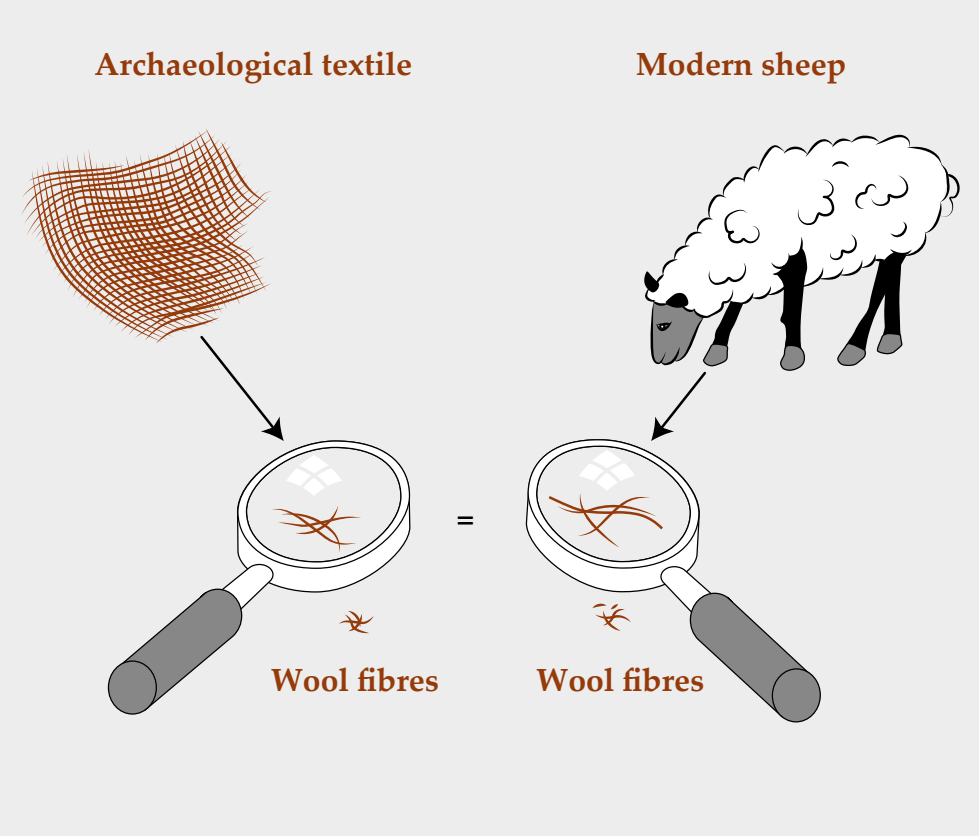
Fashioning the Viking Age was funded by the VELUX FOUNDATIONS and based at the National Museum of Denmark in close collaboration with the Centre for Textile Research at the University of Copenhagen and Land of Legends in Lejre (Mannering 2018; 2021). The project core staff comprised the project leader, archaeologist and Research Professor Ulla Mannering, the project coordinator, archaeologist and Postdoc Charlotte Rimstad, both from the National Museum of Denmark, archaeologist and Associate Professor Eva Andersson Strand, Head of the Centre for Textile Research at the University of Copenhagen, and archaeologist Ida Demant, Leader of the Textile Workshop in the Land of Legends in Lejre. The project consisted of three parts, all focusing on different aspects of Viking Age textile resources, production and clothing that together provide a new visual and tactile understanding of Viking Age textile production and clothing design which can be used for outreach purposes in teaching institutions, museums and the media as well as research.

Project Part 1, Viking Age Textile Production, focused on the reconstruction of textile tools which were subsequently used to produce replicas of known, archaeological textile finds from Hedeby in Schleswig. These textiles come in many different qualities, and it is exactly this variation that the first part of the project aimed to explore.

Project Part 2, Viking Age Male and Female Clothing, focused on the production of two full-size outfits, one for a high-status male and one for a high-status female, based on textile fragments from two Danish Viking Age burials.

Project Part 3, Viking Age Clothing Catalogue, focused on collecting the different sources for Viking Age textile tools and production, textiles and clothing, whether they be archaeological, iconographic, written or other sources. The results of Project Parts 1 and 3 are presented in separate reports (Anderson Strand & Demant 2023; Mannering & Rimstad 2023; Rimstad et al. forthcoming).

The present report presents the fibre analyses, based on yarn samples from all the textiles included in the Fashioning the Viking Age project, with the aim of obtaining a general impression of the wool used in Viking Age textiles. This material includes a selected range of samples from textiles found in the graves of Bjerringhøj and Hvilehøj from Jutland in Denmark as well as from the settlement of Hedeby in Northern Germany. Furthermore, analyses of wool samples from different modern primitive sheep breeds have been made to enable the finding of materials of comparable quality for the reconstructed textiles in Project Parts 1 and 2 (fig. 1.1). The results of the fibre measurements and calculations, made according to the method presented below, from both the archaeological textiles and the modern wool, are placed in the catalogue, found at the end of this report.



◄ Fig. 1.1: The principle of finding modern wool that resembles the Viking Age wool on fibre level.

Illustration: Charlotte Rimstad

2. Why fibre analysis?

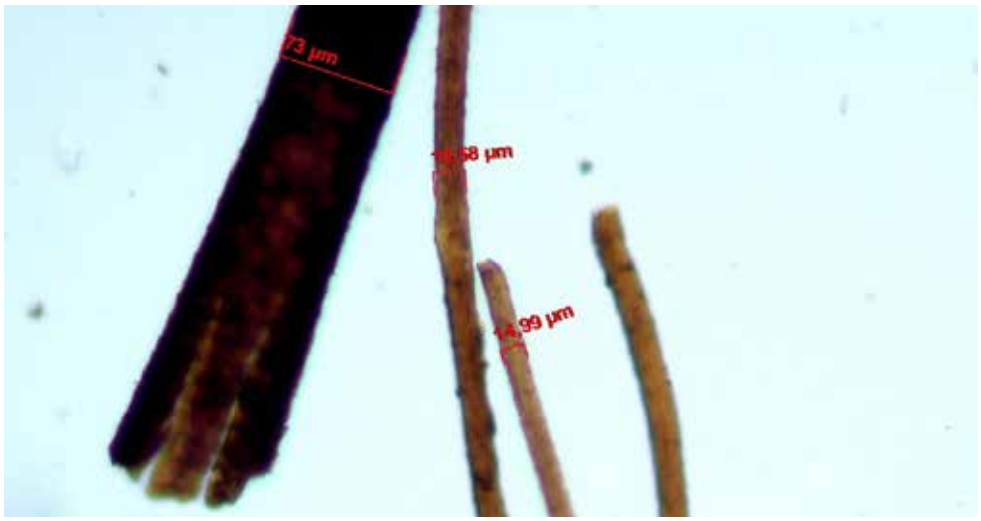
Analysis of fibres from prehistoric wool textiles, unspun wool samples and sheep fleeces/skins, consisting of measurements of individual fibre diameters, is a method used to obtain information about the available and preferred wool fibre types during a specific period of time. The interpretation is based on calculations of the frequency of the different diameter measurements. In addition to defining the wool type, the results are used to estimate the work involved in the processing of the wool before the spinning of the yarns. This includes the selection, sorting and preparation of the raw wool, that all have an impact on the quality of the end product. Further, the method can be used to evaluate the degree of uniformity of the fibres in the yarns, which in turn will have affected the spinning process, the use, and properties of the textile item.
It should be noted that samples of raw or unspun wool and fur items can only be examples of the raw material and not direct evidence of a commonly existing resource, as chosen archaeological finds may also have been specifically selected for the purposes in the burial. As such, the processing should be deduced from the results of as many analyses of different yarns and uses as possible.

Sheep were domesticated around 9000 BC in the Middle East (Bender Jørgensen and Rast-Eicher 2018; Breniquet 2014; Gleba 2012; Grömer and Saliari 2018; Ryder 1983; 2005). However, the first domesticated sheep only provided meat and skins for clothing and not wool for textile production. Mesopotamia is known as the 'Land of Wool' where wool was used to produce fabrics from the end of the third millennium BC and wool textiles appear right from the beginning as symbols of power and currency in a primitive market economy (Ryder 1983). Different sheep breeds are likely to have developed from the first ancestors simultaneously in many regions in Eurasia. In Northern Europe, the sheep follows the neolithization process in the beginning of the fourth millennium (Sørensen 2014), but wool textiles are not known in this area before the mid second millennium linked to the Nordic Bronze Age culture (Broholm and Hald 1940).

The development of sheep and sheep wool is explained as passing from the primitive to the evolved modern breeds that have fleeces consisting of fibres with as homogeneous and fine fibre diameters as possible. The dimensions of wool fibres are on the micron level (1000 microns equal 1 millimetre) and the difference of a few microns may not seem over important, but the finer the diameter of the fibres, the softer the wool will be (Wilson and Laing 1995). An increased amount of even slightly coarser fibres will result in a different textile quality and is easily recognized by touch. The wool from the early primitive breeds, is believed to have consisted of basically two fibre types, very fine (less than c. 25 microns) and very coarse fibres (more than c. 60 microns and sometimes above 200 microns). Through breeding, the fibre quality became more varied and eventually the finest fibres became slightly coarser, the coarser fibres slightly finer and in the gap between the two extremes new fibre types were developed measuring from c. 30 to 60 microns (Breniquet 2014; Breniquet and Michel 2014; Gleba 2012; 2014; Grömer and Saliari 2018; Rast-Eicher 2012; 2013; Ryder 1983; 2005). This fibre mixture corresponds to wool from todays socalled primitive sheep. The fibres in a wool fleece, from the same sheep breed, are generally known to vary depending on the age, gender and health of the animal and where on the body they have grown. This is the reason why the quality of the wool in a yarn relates to the sheep breed, the specific sheep, and the selection and processing of the raw material. Information about the raw wool as well as about the human intervention can thus be extracted from the results of the fibre measurement. As wool is a material of great diversity and the yarns in prehistoric textiles are hand-crafted, the analysis consists of studying the subtle variations in the content of fibre diameters in the individual yarns.

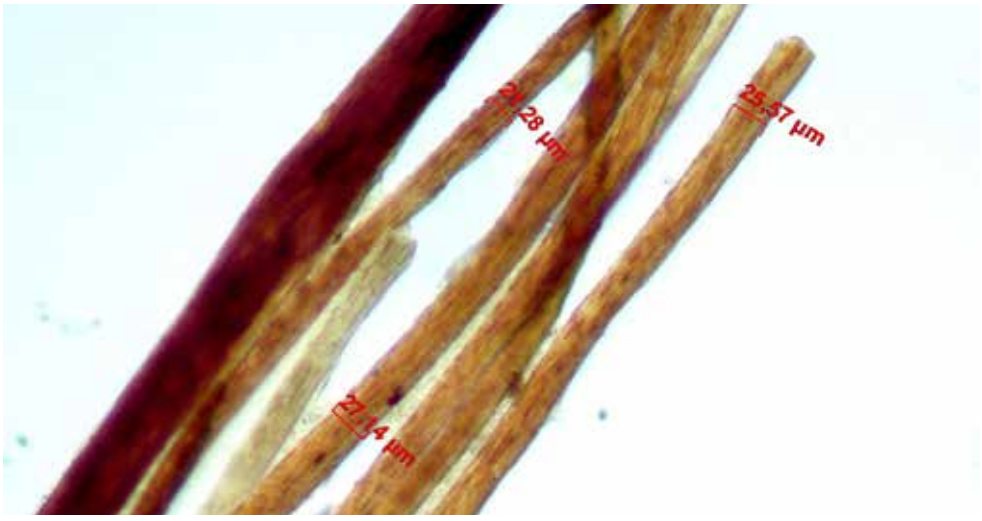
For the last 30 years, wool fibre studies have been an increasingly important parameter in the study of Danish prehistoric wool textiles (Bender Jørgensen and Walton 1986; Ryder 1988; Skals and Mannering 2014; Skals 2019; 2020; Walton 1988; 2003) but the methods of how to measure and interpret the results are still developing (Rast-Eicher 2008; Skals et al. 2018). The Danish collection of prehistoric wool textiles, dating from the Early Bronze Age to the Viking Age (c. 1500 BC-AD 1050), has during the last 15 years been subjected to fibre analysis and by comparing the fibre measurement results from the different textiles and time periods valuable information about wool development and preferences in this area has been gathered (Skals and Mannering 2014; Skals 2019; Demant et al. 2021; Mannering 2021; Mannering et al. in press). Altogether this comprehensive study has shown that the wool used in Danish textiles dating from the Early Bronze Age to the end of the Roman Iron Age (1500 BC-AD 375) has a large majority of very fine fibres with diameters less than 25 microns and a few very coarse hairs with diameters above 100 microns (fig. 2.1). It has also been proven that the large amount of ultra-fine fibres below 20 microns is a specific North European wool trademark (Rast-Eicher & Bender Jørgensen 2013).

At the end of the Danish Roman Iron Age, in the late fourth century AD, significant changes occurred in the wool textiles. The fine fibres in the yarns from the Danish Late Iron Age textiles are mixed with substantial amounts of fibres in the medium range, which until this point had been a very insignificant fibre group in the textiles (fig. 2.2). This fibre composition prevails well into the Viking Age and beyond (Mannering et al. 2021; Walton 2003). The wool fibre analysis from Bjerringhøj, Hvilehøj and Hedeby are able to characterise this overall picture in even greater detail.



◄ Fig. 2.1: From the Bronze Age to the Roman Iron Age the wool is characterised by a predominance of fine fibres often measuring less than 20 microns and the occasional very coarse fibres often measuring above 100 microns. The photo was captured at c. 100 x magnification.

Photo: Irene Skals



◄ Fig. 2.2: After the Roman Iron Age at about the end of the 4th century the wool has a more varied fibre content with fine fibres measuring c. 20-30 microns, medium fibres measuring c. 30-60 microns, and coarse fibres rarely measuring above 100 microns. The photo was captured at c. 100 x magnification.

Photo: Irene Skals

3. Method

Fibre studies are known to require specialised microscopes such as transmission light microscopes (TLM) and scanning electron microscopes (SEM). However, today it is also possible to get access to low-cost devices such as portable digital Dino-Lite microscopes that give most people the opportunity for close inspection of wool fibres. The current wool fibre study has been made using transmitted light microscopy (Primo Star iLED microscope from Zeiss equipped with an AxioCam ERc5s camera for imaging). Fibres from each yarn sample were spread onto microscope slides using glycerol for mounting. The fibres were viewed in longitudinal sections and photographed. The objective magnification was 10x. The diameters of preferably a minimum of 100 fibres from each of the samples were measured using the camera software, calibrated by a standard method for high magnification light microscopes with a stage micrometre. The calculations of the measurement results were made using a common spreadsheet (fig. 3.1).

► Fig. 3.1: Wool fibres are very fine and need to be magnified for measuring. In this study c. 150 digital photos per sample have been captured on average, and more than 7000 fibres have been measured

Photo: Charlotte Rimstad

One of the methods used for processing and organising the fibre data builds on Antoinette Rast-Eicher's classification system which consists of 11 categories defined by different combinations of the percentages of fibres of diameters measuring less than 25 microns, 25-30 microns, 30-40 microns, and so on until 100 or more microns (see table 3.1). The frequency of the measurement results is presented as bars in standard histograms, organised in two micron-steps distribution (Rast-Eicher 2008). The system was originally developed for analysing the processing of wool from Central European Bronze and Iron Age textiles with large contents of fibres measuring between 25 and 40 microns, a fibre group which is first recognised in the Danish Late Iron Age textiles. The method is used and evaluated in the present study to enable comparison of the material with other published results.

Category	Percentages of fibres defining the categories
AAA	92% < 25 µm, 8% > 25.1 µm, 1% > 30 µm, max. 40 µm
AA	85% < 25 µm, 15% > 25.1 µm, 3% > 30 µm, max. 60 µm
A	93% < 30 µm 7% > 30.1 µm, 1% > 40 µm, max. 60 µm
AB	80% < 30 µm, 15% > 30.1 µm 2% > 40 µm, max. 60 µm
B	75% < 30 µm, 25 % > 30.1 µm, 2% > 40 µm
C	66% < 30 µm, 10% > 45 µm, 1% > 50 µm
CD	80% < 40 µm, 20% > 40.1 µm, 2% > 60 µm
D	66% < 40 µm, 34% > 40.1 µm, 5% > 60 µm
E	60% < 40 µm, 40% > 40.1 µm, 10% > 60 µm
EE	50% < 40 µm, 50% > 40.1 µm, 15% > 60 µm
F	50% < 30 µm, up to 50% > 60 µm

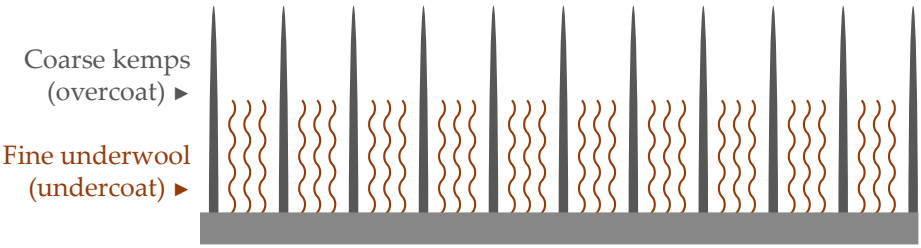
◄ Table 3.1: Definition of the fibre categories according to Rast-Eicher's system.

Further, in this study the cumulative frequency distribution has been calculated and used to evaluate the fibre measurement results. As opposed to the histogram where the percentages of similar measurements are presented in bars, the fibre measurements are in a cumulative frequency distribution diagram added together and form a curve ranging from 0 - 100% of the results. The point at which the curve starts marks the finest measurements. Where it reaches 100% marks the coarsest fibres in the yarns and the steeper the curve, the more uniform the fibre content is. Comparing the slope of the curves from different yarns helps determine similarities and differences in the individual yarns.

For further interpretation and evaluation of the fibre measurement results with respect to the raw wool and its processing, the contents of fine fibres (less than 25 microns), medium fibres (25-40 microns) and coarse fibres (above 40 microns) have been grouped. These data are presented in tables, and by comparing the three groups of fibre types and the way they are combined, and further correlating them with the histograms and cumulative frequency diagrams, it has been possible to determine overall differences in the fibre content of the wool and thus define differences in the individual yarns that can be the result of a specific fibre selection. It is necessary to stress that this creation of fibre groups is a statistical method. The transitions between the fibre groups are changeable and the concrete use of percentages of the different fibre types are only guidelines, but created according to current knowledge and expertise. This way of presenting the data is intended to show that information about fibre qualities and selection that are stored in the textiles can be revealed by investigating them from several different angles.

4. Wool from modern primitive sheep

Wool from modern primitive sheep is generally used to reconstruct ancient textiles because their fleece can in some ways be compared to prehistoric wool. The wool consists of an undercoat of fine fibres and an overcoat of coarse hair (fig. 4.1) which can be separated and combined in different ways, according to the desired finished textile. In the Viking Age the wool would be either plucked or sheared from the sheep and afterwards washed, sorted and combed (fig. 4.2) before being spun into thread and finally woven. For more details on the textile production, see Andersson Strand & Demant 2023.



► Fig. 4.1: Illustration of the difference between undercoat and overcoat in sheep wool.

Illustration: Mads Lou Bendtsen

► Fig. 4.2: Combing the wool fibres.

Photo: Charlotte Rimstad

In this study the wool from the Viking Age textiles is compared to samples of wool from ten different sheep breeds: Bluefaced Leicester, Gotland, Gute, Jacobs, Klövsjö, Roslag, Rya, Spelsau, Svärdsjö and Värmland (fig. 4.3-4.12). Samples from nine of these were kindly provided by "Den gamla Skolan", Bonderup, Sweden. It is not known from which part of the fleeces they had been picked and their pre-treatment is also unknown, but they appeared cleaned and some sorting of the wool seemed to have taken place. Further samples from four different complete fleeces from the Spelsau sheep breed obtained from 'Sultenkrogens Sheep farm', Jyderup, Denmark, were analysed. Three of these were superficially sorted into overcoat and undercoat (OC and UC respectively) and seven samples were taken, making up 17 samples altogether. The results from the individual breeds are presented in the Catalogue (page 114-141)

◄ Fig. 4.3: Bluefaced Leicester is an English longwool breed evolved through breeding in the 18th century. Its fleece has a curly, fine and lustrous wool and is the finest commercially available wool from United Kingdom.

Photo: (en.wikipedia.org).

◄ Fig. 4.4: Gotland is a domestic breed of the Northern European short-tailed sheep, named after the Swedish island, Gotland. It is thought to be the result of a crossbreeding between the Gute sheep, which is native to Gotland, and breeds from Russia and Central Asia. Its fleece consists of grey, soft and curly wool.

Photo: (en.wikipedia.org ; swedishfibre.com)

◄ Fig. 4.5: Gute is native to the Swedish island of Gotland and one of the Northern European short-tailed sheep. It is the most primitive breed native to Sweden. Its fleece is a mixture of fine wool, long coarser hair and kemp fibers. The undercoat can be very soft and silky.

Photo: (en.wikipedia.org ; swedishfibre.com ; breeds.okstate.edu)

► Fig. 4.6: Jacobs is a British breed of domestic sheep of unknown origin differing from other primitive breeds by being single-coated. Its fleece is dark with white areas and consists of soft and light wool.

Photo: (en.wikipedia.org ; site. jacobsheepsociety.com)

► Fig. 4.7: Klövsjö is a Swedish breed originating from Jämtland. Its fleece has a long and shiny outercoat and an undercoat of soft and fine wool.

Photo: (swedishfibre.com)

► Fig. 4.8: Roslag is a short-tailed breed almost exclusively found in Sweden. Its fleece has long, straight guard hair and a thick cover of curly wool.

Photo: (en.wikipedia.org ; swedishfibre.com)

◄ Fig. 4.9: Rya is a Swedish breed restored in the early 20th century because of its fleece with staples of equal amounts of outer- and undercoat consisting of long, wavy and shiny wool.

Photo: (en.wikipedia.org ; swedishfibre.com)

◄ Fig. 4.10: Spelsau is a breed of sheep from Norway and one of the Northern European short-tailed sheep breeds. It was a domestic animal from the Iron Age and represents one of the most primitive kinds of domestic sheep still present in Europe. Its fleece consists of an undercoat of very fine wool and an outer coat of long fibres.

Photo: (en.wikipedia.org ; breeds.okstate.edu/sheep)

◄ Fig. 4.11: Svärdsjö is a Swedish short-tailed local breed, originating from the town of Svärdsjö. Its fleece consists of soft, fine and wavy wool.

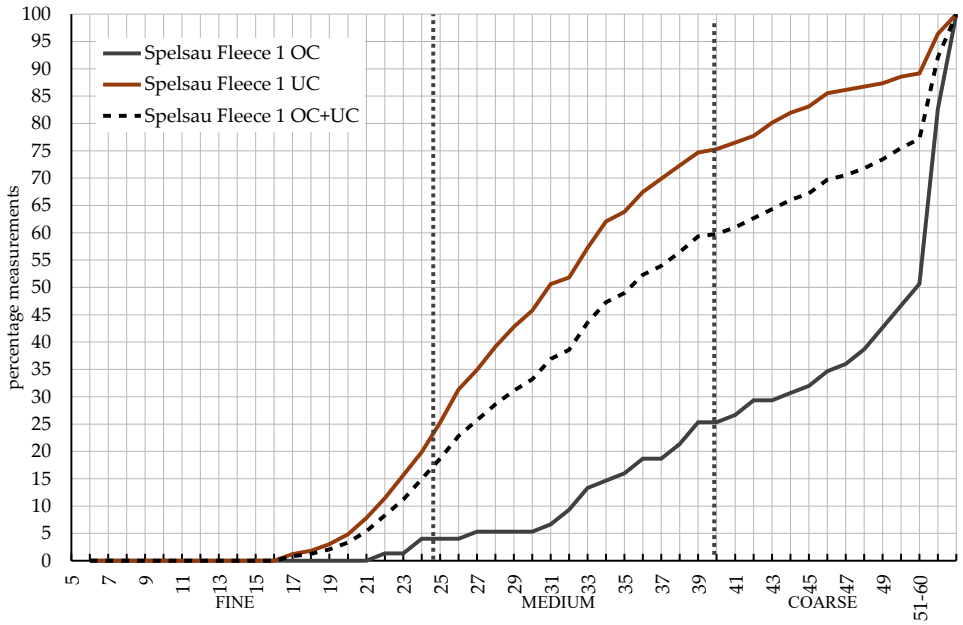
Photo: (swedishfibre.com)

► Fig. 4.12: Värmland is an old swedish breed belonging to the group of nordic short-tailed sheeps. Its fleece has an overcoat varying in length and quantity and an undercoat of fine wool.

Photo: (swedishfibre.com)

The Spelsau fleece

The rough sorting of the Spelsau fleeces 1, 2, and 4 made it possible to get an impression of how this was expressed in the statistical calculations. The fibre measurement results from the separated overcoat and undercoat of fleece 1 have been combined and they exemplify the unsorted wool. They are shown together with the separated over- and undercoat in a cumulative frequency diagram in fig. 4.13. This shows that even a rough sorting results in a large gap between the curves of the over- and undercoat and that the combined results are placed in a range between these, in this case slightly closer to the range of the undercoat. Similar results were seen for fleeces 2 and 4 (see Catalogue, page 128-135).



► Fig. 4.13: Spelsau fleece 1 overcoat and undercoat separated and combined.

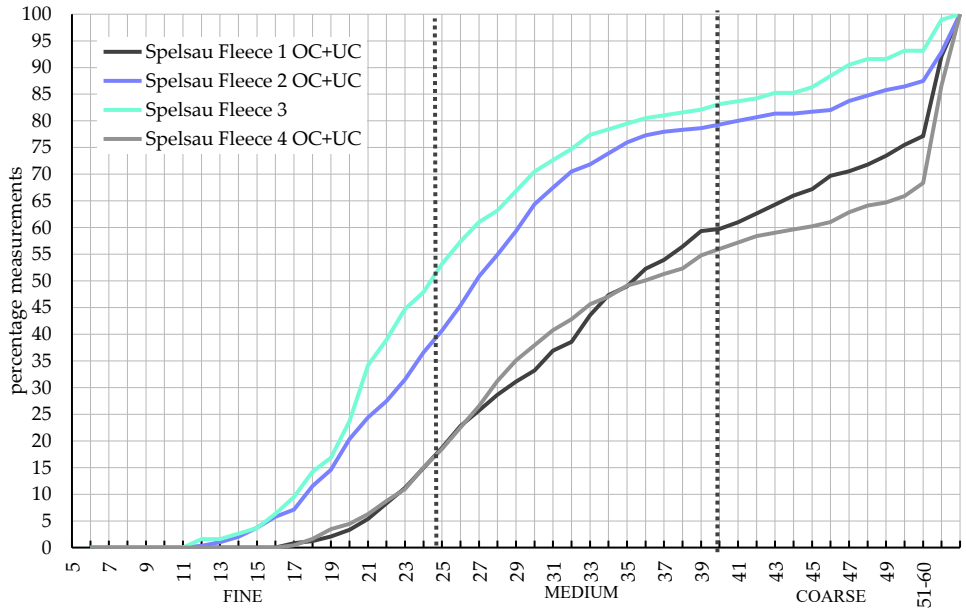
Fibre diameters in micron.

When the calculations of the combined results from Fleeces 1, 2 and 4 respectively are compared, Fleeces 1 and 4 turn out to be quite similar with a slight majority of course fibres giving gentle slopes to the curves in the diagram (table 4.1 and fig. 4.14). Fleece 2 has a majority of fine fibres which is also seen in the results from unsorted Fleece 3. The differences in the percentages cause the deviations of the two curves and the calculations illustrate the variations in wool from different fleeces from the same sheep breed. Fleece 3 is attributed the Rast-Eicher category CD because of a large content of fine and medium fibres and very few fibres above 60 microns. Fleeces 1, 2 and 4, on the other hand, all have larger contents of coarse fibres resulting in category E for Fleeces 1 and 2, while Fleece 4 in addition has fewer fine and medium fibres and therefore is categorised EE.

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Fleece 1 OC + UC	23	37	40	16-58, 60-64, 66-67, 70-72, 76, 79	E	241
Fleece 2 OC + UC	45	34	21	11-42, 44-58, 61-66, 68-69, 71, 74, 76-77, 83, 88	E	295
Fleece 3	57	26	17	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190
Fleece 4 OC + UC	23	33	44	16-75, 79-80, 83	EE	493

◄ Table 4.1: Analysis results from unsorted wool from four Spelsau fleeces.

Calculations of fibre measurements in micron.



◄ Fig. 4.14: The unsorted fleeces 1 and 4 have very similar curves while fleeces 2 and 3 are comparable.

Fibre diameters in micron.

Comparing the modern wool fibres

When the results from the separated Spelsau over- and undercoats are compared to the other modern wool samples, further distinctive differences in the distribution of the fibres can be observed and three characteristics described:

Fine fibres

A majority of fine fibres (table 4.2 and fig. 4.15) is seen in the undercoat from Spelsau fleece 2. Värmland fleece 0 resembles the sorted Spelsau wool in all three fibre groups while Gute wool has a larger content of fine and fewer medium fibres. Spelsau fleece 3 and Klövsjö wool also have a large content of fine fibres, but at the same time relatively large percentages of coarse fibres. The Gute and Värmland results could indicate that some sorting had been done or that a deliberate choice of fibres was made when the fleeces were sampled, while the large content of coarse fibres in Spelsau fleece 3 and Klövsjö wool may represent unsorted raw material.

This fibre combination results in Rast-Eicher categories CD, D and E for these samples.

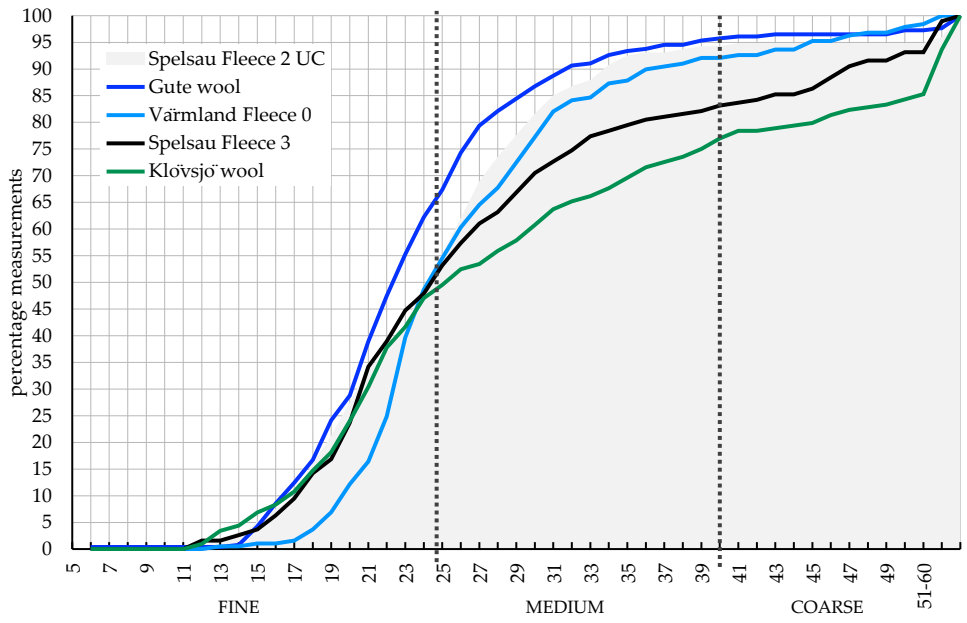
► Table 4.2: Modern wool with a majority of fine fibres.

Calculations of fibre measurements in micron.

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Spelsau Fleece 2 UC	62	32	6	11-35, 37-38, 40, 52, 58, 61, 64, 68, 74, 76, 83, 88	D	174
Gute	74	21	4	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	257
Värmland Fleece 0	60	32	8	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189
Spelsau Fleece 3	57	26	17	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190
Klövsjö	52	25	23	11-40, 42-52, 54, 56-60, 62-66, 68, 70, 73, 77	E	204

► Fig. 4.15: Modern wool with a majority of fine fibres.

Fibre diameters in micron.



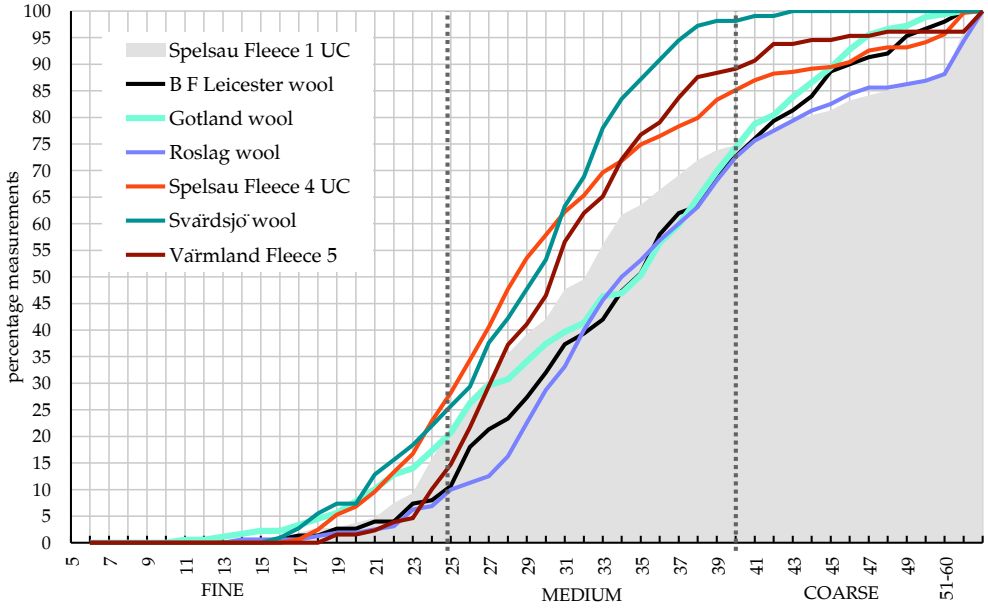
Medium fibres

A majority of medium fibres (table 4.3, fig. 4.16) is a characteristic recorded in the undercoat from Spelsau fleeces 1 and 4; in fleece 4 slightly more distinct. The two samples have similar contents of fine fibres, but differ in respect to the coarse. Gotland wool resembles particularly Spelsau fleece 1. Blue Faced Leicester, Roslag and Svärdsjö wool and Värmland fleece 5 have corresponding and larger contents of medium fibres, but differ in the contents of fine and coarse. As mentioned above, the sorting of the Spelsau fleeces was done superficially and a more meticulous processing may have been able to reduce the high content of coarse fibres even more than these examples indicate. The Rast-Eicher categories also for these samples vary between CD, D and E, and their differences are visualised in the cumulative curves.

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Spelsau Fleece 1 UC	31	44	25	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166
Spelsau Fleece 4 UC	34	51	15	16-47, 49-57, 62	CD	323
Svärdsjö wool	29	69	2	15-18, 20-38, 40, 42	CD	109
Gotland wool	27	49	24	10, 12-14, 16-51	CD	169
Värmland Fleece 5	22	67	11	18, 20-41, 43, 45, 47, 62-63, 66	D	129
B F Leicester wool	2	55	27	15-16, 20, 22-52, 57	D	150
Roslag wool	11	61	28	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

◄ Table 4.3: Modern wool with a majority of medium fibres.

Calculations of fibre measurements in micron.



◄ Fig. 4.16: Modern wool with a majority of medium fibres.

Fibre diameters in micron.

Coarse fibres

A majority of coarse fibres (table 4.4 and fig. 4.17) and different distributions of the fine and medium fibres is recorded in the overcoat from Spelsau fleeces 1, 2 and 4 and in the samples of Jacob and Rya wool. It is worth noting, that the results from the overcoat from Spelsau fleece 2 are very similar to the combined Spelsau fleece 1, signifying a difference in fineness of two fleeces from the same sheep breed. The high content of coarse fibres in the analysed overcoat samples confirm that they were picked from the coarsest part of the fleece, while it cannot be ascertained to what degree the samples from the Jacob and the Rya sheep are representative of their fleeces or of a specific sampling. Three of these results do not match any of the Rast-Eicher categories and the two remaining are attributed categories E and EE.

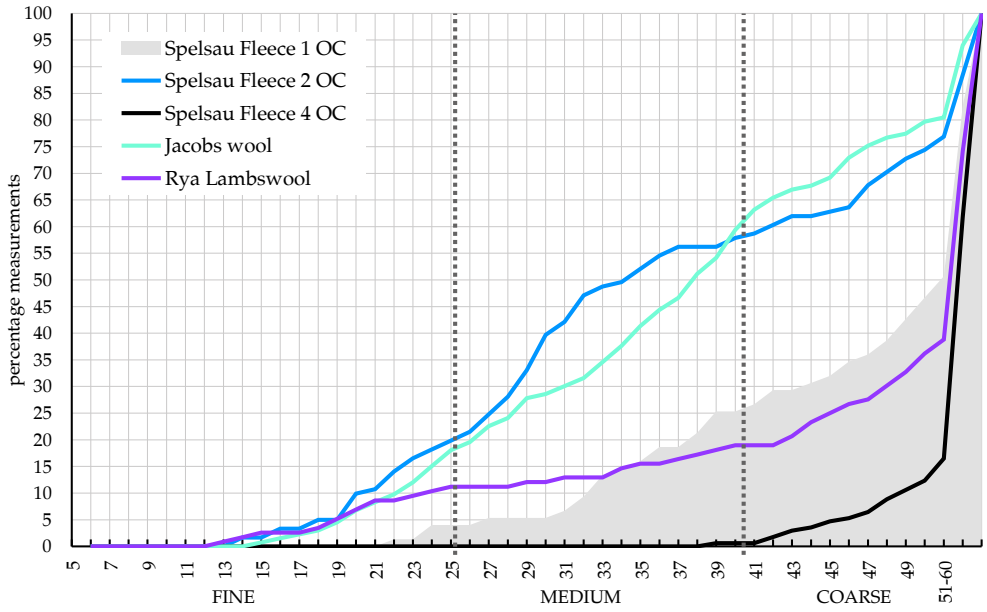
► Table 4.4: Modern wool with a majority of coarse fibres.

Calculations of fibre measurements in microns.

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.4	% ≥ 40.5	Range	Category	No. of fibres
Spelsau Fleece 1 OC	4	21	75	21, 23, 26, 30-35, 37-38, 40-41, 43-54, 56-58, 60-64, 66-67, 72, 79	No	75
Spelsau Fleece 2 OC	21	36	42	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Spelsau Fleece 4 OC	0	1	99	38, 41-75, 79-80, 83	No	170
Jacobs wool	20	40	41	14-52, 54-61, 63-64, 67-68, 81	E	133
Rya Lambswool	11	8	81	12-14, 17-20, 22-24, 28, 30, 33-34, 36-39, 42-64, 66-70	No	116

► Fig. 4.17: Modern wool with a majority of coarse fibres.

Fibre diameters in micron.



Summing up

The results from the four different Spelsau fleeces, the two Värmland fleeces and the other wool samples illustrate to what extent wool from the same sheep breed can differ and that several different fibre thicknesses can be found in the same fleece. Except the three Spelsau fleeces, which were superficially sorted, these samples were of unprocessed wool and although Rast-Eicher's categorization system is created to evaluate the processing the categories illustrate the quality differences in the raw wool. Three of the wool samples with a majority of coarse fibres have fibre combinations that do not fit any of the categories. The remaining vary between CD, which requires at least 80% of fibres above 40 microns and only allows 2% of fibres above 60 microns, and EE, where only 50% are above 40 microns and 15% are above 60%.

Altogether, the results from this investigation show that wool from different sheep breeds can have similar fibre characteristics. This means that the processing, including the first selection of raw wool and the fibre preparation, such as sorting and combing, will influence the yarn quality. The finished yarns thus reflect a combination of the quality of the available raw wool, the experience and skill of the textile crafts person and the purpose for which the fibres are prepared. The results from this investigation are compared to the Viking Age samples in the following section.

◄ Fig. 4.18: Norwegian Spelsau sheep.

Photo: Laurine Albris

5. Wool from Viking Age textiles

For the Fashioning the Viking Age project, fibre quality analyses were made of 68 samples from warp and weft yarns as well as embroidery and sewing yarns from 31 Viking Age textiles in total. Further, samples of two felt items and two unspun wool bundles were included. These derived from the graves of Bjerringhøj and Hvilehøj from Jutland in Denmark and from the settlement of Hedeby in Northern Germany (table 5.1).

► Table 5.1: Wool textiles, felt and fibre bundles included in the study of Viking Age wool types.

Location	Number	Textile/item	Yarn type	No. of samples
Bjerringhøj	C135a	2/1 twill (with embroidery)	Warp/weft from two fragments; one random warp; embroidery yarn	6
Bjerringhøj	C135b	Tabby	Unknown warp/weft direction	2
Bjerringhøj	C135c	Tabby	Unknown warp/weft direction	2
Bjerringhøj	C135d	Tabby band	Unknown warp/weft direction	3
Bjerringhøj	C136a	Tablet-woven band	Dark and light warps/weft	3
Bjerringhøj	C136c	Braided band	-	1
Bjerringhøj	C138	Tabby (inside wrist cuff)	-	1
Bjerringhøj	C139	Tabby (inside rouleaux)	-	1
Bjerringhøj	C144	Tabby (pillow)	warp/weft/decoration	3
Bjerringhøj	C150	Wool fibre bundle	-	1
Bjerringhøj	C145	Tabby (found on the ankle bone)	Unknown warp/weft direction	2
Hvilehøj	C4280a	Tabby	Warp/weft/pattern weft	3
Hvilehøj	Ad C4280d	2/2 twill	Unknown warp/weft direction and one random sample	3
Hvilehøj	Ad C4291	2/2 twill	Unknown warp/weft direction	2
Hvilehøj	Ad C4273-97 Plate 1	Wool fibre bundle	Fibres only	1
Hedeby	H2	2/2 twill (hose)	Warp/weft	2
Hedeby	H7	Upper garment with nap	Unknown warp/weft direction	1
Hedeby	H11	2/2 Twill (caftan?)	Warp/weft/lining	3
Hedeby	H14 A-B	Tabby (part of spencer dress)	Warp/weft	2
Hedeby	H14D	Felt (face mask)	Fibres only	1
Hedeby	H28A	2/2 twill (part of sleeve)	Warp/weft/dark textile	3
Hedeby	H39 A-B	Diamond twill (part of trousers)	Warp/weft/sewing yarn	3
Hedeby	H42	Felt	Dark/light	2
Hedeby	H53 A-B	2/2 twill (upper garment)	Warp/weft	2
Hedeby	H57	2/2 twill (sleeve)	Dark and light warps/wefts	4
Hedeby	H72B	Tabby (part of trousers)	Warp/weft	2
Hedeby	H91A	Tabby (part of H72 A-B)	Warp/weft	2
Hedeby	H72C	Tabby (upper garment)	Warp/weft	2
Hedeby	S3	2/2 twill (liripipe hood)	Warp/weft	2
Hedeby	S26	2/2 twill (band)	Warp	1
Hedeby	S28	2/2 twill (upper garment)	Warp/weft	2

Altogether, the results of these fibre analyses document differences in the uniformity of the fibre distributions where the content of coarse fibres can vary from 0% to 36% in the yarns with either a majority of fine or medium fibres. These factors indicate the extent of different fibre types in the Viking Age sheep fleeces and the variety of sorting. Although it is recognized that raw wool, unspun wool or fur items cannot be used as direct evidence of a commonly existing raw material – as these finds may also have been selected for specific purposes – the two wool fibre bundles from Bjerringhøj (C150) and Hvilehøj (Ad C4273-97) offer an opportunity to compare the results from each yarn from these locations with a possible raw material. No raw wool fibre bundles were found in Hedeby, but as felt items were sampled (H14 D, H42) one of these samples is here used to exemplify raw material for this group.

◄ Fig. 5.1: A few millimeters of each yarn in the textile are sampled for the fibre analysis.

Bjerringhøj

Samples with fibre distributions resembling the wool fibre bundle

Three yarn samples show results corresponding to the wool sample (C150). These are from the embroidered 2/1 twill (C135a, fragment 6), the two samples from a tabby (C135d) and a weft yarn from the pillow (C144). In the diagram their curves hover just below the wool sample through the fine and medium ranges, and just above in the coarser range (table 5.2, fig. 5.2). The two wefts (C135a, fragment 6 and C144) have contents of fine and medium fibres equivalent to the fibre bundle while the two warps deviate slightly. These six yarn samples are all categorised as CD according to the Rast-Eicher system, correlating with the fibre bundle. The same category is attributed to seven of the modern wool samples with a majority of either fine or medium fibres exemplified by Spelsau fleece 3, so in this case the categories may refer to the raw wool as well as to the processing. The results seem to indicate similarity in the raw material as well as in the extent of sorting.

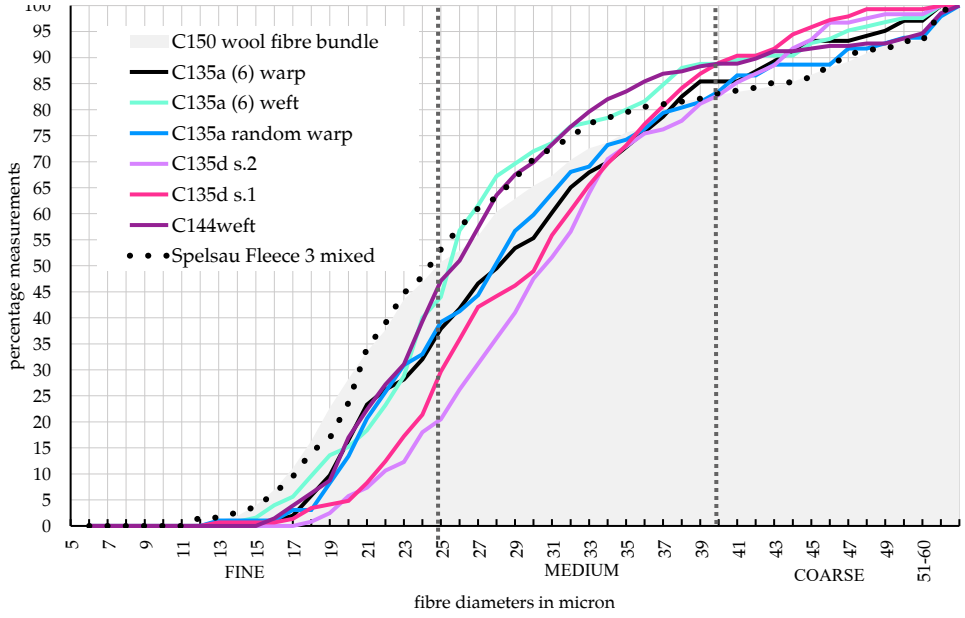
► Table 5.2: Bjerringhøj samples with similar fibre distribution as the wool fibre bundle.

Calculations of fibre measurements in microns.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
C150	Fibre bundle	53	30	17	11-54, 56-60, 64, 68	CD	361
C135a (6)	Warp	42	44	15	15-38, 41-44, 47-49, 51, 53, 59	CD	103
C135a (6)	Weft	57	32	11	12, 14-38, 40-41, 44-49, 52-53	CD	125
C135a	Random warp	41	42	16	12, 16, 18-40, 42, 46, 48-49, 51, 54, 56-57, 70-71	CD	97
C135d	Sample 1	36	53	11	12, 16-40, 42-47, 52	CD	145
C135d	Sample 2	26	57	17	17-45, 47-48, 51, 55	CD	122
C144	Weft	51	38	11	15-39, 41-42, 44-45, 47, 49-51, 53-54, 57, 59, 62, 71, 112	CD	206
Spelsau Fleece 3	Wool	57	26	17	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

► Fig. 5.2: Bjerringhøj yarn samples with fibre distributions resembling the fibre bundle.

Fibre diameters in microns.



Samples with fewer fine and more coarse fibres than the fibre bundle

Six yarns from four different textiles have fibre contents comparable to the unsorted wool in the medium range, but with fewer fine and more coarse fibres (table 5.3, fig. 5.3). These are the other two samples from the embroidered 2/1 twill (C135a, fragment 11), the embroidery yarn from the same textile, the dark warp in the tablet woven band (C136a), the yarn from the braided band (C136c), and the yarn from a tabby textile (C139). In the diagram their curves hover just below the fibre bundle throughout. These samples are characterised by similar contents of fine and medium fibres and in some cases also of coarse fibres. The embroidery yarn deviates slightly with a smaller amount of coarse fibres.

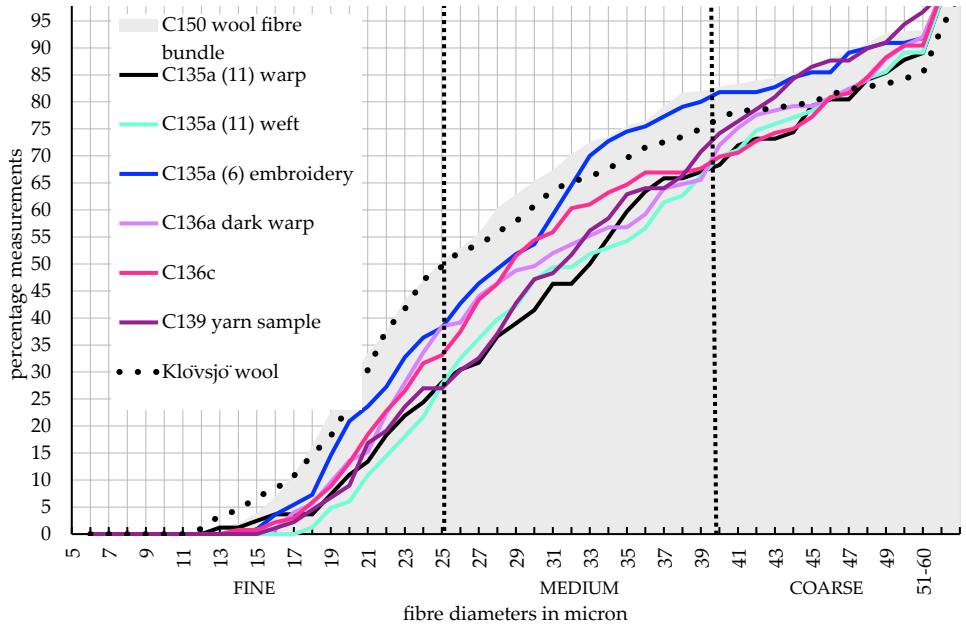
With the exception of the embroidery yarn (C135a) which is attributed the Rast-Eicher category CD, the remaining samples are either category D because of fewer fibres below 40 microns and more above 60 microns. Four of the modern wool samples with a majority of fine or medium fibres are attributed category D and one category E, the Klövsjö wool, which is used to exemplify the similarity of the modern wool to the yarn samples. As in the case above, the categories do not conclusively classify the processing, as raw wool on its own can have similar categories. The results could indicate a less specific selection of the raw wool than above.

It is worth noting that the warp and weft samples taken from the same textile (C135a) ended up in different fibre groups. The differences are not significant enough to suggest that the textile is constructed from different fabrics but are rather indications of the variations that naturally occur in large, handcrafted textiles.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
C150	Fibre bundle	53	30	17	11-54, 56-60, 64, 68	CD	361
C135a (11)	Warp	30	38	32	12, 14-15, 18-30, 32-36, 38-41, 43-45, 47-50, 54, 56-59, 75	D	82
C135a (11)	Weft	33	37	30	17-30, 32-49, 52-56, 58-89, 63	D	83
C135a (6)	Embroidery	43	39	18	14-39, 42-44, 46-48, 50-53, 56-57, 60	CD	110
C136a	Dark warp	39	33	28	14, 16-33, 35-43, 45-55	D	125
C136c	Yarn sample	38	32	30	13, 15-35, 38-49, 51,55, 57, 59	D	136
C139	Yarn sample	30	44	36	15-23, 25-35, 37-45, 47-51, 53-54	D	89
Klövsjö	Wool	52	25	23	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	E	204

◄ Table 5.3: Bjerringhøj samples: fewer fine and more coarse fibres than the wool fibre bundle.

Calculations of fibre measurements in microns.



◄ Fig. 5.3: Bjerringhøj samples with fewer fine and more coarse fibres than the wool fibre bundle.

Fibre diameters in microns.

Samples with much fewer coarse fibres than the wool fibre bundle

Eight yarns are distinguished by having very few or no coarse fibres. These are the five samples from the assumed same open tabby weave (C135b, C138, C145), two samples from a balanced tabby (C135c) and the weft from the tablet-woven band (C136a) (table 5.4, fig. 5.4). In the diagram they appear with much steeper curves than the fibre bundle.

Some of them have a small majority of fine fibres, only two slightly larger than the fibre bundle (sample 2 from C135b and sample 2 from C135c). Others have small majorities of medium fibres, and all have more medium fibres than the fibre bundle. The lack of coarse fibres must be the result of thorough sorting and combing. The wool may have been selected from parts of the fleece with predominantly finer fibres and the removal of the coarse fibres has also resulted in an increased content of fine and medium fibres and than in the raw wool.

The Rast-Eicher categories vary for this group between AB, B and C which have not been attributed to any of the modern wool samples. These categories can therefore be seen as referring specifically to the wool processing. The large contents of both fine and medium fibres do not signify major differences in the raw material, but the resulting fibre combinations are not seen in any of the unsorted modern wool samples.

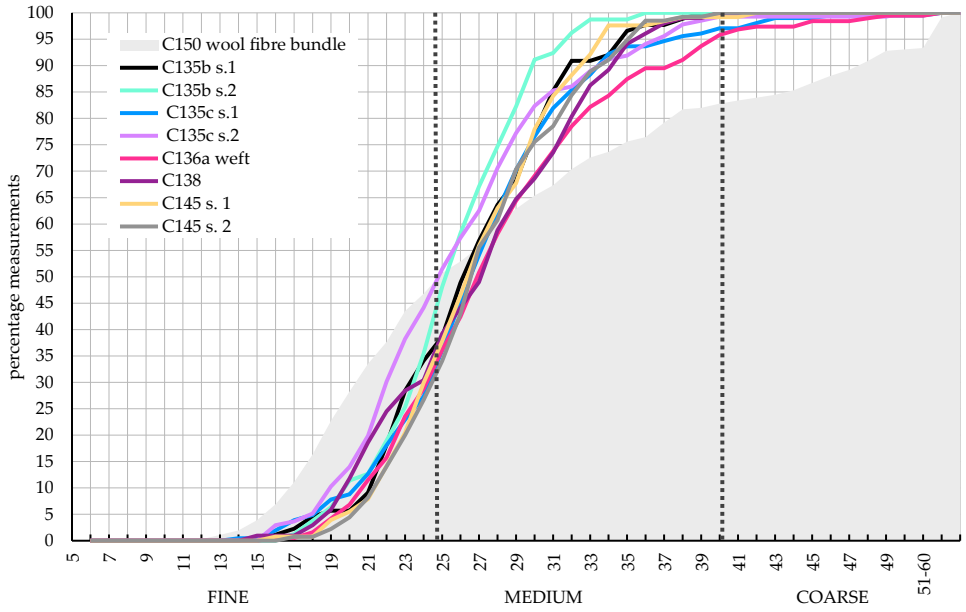
► Table 5.4: Bjerringhøj samples with much fewer coarse fibres than the wool fibre bundle.

Calculations of fibre measurements in microns.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
C150	Fibre bundle	53	30	17	11-54, 56-60, 64, 68	CD	361
C135b	Sample 1	49	51	0	15-18, 20-31, 33-35, 37-38	AB	88
C135b	Sample 2	58	42	0	16-32, 35	AB	79
C135c	Sample 1	45	52	3	13, 15-34, 36-39, 41-42, 45, 56	C	205
C135c	Sample 2	57	42	1	15-39, 49	AB	136
C136a	Weft	42	53	4	15, 17-35, 37-41, 47-48, 52	C	136
C138	Padding	44	56	0	14, 17-37, 39	C	102
C145	Sample 1	45	54	1	15, 18-33, 36-37, 41	B	127
C145	Sample 2	42	58	0	16, 18-35, 37, 39	B	135

► Fig. 5.4: Bjerringhøj samples with much fewer coarse fibres than the wool fibre bundle.

Fibre diameters in microns.



Samples with few fine fibres and larger contents of coarse fibres than the wool fibre bundle

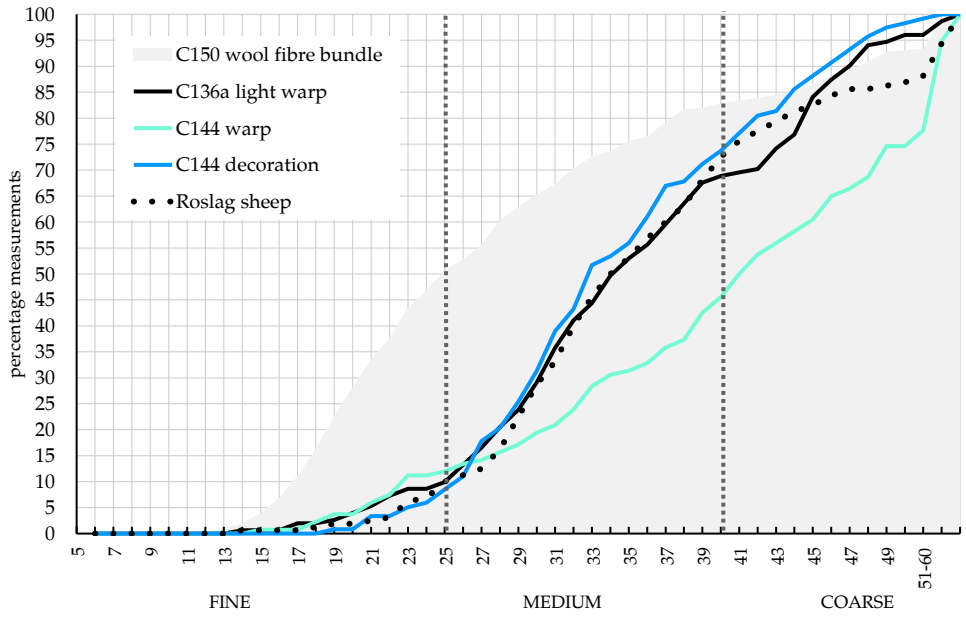
The three samples with these characteristics are the warp and the decorative yarn from the pillow (C144) and the light warp in the tablet-woven band (C136a) (table 5.5, fig. 5.5). These yarns have a large content of coarse fibres. Most likely the raw wool for these textiles was chosen with the specific purpose of making a strong yarn in mind.

One sample (C144) is attributed the Rast-Eicher category EE, and the other two are categorised D. Category D has been attributed to the modern wool samples with a majority of either fine or medium fibres, but EE only attributed to samples with a majority of coarse fibres. The categories can therefore refer to both the wool and the processing. Of the modern samples the Blue Faced Leicester, Jacob and Roslag wool have comparable results, exemplified by the Roslag wool which has almost identical results as the yarn for the decoration of the pillow (C144).

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
C150	Fibre bundle	53	30	17	11-54, 56-60, 64, 68	CD	361
C136a	Light warp	13	56	31	13, 16, 18-22, 24-49, 51-52, 56, 62, 66	D	151
C144	Warp	13	52	54	14, 17-18, 20-22, 24-48, 50, 52-63, 67	EE	134
C144	Decoration	11	63	26	18, 20, 22-50, 57	D	118
Roslag	Wool	11	61	28	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

◄ Table 5.5: Bjerringhøj samples with larger contents of coarse fibres than the wool fibre bundle.

Calculations of fibre measurements in microns.



◄ Fig. 5.5: Bjerringhøj samples with larger contents of coarse fibres than the wool fibre bundle.

Fibre diameters in microns.

To sum up, the general impression of the Bjerringhøj wool samples is that medium fibres constitute a similar content in all yarns and never less than c. 30% of the fibres. The yarns are also very similar in the content of finer fibres, ranging below 25 microns. In the diagrams, this is illustrated by the curves that all begin below the wool fibre bundle. Based on these observations the raw material appears very similar in all yarns from this context.

Hvilehøj

Samples with fibre distributions resembling the wool fibre bundle

The two wefts in the patterned tabby (C4280a) have curves below the wool fibres in the fine and medium ranges but rising above in the coarse range (table 5.6, fig. 5.6). The fibre bundle has a majority of fine fibres while in the two yarn samples the majorities are medium fibres, which suggest a slight difference in the raw material. The fewer coarse fibres in the yarns must be seen as the result of combing.

The fibre bundle is attributed the Rast-Eicher category D, similar to the weft (C4280a), while the pattern weft (C4280a) is E. From the modern wool samples we know that these categories can refer to the wool type as well as to the processing. These samples all have a majority of medium fibres and a close similarity to the undercoat from Spelsau fleece 4.

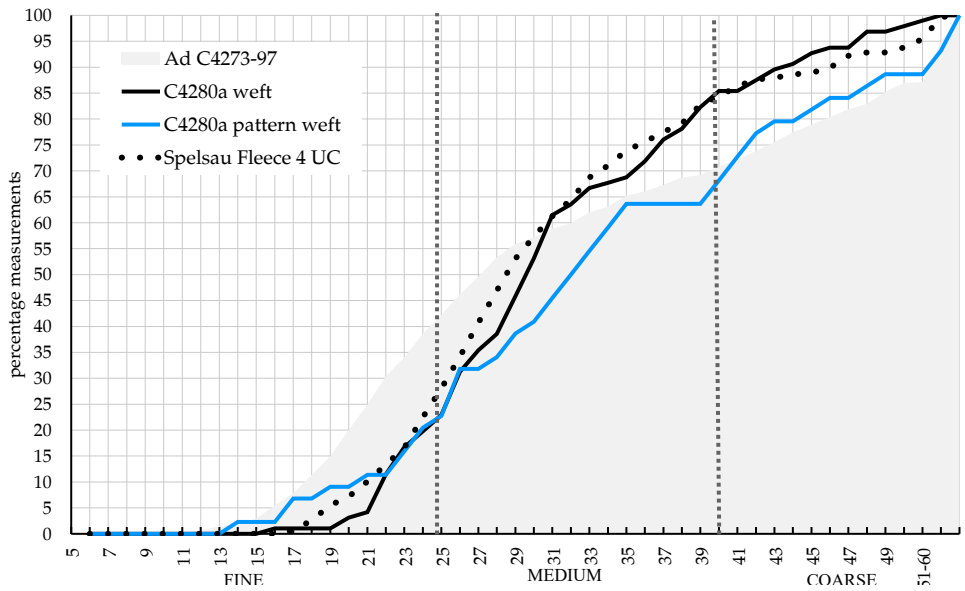
► Table 5.6: Hvilehøj samples comparable to the wool fibre bundle.

Calculations of fibre measurements in microns.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Ad C4273-97	Fibre bundle	47	25	28	9, 11-69, 71-72, 78, 80	D	474
C4280a	Weft	31	54	15	15, 19-39, 41-45, 47, 49-50, 54	D	96
C4280a	Pattern weft	32	36	32	13, 16, 18, 20, 22-34, 39-42, 44-45, 47-48, 52, 55, 67, 78, 87	E	44
Spelsau Fl. 4	Undercoat	34	51	15	16-47, 49-57, 62	CD	323

► Fig. 5.6: Hvilehøj samples comparable to wool fibre bundle.

Fibre diameters in microns.



Samples with larger contents of fine fibres than the wool fibre bundle

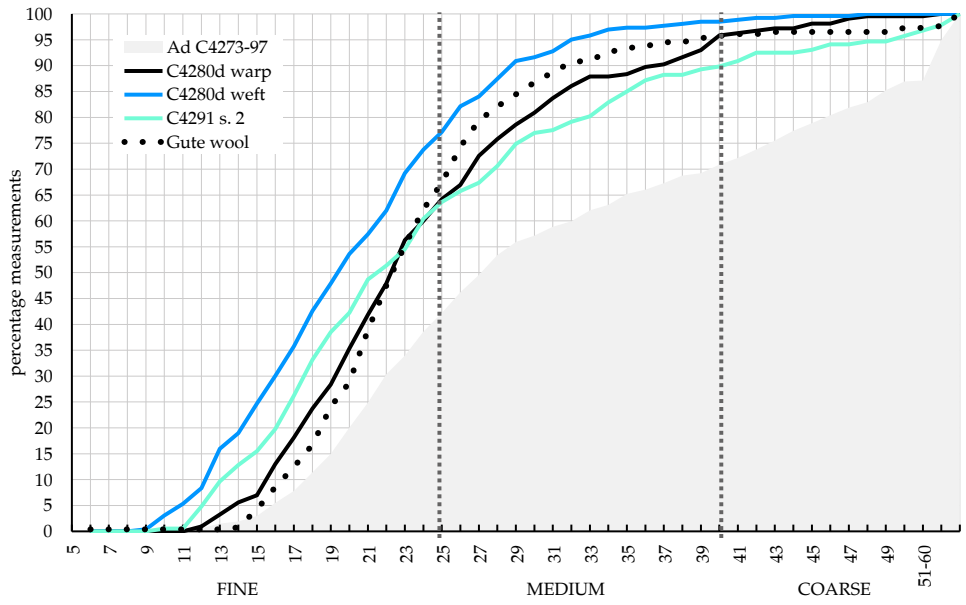
The two yarns in the 2/2 twill (C4280d) and the weft in the 2/1 twill rolls (C4291) have large majorities of fine fibres and a few coarse fibres, but resemble the fibre bundle in respect to the medium fibres. In the diagram their curves are separated from that of the wool fibre bundle (table 5.7, fig. 5.7). They are attributed the Rast-Eicher categories are A, C and CD. None of the modern wool samples are categorised A and C and as such these categories must reflect the processing. Category CD attributed to the weft (C4291) is in this case caused by 2% of fibres being above 60 microns. The Gute wool can be used to exemplify the similarity to the group of modern wool samples.

The results suggest that the wool for these yarns was subjected to very careful selection and combing.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Ad C4273-97	Fibre bundle	47	25	28	9, 11-69, 71-72, 78, 80	D	474
C4280d	Sample 1	67	29	4	11-32, 34-51, 44, 46-47, 54	C	215
C4280d	Sample 2	82	16	2	8-34, 36-38, 40-41, 43, 47	A	263
C4291	Weft	66	24	10	9, 11-36, 38-41, 44-45, 47, 49-50, 52, 58, 61, 64, 96, 119	CD	187
Gute	Wool	74	21	4	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256

◄ Table 5.7: Hvilehøj samples with larger contents of fine fibres than the wool fibre bundle.

Calculations of fibre measurements in microns.



◄ Fig. 5.7: Hvilehøj samples with larger content of fine fibres than wool fibre bundle.

Fibre diameters in microns.

Samples with larger content of coarse fibres than the wool fibre bundle

The last two yarn samples from Hvilehøj are the warps in the patterned tabby (C4280a) and in the 2/1 twill (C4291). They both have large contents of coarse fibres and the curves in the diagram are well below the wool fibre bundle (table 5.8, fig. 5.8). The contents of medium fibres correlate with the fibre bundle and suggest some similarity in the raw material. The large amount of coarse fibres must signify a specific choice of fibres to accommodate the use of the yarns. These fibre combinations resemble the results of the overcoat from Spelsau fleece 2. One sample (C4280a warp) does not match any of the Rast-Eicher categories, the other (C4291 warp) is category EE. These two categories are both used to qualify the unsorted modern wool samples with a majority of coarse fibres and can therefore refer to both the raw wool and the processing.

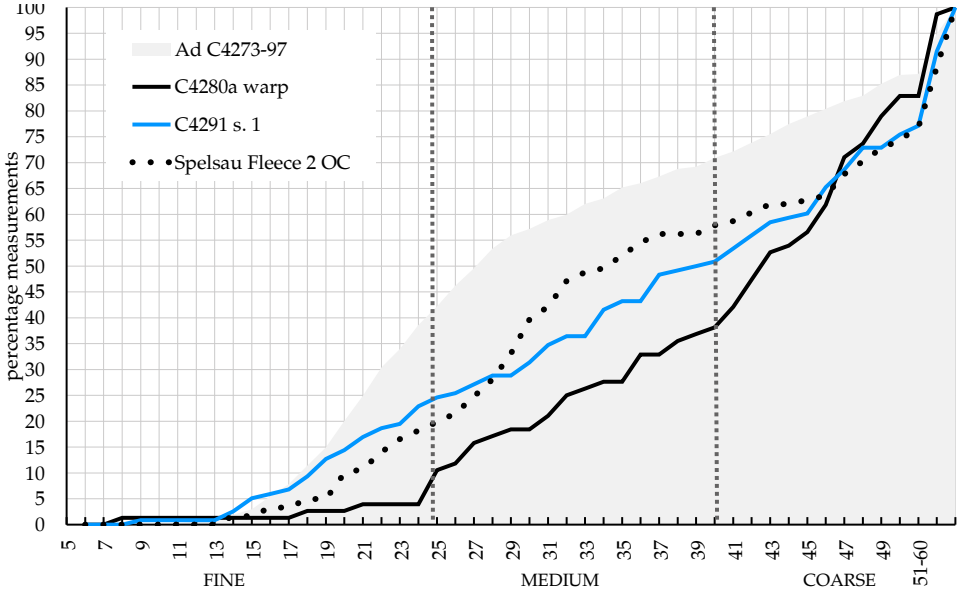
► Table 5.8: Hvilehøj samples with more coarse fibres than the wool fibre bundle.

Calculations of fibre measurements in microns.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
Ad C4273-97	Fibre bundle	47	25	28	9, 11-69, 71-72, 78, 80	D	474
C4280a	Warp	12	26	62	7, 17, 20, 24-28, 30-33, 35, 37-49, 51-54, 58, 63	no	75
C4291	Warp	25	25	49	8, 13-27, 29-31, 33-34, 36-47, 49-50, 52, 54-55, 57, 59-60, 62-66, 70, 79	EE	118
Spelsau Fl. 2	Overcoat	34	36	42	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121

► Fig. 5.8: Hvilehøj samples with more coarse fibres than the wool fibre bundle.

Fibre diameters in microns.



Fewer yarns have been available for study from Hvilehøj, but a similar variety as in the Bjerringhøj results is seen when the results from the Hvilehøj textiles are compared to the wool fibre bundle (Ad 4273-97) found in this grave. With this small number of textiles, it is difficult to make general conclusions. However, some of the fibres, especially the ones that are comparable to the wool fibre bundle, resemble the Bjerringhøj samples in the almost equal contents of fine and medium fibres. This could indicate the existence of a local breed of sheep from which most of these textiles were produced.

The two samples from the 2/2 twill (C4280d) and the weft from the twill rolls (C4291) appear different, especially in respect to the content of fine fibres. It is not possible to determine whether this wool came from a slightly different breed of sheep but it is definitely the result of a specific selection and very thorough sorting of the wool.

Hedeby

For comparison with the Hedeby samples, one of the two felt items has been used. The wool for the felt will also have been subjected to some kind of sorting, but as the sample from the mask (H14D) has the most varied fibre results (see Catalogue page 90-91), this specimen was selected for comparison. All the fibre samples are listed in the tables, but in the diagrams three samples have been selected to illustrate the results.

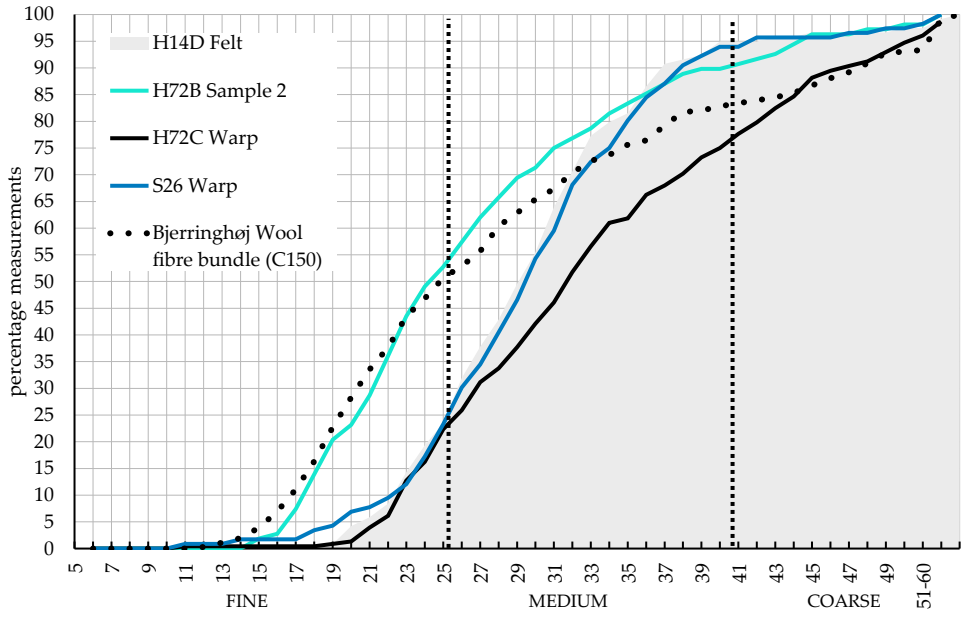
Samples with larger contents of fine and coarse fibres than the felt item

The warp in S26 has results correlating exactly with the felt. The fibre combination is similar and suggests very similar raw material and processing. Further, 11 samples are characterised by fewer medium fibres and larger contents of fine and coarse fibres than the felt (table 5.9, fig. 5.9). These are warps and wefts in the H14 A-B and H72B, the warps from textiles H72C and S28, the sample from the lining of H11, and the weft from the H53 A-B. The differences seen in the contents of fine and medium fibres suggest variations in the raw material. The felt sample (H14 D) is attributed Rast-Eichers's category CD as are also six yarn samples. Two of the remaining three samples are category D and one is E. The results are closest to the group of modern wool with a majority of medium fibres which are categorised CD or D, but none of the samples matches completely. However, the fibre bundle from Bjerringhøj (C150) correlates closely with the two samples from H14 A-B.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
H14 D	Felt	32	63	5	15, 19-39, 42, 49, 51, 64	CD	119
H11	Lining	37	48	15	17, 19-40, 42-54, 56-57, 60-62, 64-65, 70	E	241
H14 A+B	Warp	46	36	19	12, 15-54, 56-57, 60-61, 63, 73	CD	169
H14 A+B	Weft	50	36	14	14, 16-48, 50-51, 59	CD	175
H53 A-B	Weft	30	46	23	16-50, 52-57, 60, 73	D	237
H72 B	Sample 1	52	34	14	14-23, 25-36, 39-41, 43, 45, 48, 51-52, 54, 56-57	CD	103
H72 B	Sample 2	57	32	10	14-38, 40-44, 47, 49, 51, 54	CD	108
H72 C	Warp	26	49	25	10, 18-53, 55, 61, 65, 68	D	228
S26	Warp	30	64	6	10, 13, 17-39, 41, 46, 48, 50, 53	CD	116
S28	Warp	50	34	16	13-30, 32-42, 44-45, 47-52, 61	CD	124
C150	Fibre bundle	53	30	17	11-54, 56-60, 64, 68	CD	361

◄ Table 5.9: Hedeby samples with more fine and coarse fibres than the felt.

Calculations of fibre measurements in microns.



◄ Fig. 5.9: Hedeby samples with more both fine and coarse fibres than felt.

Fibre diameters in microns.

Samples with larger content of fine fibres and fewer medium or coarse fibres than the felt item

Two textiles are represented in this group with both warps and wefts. These are H91A and S28. Further, six samples are wefts from textiles H2, H11, H57 (light and dark), H72C and S3. The remaining two samples are the dark and light felt (H42). The generally much larger content of fine fibres suggests that this wool was selected specifically, and the few coarse fibres indicate thorough sorting and combing (table 5.10, fig. 5.10). Nine of these samples are categorised as CD in the Rast-Eicher system, which is similar to the felt, while one is AB, one is B and one C. As none of the modern wool samples are attributed categories AB, B and C these must refer to the processing. CD is attributed to several of the modern wool samples with a majority of fine fibres exemplified by the Värmland fleece 0.

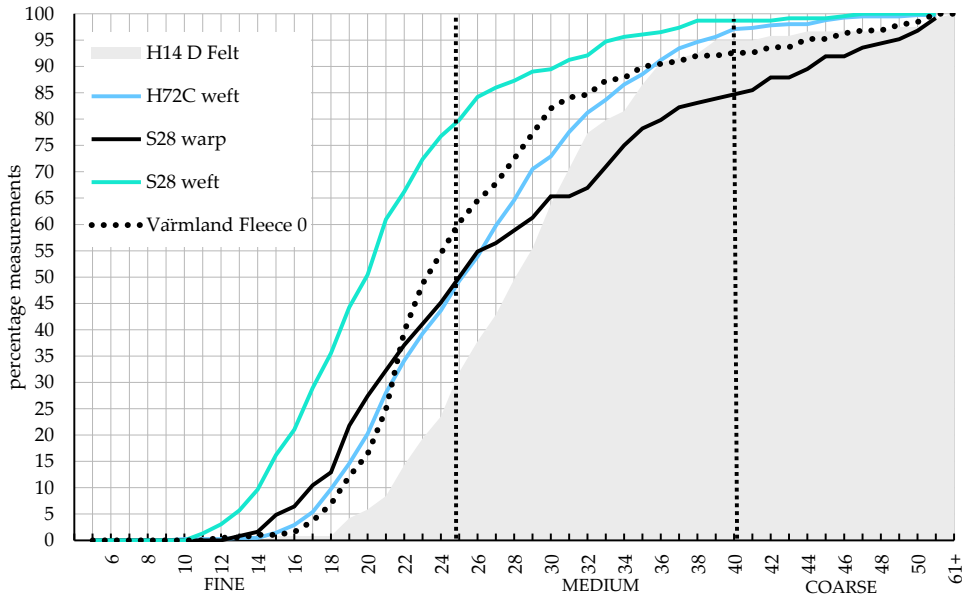
► Table 5.10: Hedeby samples with larger contents of fine fibres and fewer medium or coarse than the felt.

Fibre diameters in microns.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
H14 D	Felt	32	63	5	15, 19-39, 42, 49, 51, 64	CD	119
H2	Weft	66	29	5	14-39, 42-43, 49, 51, 53, 58-59	CD	187
H11	Weft	78	18	4	13-36, 38-39, 42-44, 47, 52, 54, 57	CD	279
H42	Dark felt	71	22	8	9-34, 36, 38-40, 42-47, 50, 55-56, 64, 69,78	CD	227
H42	Light felt	81	17	2	11-38, 44-45, 48-49, 70, 77	B	319
H57	Dark weft	55	35	10	17-37, 39-41, 44, 46-49, 51, 55-58, 65, 73	CD	201
H57	Light weft	65	22	13	10-46, 49-51, 54-58, 60, 64, 88	CD	202
H91 A	Warp	57	34	9	14-39, 41-43, 46, 48, 55, 67, 69	CD	122
H91 A	Weft	72	23	5	13-37, 39, 41-42, 44, 46, 49, 51, 64	CD	165
H72 C	Weft	49	46	5	10, 13, 15-43, 45-47, 50, 62	C	410
S3	Weft	58	35	7	15-34, 36-39, 44-45, 48-50, 53, 57, 61, 63, 81	CD	187
S28	Warp	50	34	16	13-30, 32-42, 44-45, 47-52, 61	CD	124
S28	Weft	80	19	1	11-38, 43, 46-47	AB	228
Värmland	Fleece 0	60	32	8	18, 20-41, 43, 45, 47, 62-63, 66	CD	129

► Fig. 5.10: Hedeby samples with larger contents of fine fibres and fewer medium or coarse than the felt.

Fibre diameters in microns.



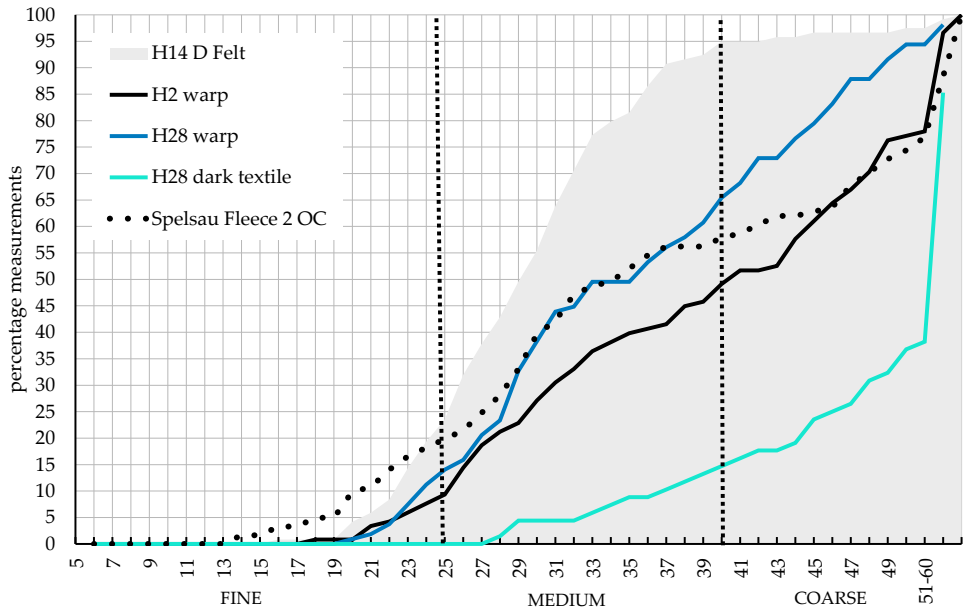
Samples with larger contents of coarse fibres than the felt item

The remaining nine samples have very large contents of coarse and medium fibres. Six of these are warps (H2, H11, H28 A, H57, S3). Two are unidentified (H7 and H28 A dark textile) and one is a sewing yarn (table 5.11, fig. 5.11). Five samples are attributed the Rast-Eicher category EE, one is D, one is E and in two cases the categories did not fit. The results indicate that the wool was selected specifically. The results are comparable to the group of modern wools with a majority of coarse fibres exemplified by the overcoat from Spelsau fleece 2.

Number	Yarn	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	Range	Category	No. of fibres
H14 D	Felt	32	63	5	15, 19-39, 42, 49, 51, 64	CD	119
H2	Warp	14	35	51	17, 20-40, 42-58, 60, 64, 68, 70	E EE	118
H7	Yarn sample	7	41	52	21-24, 26-60, 62-66, 72, 81	EE	172
H11	Warp	22	35	43	20-26, 28-44, 46-51, 56, 64, 76, 78	EE	89
H28 A	Warp	16	50	35	19-32, 35-41, 43-46, 48-49, 51-52, 54, 62, 76	D	107
H28 A	Dark textile	0	15	85	27-28, 32-34, 36-41, 43-60, 62-65, 67	no	68
H39 A	Sewing	19	40	41	13, 19-20, 22-40, 42-47, 49, 51-55, 58-60, 72	EE	97
H57	Dark warp	9	41	50	18-21, 23-36, 38-45, 47-53, 55-56, 59, 61, 63, 65, 70-71, 87	EE	135
H57	Light warp	7	40	53	19, 23-36, 38-51, 53-60, 67, 69-70, 73, 76, 78, 86	EE	100
S3	Warp	7	32	61	19, 21-59, 61, 63-64, 66, 68, 70-71, 74-75	no	118
Spelsau Fl. 2	Overcoat	21	36	42	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121

◄ Table 5.11: Hedeby samples with much larger content of coarse fibres than the felt.

Calculations of fibre measurements in microns.



◄ Fig. 5.11: Hedeby samples with larger content of coarse fibres than the felt.

Fibre diameters in microns.

The Hedeby textiles show similarities with the textiles from Bjerringhøj and Hvilehøj in the way wool generally must have been processed. The fibre distributions in the samples with more fine and coarse fibres than the felt, resemble the fibre distribution in the wool fibre bundle from Bjerringhøj (C150). Fine and medium fibres each constitute from around one third to half of the results. In respect to the samples with a majority of fine fibres some resemblance to the Hvilehøj samples is seen, exemplified in the diagrams where the curves are placed above the felt sample.

Altogether, these comparative analyses of all yarn samples with the unsorted wool and the felt samples have shown that variations of the raw material in respect to the contents of fine and medium fibres existed. A few yarns have very characteristic majorities of fine fibres. These are the three samples from Hvilehøj (the warp and weft from C4280d and the weft from C4291), three wefts from Hedeby (textiles S29, H39 A-B, H91 A) and the Hedeby felt (H42). This suggests that this fibre content was rare and that the wool in these cases had been subjected to very careful selection and combing.

Also the yarns with large contents of coarse fibres are examples of specific selection and sorting. This is supported by the fact that a majority of coarse fibres only appear in warps. Between these two very different yarn types is a large number of samples where the three fibre types are represented in various combinations and the contents of coarse fibres constitute from c. 10-30%. These samples most resemble the unsorted wool fibre bundles. It must be assumed that they have been subjected to processing and therefore they could indicate that a large part of the raw wool may have been unsuited for specific selection and was sorted and combed to enable easy spinning.

◄ Fig. 5.12: Wool fibres after combing, ready to be spun.

Photo: Ida Demant

6. Fibre distribution and yarn functions

The above presented investigation of the fibre contents in relation to unsorted wool and felt documents widespread fibre distributions from yarns with a large majority of fine fibres to a large majority of coarse fibres. It has revealed a correlation between fibre combination and yarn function. This will be investigated further in the following where the variations in the fibre distributions are examined and arranged into different groups. The contents of coarse fibres are for statistical purposes differentiated as below or above 10% but the amount is changeable. The reason for this choice is based on the fact that about an equal number of samples with a majority of fine or medium fibres had less than 10% or more than 10% coarse fibres.

► Fig. 6.1: Through processing the different fibre types contained in fibre bundles are sorted and combed to create the desired yarns.

Photo: The National Museum of Denmark

Yarns with a majority of fine fibres and less than 10% coarse fibres

This group comprises samples with 50-86% fine fibres and less than 10% coarse fibres (table 6.1).

Fifteen samples from 11 textiles and one felt item belong here. The Rast-Eicher categories vary from A to CD depending on the specific percentages of the finest fibres and the largest diameters measured. This fibre combination occurs mainly in wefts from textiles where the associated warps have coarser fibre combinations, but also in two textiles with similar fibre combination in warp and weft. It is furthermore recorded in yarns from two textiles with unidentified warp and weft and a felt item. This kind of fibre combination has some resemblance to the wool from earlier periods, such as for instance the Roman Iron Age (Demant et al. 2021; Mannering et al. in press). The wool for these yarns may have been selected specifically and processed thoroughly or perhaps some sheep breeds existed which produced wool resembling this earlier type.

The very large content of fine fibres is difficult to obtain from any of the modern primitive sheep breeds. Of the modern wool samples with a majority of fine fibres (table 4.2) the Gute wool is closest (74%) while Spelsau sheep fleece 2 and Värmland fleece 0 have about 60% of fine and very few coarse fibres.

Location	Warp	Weft	Warp/weft unknown	Other	Category	Additional comments
Bjerringhøj			C135b sample 2		AB	Sample 1 see Table 6.2
			C135c sample 2		AB	Sample 1 see Table 6.2
Hvilehøj	C4280d	C4280d			C/A	Very large content of fine fibres.
Hedeby		H2			CD	Warp see Table 6.5
		H11			CD	Warp see Table 6.5
		H28 A			C	Warp see Table 6.4
		H39 A-B			C	Warp see Table 6.4, sewing see Table 6.5
				H42 dark/light	CD/B	
	H91 A	H91 A			CD	
		H72 C			C	Warp H72 C see Table 6.4
		S3			CD	Warp S3 see Table 6.5
		S28			AB	Warp S28 see Table 6.3

◄ Table 6.1: Yarns with a majority of fine fibres and less than 10% coarse fibres.

Yarns with a majority of medium fibres and less than 10% coarse fibres

This group comprises samples with 49-59% medium fibres and less than 10% coarse fibres (table 6.2).

Eight samples from six textiles and one felt item belong here. Rast-Eicher categories vary from AB to CD, which is a slightly narrower span than in the abovementioned group and is caused by the larger contents of medium fibres. The wool is in this case seen as deliberately picked from the best parts of fleeces while the coarse fibres have been removed through processing.

This fibre combination is recorded in both warp and weft in one textile, in one weft where the associated warps are coarser, one warp (from a textile where only one sample was picked), in three yarns from textiles with unidentified warp and weft, and in one example of felt.

This division places two yarn samples from the Bjerringhøj textiles, C135b and C135c respectively, in different groups. In both cases sample 1 has a small majority of medium fibres (51% and 52%) and sample 2 a small majority of fine fibres (58% and 57%). It is possible that these differences are natural variations in the handcrafted yarns, and the two yarns in each textile could well be described as similar.

The Svärdsjö wool which is among the modern wool samples with a majority of medium fibres (see table 4.3) has results comparable to these samples.

Location	Warp	Weft	Warp/weft unknown	Other	Category	Additional comments
Bjerringhøj			C135b sample 1		AB	Sample 2 see Table 6.1
			C135c sample 1		C	Sample 2 see Table 6.1
		C136a			C	Dark warp see Table 6.3; light warp see Table 6.4.
			C138		C	
	C145	C145			B	
Hedeby				H14 D felt	CD	
	S26				CD	

◄ Table 6.2: Yarns with a majority of medium fibres and less than 10% coarse fibres

Yarns with a majority of fine and more than 10% coarse fibres

This group comprises samples with 32-57% fine fibres and more than 10% coarse fibres (table 6.3).

The results from 15 yarn samples from eight textiles, one felt item, and two fibre bundles belong here. The Rast-Eicher categories vary between CD and D and are caused by the large contents of coarse fibres.

Besides the two fibre bundles, this fibre combination is recorded in both warp and weft from two textiles, in three wefts where the associated warps are coarser, in two warps where the associated wefts are finer and in one embroidery yarn. The raw material is in this case interpreted as selected from more diverse parts of the fleeces. Some coarse fibres must in all cases have been removed.

Klövsjö wool and Spelsau fleece 3 from the group of modern wool with a majority of fine fibres have fibre contents comparable to this group (52% and 57% respectively of fine fibres).

► Table 6.3: Yarns with a majority of fine fibres and more than 10% coarse fibres.

Location	Warp	Weft	Warp/weft unknown	Other	Category	Additional comments
Bjerringhøj		C135a (6)		C135a (6) embroidery	CD/CD	Warp (6) and random warp see Table 6.4
	C136a dark				D	Weft see Table 6.2, light warp see Table 6.4
			C136c		D	
		C144			CD	Warp see Table 6.5, decoration see Table 6.4
				C150	CD	
Hvilehøj					D	
		C4291 sample 2		Ad 4273-97	CD	Sample 1 see Table 6.5
Hedeby	H14 A-B	H14 A-B			CD/CD	
		H57 dark/ light			CD/CD	Warps see Table 6.5
	H72B	H72 C			CD/CD	
	S28				CD	Weft see Table 6.1

Yarns with a majority of medium and more than 10% coarse fibres

This group comprises samples with 36-57% medium fibres and more than 10% coarse fibres (table 6.4) and 17 samples from 11 textiles belong here. The Rast-Eicher categories vary between CD and D similar to the group above. The categories thus do not take into account the difference between the fine and medium fibres, which is emphasised in this study. The raw wool is in these cases seen as selected from parts of the fleeces with varied fibre combinations. The coarser fibres have been removed to varied degrees.

This fibre combination is used in both warps and wefts in three textiles, in four warps where the associated wefts are finer, in two wefts where the associated warp is coarser and in a yarn used for a sewn decoration.

The modern wool samples with a majority of medium fibres (see table 4.3) have measurements correlating with these results.

Location	Warp	Weft	Warp/weft unknown	Other	Category	Additional comments
Bjerringhøj	C135a (6)/ random				CD/CD	Weft and embroidery (6) see Table 6.3
	C135a (11)	C135a (11)			D	
	C135d S. 1	C135d S. 2			CD	
	C136a light				D	Dark warp see Table 6.3; weft see Table 6.2
			C139		D	
				C144 deco-ration	D	Warp see Table 6.5; weft see Table 6.3
Hvilehøj		C4280a weft/pattern			D/E	Warp see Table 6.5
Hedeby			H11 lining		E	
	H28 A				D	Weft see Table 6.1
	H39 A				D	Weft sewing see Table 6.5
	H53 A	H53 A-B			D	
	H72 C				D	Weft see Table 6.1

◄ Table 6.4: Yarns with a majority of medium fibres and more than 10% coarse fibres.

Samples with a majority of coarse fibres

This group comprises samples with 41-85% coarse fibres (table 6.5) and 11 samples from ten textiles belong here. The categories vary between E and EE and two samples have very small amounts of fine/medium fibres and large contents of coarse fibres which place them outside the Rast-Eicher category system. Apart from the two textiles where the warp and weft are unidentified and one sewing yarn, the samples are all warps. The wool used for these yarns must have been selected from specific parts of the fleeces where the coarser fibres predominated.

Comparable fibre contents are recorded in five samples of modern wool with a majority of coarse fibres, the overcoats from Spelsau fleeces 1, 2 and 4, the Jacob and the Rya wool (see table 4.4).

Location	Warp	Weft	Warp/weft unknown	Other	Category	Additional comments
Bjerringhøj	C144				EE	Weft see Table 6.3; deco-ration see Table 6.4
Hvilehøj	C4280a				No	Wefts see Table 6.4
	C4291				EE	Weft see Table 6.3
Hedeby	H2				EE	Weft see Table 6.1
			H7		EE	
			H28 A dark textile		No	
	H11				EE	Weft see Table 6.1
	H57 dark/light				EE/EE	Wefts see Table 6.3
	S3				No	Weft see Table 6.1
				H39 A-B sewing	E	

◄ Table 6.5 : Yarns with a majority of coarse fibres.

7. Fibre distribution in the yarns in relation to weave type

From the evaluation of the yarn samples compared to the unprocessed wool sample and the study of fibre combinations and yarn functions, it is evident that some fibre combinations were favoured for warps and others for weft. The craftspeople must have been able to sense or feel the different fibre combinations in the yarns when the choice of material for the different textile qualities had to be made.
The different combinations of fibre distribution in the yarns can now be correlated with their function in the weavings as warp, weft or other uses and in the context of Hedeby, Bjerringhøj and Hvilehøj create interesting and, until now, unrecognised differences.

The Viking Age raw wool seems to have consisted of an extensively varied fibre content. This has added the possibility to produce different textiles based on the fibre content in the yarns in addition to, for instance, spin direction and yarn thickness. Two different types of fibre combinations can be seen:

Type 1 has similar fibre contents in warp and weft and three different combinations are seen:

Type 1a. Large content of fine fibres and very few coarse in both yarns.

Type 1b. Large content of fine and medium fibres and very few coarse in both yarns.

Type 1c. Large content of fine and medium fibres and a considerable content of coarse fibres in both yarns.

Type 2 has different fibre combinations in warp and weft and two different combinations are seen:

Type 2a. The warp has a majority of coarse fibres, the weft has a large content of fine or medium fibres.

Type 2b. The warp has a large content of medium fibres, the weft has a large content of fine fibres.

Of the 31 Viking Age textiles studied in this project, warp and weft were analysed from 21 textiles and the variety of items from Hedeby, Bjerringhøj and Hvilehøj are shown in table 7.1. Only textiles with samples from both warp and weft are included.

Location	Number	Wool textile	Type
Bjerringhøj	C135a	2/1 twill with embroidery	1c
	C135b, C138, C145 (assumed similar)	Tabby (open weave)	1b
	C135c	Tabby (balanced, large fragment)	1b
	C135d	Tabby (balanced, band shaped)	1c
	C136a	Tablet-woven band	2a
	C144	Tabby (pillow)	2a
Hvilehøj	C4280a	Tabby with weft pattern	2a
	C4280d	2/2 twill	1a
	C4291	2/2 twill (rolls on fur)	2a
Hedeby	H2	2/2 twill (stocking in 2/2 twill	2a
	H11	Caftan?	2a
	H14A-B	Part of spencer dress	1a/1b
	H28A	Part of sleeve	2b
	H39 A-B	Part of trousers	2b
	H53 A-B	Upper garment	1c
	H57	Sleeve	2a
	H72B	Part of trousers	1a
	H91A	Part of H72 A-B	1a
	H72C	Upper garment	2b
	S3	Liripipe hood	2a
	S28	Upper garment	2a

◄ Table 7.1: Typology in respect to fibre combination in warps and wefts.

Bjerringhøj

Of the six Bjerringhøj textiles, four have similar fibre content in the two yarns. Three tabbies (C135b, C138, C145 assumed to be from the same fabric, and C135c) are consistent with Type 1b (large content of fine or fine and medium fibres and few coarse), while one twill (C135a) and one tabby (C135d) are consistent with Type 1c (large content of fine or fine and medium fibres and a considerable amount of coarse).

The tablet woven band (C136a) and the tabby pillow (C144) have different fibre combinations in the warps and wefts, consistent with Type 2a (majority of coarse fibres in warp, large content of fine or medium fibres in weft).

It is difficult to make a general conclusion in respect to these preferences, but based on the fibre contents alone this makes three quality differences for the eight textiles, and of the textiles with similar fibre content in warp and weft only one is a twill while the remaining are tabbies.

Hvilehøj

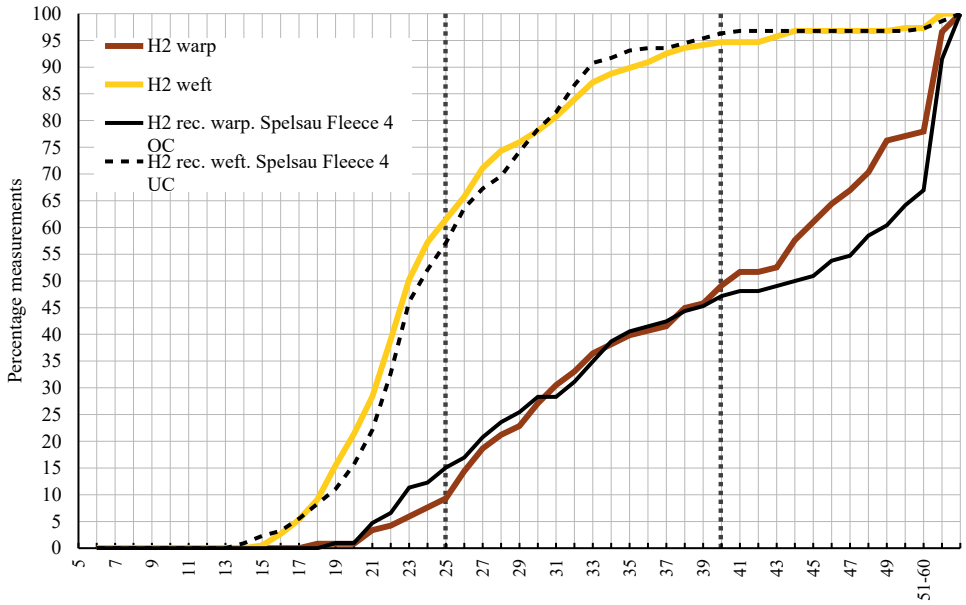
Warp and weft were analysed from the three Hvilehøj textiles and the 2/2 twill (C4280d) has similar warp and weft consistent with type 1a (large content of fine fibres, few coarse) while the two other textiles, the patterned tabby weave (C 4280a) and the 2/1 twill used in the rolls (C4291) have different warps and wefts consistent with Type 2a (majority of coarse fibres in warp, large content of fine or medium fibres in weft).

Hedeby

Among the textiles from Hedeby selected for this study, it has been possible to analyse both warp and weft from 12 textiles. Of these only four have similar fibre content in the two yarn systems. Two of these have fibre contents consistent with Type 1a (large content of fine fibres, few coarse). These are the tabby fragments H72B and H91A. The tabby fragment H14 A-B could be either Type 1a or 1b (large content of fine / fine and medium fibres, few coarse). The lozenge twill fragment

H53 A-B has a fibre combination consistent with Type 1c (large content of fine or fine and medium fibres and a considerable amount of coarse).
In the remaining eight textiles, warps and wefts differ. Five may be defined as Type 2a (majority of coarse fibres in warp, large content of fine or medium fibres in weft). These are the 2/2 twills H2, H11, H57, S3 and S28.
The remaining three textiles may be defined as Type 2b (majority of medium fibres in warp, large content of fine fibres in weft) and are the 2/2 twill H28A, the lozenge twill H39 and finally the tabby H72C.
This shows that different warps and wefts were favoured in the majority of the textiles from Hedeby.

From the three locations different fibre contents in warp and weft are seen in 12 of the 21 textiles analysed and of these eight are twills, three are tabbies and one is a tablet weave. Similar fibres in both yarn systems appear slightly less frequently and are seen in nine textiles, six of which are tabbies and three are twills. Of the textiles with different warp and weft, the warp always has a larger content of coarse fibres than the weft and a majority of coarse fibres is only recorded in warps which in the cases of unidentified yarns can be used as an indicating characteristic.



► Fig. 7.1: Textile H2, a 2/2 twill, is an example of textile type 2a - a warp with a majority of coarse fibres and a weft with a majority of fine fibres. It was chosen for reconstruction and the results from the original textile and the reconstruction are here compared.

Fibre diameter in microns.

► Fig. 7.2A: Enlarged detail of the original weaving.
B: Enlarged detail of the reconstruction.

Photo: A, Charlotte Rimstad.
B, Ida Demant.

8. Conclusion

The wool samples from Bjerringhøj, Hvilehøj and Hedeby have provided an excellent possibility to study and compare wool production methods used for a selected number of Viking Age yarns. Altogether the results seem to be confined to a general wool characteristic consisting of varied fibre contents, here defined as fine, medium and coarse fibre groups.
The two examples of presumably unsorted wool staples included in this study (Hvilehøj Ad C4273-97 and Bjerringhøj C150) were compared with the fibre composition in the textile yarn samples. The unsorted wool correlated well with the results from yarns that had a majority of fine fibres, but several variations of fibre distributions in the yarns differed from these examples.
In the case of Hedeby, the sample from the felt mask (H14 D) was used for the comparative analyses and showed that Hedeby yarns consist of similar varieties of fibre distributions as seen in the Bjerringhøj and Hvilehøj samples. Further, it was found that the content of coarse fibres in the felt was small, presumably because also this wool was carefully processed for the purpose. This means that the contents of fine, medium and coarse fibres in the Viking Age raw wool had the capacity to give a varied range of fibre compositions and that the specific content in each case was deliberate and had an impact on the quality and use of the finished yarns. Considering the fact that so many different fibre types are present in our results, a very careful selection, sorting and combing of the wool from each fleece must have been done prior to spinning the fibres for the specific textiles.

Comparing the yarns in the textiles to the unsorted wool and felt samples made it apparent that fibre distributions also vary in relation to the selected warps and wefts, which adds yet another dimension to the knowledge of wool fibre processing. As such it became apparent that some textiles had similar fibre contents in warp and weft and others different. These characteristics cannot be coincidental and must express a conscious choice and wish of storing specific fibre abilities in the different yarns. In this way the analyses also reveal great skill and a creative use of the available resources by the textile producers.

Observing these wool variations in the yarns has revealed the extent of the processing and its impact on the finished yarns. There is no question that the selection, sorting and combing of the wool required skill and experience and expresses the ability to get the most out of the raw material at hand. Using Rast-Eicher's quality category system both for the modern wool samples, the unsorted wool and the processed yarns has shown that the only categories that could decidedly qualify the processing were A to C which had not been attributed to any of the wool samples and here qualified yarns with very few coarse fibres (categories AAA and AA had not been attributed to any samples in this study).

Wool processing appears to consist of many choices and the initial selection and sorting seems of particular importance. Which raw material should be picked for which type of yarn? When the yarns are finished more choices need to be made such as which yarn to choose for warp, weft or sewing and for tabby or twill? This report has revealed the conscious and maybe subconscious choices taken during production, but there can be no doubt that these factors were acknowledged or sensed during use, and that wool processing was a very important part of textile production.

The modern wool samples analysed in this study have shown characteristics comparable to the Viking Age wool, although the content of fine fibres recorded in the ancient samples seem to be difficult to match. Spelsau wool has traditionally been evaluated as a valid substitute for Viking Age wool and this study cannot disagree with this, but the analysis of the four different Spelsau fleeces has shown how varied they can be and that other possibilities such as the Gotland, Gute, Svärdsjö and Värmland wool may be considered. However, experienced hand spinners can tell that some wool, such as Gute wool, is difficult to spin, and others can be difficult to obtain, the Svärdsjö for instance. So choosing wool for reconstructions is also a matter of assessing what is possible.
The analysed samples of the modern wool types suggested here for reconstructions all had large contents of fine and medium fibres. When looking for wool for reconstructions this characteristic is important but also the most difficult to attain. This may however be achieved by thorough combing of wool consisting of many fine and medium fibres.

◄ Fig. 8.1: Grazing Gute sheep in Lejre Land of Legends.

Photo: Charlotte Rimstad

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Appendix Bjerringhøj

Bjerringhøj, C135a. 2/1 twill with embroidery

► Table 10.1: Analyses of five yarn samples from different fragments. Warp, weft and embroidery from Sample 6, warp and weft from Sample 11 and warp from a random sample

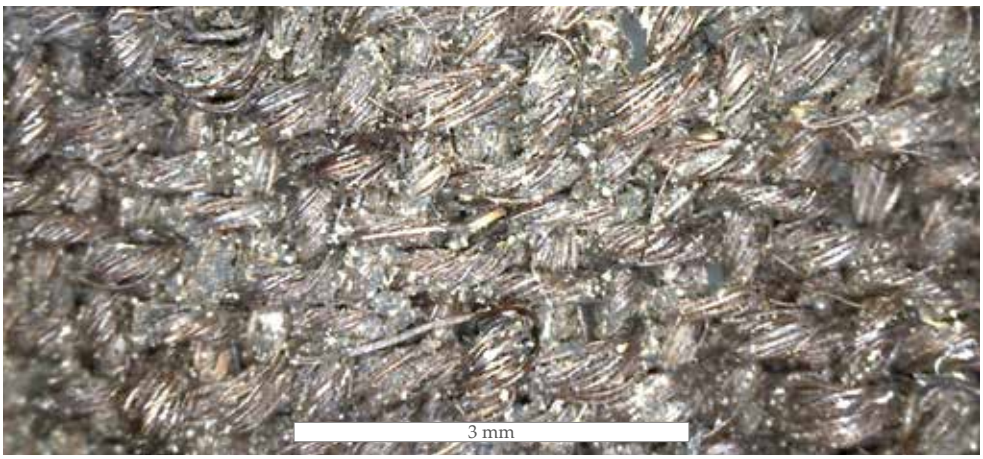
Fibre colour	Reddish, no visible pigmentation
Fibre distribution	Fragment (6): Warp and weft differ slightly. In the warp, the contents of fine and medium fibres are similar. In the weft, the fine fibres dominate at the expense of the medium fibres. The contents of coarse fibres are similar. The embroidery yarn and the random warp correlate with this warp. Fragment (11): The warp and weft appear similar and consist of almost equal contents of the three fibre types
Resemblance to modern primitive sheep	None of the tested modern wool samples match perfectly. The undercoat from Spelsau fleece 4 correlates with warp (6), especially in the content of coarse fibres The Värmland fleece 0 correlates with weft (6) with minor deviations. The undercoat from Spelsau fleece 1 correlates with warp and weft (11), but deviates especially in the content of coarse fibres
Comments to diagrams	Cumulative frequency diagram: Weft (6) has a slightly steeper curve than the other samples resulting from the larger content of fine fibres Warp (6), the embroidery yarn and the random warp have similar curves, positioned slightly below weft (6) from the start of the medium range. Warp and weft (11) have curves with gentler slopes positioned below the other yarns Histograms: Fragment (6), the larger content of fine fibres in the weft results in a couple of higher peaks. Fragment (11), broader ranges and several low peaks characterize both yarn samples
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns
Warp/weft fibre combination	1c
Further comments	The differences between the samples from the two fragments may be random but could also indicate nuances in the selection and sorting The particular fibre distribution in the warp/weft (11) corresponds to C136a dark warp and C136c. A reconstruction was made of this textile and is described in Mannering & Rimstad 2023.
No. of micrographs	272

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp (6)	42	44	15	0	15-38, 41-44, 47-49, 51, 53, 59	CD	103
Weft (6)	57	32	11	0	12, 14-38, 40-41, 44-49, 52-53	CD	125
Warp(11)	30	38	32	1	12, 14-15, 18-30, 32-36, 38-41, 43-45, 47-50, 54, 56-59, 75	D	82
Weft (11)	33	37	30	1	17-30, 32-49, 52-56, 58-89, 63	D	83
Random warp	41	42	16	2	12, 16, 18-40, 42, 46, 48-49, 51, 54, 56-57, 70-71	CD	97
Embroidery	43	56	1	1	14-39, 42-44, 46-48, 50-53, 56-57, 60	CD	110
Spelsau Fl. 4 UC	34	51	15		16-47, 49-57, 62	CD	323
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189
Spelsau Fl. 1 UC	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166

◄ Fig. 10.1: 2/1 twill textile C135a. Fragment with embroidery.

Photo: Roberto Fortuna



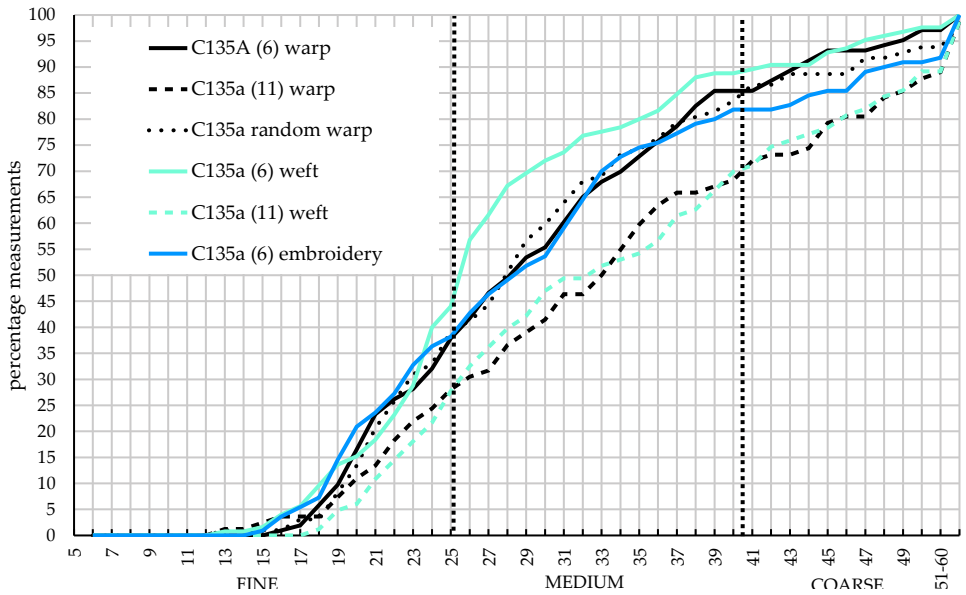
◄ Fig. 10.2: Enlarged detail of C135a (6).

Photo: Charlotte Rimstad

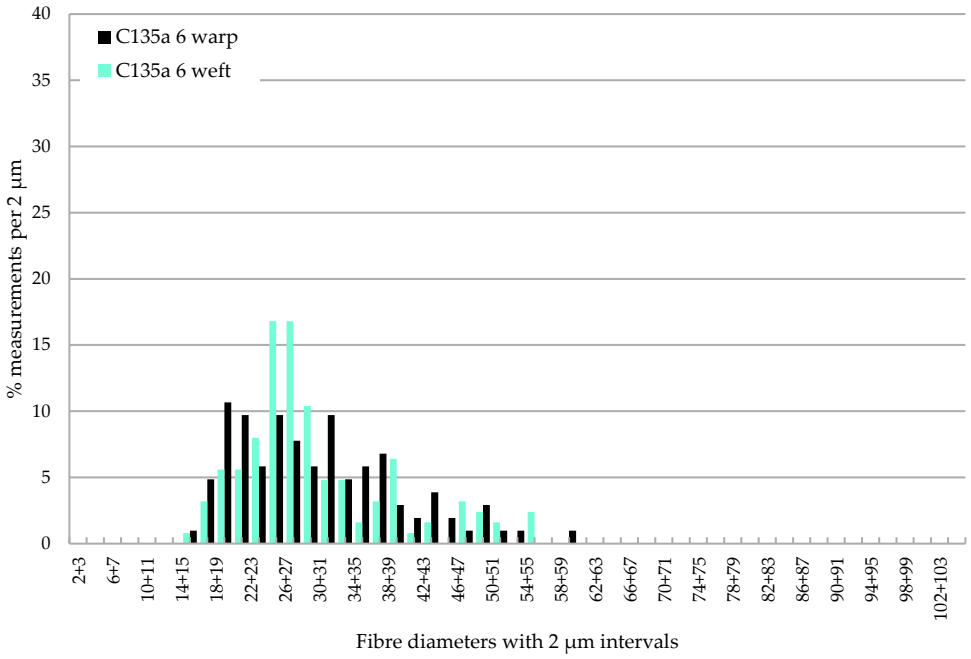
◄ Fig. 10.3: Enlarged detail of C135a (11).

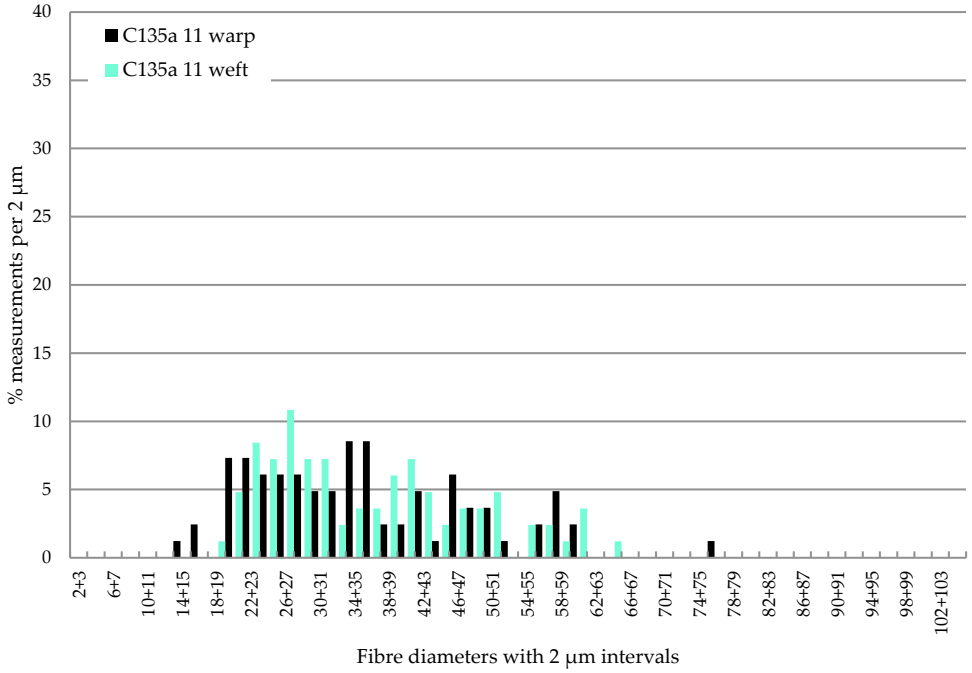
Photo: Charlotte Rimstad

► Fig. 10.4: The differences in the fibre analyses of the warp and weft from the two fragments become distinct in the medium range. The curves representing warp 6, the random warp and the embroidery yarn are almost identical.

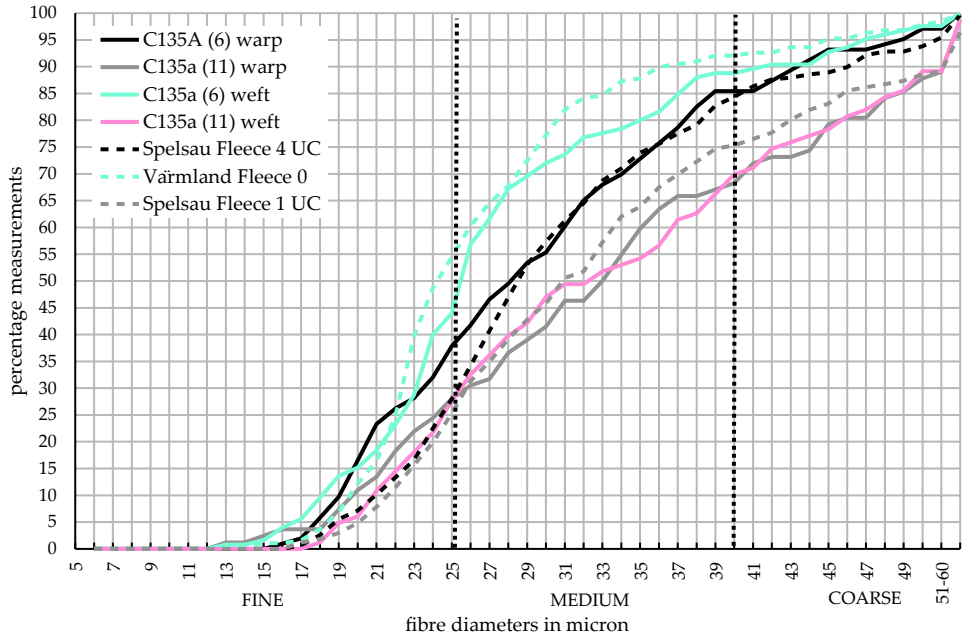


► Fig. 10.5: The difference in the results from warp and weft 6, which in the cumulative frequency diagram is seen as a separation of the curves, appear as two high peaks in the weft at around 25-30 microns.





◄ Fig. 10.6: Warp and weft of C135a (11) appear very similar. The almost equal content of the three fibre groups results in broad ranges and low peaks.



◄ Fig. 10.7: The results from textile C135a are not easily matched with the modern wool. In this diagram they are compared to three different samples.

Bjerringhøj, C135b. Open tabby

► Table 10.2: Analyses of sample 1 and 2 from C135b.

Fibre colour	Shades of blue visible in many fibres, no visible pigmentation
Fibre distribution	Almost equal amounts of fine and medium fibres, a small majority of medium fibres in sample 1 and of fine in sample 2. No coarse fibres are recorded
Resemblance to modern primitive sheep	The Värmland fleece 0 sample correlates best, especially to the weft in respect to the large content of fine fibres
Comments to diagrams	Cumulative frequency diagram: The separation of the two curves reflects the minor differences Histograms: The bars representing the two yarns are almost similar with narrow cohesive ranges. One high peak in the weft deviates
Category definitions	AB: 80% below 30, 15% above 30, 2% above 40, max. 60 microns CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	1b
Further comments	Warp and weft unidentified on sampling. The two yarns appear to be from similar raw material and the differences in the results are most likely random. The results are very similar to textile C138 and C45
No. of micrographs	100

Calculations of fibre measurements in microns

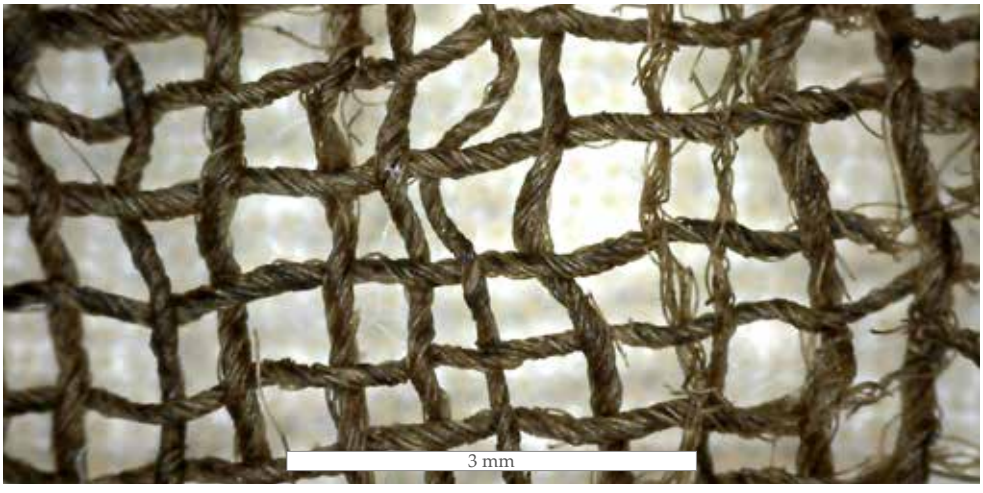
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	49	51	0	0	15-18, 20-31, 33-35, 37-38	AB	88
Sample 2	58	42	0	0	16-32, 35	AB	79
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

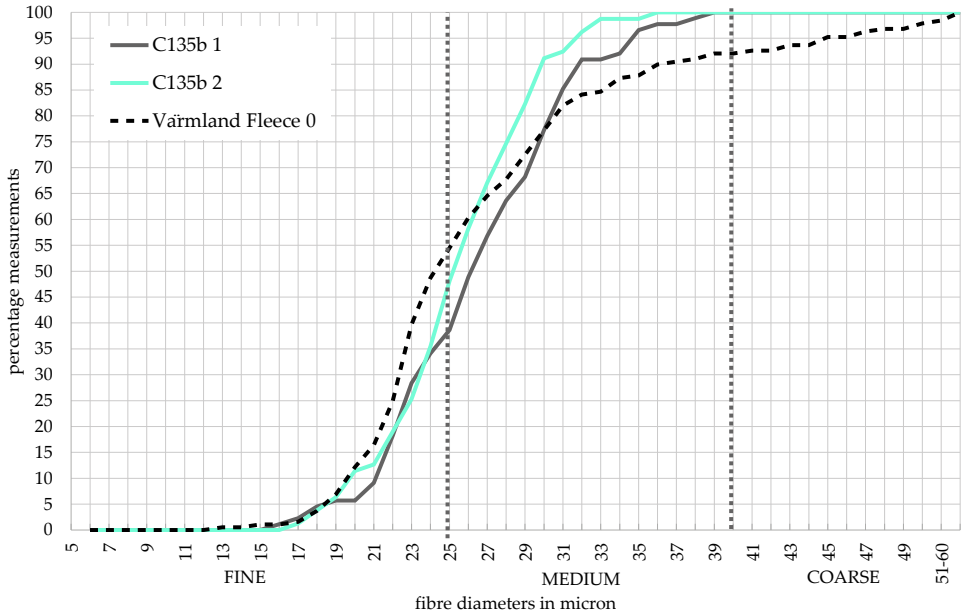
► Fig. 10.8: Open tabby textile C135b.

Photo: Roberto Fortuna

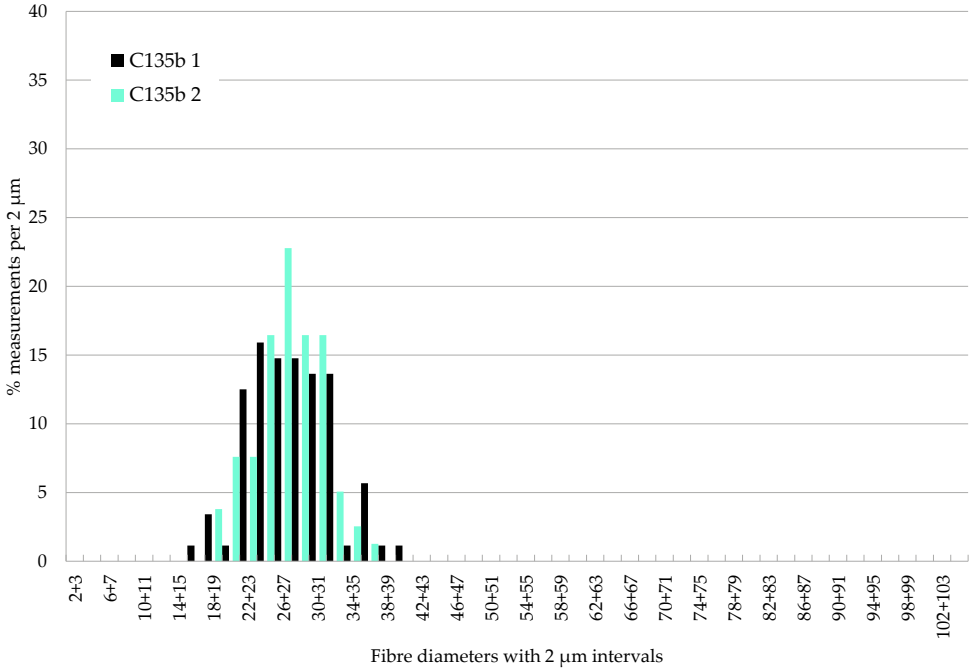
► Fig. 10.9: Enlarged detail of the open tabby C135b.

Photo: Charlotte Rimstad





◄ Fig. 10.10: The two yarns appear very similar with steep curves, only slightly separated in the medium range, and no coarse fibres. The Värmland fleece 0 sample has correlating results in the fine and medium ranges but some coarse fibres.



◄ Fig. 10.11: The uniformity of these yarns is indicated by the narrow ranges and almost identical peaks exepting one high peak in sample 2 around 25 microns.

Bjerringhøj, C135c. Tabby

► Table 10.3: Analyses of samples from the warp and the weft from C135c.

Fibre colour	Reddish, no visible pigmentation
Fibre distribution	Almost equal amounts of fine and medium fibres, a small majority of medium in sample 1 and of fine in sample 2. A few coarse fibres are recorded
Resemblance to modern primitive sheep	The Värmland fleece 0 does not correspond perfectly but is the best match, especially to sample 2 in respect to the fine fibres. It has fewer medium fibres as indicated by the diagram. Deviations are seen in the medium and coarse ranges.
Comments to diagrams	Cumulative frequency diagram: The two curves separate in the fine and medium ranges because of the differences in the majority of fibres. The primitive wool sample corresponds well with the weft until towards the coarse range Histograms: The two yarns have corresponding ranges and peaks
Category definitions	AB: 80% below 30, 15% above 30, 2% above 40, max. 60 microns C: 66% below 30, 10% above 45, 1% above 50 microns CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	1b
Further comments	The results are very similar to textiles C135b although the two textiles differ in other aspects
No. of micrographs	169

Calculations of fibre measurements in microns

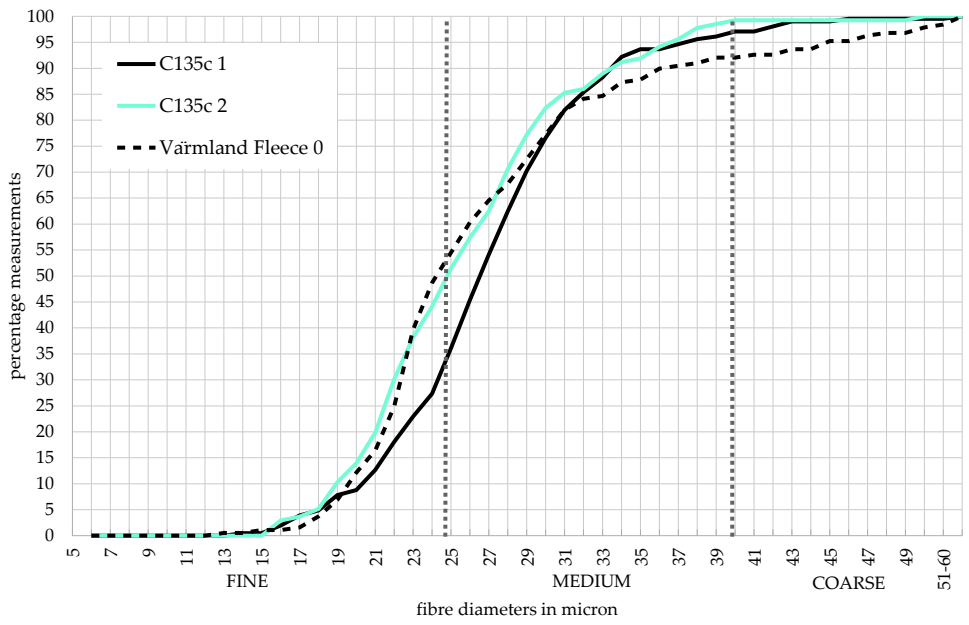
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	45	52	3	0	13, 15-34, 36-39, 41-42, 45, 56	C	205
Sample 2	57	42	1	0	15-39, 49	AB	136
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

► Fig. 10.12: Tabby textile C135c.

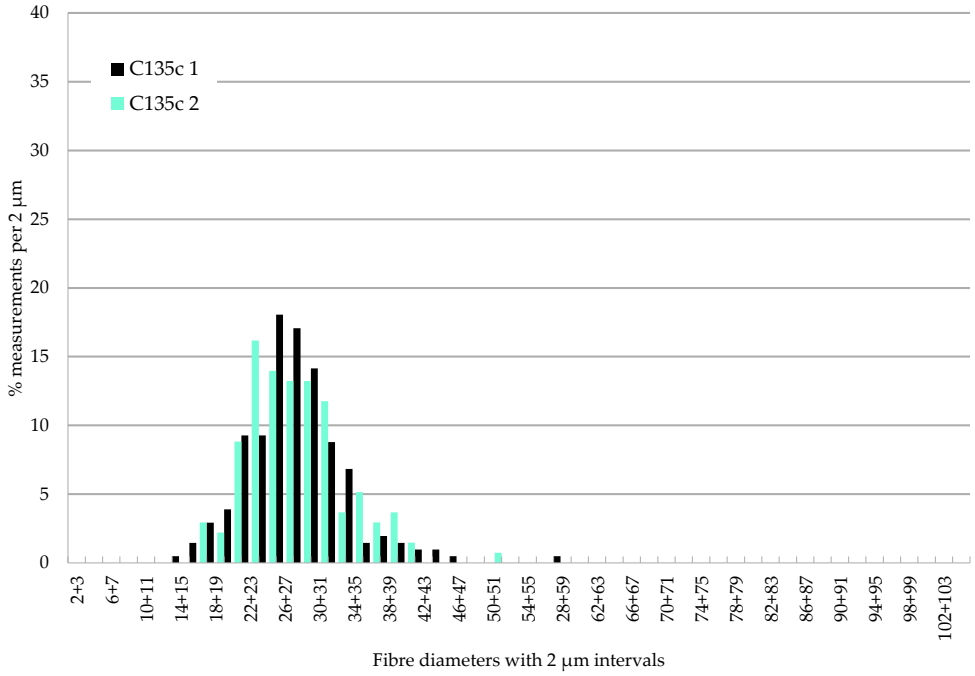
Photo: Roberto Fortuna

► Fig. 10.13: Enlarged detail of C135c.

Photo: Charlotte Rimstad



◄ Fig. 10.14: A small difference in the majority of fibres cause the separation of the curves. The Värmland fleece 0 correlates especially with sample 2.



◄ Fig. 10.15: Very similar ranges and peaks indicate the similarity of the two yarns.

Bjerringhøj, C135d. Tabby band

► Table 10.4: Analyses of samples from the warp and the weft.

Fibre colour	Some white, some different shades of darker colour
Fibre distribution	Almost equal contents of all fibre types. A small majority of fine fibres and slightly fewer coarse are seen in sample 1
Resemblance to modern primitive sheep	The fibre distribution in the undercoat from the Spelsau fleece 4 is very similar to the two yarns
Comments to diagrams	Cumulative frequency diagram: The differences in especially the contents of fine fibres result in the small gap between the two curves. The primitive wool sample follows sample 1 in the beginning and sample 2 towards the end Histograms: The two histogram have similar ranges and small deviations in the peak heights
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	1c
Further comments	The differences between the two yarns are inconclusive and may be due to random circumstances. However, if they were the intended results of the processing, sample 2 with the smallest percentage of fine and the largest of coarse fibres could be the warp and sample 1 the weft
No. of micrographs	216

Calculations of fibre measurements in microns

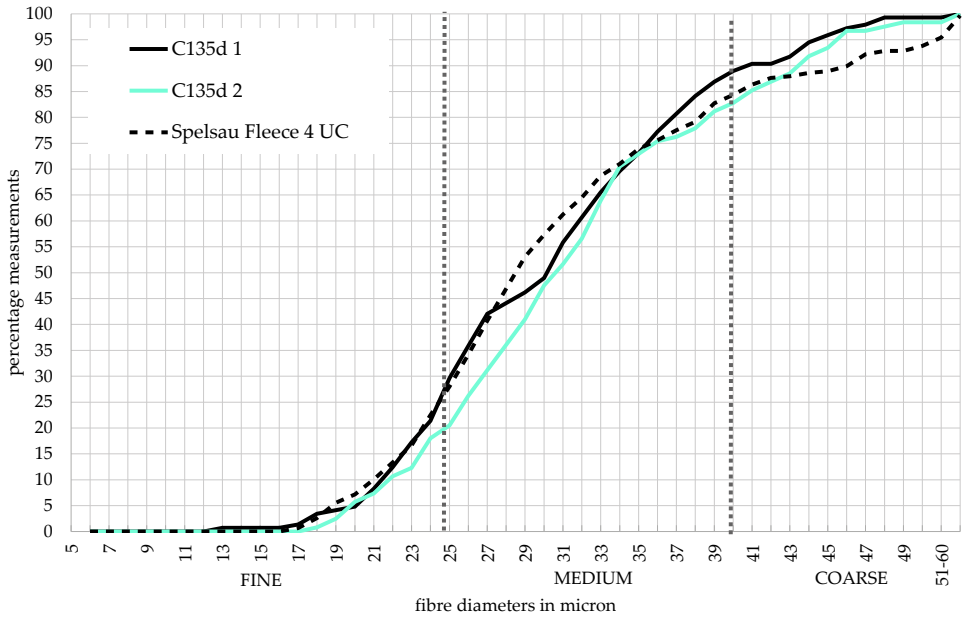
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	36	53	11	0	12, 16-40, 42-47, 52	CD	145
Sample 2	26	57	17	0	17-45, 47-48, 51, 55	CD	122
Värmland Fl. 0	34	51	15	1	16-47, 49-57, 62	CD	323

► Fig. 10.16: Tabby textile C135d.

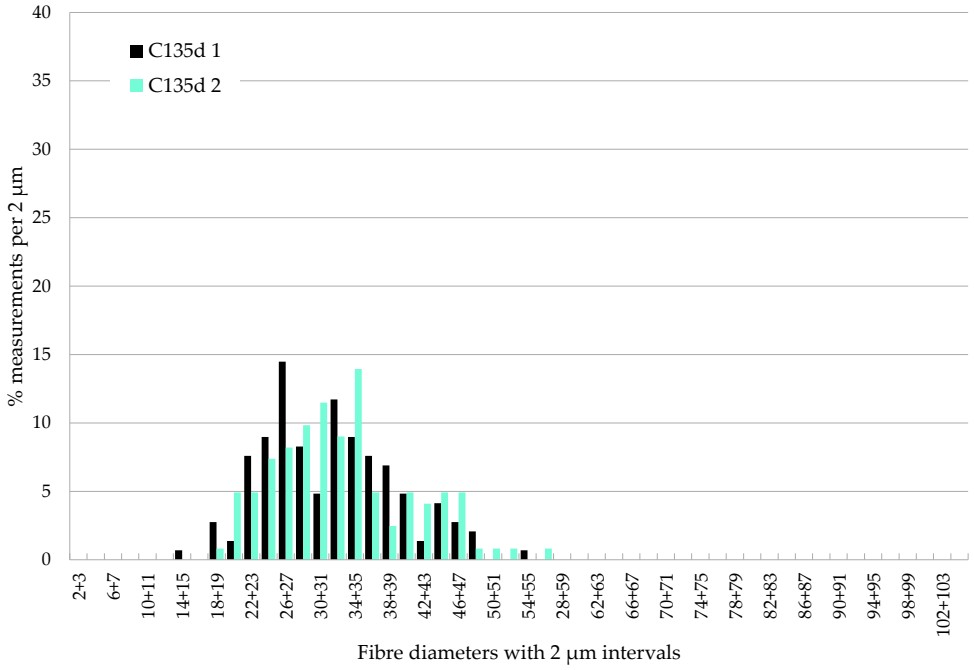
Photo: Roberto Fortuna

► Fig. 10.17: Enlarged detail of C135d.

Photo: Charlotte Rimstad



◄ Fig. 10.18: The two yarns have almost identical curves and the undercoat sample from Spelsau Fleece 1 corresponds well.



◄ Fig. 10.19: The two samples have very similar ranges and peaks in the histogram.

Bjerringhøj, C136a. Tablet-woven band

► Table 10.5: Analyses of samples from the dark and light warp and from the weft.

Fibre colour	Light fibres appear without pigmentation. Dark fibres are very dark
Fibre distribution	The dark warp has almost equal contents of the three fibre types with a small majority of fine fibres. The light warp and the weft have corresponding contents of medium fibres but differ in the fine and coarse where the weft has a large content of fine fibres while the light warp has a large content of coarse fibres
Resemblance to modern primitive sheep	The undercoat from the Spelsau fleece 1 is comparable to the dark warp but has a larger content of medium fibres The Roslag wool varies only very little from the light warp. It was difficult to find a primitive wool comparable to the weft. The Värmland fleece 0 is the best match but has a larger content of fine fibres
Comments to diagrams	Cumulative frequency diagram: The dark warp and the weft have corresponding curves in the fine range after which they separate. A large gap separates the light warp from the other two yarns, but this yarn corresponds well with the Roslag wool Histograms: The large amount of fine fibres in the dark warp results in the high peaks towards the left while the light warp has a concentration of fibres in the medium range. The concentration of fibres in the weft is seen as some high peaks between the two other yarns
Category definitions	C: 66% below 30, 10% above 45, 1% above 50 microns D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Warp/weft fibre combination	2a
Further comments	The particular fibre distribution in the dark warp corresponds to C135a warp/weft (11) and C136c
No. of micrographs	346

Calculations of fibre measurements in microns

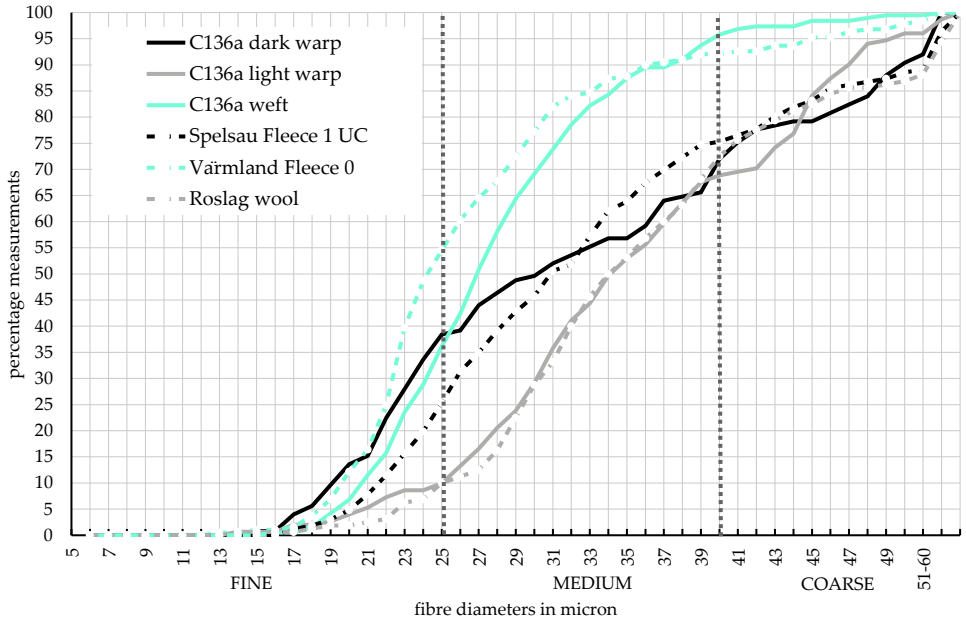
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Dark warp	39	33	28	0	14, 16-33, 35-43, 45-55	D	125
Light warp	13	56	31	1	13, 16, 18-22, 24-49, 51-52, 56, 62, 66	D	151
Weft	42	53	4	0	15, 17-35, 37-41, 47-48, 52	C	191
Spelsau Fl. 1 UC	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166
Roslag	11	61	28	6	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

▼ Fig. 10.20: Tablet-woven band C136a.

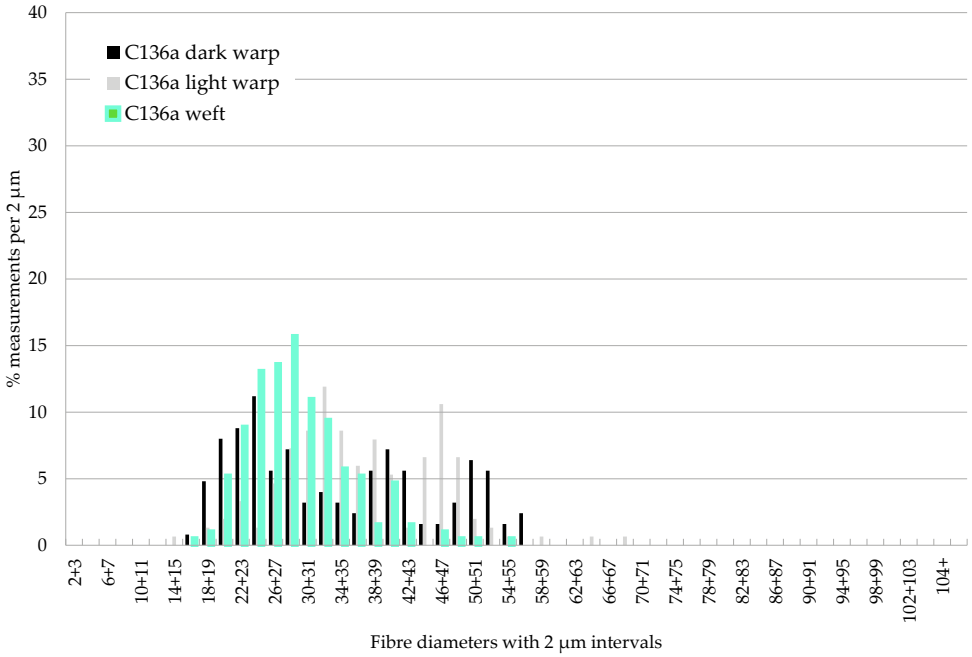
Photo: Roberto Fortuna

► Fig. 10.21: Enlarged detail of the tablet weave. The colour difference is not visible in the picture.

Photo: Charlotte Rimstad



◄ Fig. 10.22: The dark warp and the weft are almost similar in the fine range differing from the light warp but in the coarse range the two warps approach each other. Of the modern wool the Roslag sample compares well with the light warp while the undercoat from the Spelsau Fleece 1 and the Värmland Fleece 0 are closest to the dark warp and the weft.



◄ Fig. 10.23: The similarity of the dark warp and the weft in the fine range is also clear in this diagram. The fibre content in the dark warp creates three areas with high peaks while the large content of medium and coarse fibres in the light warp creates two areas with high peaks.

Bjerringhøj, C136c. Braided band

► Table 10.6: Analysis of one yarn sample.

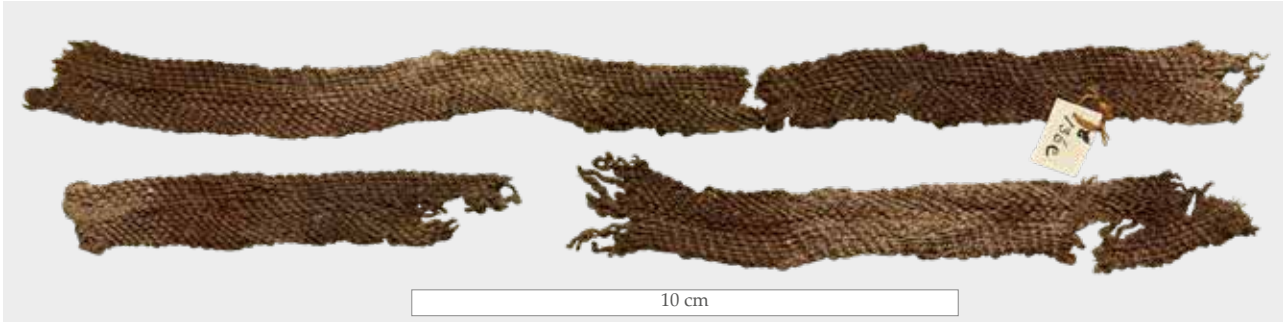
Fibre colour	Shades of dark, some very dark
Fibre distribution	Almost equal contents of all fibre types with a small majority of fine fibres
Resemblance to modern primitive sheep	The undercoat from the Spelsau fleece 1 corresponds best but has a slightly larger content of medium fibres and minor deviations in the two other fibre types
Comments to diagrams	Cumulative frequency diagram: The smaller content of fine and coarse fibres in the Spelsau sample causes the separation of the two curves Histograms: The fibre distribution results in higher peaks in two areas
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns
Warp/weft fibre combination	1c
Further comments	The particular fibre distribution in this yarn corresponds to C135a warp/weft (11) and C136a dark warp
No. of micrographs	106

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Yarn sample	38	32	30	0	13, 15-35, 38-49, 51,55, 57, 59	D	136
Spelsau Fl. 1 UC	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166

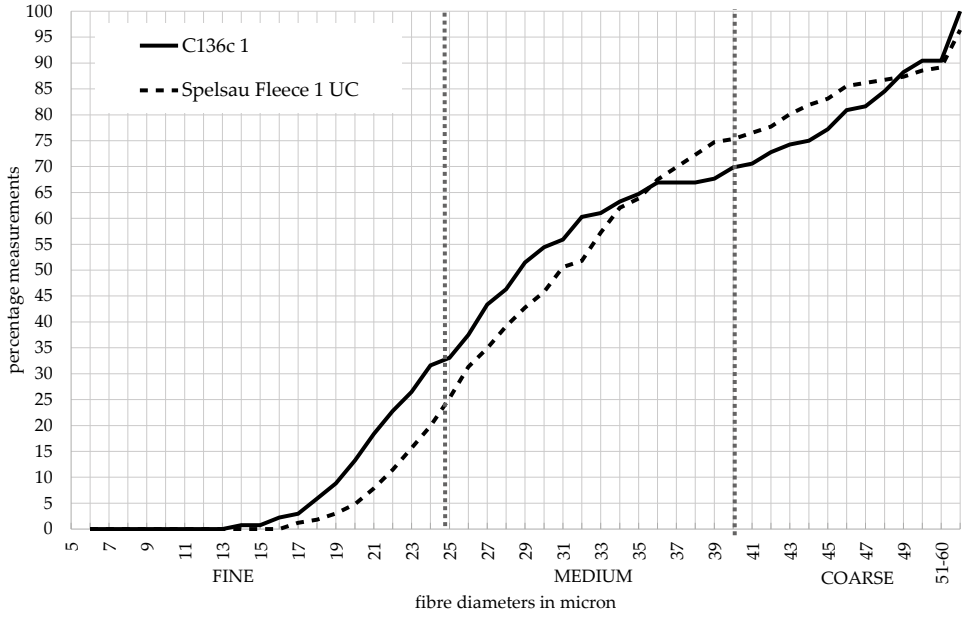
▼ Fig. 10.24: Braided band C136c.

Photo: Roberto Fortuna

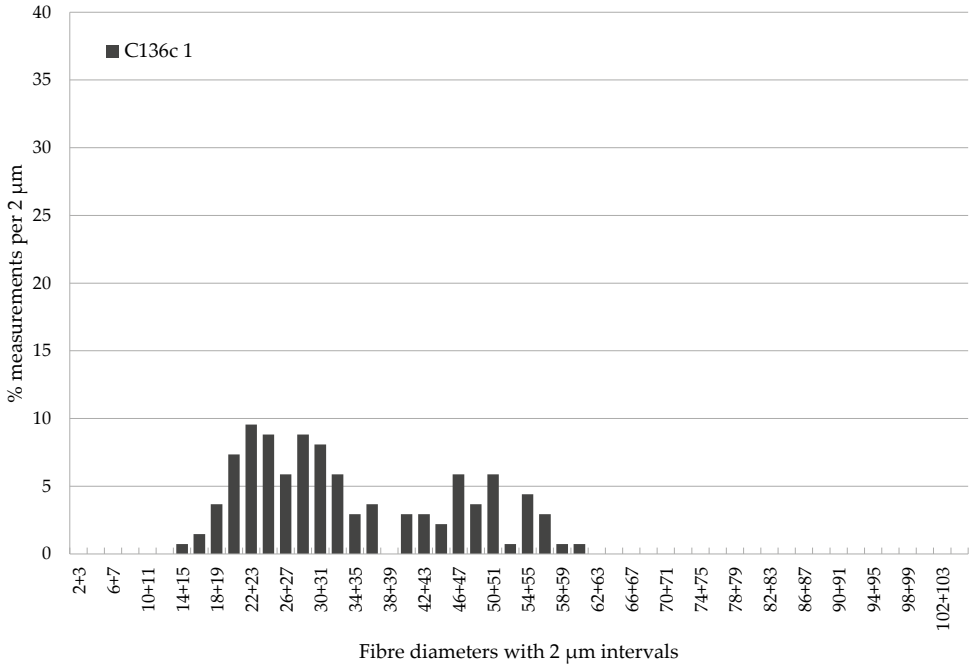


► Fig. 10.25: Enlarged detail of the braided band.

Photo: Charlotte Rimstad



◄ Fig. 10.26: The almost equal content of the three fibre groups result in a gently sloping curve which has closest resemblance to the undercoat from Spelsau Fleece 1.



◄ Fig. 10.27: The fibre distribution gives a broad range. The concentration of similar fibres is uneven and does not exceed 10%.

Bjerringhøj, C138. Open tabby

► Table 10.7: Analysis of one sample.

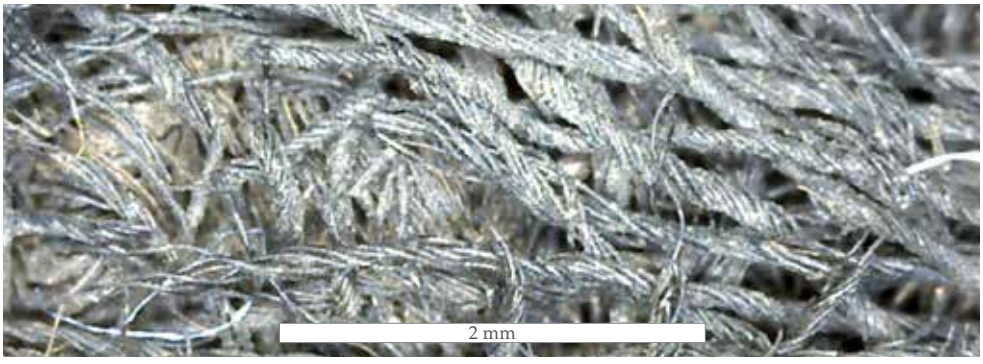
Fibre colour	Shades of blue are visible
Fibre distribution	The results have a majority of medium fibres, a large content of fine and no coarse fibres
Resemblance to modern primitive sheep	None of the primitive wool samples match perfectly. The undercoat from the Spelsau fleece 4 correlates in respect to the content of medium fibres but has fewer fine and more coarse fibres
Comments to diagrams	Cumulative frequency diagram: Comparing the yarn sample to the Spelsau sample their differences appear more distinct than suggested by the calculation Histograms: The fibre distribution results in a narrow range with the highest peak in the centre
Category definitions	C: 66% below 30, 10% above 45, 1% above 50 microns CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The textile is interpreted as the same fabric as C135b and C145, but correlation to the primitive wool samples is interpreted differently - Spelsau fleece 4 as opposed to Värmland fleece 0, which illustrates the difficulties in finding equivalent modern wool.
No. of micrographs	78

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Yarn sample	44	56	0	0	14, 17-37, 39	C	102
Spelsau Fl. 4 UC	34	51	15	1	16-47, 49-57, 62	CD	323

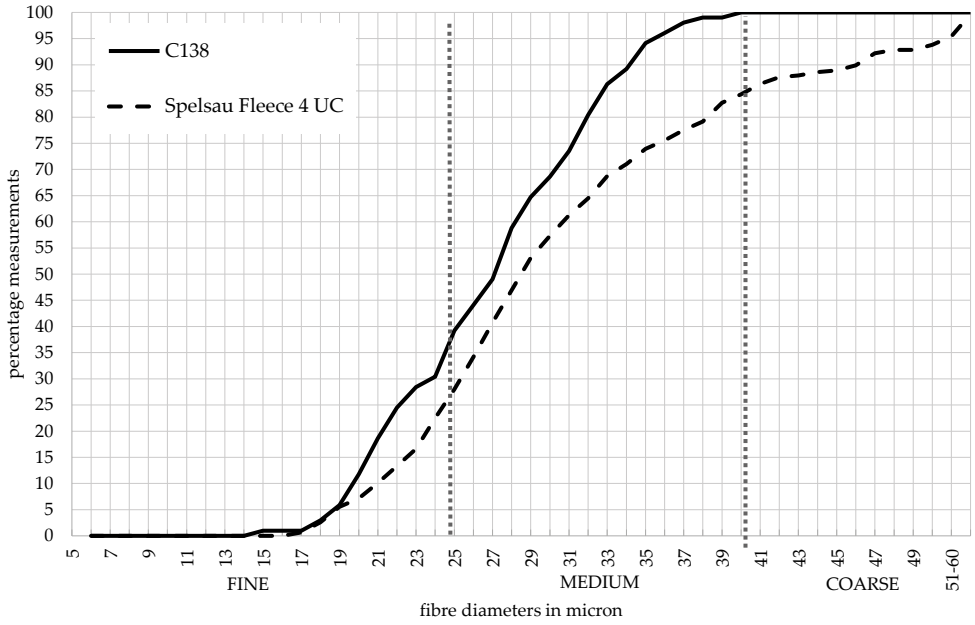
► Fig. 10.28: Textile C138. Wrist cuffs with wool padding in tabby weave. The padding is visible as a dark spot where the silk has deteriorated, shown with a white arrow.

Photo: Roberto Fortuna.

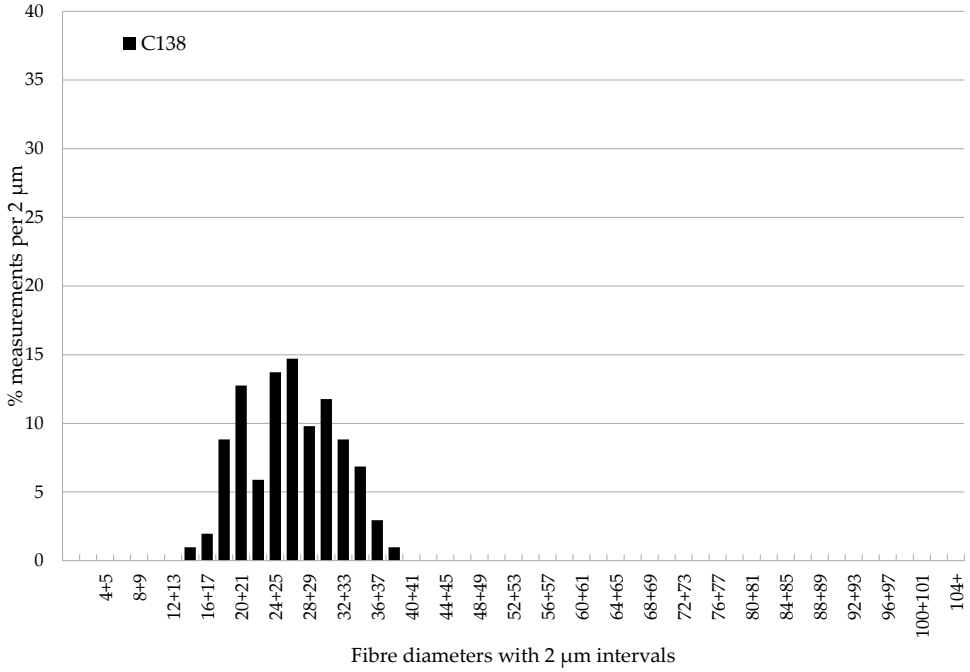


► Fig. 10.29: Enlarged detail of the yarns.

Photo: Charlotte Rimstad.



◄ Fig. 10.30: Large amounts of fine and medium fibres in this yarn give the steep curve and could indicate a specific selection of raw material.The undercoat from Spelsau fleece 4 correlates in respect to the content of medium fibres but has fewer fine and more coarse fibres causing the gap between the two curves.



◄ Fig. 10.31: The uniformity of the fibres results in a narrow range. The largest content of similar fibres is just below 15%.

Bjerringhøj, C139. Tabby

► Table 10.8: Analysis of one sample.

Fibre colour	Pigmented. Appearing as shades of dark brown
Fibre distribution	A small majority of medium fibres and almost equal amounts of fine and coarse fibres are recorded
Resemblance to modern primitive sheep	The fibre distribution corresponds to the samples of Gotland wool and the undercoat from the Spelsau fleece 4
Comments to diagrams	Cumulative frequency diagram: The results are compared to the two samples from the primitive sheep, that have closest resemblance. These are both separated from the yarn sample in the medium range. The Gotland wool above and the Spelsau wool below the curve from the yarn Histograms: This fibre distribution gives a broad cohesive range with several peaks
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns
Warp/weft fibre combination	1c
Further comments	-
No. of micrographs	70

Calculations of fibre measurements in microns

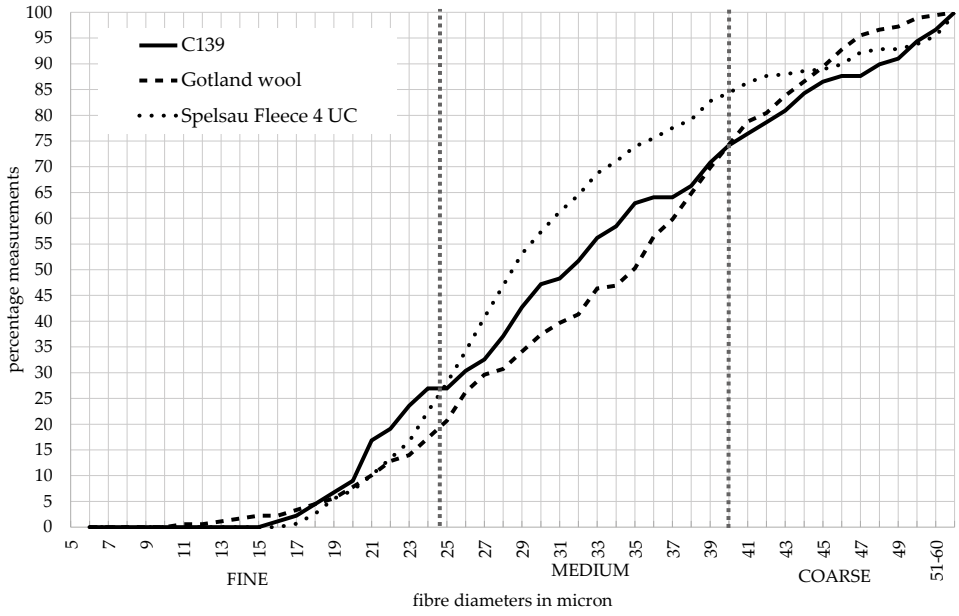
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	30	44	26	0	15-23, 25-35, 37-45, 47-51, 53-54	D	89
Gotland	26	48	26	0	10, 12-14, 16-51	CD	179
Spelsau Fl. 4 UC	34	51	15	1	16-47, 49-57, 62	CD	323

▼ Fig. 10.32: Textile C139. Rouleau with padding of wool tabby weave. The padding is visible as dark spots where the silk has deteriorated, shown with a white arrow.

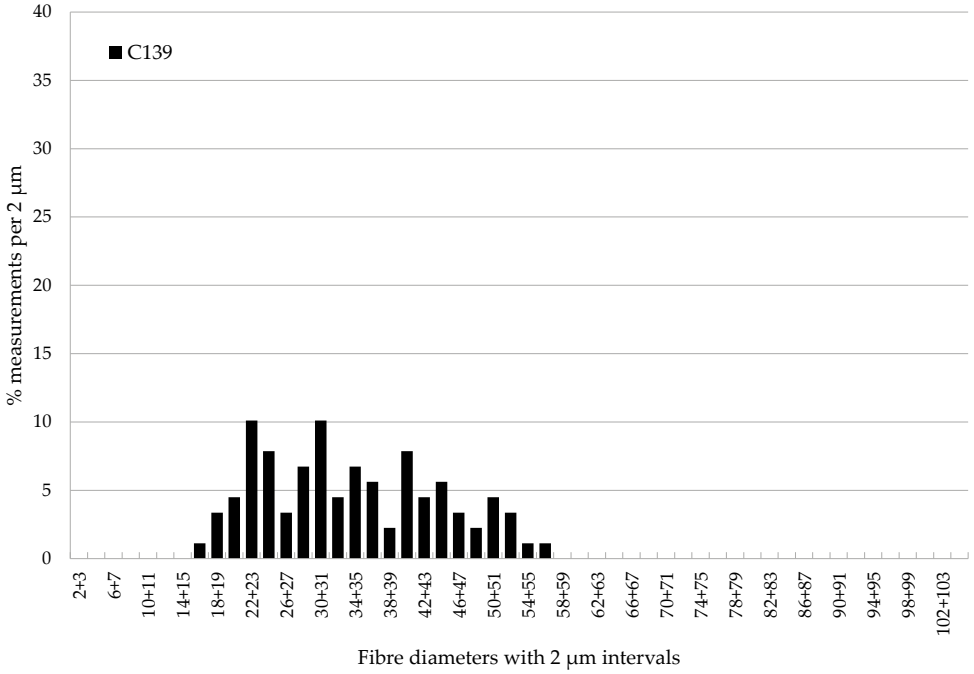
Photo: Roberto Fortuna

► Fig. 10.33: Enlarged detail showing the yarns from the padding inside the rouleau. A bit of the silk covering is visible in the lower left corner.

Photo: Charlotte Rimstad



◄ Fig. 10.34: The combination of a small majority of medium fibres and almost equal amounts of fine and coarse fibres result in a gentle curve. The closest resemblance to modern wool is found in either Gotland wool or the undercoat from Spelsau 4.



◄ Fig. 10.35: The fibre distribution gives a broad cohesive range and the concentration of similar fibres does not exceed 10%.

Bjerringhøj, C144. Tabby (pillow)

► Table 10.9: Analyses of samples from the warp, the weft and the decorative yarn.

Fibre colour	In the warp and weft, a mixture of dark and light fibres and shades of blue are seen. In the decorative yarn the fibres are light, reddish brown
Fibre distribution	The warp and weft samples have similar contents of medium fibres but in the warp the coarse fibres constitute the majority while in the weft the majority is fine. The decorative yarn has a large majority of medium fibres and fewer fine than coarse fibres.
Resemblance to modern primitive sheep	The fibre distribution from the overcoat from the Spelsau fleece 2 and the Jacobs wool have closest similarity to warp. The Värmland Fleece 0 corresponds to the weft. The Roslag wool is comparable to the embroidery yarn
Comments to diagrams	Cumulative frequency diagram: The warp and weft are separated by a wide gap and the embroidery yarn is placed between the two Histograms: The warp and weft have comparable cohesive ranges, but the weft has higher peaks because of the much larger content of fine fibres
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	2a
Further comments	The decorative yarn appears to be from different raw material to the yarns in the weaving
No. of micrographs	339

Calculations of fibre measurements in microns

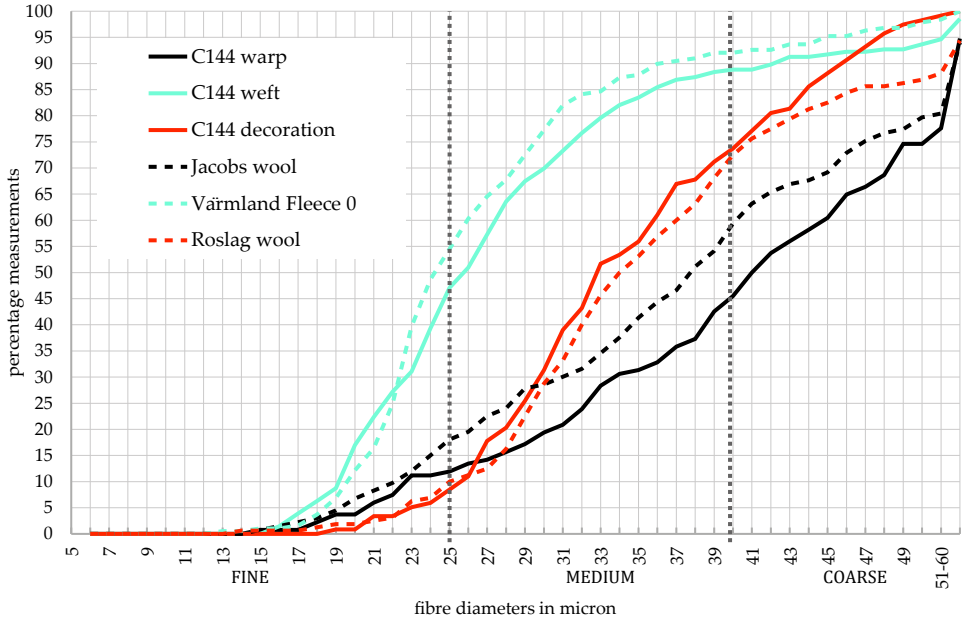
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	13	32	54	6	14, 17-18, 20-22, 24-48, 50, 52-63, 67	EE	134
Weft	51	38	11	1	15-39, 41-42, 44-45, 47, 49-51, 53-54, 57, 59, 62, 71, 112	CD	206
Decoration	11	63	26	0	18, 20, 22-50, 57	D	118
Jacob	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133
Spelsau Fl. 2 OC	21	36	42	12	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189
Roslag	11	61	28	6	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

► Fig. 10.36: Textile C144. Pillow in tabby weave.

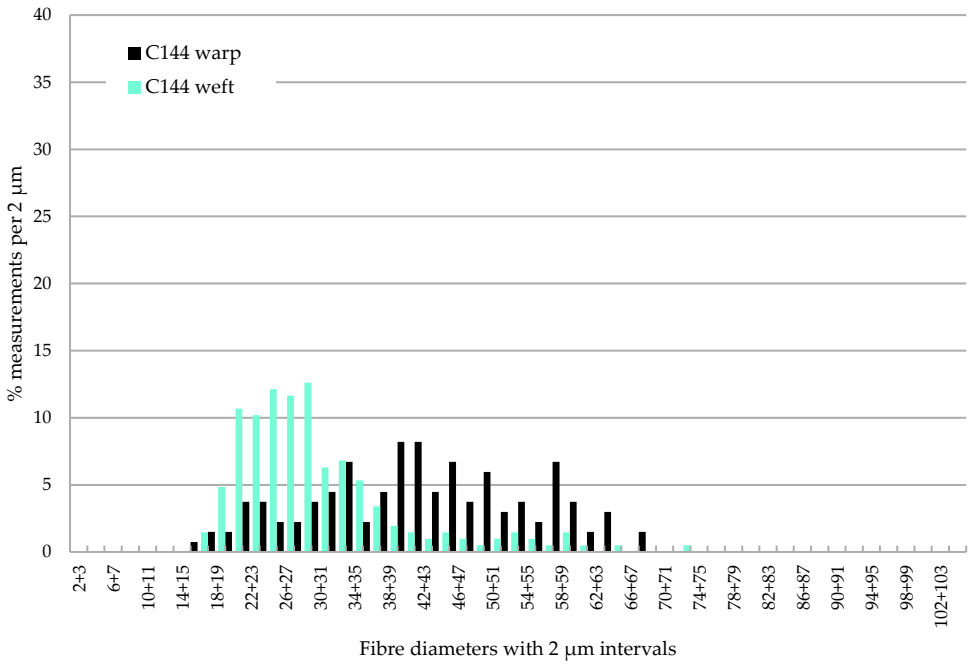
Photo: Roberto Fortuna

◄ Fig. 10.37: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 10.38: The majority of fine fibres in the weft and of coarse fibres in the warp creates a large gap between the two curves. The majority of medium fibres in the yarn for the decoration places this curve between the warp and weft. The results could indicate a different selection of materials in all cases. Jacobs wool has the closest resemblance to the warp and Värmland 0 to the weft. The yarn for the decoration and Roslag wool have similar curves.



◄ Fig. 10.39: Both warp and weft have broad cohesive ranges. The concentration of similar fibres in the warp does not exceed 10%. In the weft it increases evenly to above 10% and ends in many low bars below 5%.

Bjerringhøj, C145. Open tabby

► Table 10.10: Analyses of samples from the two yarn systems

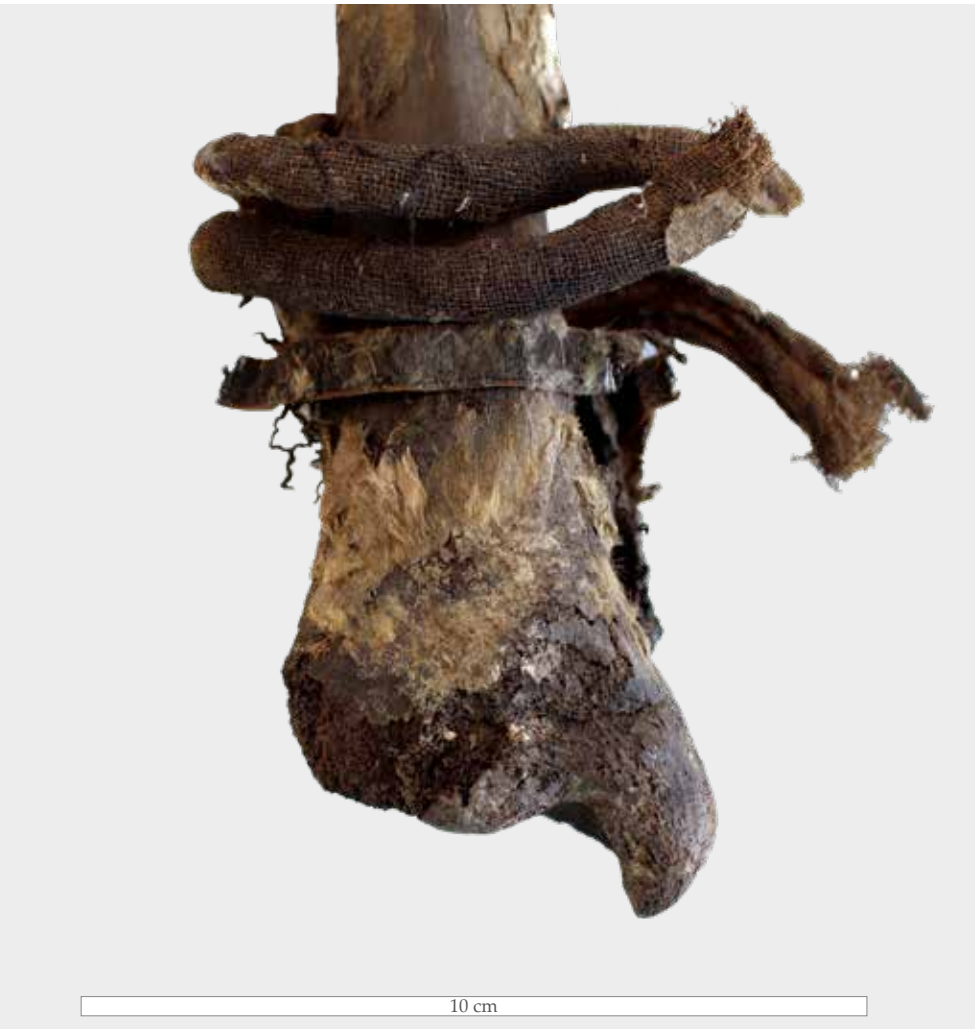
Fibre colour	Shades of blue are visible
Fibre distribution	Almost equal amounts of fine and medium fibres, with a small majority of medium fibres. The one percentage coarse fibres in sample 1 is the result of just one fibre measuring 41 microns
Resemblance to modern primitive sheep	The fibre distribution from the Värmland Fleece 0 sample is not a perfect match but it has the closest resemblance in spite of its majority of the fine fibres
Comments to diagrams	Cumulative frequency diagram: The two yarns have almost completely similar curves Histograms: Narrow cohesive ranges with the highest peaks concentrated around the middle
Category definitions	B: 75% below 30, 25 % above 30, 2% above 40 microns CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	1b
Further comments	The warp and weft directions could not be identified. The textile is identified as the same fabric as C135b and C138
No. of micrographs	201

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	45	54	1	0	15, 18-33, 36-37, 41	B	127
Sample 2	42	42	0	0	16, 18-35, 37, 39	B	135
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

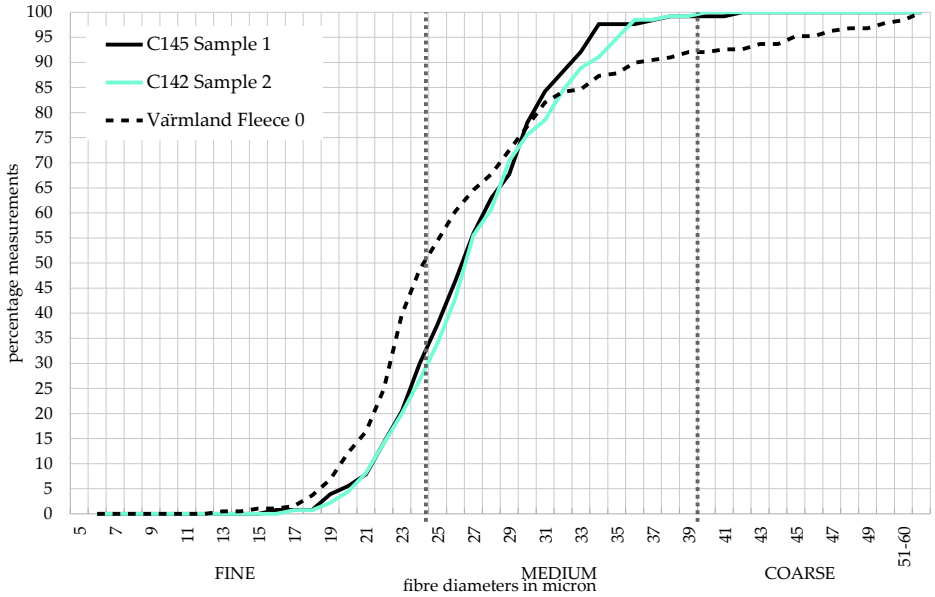
► Fig. 10.40: Textile C145. Wool roll padding in situ on ancle of tibia bone.

Photo: Charlotte Rimstad



▼ Fig. 10.41: Enlarged detail of the padding.

Photo: Charlotte Rimstad



◄ Fig. 10.42: The two yarns have identical steep curves signifying specific selections and similar processing. Värmland fleece 0 recembles the most.

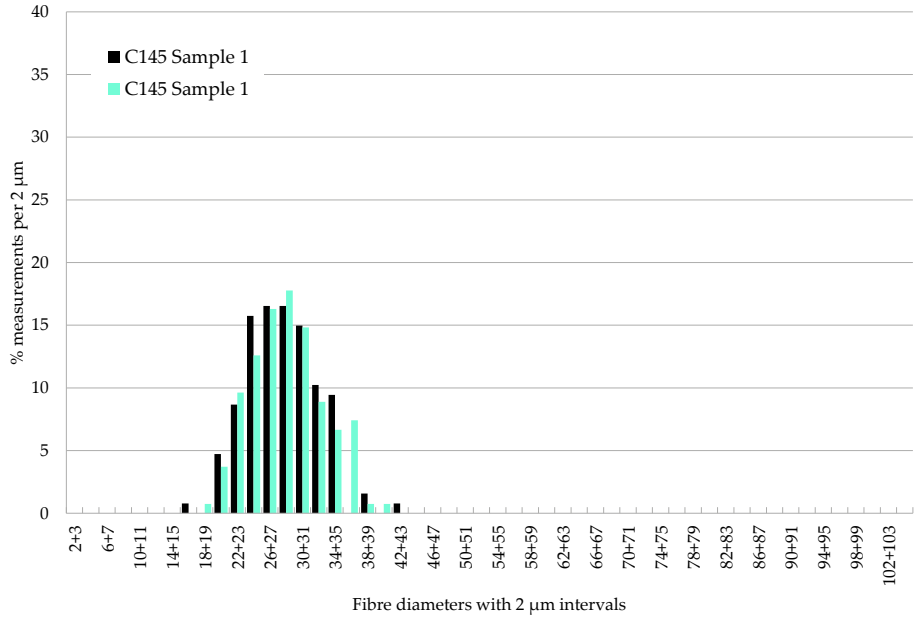


Fig. 10.43: The two yarns both have narrow ranges and concentrations of similar fibres reaching just above 15%.

Bjerringhøj, textile C150. Wool fibre bundle

► Table 10.11: Analysis of one sample.

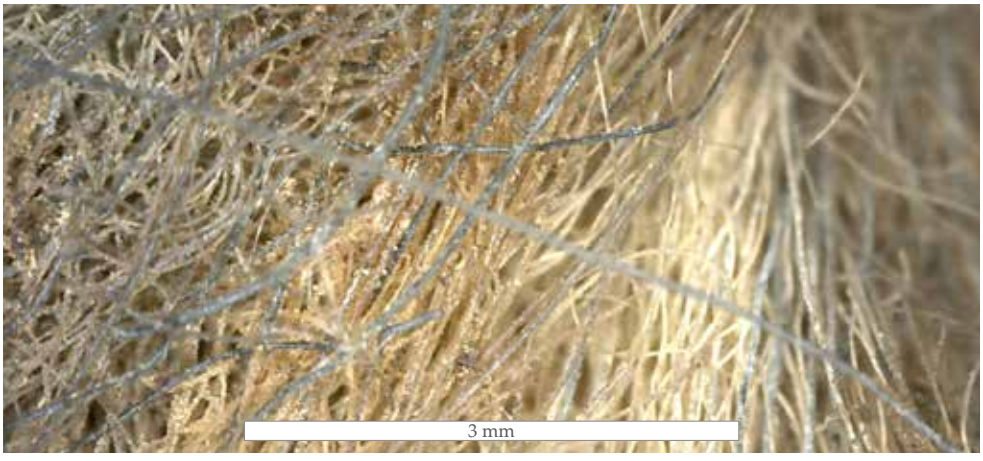
Fibre colour	White fibres are mixed with fibres of varied shades of brown from very light to very dark or black
Fibre distribution	Fine fibres constitute the majority, but large contents of medium and coarse fibres are also recorded
Resemblance to modern primitive sheep	The Spelsau Fleece 3 has almost identical results
Comments to diagrams	Cumulative frequency diagram: The minor differences between the fibre bundle and the primitive sheep is reflected in deviations in the curves in the fine and medium ranges Histograms: The measurements have a wide range and several peaks of variable heights
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The fibre bundle appears unsorted
No. of micrographs	178

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Fibre sample	53	30	17	1	11-54, 56-60, 64, 68	CD	361
Spelsau Fl. 3	57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

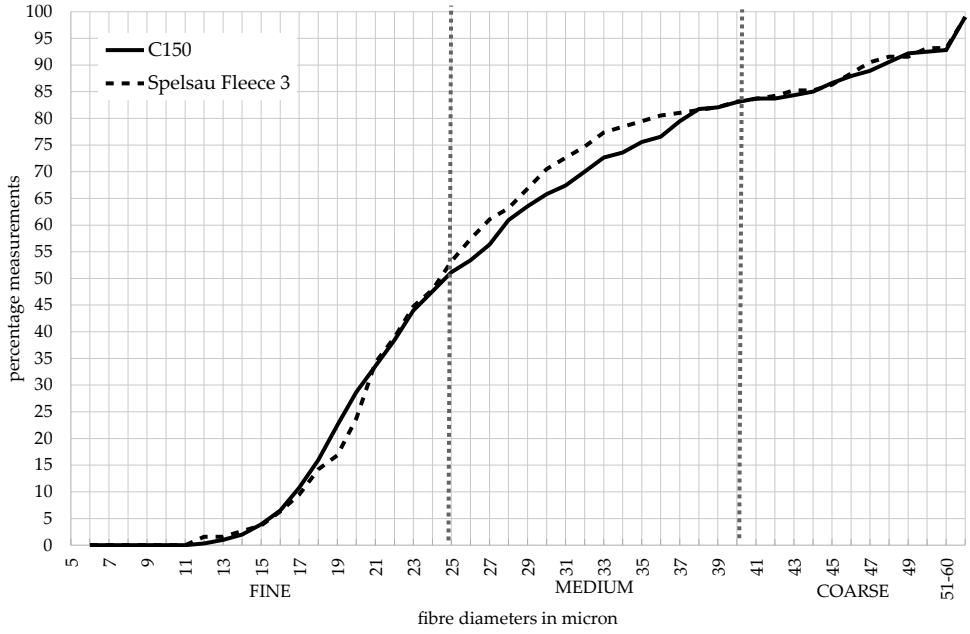
► Fig. 10.44: Textile C150. Wool fibre bundles.

Photo: Roberto Fortuna

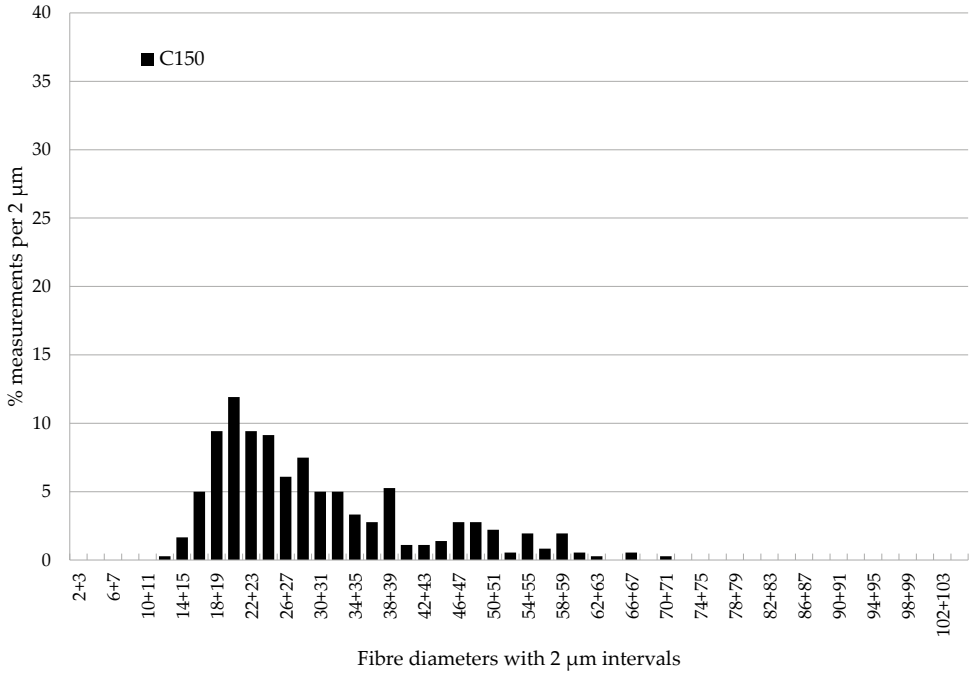


► Fig. 10.45: Enlarged detail of the fibres.

Photo: Charlotte Rimstad



◄ Fig. 10.46: The large content of fine fibres in this otherwise un-processed fibre bundle could indicate a specific selection. The content of coarse fibres remaining could signify a lack of combing. The results corresponds well with Spelsau 3.



◄ Fig. 10.47: The fibre distribution gives a broad cohesive range and the low bars towards the right.

Appendix Hvilehøj

Hvilehøj, C4280a. Tabby with pattern weft

► Table 11.1: Analyses of samples from the warp, the ground weft and the pattern weft of C4280a.

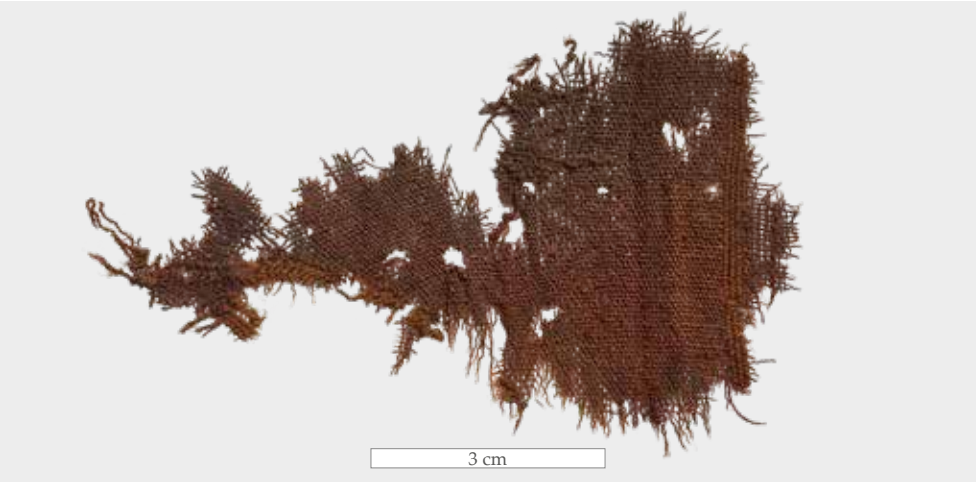
Fibre colour	Unpigmented and reddish appearance
Fibre distribution	The warp has a small content of fine fibres and a very large content of coarse fibres. The ground weft and the pattern weft have equal percentages of fine fibres but the remaining fibres are distributed differently with a large content of medium fibres in ground weft while in the pattern weft the contents of medium and coarse fibres are equal
Resemblance to modern primitive sheep	None of the primitive wool samples match the warp well and the overcoat from the Spelsau Fleece 1 is the closest. The undercoat from the Spelsau Fleece 4 is comparable to the ground weft and the undercoat from the Spelsau Fleece 1 to the pattern weft
Comments to diagrams	Cumulative frequency diagram: The gap between the warp and the ground weft is distinct. The curve of the pattern weft is separated from the ground weft because of its larger content of coarse fibres Histograms: All yarns have broad ranges and many irregular peaks
Category definitions	The fibre distribution in the warp does not fit any of the categories CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Warp/weft fibre combination	2a
Further comments	Warp and weft directions were not identified on sampling but was defined through the fibre analyses. The difference between the three yarns could be due to the processing and not distinctly different raw material
No. of micrographs	149

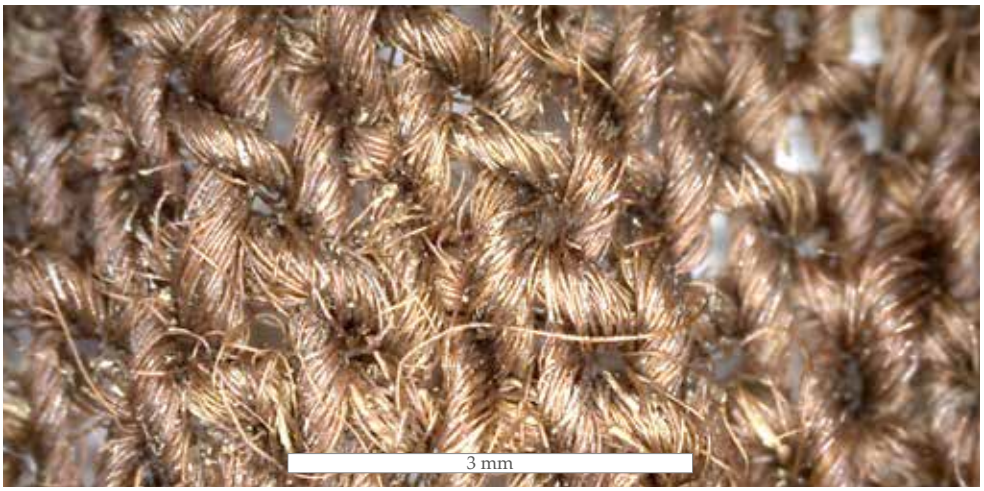
Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	12	26	62	1	7, 17, 20, 24-28, 30-33, 35, 37-49, 51-54, 58, 63	no	76
Weft	31	54	15	0	15, 19-39, 41-45, 47, 49-50, 54	CD	96
Pattern	32	36	32	7	13, 16, 18, 20, 22-34, 39-42, 44-45, 47-48, 52, 55, 67, 78, 87	E	44
Spelsau Fl. 1 OC	4	21	75	20	21, 23, 26, 30-35, 37-38, 40-41, 43-54, 56-58, 60-64, 66-67, 72, 79	no	75
Spelsau Fl. 4 UC	34	51	15	1	16-47, 49-57, 62	CD	323
Spelsau Fl. 1 UC	31	44	25	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166

► Fig. 11.1: Textile C4280a. A fragment with parts of the pattern.

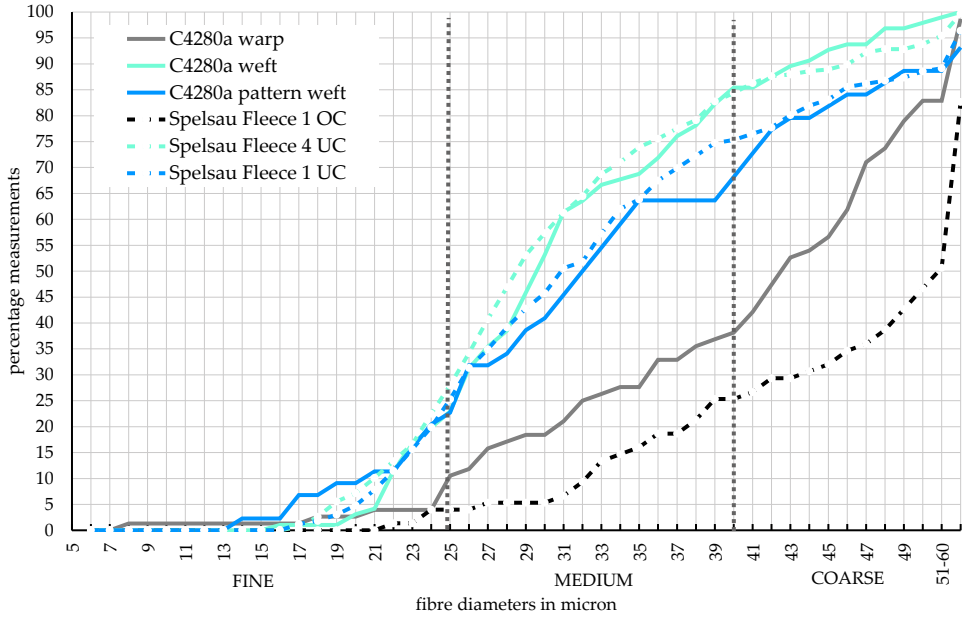
Photo: Roberto Fortuna



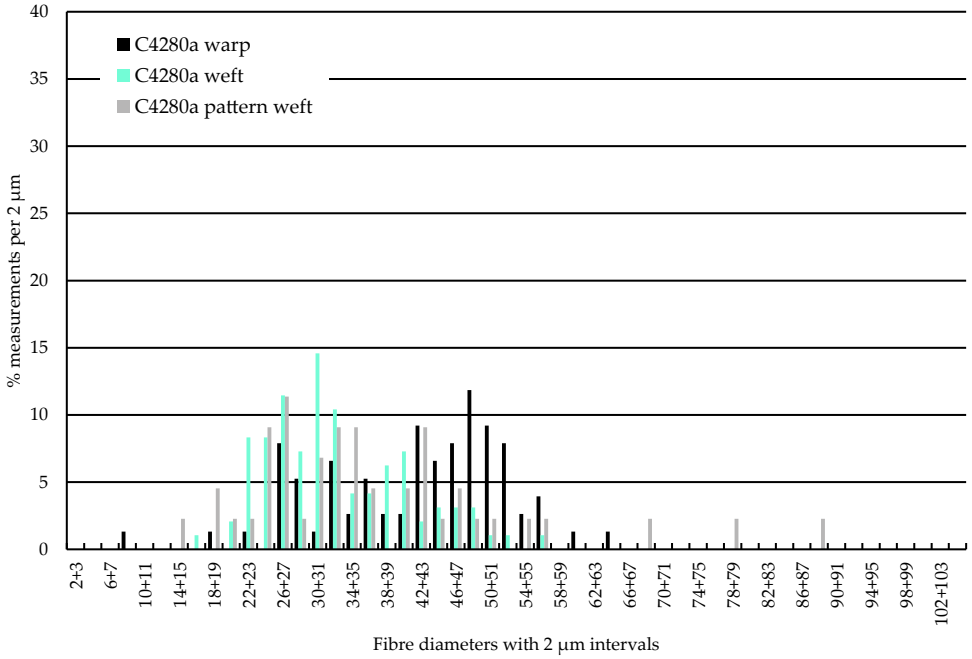


◄ Fig. 11.2: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 11.3: The majority of coarse fibres in the warp and of medium fibres in the ground weft indicate specific selection of material. The two wefts have only similar contents of fine fibres and could be processed slightly differently. The undercoats from Spelsau 4 and 1 correlate well with the ground weft and the pattern weft respectively. The overcoat from Spelsau 1 is here compared to the warp, but has fewer fine and more coarse fibres



◄ Fig. 11.4: The three yarns have broad ranges and in the case of the pattern weft many scattered bars towards the right. The concentrations of similar fibres vary mainly below 10% but reach almost 15% in the weft.

Hvilehøj, C4280d. 2/2 twill

► Table 11.2: Analyses of samples from two fragments of the same textile.

Fibre colour	Bluish green
Fibre distribution	The distribution of the fine and medium fibres in sample 1 and 2 differ slightly, but the fine fibres constitute the majority in the results from all three samples and very few coarse fibres are recorded
Resemblance to modern primitive sheep	The Gute wool and the undercoat from the Spelsau Fleece 2 have closest resemblance to these yarns
Comments to diagrams	Cumulative frequency diagram: The difference in samples 1 and 2 in the content of fine fibres appears like a narrow gap between the two yarns and the primitive wool correlates best with sample 1 Histograms: The histograms of samples 1 and 2 are very similar, narrow ranges and almost symmetrical
Category definitions	A: 93% below 30 µm 7% abowe 30, 1% abowe 40, max. 60 microns. C: 66% below 30, 10% above 45, 1% above 50 microns CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns
Warp/weft fibre combination	1a
Further comments	The results are indicative of similar wool and processing
No. of micrographs	279

Calculations of fibre measurements in microns

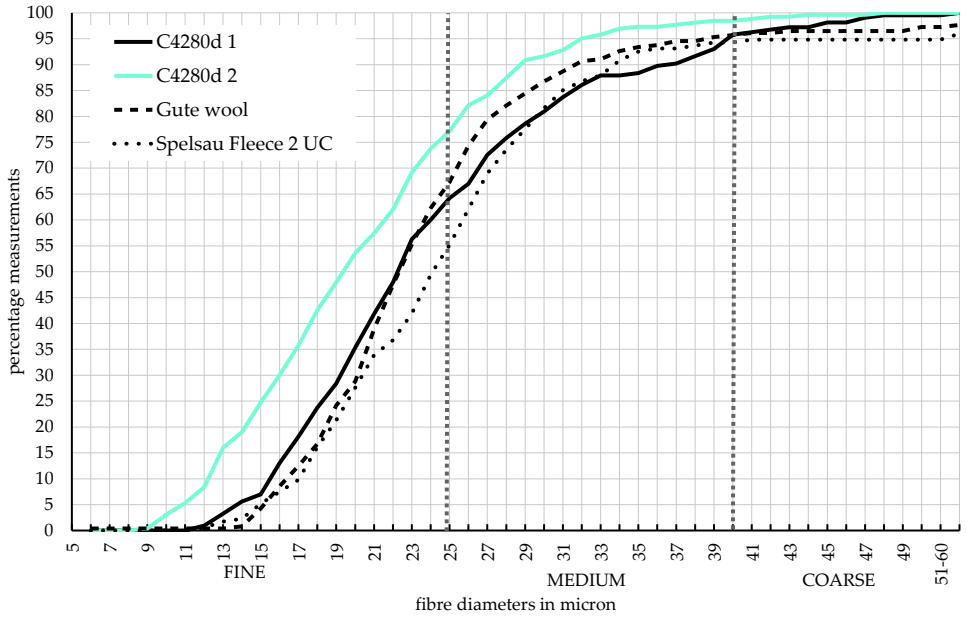
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	67	29	4	0	11-32, 34-51, 44, 46-47, 54	C	215
Sample 2	82	16	2	0	8-34, 36-38, 40-41, 43, 47	AB	263
Random	70	23	7	0	8, 10-11, 13-16, 18-25, 27-30, 33, 36, 42, 46	C	44
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256
Spelsau Fl. 2 UC	62	32	6	4	11-35, 37-38, 40, 52, 58, 61, 64, 68, 74, 76, 83, 88	D	174

► Fig. 11.5: Textile C4280d. Fragment showing the 2/2 twill underneath the fur.

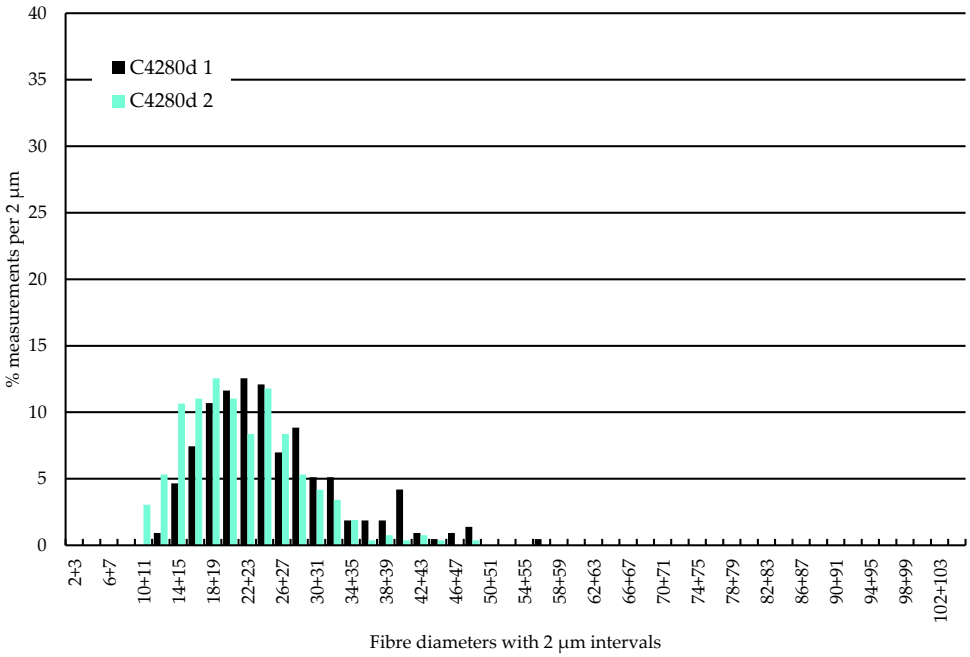
Photo: Roberto Fortuna

◄ Fig. 11.6: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 11.7: Both warp and weft have large contents of fine fibres but their curves are separated throughout and the material may have been selected slightly differently. Both Gute wool and the undercoat from Spelsau 1 correlate well especially to the warp.



◄ Fig. 11.8: Both yarns have narrow ranges and the concentrations of similar fibres increase evenly to above 10%. In this diagram the two yarns do not appear different.

Hvilehøj, Ad C4273-97 Plate 1. Wool fibre bundle

► Table 11.3: Analysis of one sample

Fibre colour	A mixture of white and pigmented fibres
Fibre distribution	The fine fibres constitute the majority, and the contents of medium and coarse fibres are almost equal
Resemblance to modern primitive sheep	The results are comparable to the Klövsjö wool
Comments to diagrams	Cumulative frequency diagram: The slightly smaller content of fine fibres in the wool bundle results in the small gap between this and the Klövsjö wool Histograms: The results create a broad cohesive range with an even and short upward motion which trails off towards the right
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Further comments	-
No. of micrographs	192

Calculations of fibre measurements in microns

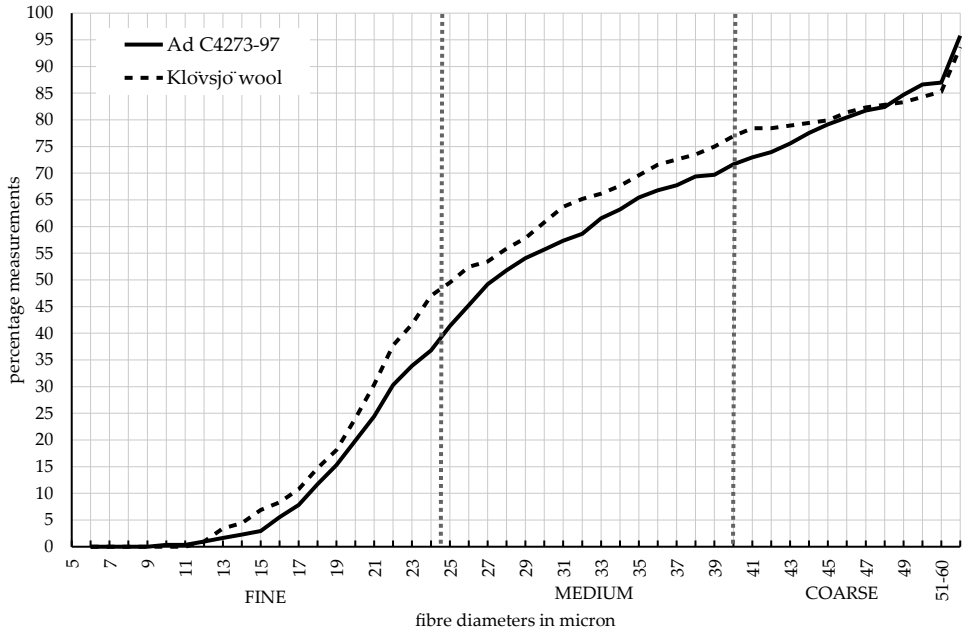
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Fibre sample	47	25	28	5	9, 11-69, 71-72, 78, 80	D	474
Klövsjö	52	25	23	7	11-40, 42-52, 54, 56-60, 62-66, 68, 70, 73, 77	E	204

► Fig. 11.9: Bundle of wool fibres.

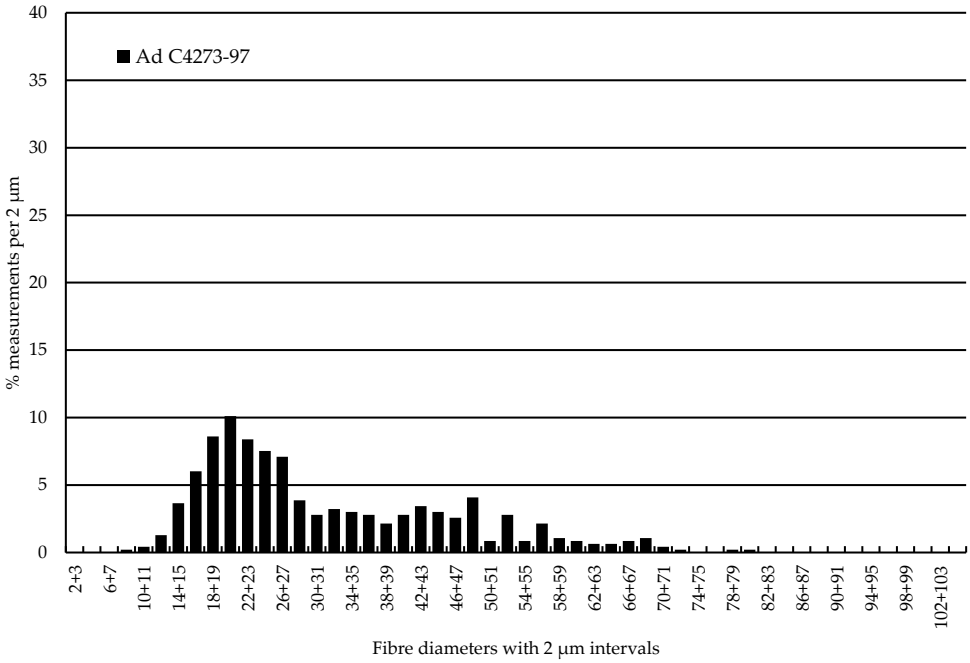
Photo: Roberto Fortuna

► Fig. 11.10: Enlarged photo of the fibres

Photo: Charlotte Rimstad



◄ Fig. 11.11: The majority of fine fibres indicate a specific selection while the equal contents of medium and coarse could signify the lack of combing.The Klövsjö wool correlates well with the fibre bundle.



◄ Fig. 11.12: The fibre distribution gives a broad cohesive range with many low bars below 5% towards the right. The concentration of similar fibres increases evenly to 10%.

Hvilehøj, C4291. 2/1 twill rolls

► Table 11.4: Analyses of samples from the warp and weft from one of the rolls

Fibre colour	Different shades of brown pigmentation
Fibre distribution	The warp has a majority of coarse fibres and an equal content of fine and medium fibres. The weft has a majority of fine fibres. The content of medium fibres is similar in the two yarn samples
Resemblance to modern primitive sheep	The results from the warp are comparable to the Jacobs wool. The calculations of the Spelsau Fleece 3 appear closest to the weft, but the deviations between the two creates a gap
Comments to diagrams	Cumulative frequency diagram: The two yarns have similar starting point, but the curves separate because of the difference in the content of fine fibres Histograms: Both yarns have broad ranges with many uneven peaks
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns E: 60% < 40 µm, 40% > 40.1 µm, 10% > 60 µm EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	2a
Further comments	Warp and weft were unidentified on sampling and defined through the fibre analysis. The similar content of medium fibres as well as similarities in the fibre distribution indicate that the wool for this textile could be from the same raw material, possibly resembling the wool fibre bundle (Ad C.4273-97)
No. of micrographs	232

Calculations of fibre measurements in microns

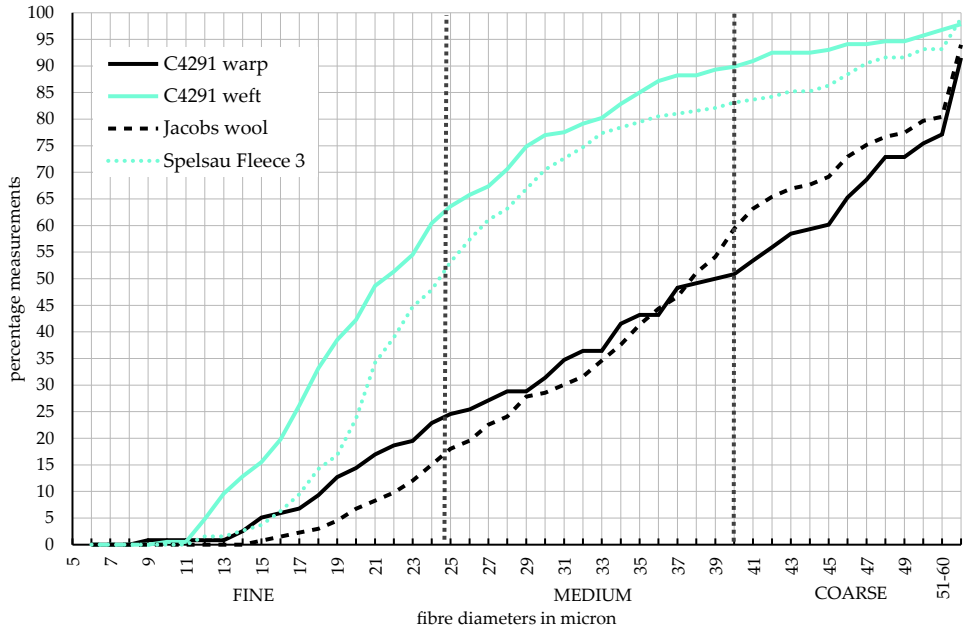
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	25	25	49	9	8, 13-27, 29-31, 33-34, 36-47, 49-50, 52, 54-55, 57, 59-60, 62-66, 70, 79	EE	118
Weft	66	24	10	2	9, 11-36, 38-41, 44-45, 47, 49-50, 52, 58, 61, 64, 96, 119	CD	187
Jacob	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133
Spelsau Fl. 3	57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

► Fig. 11.13: C4291. The fragments of rolled fabric.

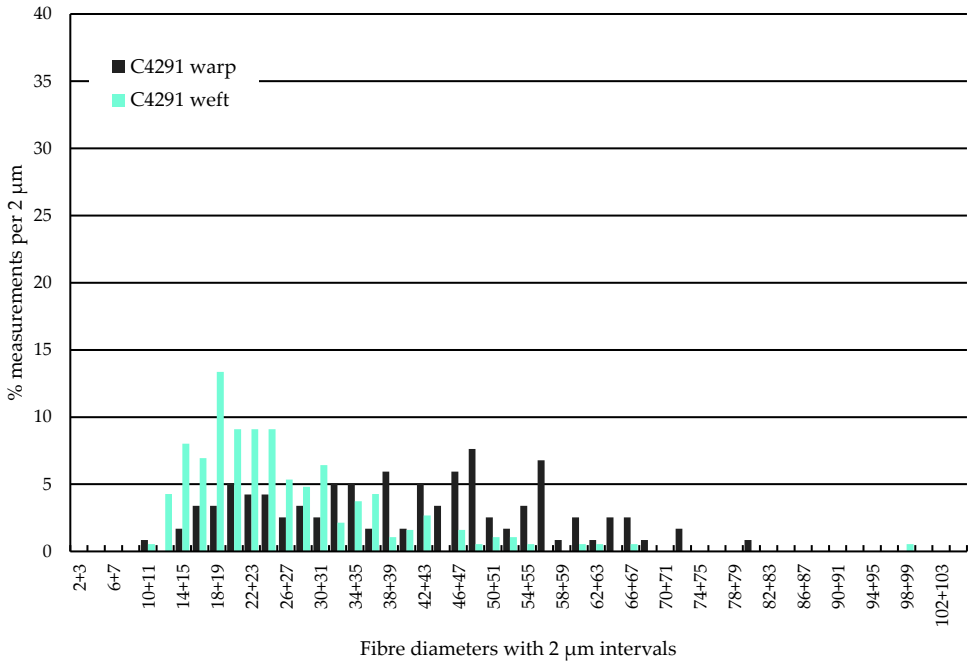
Photo: Roberto Fortuna

◄ Fig. 11.14: Enlarged detail showing the fibres in the yarns.

Photo: Charlotte Rimstad



◄ Fig. 11.15: The majority of coarse fibres in the warp and of fine fibres in the weft together with the equal contents of medium fibres could indicate different processing of the same material. Jacobs wool is the best match to the warp and Spelsau 3 to the weft.



◄ Fig. 11.16: Both warp and weft have broad cohesive ranges. The concentration of similar fibres is in the warp distributed into many bars of uneven heights, mainly below 5%. The weft has one peak above 10% but the concentrations are otherwise below 10 and 5%.

Appendix Hedeby

Hedeby Harbour, H2. 2/2 twill

► Table 12.1: Analyses of samples from the warp and the weft

Fibre colour	Brown warp and mainly white weft
Fibre distribution	The contents of medium fibres in the two yarn samples are almost similar but, in the warp, the coarse fibres constitute about half of the measurements and the content of fine fibres is consequently low. In the weft fine fibres make up more than half of the measurements and very few coarse fibres have been recorded
Resemblance to modern primitive sheep	The overcoat from the Spelsau Fleece 2 corresponds to the warp in respect to the medium fibres but differs slightly in the contents of fine and coarse. The undercoat from the Spelsau Fleece 2 and the weft have corresponding results in all three fibre types
Comments to diagrams	Cumulative frequency diagram: The large gap between the warp and weft indicates how their fibre contents differ. The deviations in the contents of fine and coarse fibres result in the separation of the curve of the Spelsau Fleece 2 overcoat from the warp. The undercoat from the Spelsau Fleece 2 is a good match to the weft Histograms: The coherent ranges of the two yarns are comparable. The warp has several low, uneven peaks while the weft has high peaks in the fine range only
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	2a.
Further comments	A reconstruction was made of this textile and is described in Andersen & Demant 2023.
No. of micrographs	172

Calculations of fibre measurements in microns

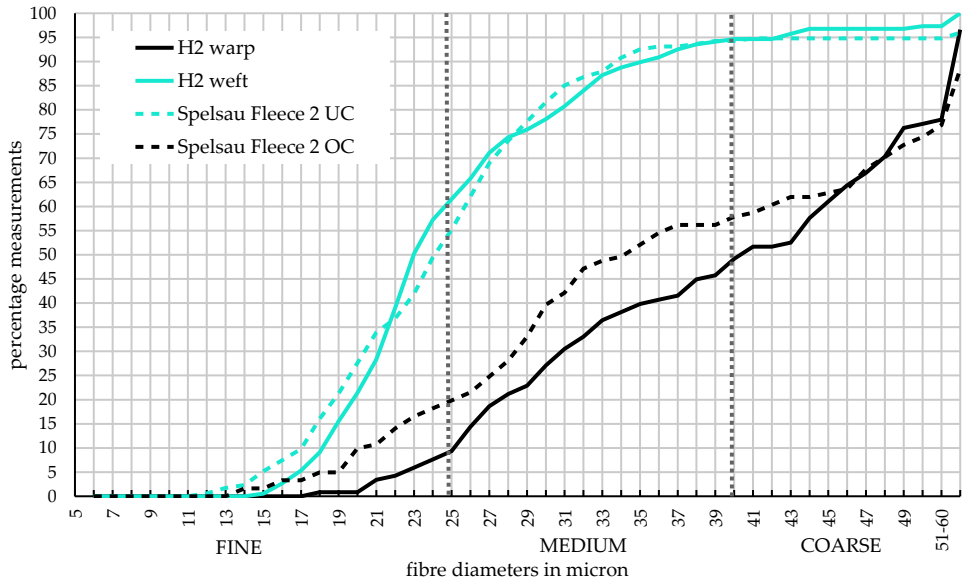
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	14	35	51	4	17, 20-40, 42-58, 60, 64, 68, 70	EE	118
Weft	66	29	5	0	14-39, 42-43, 49, 51, 53, 58-59	CD	187
Spelsau Fl. 2 OC	21	36	42	12	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Spelsau Fl. 2 UC	62	32	6	4	11-35, 37-38, 40, 52, 58, 61, 64, 68, 74, 76, 83, 88	D	174

► Fig. 12.1: Textile H2. Hose in 2/2 twill.

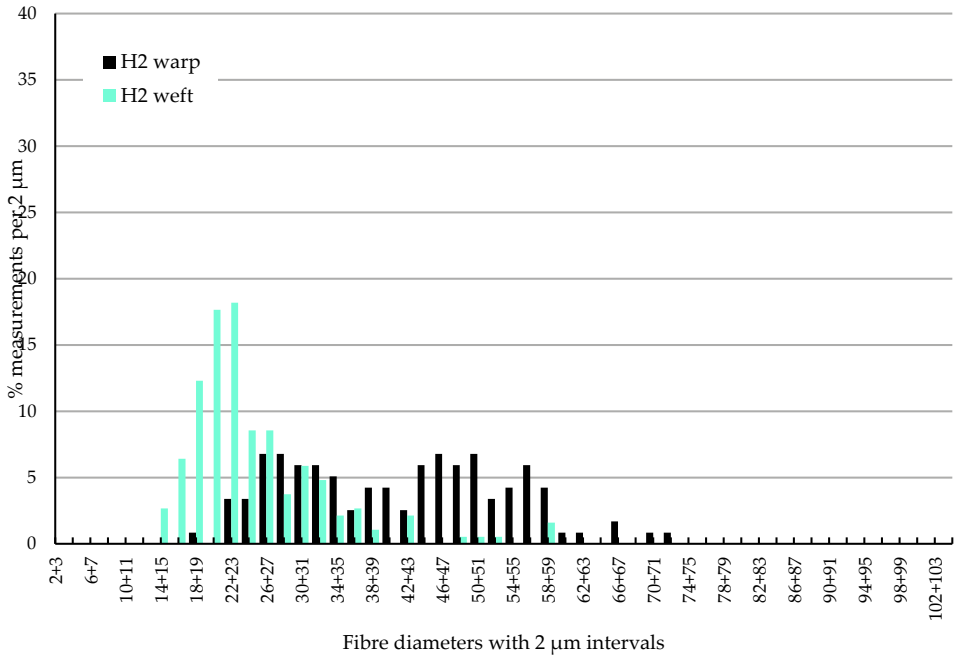
Photo: Charlotte Rimstad

◄ Fig. 12.2: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.3: The majority of coarse fibres in the warp and fine fibres in the weft and the almost similar contents of medium fibres could indicate similarity in the material but differences in the processing. The overcoat from Spelsau 2 correlates especially in the content of medium fibres with the warp. The undercoat from Spelsau 2 has results very similar to the weft.



◄ Fig. 12.4: The two yarns have similar cohesive ranges. The concentrations of similar fibres differ and results in many low bars slightly above or below 5% in the warp. The fibre concentration increases evenly in the weft until slightly below 20% followed by lower bars, mainly below 5%

Hedeby Harbour, H7. 2/2 twill

► Table 12.2: Analysis of one yarn sample.

Fibre colour	A mixture of white and different shades of brown
Fibre distribution	Medium and coarse fibres each constitute almost half of the measurements and very few fine fibres have been recorded
Resemblance to modern primitive sheep	None of the samples from primitive sheep breeds has a comparable fibre distribution. The Jacob's wool has some resemblance in respect to the equal amounts of medium and coarse fibres but has a higher percentage of fine fibres and the Roslag wool has a comparable content of fine fibres but differ in the distribution of the medium and coarser fibres
Comments to diagrams	Cumulative frequency diagram: The curve is well into the medium range before 25% of the measurements are reached which is comparable to the Roslag wool Histogram: A broad cohesive range and several low peaks with the highest just reaching 10% of the measurements at c. 45 microns
Category definitions	E: 60% below 40, 40% above 40, 10% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Further comments	Warp and weft direction was not identified on sampling. The high content of coarse fibres correlates with warps in other textiles. Similar fibre content is found in the light warp in textile H57
No. of micrographs	90

Calculations of fibre measurements in microns

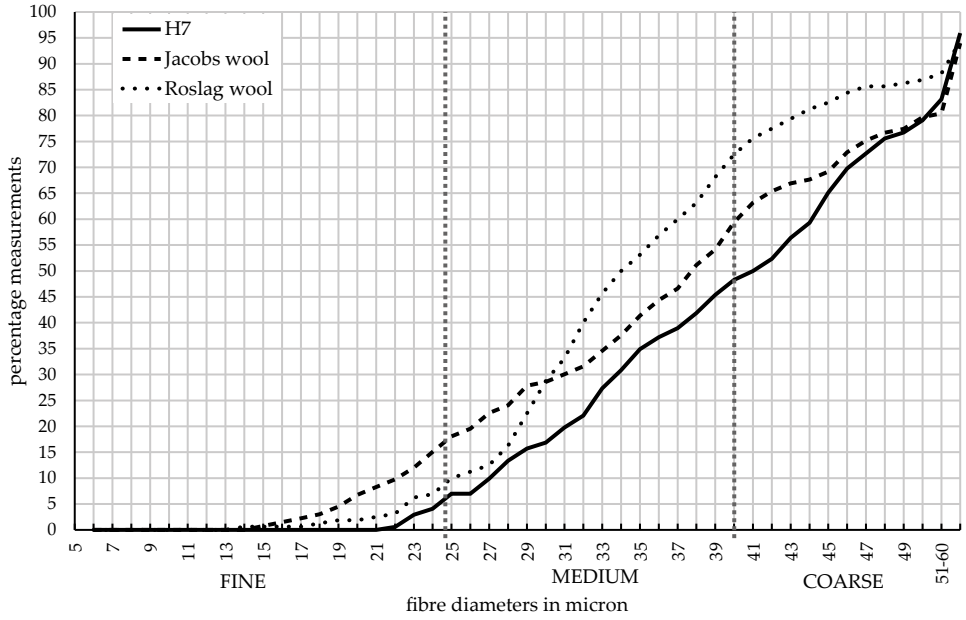
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Yarn Sample	7	41	52	5	21-24, 26-60, 62-66, 72, 81	EE	172
Jacob	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133
Roslag	11	61	28	6	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

► Fig. 12.5: Textile H7. Upper garment. 2/2 twill

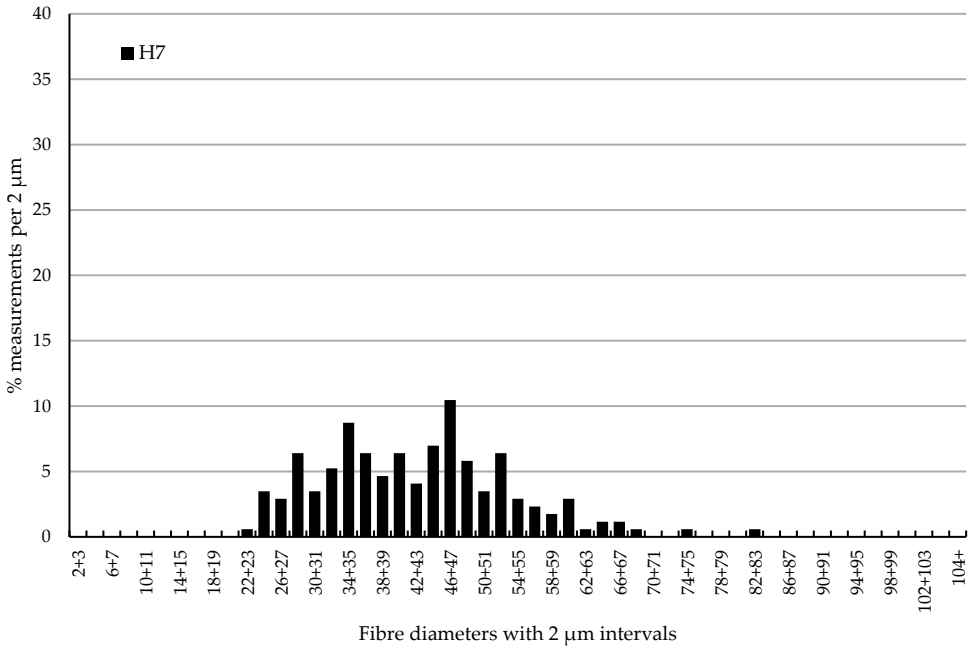
Photo: Charlotte Rimstad

◄ Fig. 12.6: Enlarged detail of the yarns visible behind a protective net

Photo: Charlotte Rimstad



◄ Fig. 12.7: Because of very few fine fibres and a large content of coarse fibres this yarn could be interpreted as warp and the fibres in that case selected specifically. Of the modern samples Roslag wool correlates best in the fine range and Jacobs wool in the medium range.



◄ Fig. 12.8: The results give a broad cohesive range. Although the bars are low and uneven they form an almost symmetrical curve.

Hedeby Harbour, H11. 2/2 twill

► Table 12.3: Analyses of samples from the warp and the weft of the main textile and a light-coloured yarn from the lining

Fibre colour	Different shades of brown in the warp. White and brown in the weft and mostly white in the lining.
Fibre distribution	Coarse and medium fibres predominate in the warp. The weft has a large majority of fine fibres and very few coarse. The lining sample has a majority of medium and fine fibres
Resemblance to modern primitive sheep	The warp results are almost equal to the samples of Jacob's wool and the overcoat from the Spelsau Fleece 2. The weft results are comparable to the the Gute wool. The lining sample has results comparable to the undercoat from the Spelsau Fleece 4
Comments to diagrams	Cumulative frequency diagram: Wide gaps between the curves of the three yarns illustrate their differences. Of the two possible modern wool samples the curves from the Jacob's wool and the warp correlate best Histograms: The rather large contents of the three fibre types in the warp are indicated by several peaks in the histogram, while the concentration of fine fibres in the weft gives high peaks in the fine range
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	2a
Further comments	The weft results are comparable to the weft in textile S29. Warp and weft direction in the lining cannot be interpreted based on these results
No. of micrographs	120

Calculations of fibre measurements in microns

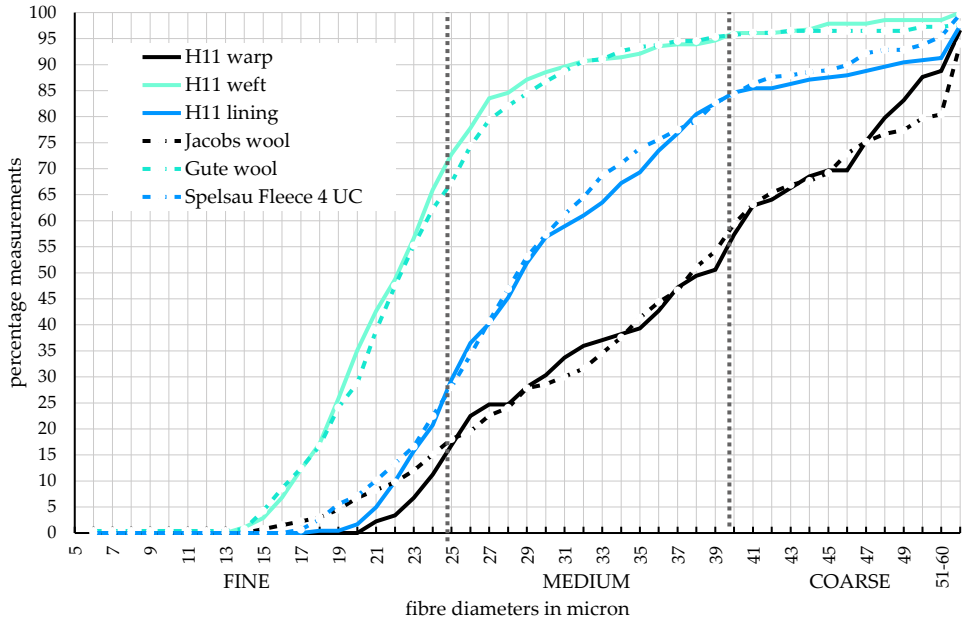
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	22	35	43	3	20-26, 28-44, 46-51, 56, 64, 76, 78	EE	89
Weft	78	18	4	0	13-36, 38-39, 42-44, 47, 52, 54, 57	CD	279
Lining	37	48	15	3	17, 19-40, 42-54, 56-57, 60-62, 64-65, 70	E	241
Jacobs wool	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133
Spelsau Fl. 2 OC	21	36	42	12	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256
Spelsau Fl. 4 UC	34	51	15	1	16-47, 49-57, 62	CD	323

► Fig. 12.9: Textile H11. Caftan? 2/ 2 twill.

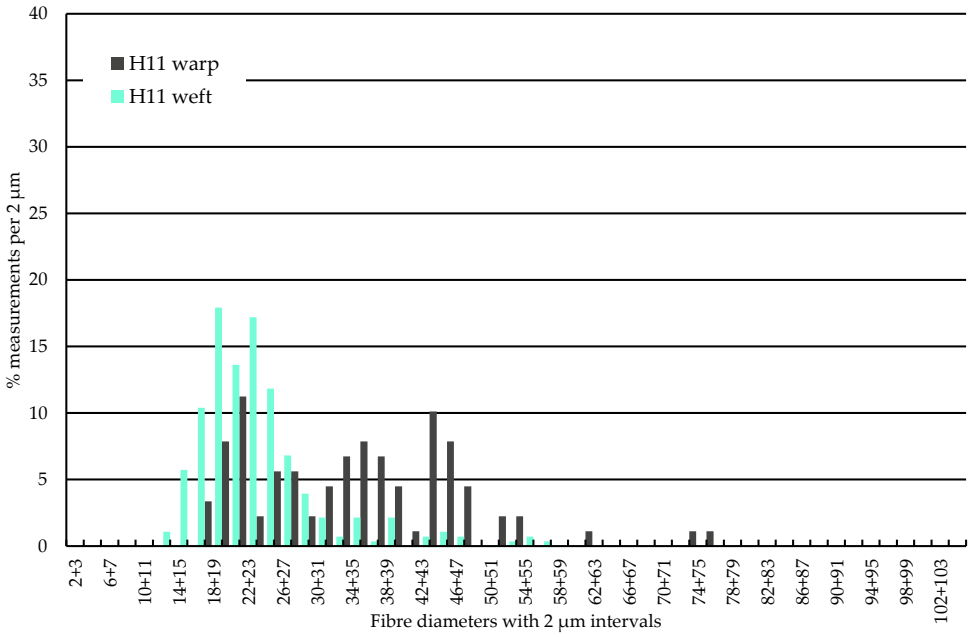
Photo: Charlotte Rimstad

◄ Fig. 12.10: Enlarged detail of the yarns with a mixture of dark and light fibres.

Photo: Charlotte Rimstad



◄ Fig. 12.11: The warp has a majority of coarse and medium fibres and the weft of fine fibres indicative of specific selection and processing. The yarn from the lining has a majority of medium and fine fibres and could be both warp or weft. Jacobs wool correlates well with the warp, Gute wool with the weft and the undercoat from Spelsau 4 with the lining



◄ Fig. 12.12: The results from the warp is seen as three areas with taller peaks and a few scattered bars in the coarse range. The heights of the weft bars increase evenly until above 15% and decrease into uneven bars below 5%.

Hedeby Harbour, H14 A-B. Tabby

► Table 12.4: Analyses of samples from the warp and weft

Fibre colour	White or light brown
Fibre distribution	The two yarns appear similar with a small majority of fine fibres, equal contents of medium fibres and only small deviations in the contents of fine and coarse fibres
Resemblance to modern primitive sheep	The results from the Klövsjö wool have the closest resemblance especially to the weft but has a smaller amount of medium fibres than any of the two yarns
Comments to diagrams	Cumulative frequency diagram: The larger content of fine fibres and smaller of coarse fibres in the weft cause the separation of the curves Histograms: The two yarns have similar cohesive ranges and three areas of higher peaks corresponding to the fibres types
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Warp/weft fibre combination	1c
Further comments	The weft results are comparable to the warp in S29. A reconstruction was made of this textile and is described in Andersen & Demant 2023.
No. of micrographs	150

Calculations of fibre measurements in microns

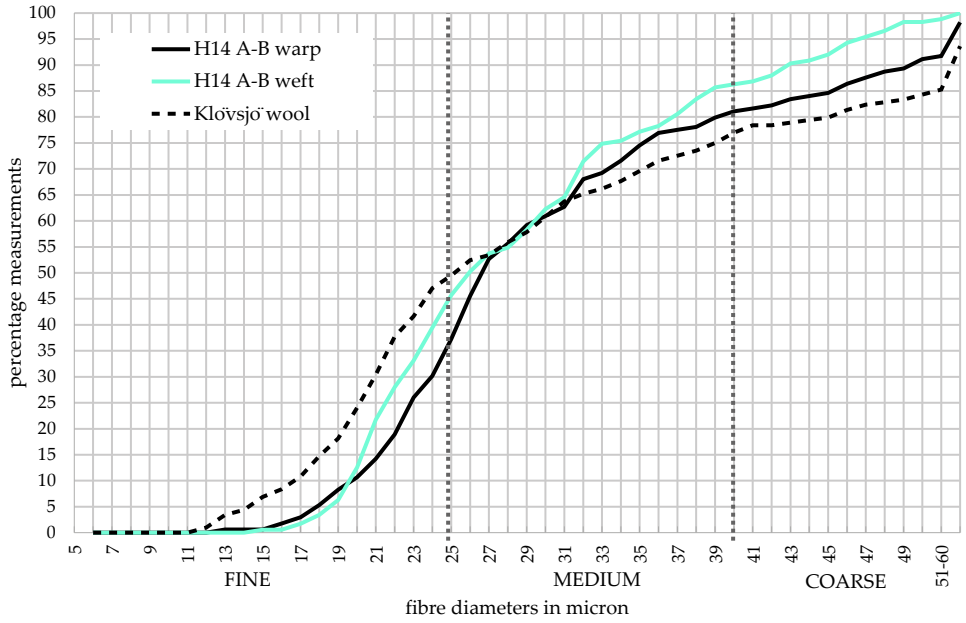
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	46	36	19	2	12, 15-54, 56-57, 60-61, 63, 73	CD	169
Weft	50	36	14	0	14, 16-48, 50-51, 59	CD	175
Klövsjö	52	25	23	7	11-40, 42-52, 54, 56-60, 62-66, 68, 70, 73, 77	E	204

► Fig. 12.13: Textile H14 A-B. Part of spencer dress. Tabby.

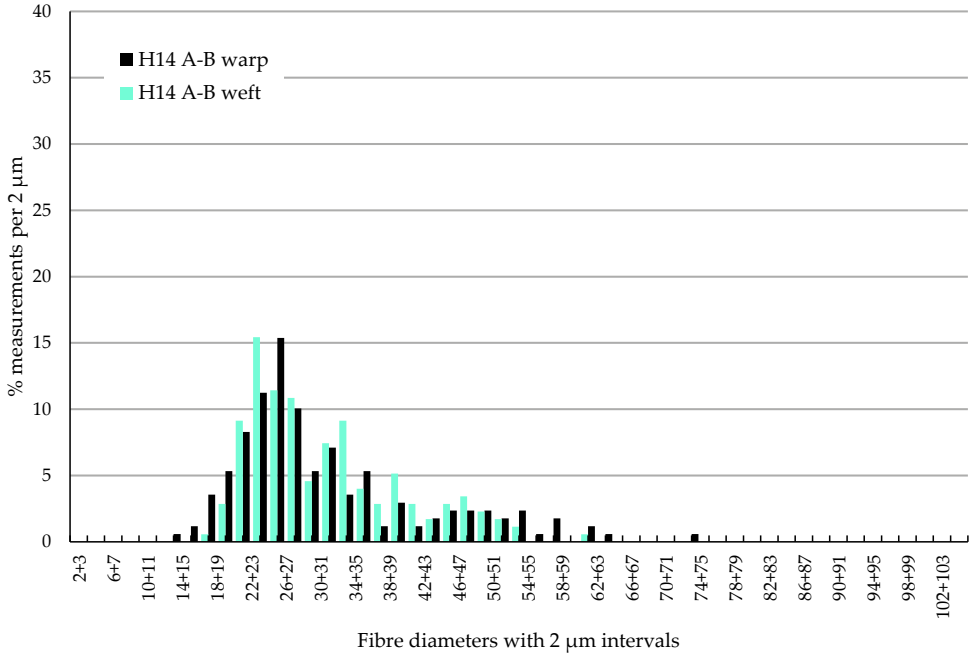
Photo: Charlotte Rimstad

◄ Fig. 12.14: Enlarged detail of the yarns, visible behind a protective net.

Photo: Charlotte Rimstad



◄ Fig. 12.15: These two yarns have been selected from similar material with a majority of fine and medium fibres and processed similarly. Very small nuances cause the separation of the curves. The Klövsjö wool has slightly more fine and coarse fibres but is the best match.



◄ Fig. 12.16: The results from the two yarns have similar cohesive ranges and peak heights.

Hedeby Harbour, H14D. Felt

► Table 12.5: Analysis of one sample

Fibre colour	White
Fibre distribution	Medium fibres constitute more than half of the measurements and only very few coarse fibres have been recorded
Resemblance to modern primitive sheep	The majority of medium fibres and the percentage of fine fibres correspond to the results from the Svärdsjö wool
Comments to diagrams	Cumulative frequency diagram: The high content of fine and medium fibres results in the steep curve. The Svärdsjö wool corresponds well through the medium range Histogram: The high content of fine and medium fibres gives a narrow cohesive range centered relatively symmetrically around 30 microns
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The lack of coarse fibres may signify a careful processing of the fibres. Corresponding fibre content is recorded in S26
No. of micrographs	75

Calculations of fibre measurements in microns

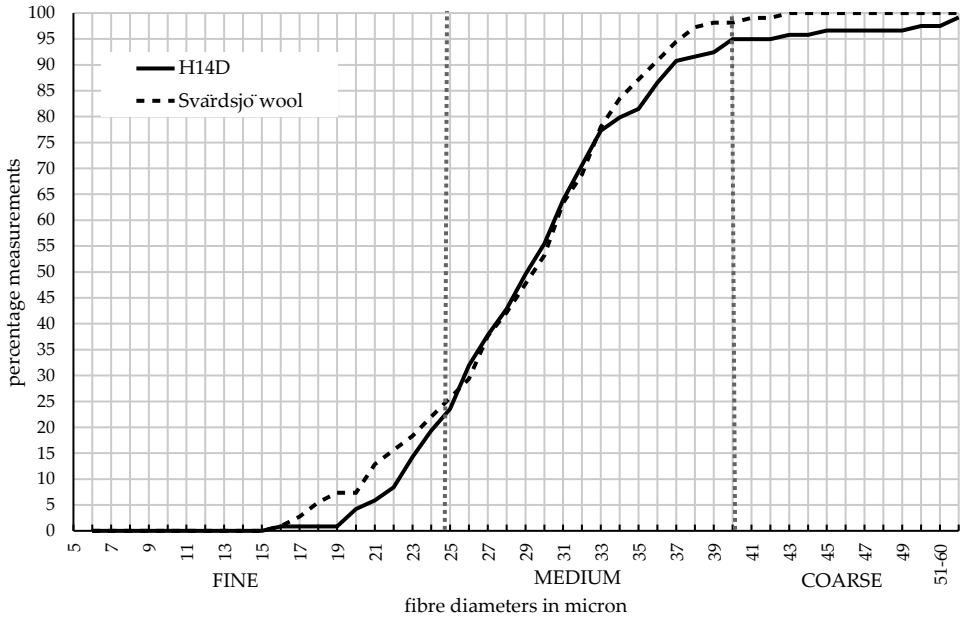
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
H14 D felt	32	63	5	0	15, 19-39, 42, 49, 51, 64	CD	119
Svärdsjö	29	69	2	0	15-18, 20-38, 40, 42	CD	109

► Fig. 12.17: Textile H14D. Face mask. Felt.

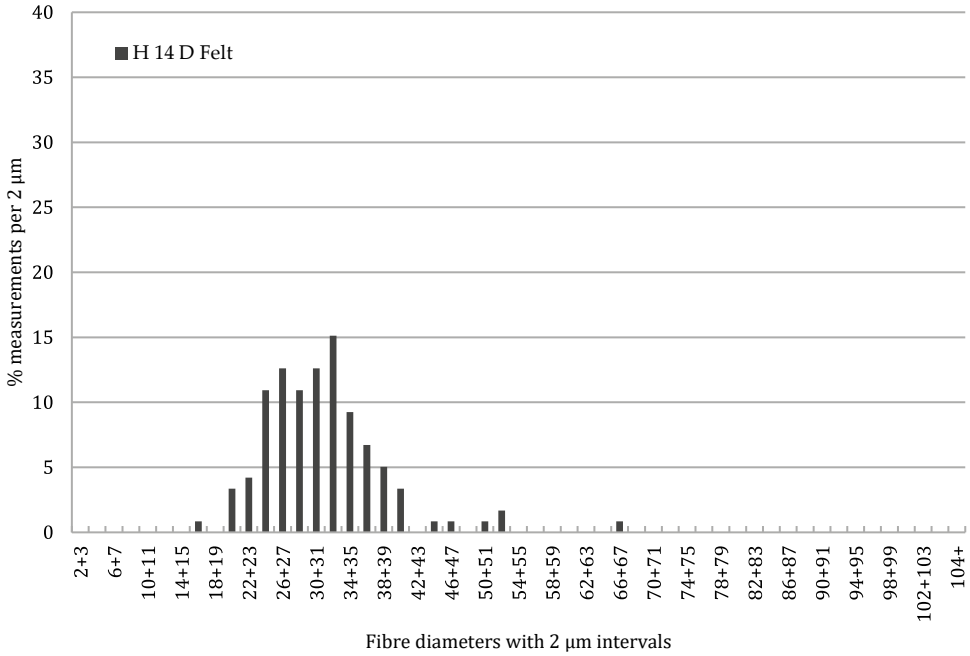
Photo: Charlotte Rimstad

► Fig. 12.18: Enlarged detail of the fibres.

Photo: Charlotte Rimstad



◄ Fig. 12.19: The large majority of medium and fine fibres and very few coarse could signify a careful sorting and combing. The Svärdsjö wool correlates well



◄ Fig. 12.20: A narrow cohesive range is positioned almost symmetrically around the highest peaks and ends with a few scattered bars.

Hedeby Harbour, H28A. 2/2 twill

► Table 12.6: Analyses of samples from the warp and weft of the main textile and one yarn from the dark textile forming part of the sleeve

Fibre colour	Warp and weft with different shades of brown. Dark textile with mostly dark fibres
Fibre distribution	The warp has a majority of medium and coarse fibres while the weft has a majority of fine and medium fibres. The contents of medium fibres are almost similar. The sample from the dark textile has an extremely high content of coarse and no fine fibres
Resemblance to modern primitive sheep	The Blue Faced Leicester wool compares best with the warp although the results deviate in all three fibre types. Both the Värmland Fleece 0 and the undercoat from the Spelsau Fleece 2 are comparable to the weft. The Rya wool has a content of coarse fibres comparable to the yarn from the lining, but some fine fibres have also been recorded
Comments to diagrams	Cumulative frequency diagram: The three yarns are separated by large gaps. The curves representing the Blue faced Leicester wool and the Värmland Fleece 0 samples are close to the warp and weft respectively. None of the primitive wool samples match the dark textile. The one with the closest curve is the Rya wool Histograms: The results from the warp give several lower peaks while the weft has a more evenly distribution of the fibres. The highest concentration of fibres is around 30 microns for both yarns
Category definitions	C: 66% below 30, 10% above 45, 1% above 50 microns D: 66% below 40, 34% above 40, 5% above 60 microns CD: 80% below 40, 20% above 40, 2% above 60 microns The very high percentage of coarse fibres is not encompassed by the categorisation system.
Warp/weft fibre combination	2c
Further comments	The sample from the dark textile consisting of mainly coarse fibres resembles no other Viking Age yarn analysed in this study
No. of micrographs	197

Calculations of fibre measurements in microns

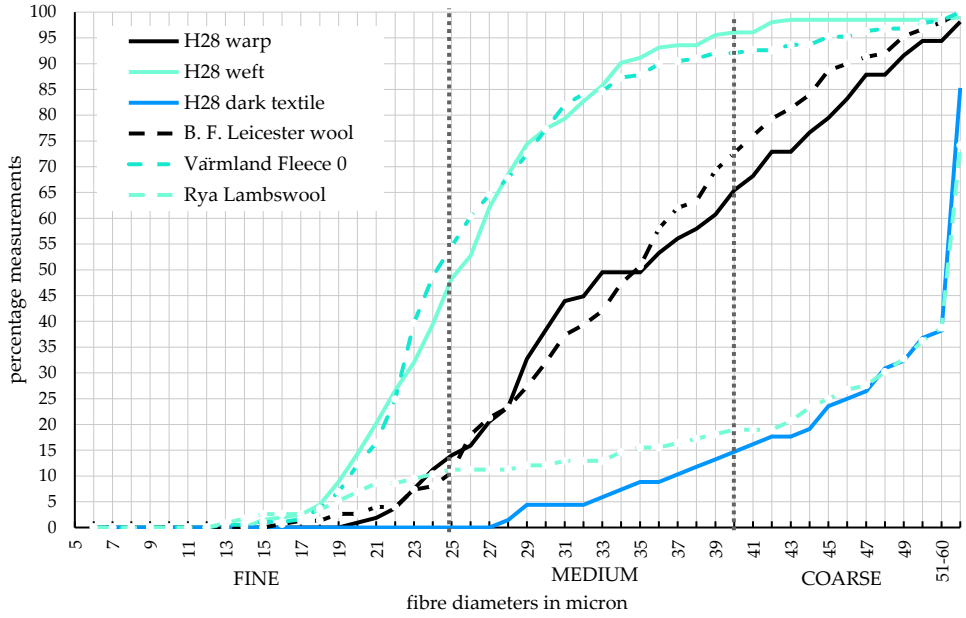
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	16	50	35	2	19-32, 35-41, 43-46, 48-49, 51-52, 54, 62, 76	D	107
Weft	53	43	4	1	14-36, 38-39, 41-42, 54, 61, 73	C	203
Dark textile	0	15	85	18	27-28, 32-34, 36-41, 43-60, 62-65, 67	no	68
Blue Faced Leicester	18	55	27	0	15-16, 20, 22-52, 57	D	150
Spelsau Fl. 2 UC	62	32	6	4	11-35, 37-38, 40, 52, 58, 61, 64, 68, 74, 76, 83, 88	D	174
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189
Rya	11	8	81	30	12-14, 17-20, 22-24, 28, 30, 33-34, 36-39, 42-64, 66-70	no	116

► Fig. 12.21: Textile H28A. Part of sleeve. 2/2 twill. The dark textile is seen in the middle of the fragment.

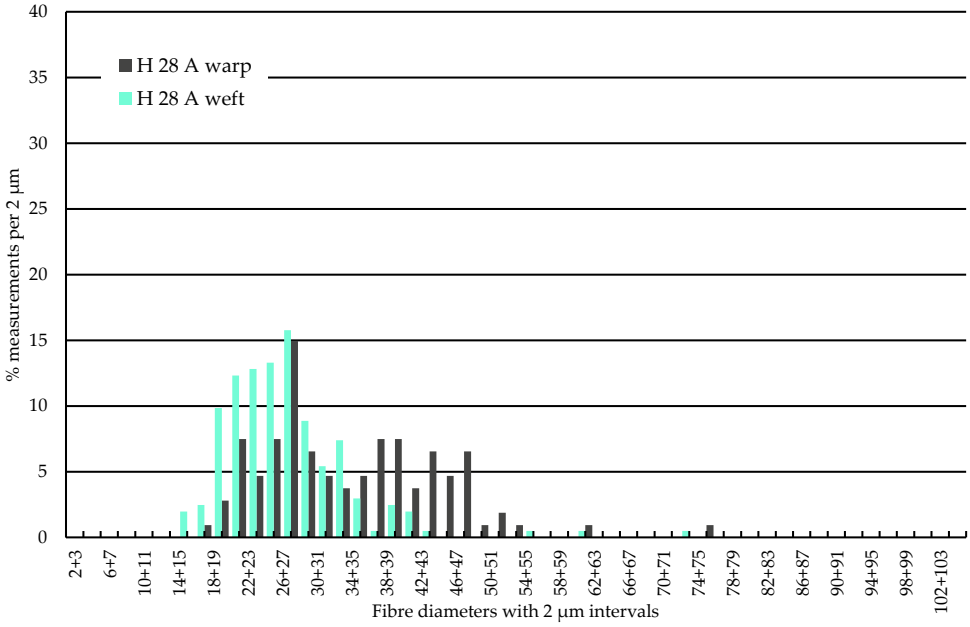
Photo: Charlotte Rimstad

◄ Fig. 12.22: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.23: The warp has a majority of medium and coarse fibres and the weft of fine and medium fibres. This could be the result of different sorting and combing of almost similar material. The yarn from the dark textile has a very large majority of coarse fibres and no fine and is therefore probably a sample from the warp. The warp and weft correlate well with Blue Faced Leicester wool and Värmland 0 respectively while the lining resembles Rya wool.



◄ Fig. 12.24: Both yarns have tall peaks reaching 15% at the same location, but the weft has several corresponding bars before that, while the warp has several lower bars of uneven heights before and after.

Hedeby Harbour, H39A-B. 2/2 diamond or herringbone twill

► Table 12.7: Analyses of samples from the warp, the weft and a sewing thread

Fibre colour	Warp and weft with mostly white fibres. Sewing thread with mostly dark fibres
Fibre distribution	The warp has equal amounts of fine and medium fibres and a high content of coarse fibres. The weft is distinguished by a high percentage of fine and very few coarse fibres. In the sewing thread the contents of medium and coarse fibres are similar and high resulting in a low content of fine fibres
Resemblance to modern primitive sheep	The undercoat from the Spelsau Fleece 1 has some similarity to the warp but varies slightly, especially in the medium range. The Gute and the Jacobs wool have results corresponding to the weft and the sewing yarn respectively
Comments to diagrams	Cumulative frequency diagram: The gaps between the three curves clearly indicate the differences in the three yarns. The deviations between the yarns and the modern wool samples are most distinct in the case of the warp and the Spelsau Fleece 1 undercoat in the fine and medium ranges Histograms: The differences between warp and weft are here expressed as differences in the curvature of the bars created by the results. The warp has several lower peaks and the weft a more uniform outline
Category definitions	C: 66% below 30, 10% above 45, 1% above 50 microns CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Warp/weft fibre combination	2b
Further comments	Not many samples in this study have a fibre distribution similar to the warp. A reconstruction was made of this textile and is described in Andersen & Demant 2023
No. of micrographs	203

Calculations of fibre measurements in microns

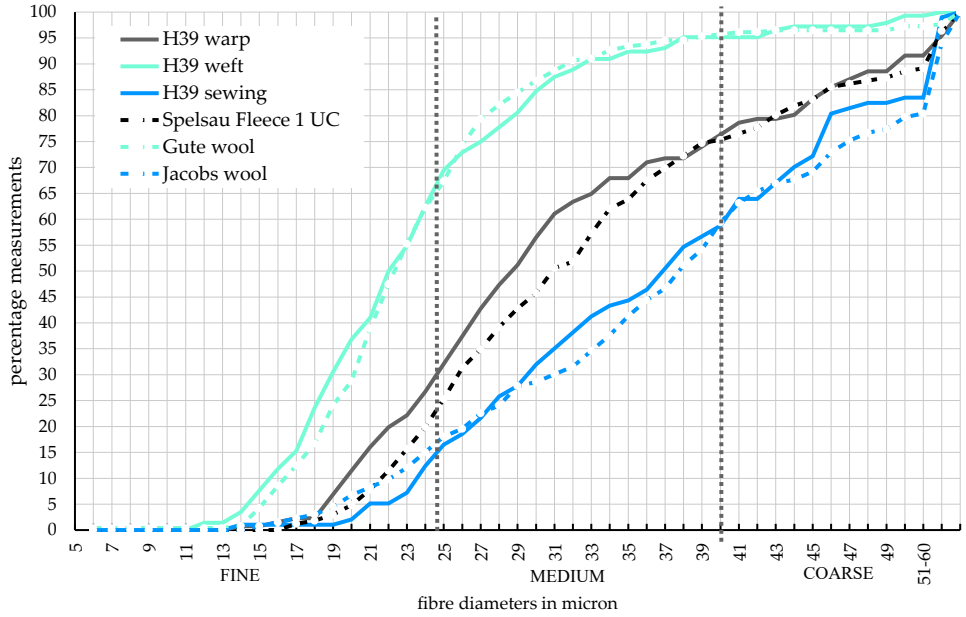
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	37	39	24	5	13, 15-16, 18-33, 35-36, 38-41, 43-47, 49, 51-52, 56-57, 61, 65, 72-73	D	131
Weft	73	22	5	0	11, 13-32, 34-36, 42-43, 48-49, 51	C	144
Sewing	19	40	41	2	13, 19-20, 22-40, 42-47, 49, 51-55, 58-60, 72	E	97
Spelsau Fl. 1 UC	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256
Jacob	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133

► Fig. 12.25: Textile H39 A-B. Part of trousers. 2/2 twill.

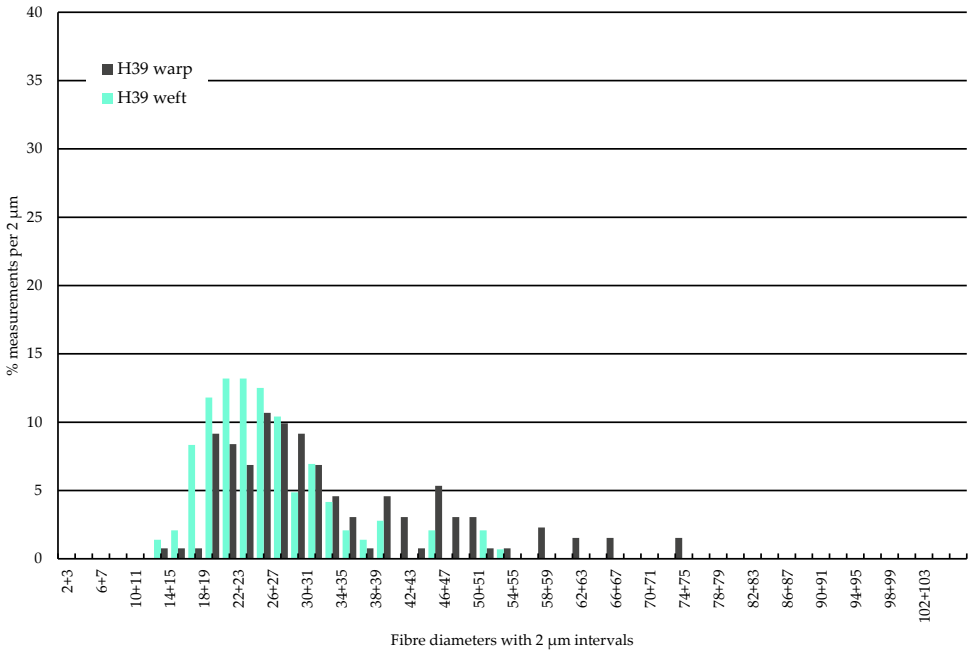
Photo: Charlotte Rimstad

◄ Fig. 12.26: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.27: The warp has almost equal contents of the three fibre types while the weft has a large majority of fine and medium fibres. These results could be indicative of specific selection of material. The sewing yarn has fewer fine fibres and equal contents of medium and coarse fibres and could be from slightly different material. The undercoat from Spelsau 1 correlates well with the warp. Gute wool and the weft have similar curves and Jacobs wool correlates with the sewing yarn.



◄ Fig. 12.28: The cohesive ranges of the two yarns are almost similar but the warp has a few more scattered bars towards the right. The sizes of the weft bars increase and decrease more evenly.

Hedeby Harbour, H42. Felt

► Table 12.8: Analyses of samples from the dark and light felt.

Fibre colour	Dark part with different shades of brown. Light part of unpigmented fibres
Fibre distribution	The results from the two samples have similar contents of the three fibre types with high percentages of fine and very few coarse fibres
Resemblance to modern primitive sheep	The Gute wool and the dark felt have similar fibre distributions. The light felt has a slightly larger percentage of fine fibres
Comments to diagrams	Cumulative frequency diagram: The light sample has a slightly steeper curve than the dark felt and the Gute wool because of the larger percentage of fine fibres Histograms: The two results appear quite similar but the light felt has higher peaks at c. 25 microns
Category definitions	B: 75% below 30, 25 % above 30, 2% above 40 microns CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The differences in the results may be due to randomness. The light felt has results corresponding to the weft in S29 and the dark felt corresponds to the weft in H91A
No. of micrographs	214

Calculations of fibre measurements in microns

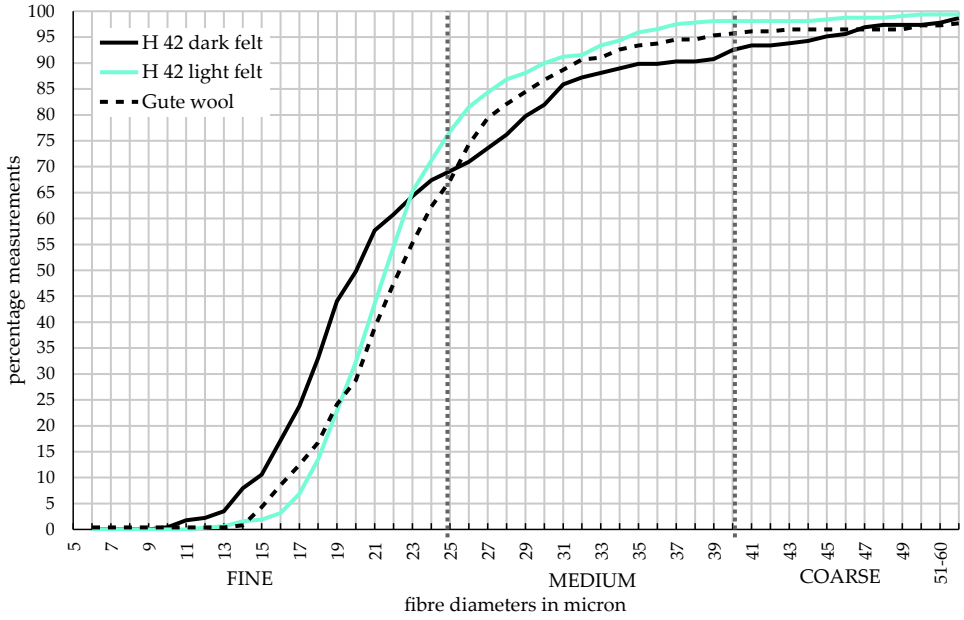
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Dark felt	71	22	8	1	9-34, 36, 38-40, 42-47, 50, 55-56, 64, 69,78	CD	227
Light felt	81	17	2	1	11-38, 44-45, 48-49, 70, 77	B	319
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256

► Fig. 12.29: Textile H42. Fragment of felt.

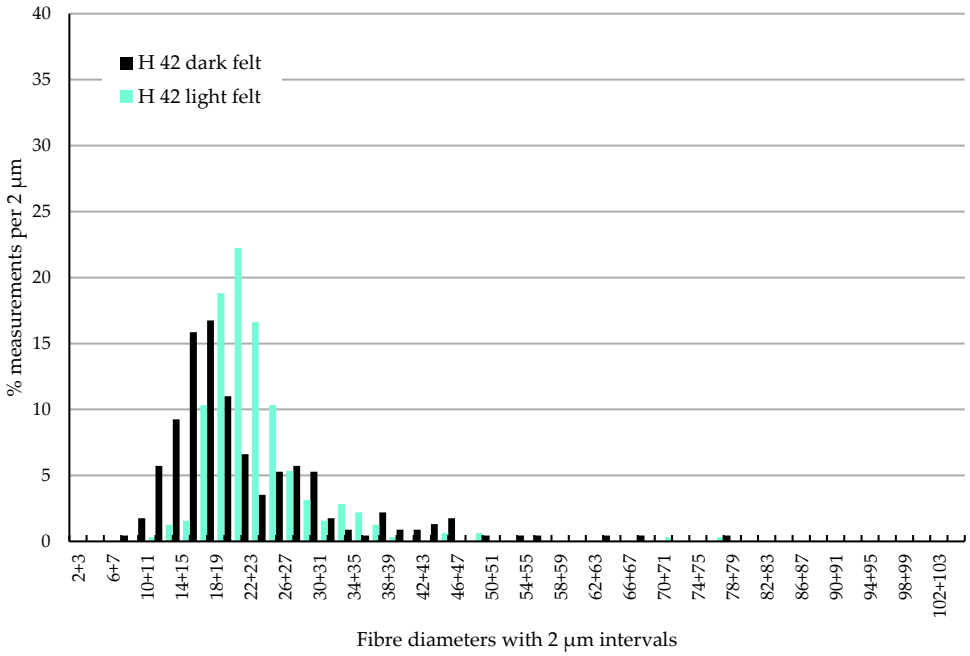
Photo: Charlotte Rimstad

◄ Fig. 12.30: Enlarged detail of the fibres.

Photo: Charlotte Rimstad



◄ Fig. 12.31: The dark felt has fewer fine fibres than the light felt and slightly more medium and coarse fibres which result in the separation of the curves. The diferences may be nuances in the processing of very similar material. The Gute wool correlates well especially with the light felt.



◄ Fig. 12.32: The heights of the bars increase and decrease evenly in both cases and peak at above 15% and 25% in the case of the dark and light felt respectively. The bars become low and scattered towards the right.

Hedeby Harbour, H53A-B. 2/2 twill with pile

► Table 12.9: Analyses of samples from warp and weft

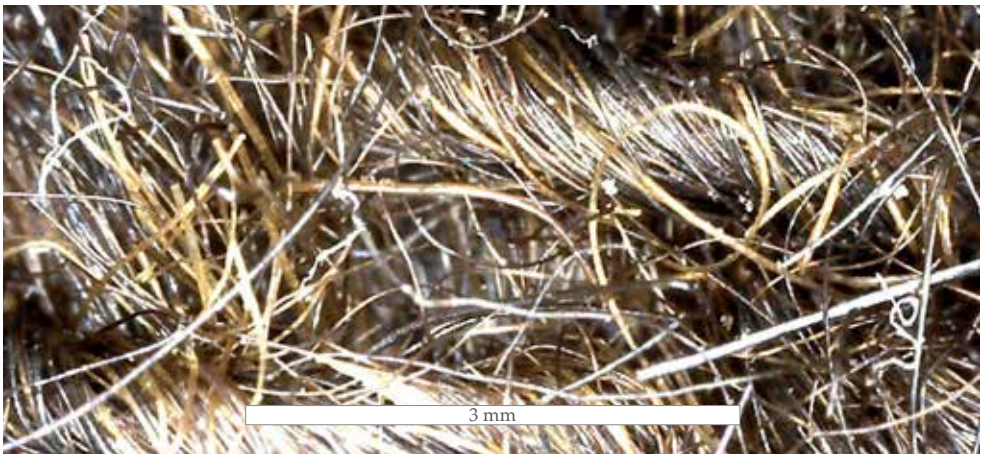
Fibre colour	Different shades of brown
Fibre distribution	In both yarns, the contents of medium fibres are slightly higher than of fine fibres but in the warp the coarse and medium fibres are equal whereas in the weft the content of medium fibres is larger than the coarse
Resemblance to modern primitive sheep	The overcoat sample from the Spelsau Fleece 2 is comparable to the warp. The undercoat sample from the Spelsau Fleece 1 is a better match for the weft
Comments to diagrams	Cumulative frequency diagram: The slightly larger contents of fine and medium fibres result in a steeper curve for the weft. The large content of coarse fibres in the modern wool sample causes the separation of the curve from the warp. Histograms: The weft has a few higher peaks than the warp, but the results appear similar with broad ranges and several peaks
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	1c
Further comments	It cannot be determined whether the differences in the distributions are due to randomness of the specific samples or to some slight difference in the processing
No. of micrographs	201

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	25	38	36	0	12, 15-55, 57, 59	D	244
Weft	30	46	23	1	16-50, 52-57, 60, 73	D	237
Spelsau Fl. 2 OC	21	36	42	12	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Spelsau Fl. 1 UC	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166

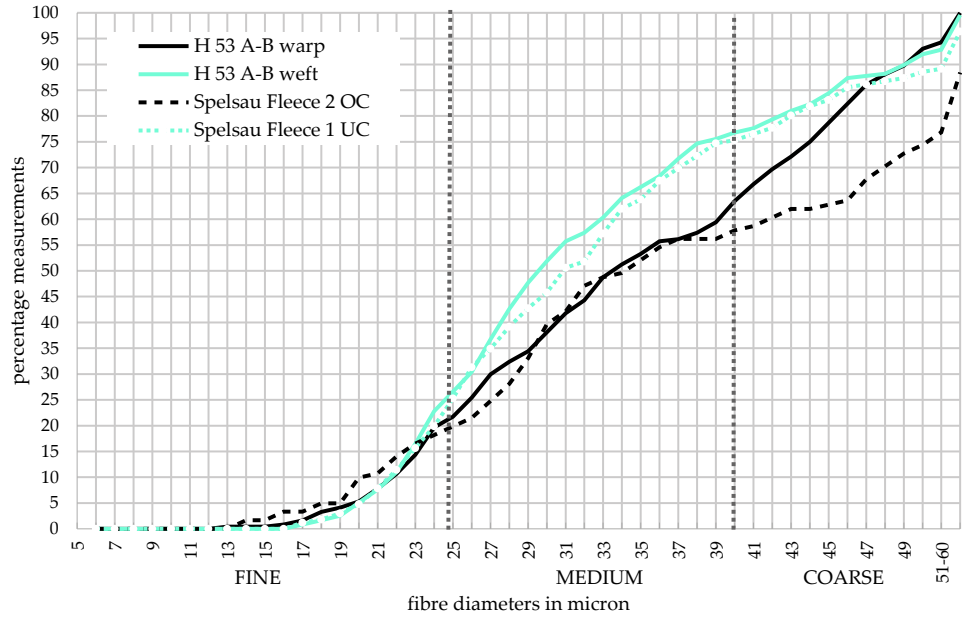
► Fig. 12.33: Textile H53 A-B. Upper garment. 2/2 twill.

Photo: Charlotte Rimstad

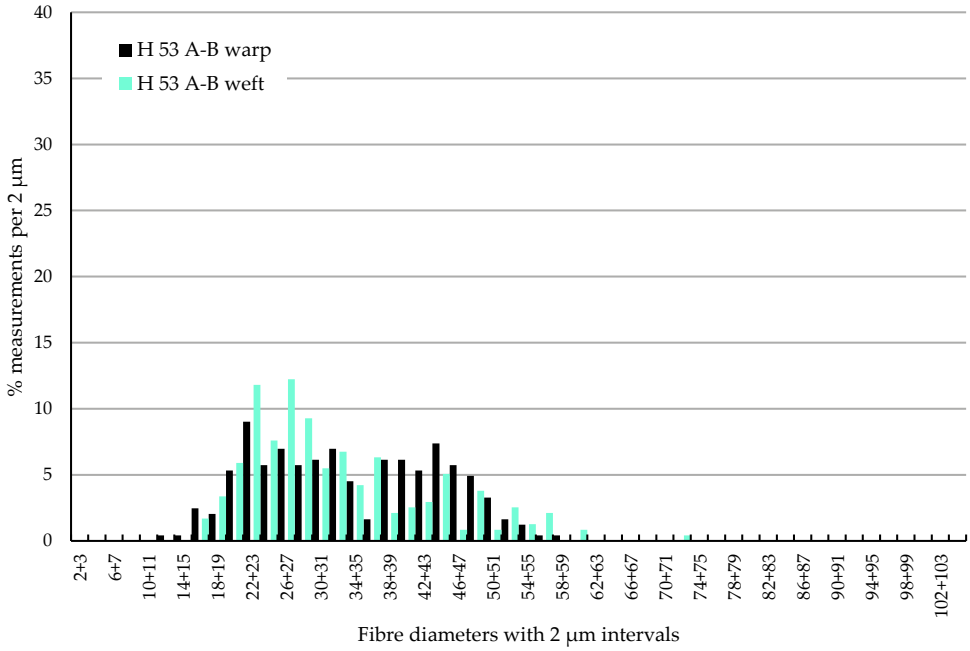


◄ Fig. 12.34: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.35: Small differences in the contents of the three fibre types are found in the warp and weft but it is difficult to determine whether they are the result of choice or random. The overcoat from Spelsau 2 corresponds well with the warp until the coarse range. The undercoat from Spelsau 1 correlates well with the weft throughout.



◄ Fig. 12.36: The cohesive ranges and the positioning of the bars representing the two yarns are very similar. The heights of the bars differ slightly.

Hedeby Harbour, H57. 2/2 twill

► Table 12.10: Analyses of samples from the dark and light warps and wefts

Fibre colour	Dark warp with mostly very dark brown, some white and lighter brown fibres. Light warp with mostly white fibres. Dark weft with different shades of brown, some white. Light weft with mostly white fibres
Fibre distribution	The two warps have a small majority of coarse fibres and very few fine. The two wefts have a majority of fine fibres, slightly more distinct in the light weft, and very few coarse fibres
Resemblance to modern primitive sheep	None of the modern wool samples compare well to these yarns. The Jacob wool could match the warp if the content of fine fibres were reduced. The Värmland Fleece 0 sample is comparable to the dark weft but has slightly more fine fibres. The Spelsau Fleece 3 sample is close to the light weft in respect to the fine fibres but deviates in the medium and coarse
Comments to diagrams	Cumulative frequency diagram: The similarity in the fibre contents of the two warps and the differences in the two wefts are illustrated in this diagram as are also the deviations in the closest modern wool samples Histograms: The four yarns all have broad ranges and several peaks because of the varied fibre contents. The high peaks of the wefts in the fine range result in lower peaks further on
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Warp/weft fibre combination	2a
Further comments	-
No. of micrographs	359

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Dark warp	9	41	50	7	18-21, 23-36, 38-45, 47-53, 55-56, 59, 61, 63, 65, 70-71, 87	EE	135
Light warp	7	40	53	12	19, 23-36, 38-51, 53-60, 67, 69-70, 73, 76, 78, 86	EE	100
Dark weft	55	35	10	1	17-37, 39-41, 44, 46-49, 51, 55-58, 65, 73	CD	201
Light weft	65	22	13	1	10-46, 49-51, 54-58, 60, 64, 88	CD	202
Jacob	20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189
Spelsau Fl. 3	57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

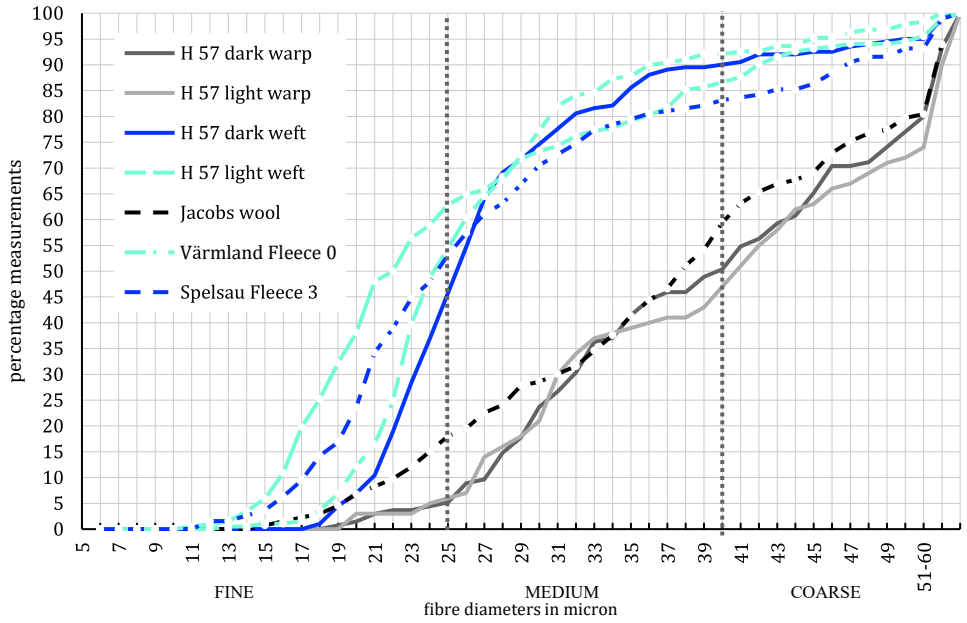
► Fig. 12.37: Textile H57. Sleeve. 2/2 twill.

Photo: Charlotte Rimstad

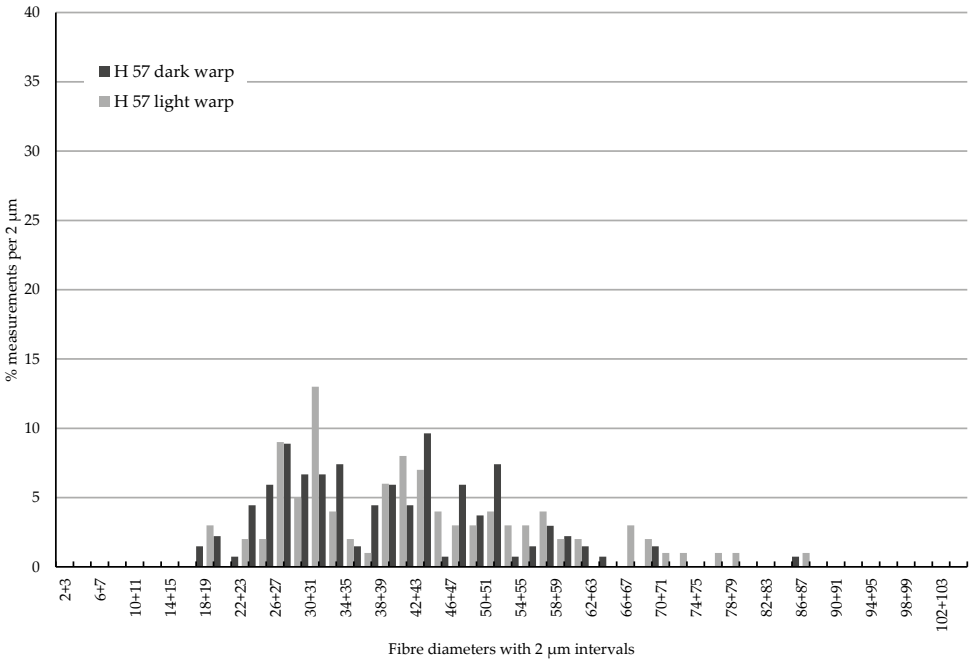
◄ Fig. 12.38: A: Enlarged detail of the yarns in the light brown fabric. B: Enlarged detail of the yarns in the dark brown fabric.

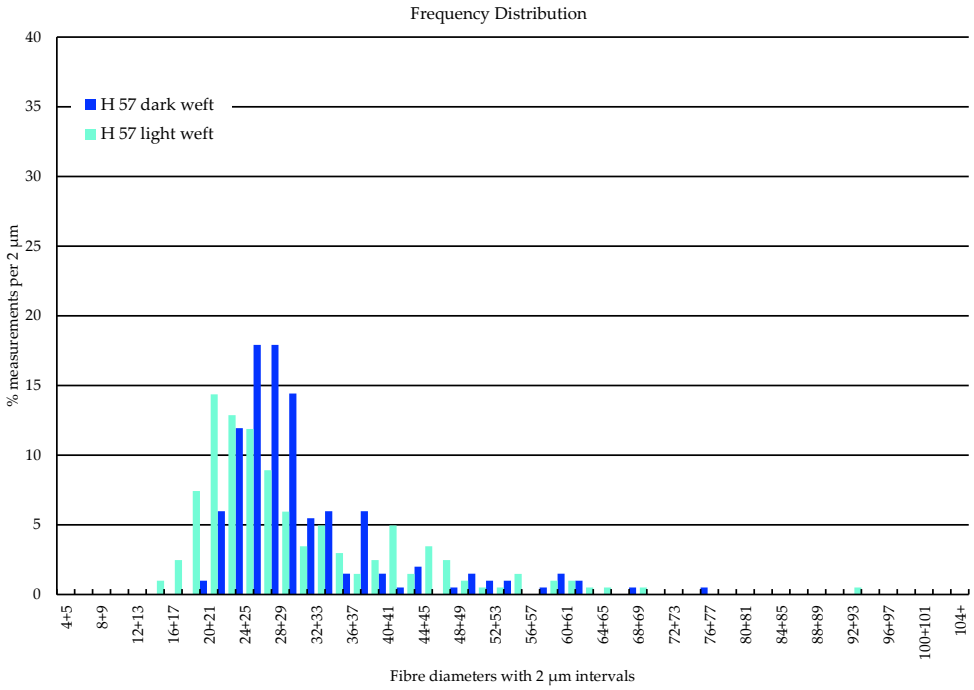
Photo: Charlotte Rimstad

► Fig. 12.38: The two warps have similar fibre contents consisting of a large majority of coarse and medium fibres. The two wefts both have a majority of fine and medium fibres although differing in the specific amounts. These results are indicative of specific selection of wool in each case. Jacobs wool is the best match for the warps and Värmland 0 as well as Spelsau 3 correlate with the wefts.



► Fig. 12.39: The two warps have broad cohesive ranges and low peaks of uneven heights.





◄ Fig. 12.40: The two wefts both increase and decrease evenly with the tallest peaks at just below and above 15% of the measurements. They have similar cohesive ranges with many low and scattered bars towards the right.

Hedeby Harbour, H72B. Tabby

► Table 12.11: Analyses of samples from the warp and the weft

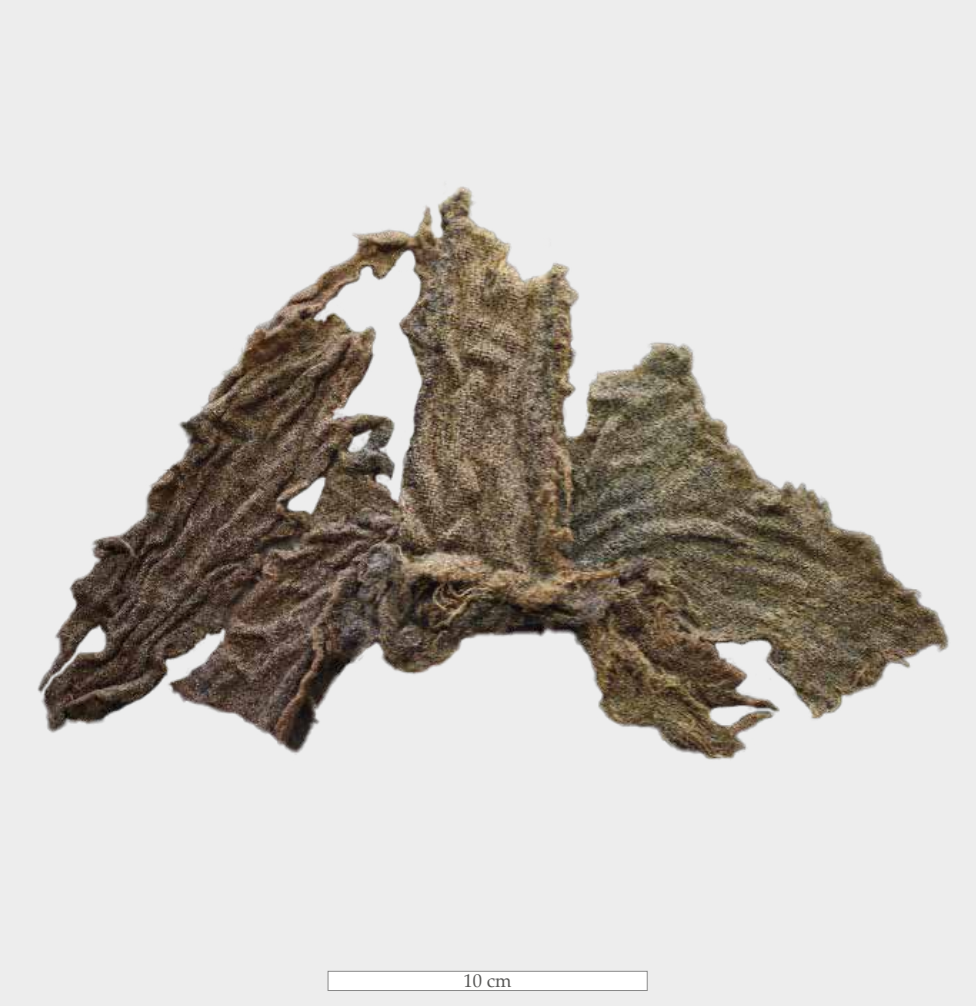
Fibre colour	Unpigmented with barely visible traces of blue
Fibre distribution	The results are similar with almost equal contents of all three fibre types
Resemblance to modern primitive sheep	The Spelsau Fleece 3 has comparable fibre distributions with only few deviations
Comments to diagrams	Cumulative frequency diagram: The corresponding curves for the warp and weft indicate similar wool and processing and the Spelsau Fleece 3 correlates well Histograms: The two histograms have similar cohesive ranges and peaks
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	1b or 1c
Further comments	Warp and weft were not identified on sampling. The fibres were very tangled together on the surface and the two yarn systems were difficult to separate. The results indicate similar material and processing
No. of micrographs	121

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Sample 1	52	34	14	0	14-23, 25-36, 39-41, 43, 45, 48, 51-52, 54, 56-57	CD	103
Sample 2	57	32	10	0	14-38, 40-44, 47, 49, 51, 54	CD	108
Spelsau Fl. 3	57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

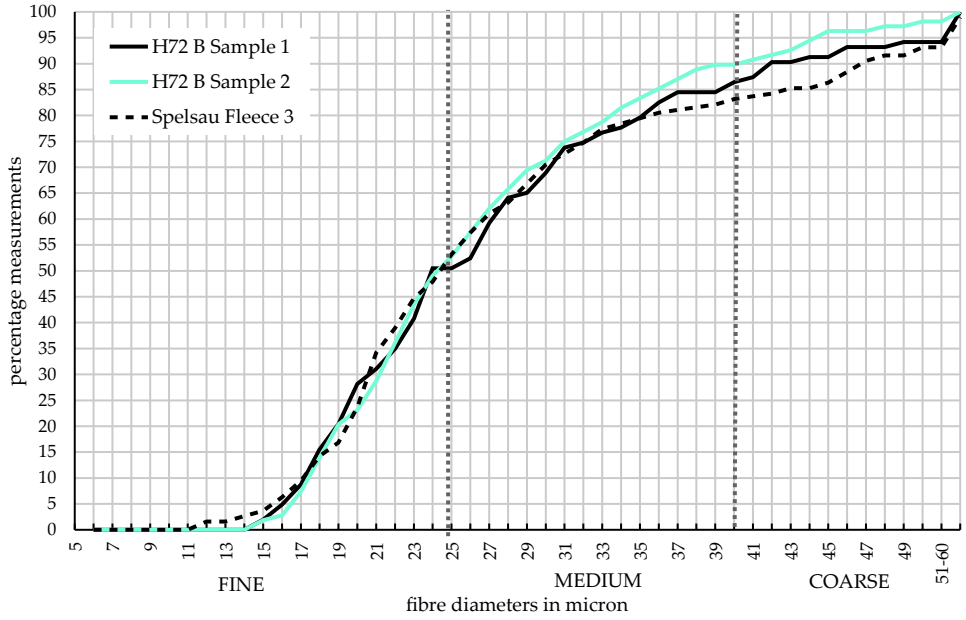
► Fig. 12.41: Textile H72B. Part of trousers. Tabby.

Photo: Charlotte Rimstad

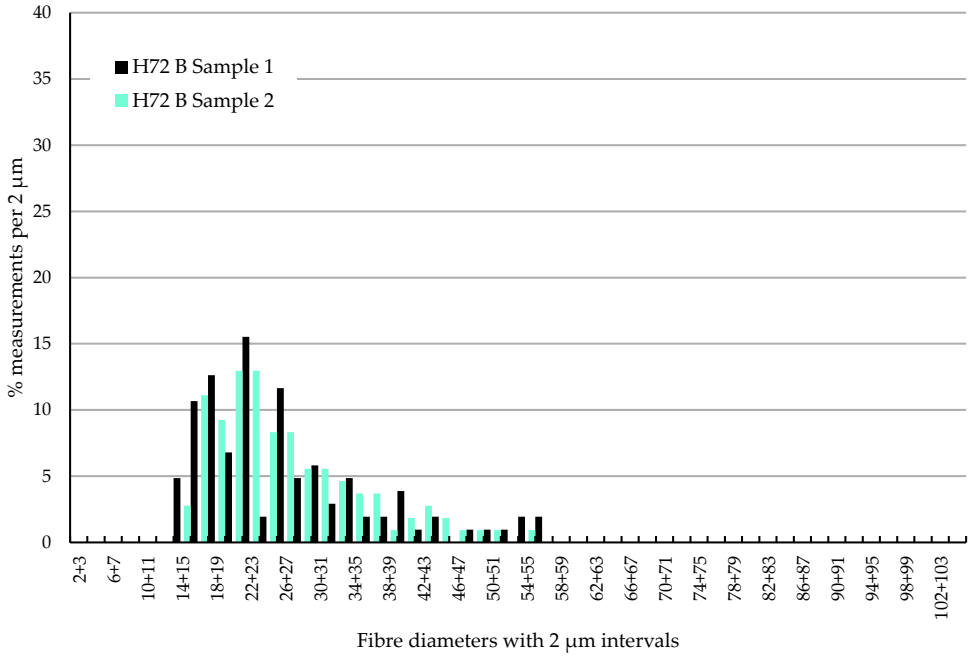


► Fig. 12.42: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.43: The two yarns have similar fibre contents and appear to be processed in the very same manner. The results correspond well to Spelsau 3.



◄ Fig. 12.44: The two yarns have similar cohesive ranges and heights of the bars trailing off towards the right.

Hedeby Harbour, H72C. Tabby

► Table 12.12: Analyses of samples from the warp and weft

Fibre colour	White/unpigmented or light shades of brown
Fibre distribution	The contents of medium fibres in the two yarns are similar but, in the warp, the remaining fibres are evenly distributed between fine and coarse fibres while in the weft only very few coarse fibres have been recorded resulting in the content of fine fibres being equal to the medium fibres
Resemblance to modern primitive sheep	The warp and the Gotland wool and the undercoat from the Spelsau Fleece 1 have similar results. The weft is comparable to the Värmland Fleece 0
Comments to diagrams	Cumulative frequency diagram: Warp and weft are separated by a small gap resulting from the differences in the contents of fine and coarse fibres. The Spelsau Fleece 1 undercoat appears to be the best match for the warp. The Värmland wool differs from the weft in the contents of fine and medium fibres which result in the deviations in the curves Histograms: The two samples appear quite similar, but the weft has slightly higher peaks towards the left
Category definitions	C: 66% below 30, 10% above 45, 1% above 50 microns CD: 80% below 40, 20% above 40, 2% above 60 microns D: 66% below 40, 34% above 40, 5% above 60 microns
Warp/weft fibre combination	2b
Further comments	-
No. of micrographs	216

Calculations of fibre measurements in microns

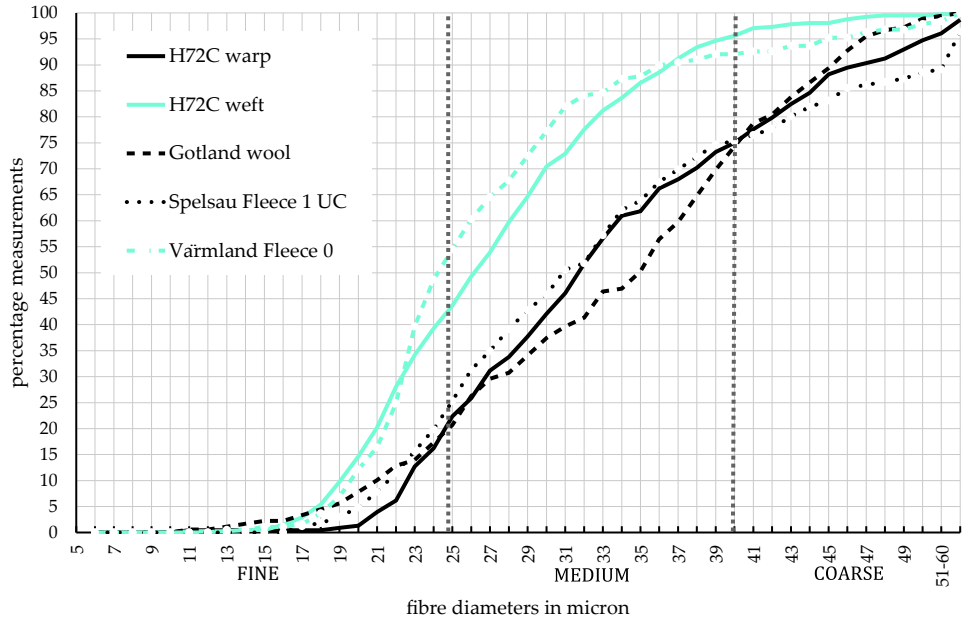
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	26	49	25	1	10, 18-53, 55, 61, 65, 68	D	228
Weft	49	46	5	0	10, 13, 15-43, 45-47, 50, 62	C	410
Gotland	26	48	26	0	10, 12-14, 16-51	CD	179
Spelsau Fl. 1 UC	31	44	25	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

► Fig. 12.45: Textile H72 C. Upper garment. Tabby.

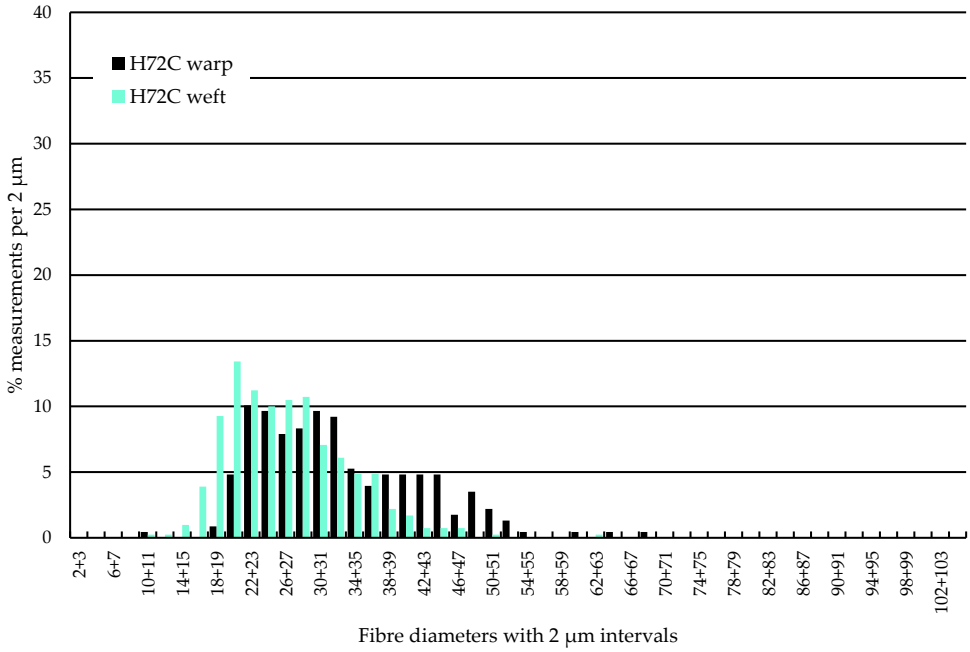
Photo: Charlotte Rimstad

◄ Fig. 12.46: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.47: The warp has a majority of medium fibres and equal contents of fine and coarse. The weft has a large majority of fine and medium fibres and very few coarse. The differences create a gap between the two curves and indicates differences in the processing. Both Gotland wool and the undercoat from Spelsau 1 correlate with the warp while Värmland 0 is the best match for the weft.



◄ Fig. 12.48: The two yarns have almost similar cohesive ranges but differ in the heights of the bars.

Hedeby Harbour, H91A. Tabby

► Table 12.13: Analyses of samples from the warp and the weft.

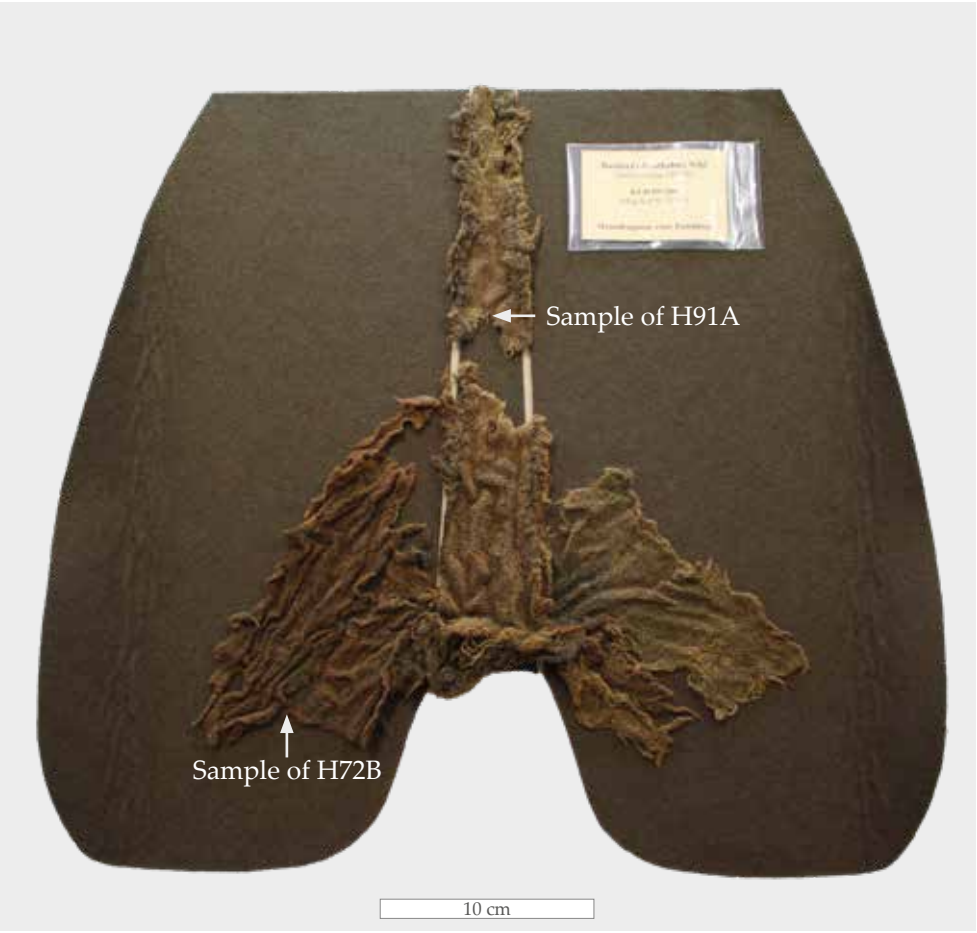
Fibre colour	Mostly white/unpigmented, some with lighter shades of brown
Fibre distribution	Fine fibres constitute the majority in both warp and weft, but a larger majority in the weft with fewer medium fibres as result. Only few coarse fibres have been recorded
Resemblance to modern primitive sheep	The Spelsau Fleece 3 is comparable to the warp in respect to fine and medium fibres but has more coarse fibres. The Gute wool corresponds to the weft
Comments to diagrams	Cumulative frequency diagram: The differences in the fibre distributions in the warp and weft are seen clearly, as is the comparability to the modern wool samples Histograms: Only a couple of high peaks in the weft are indicative of the differences in the contents of fine fibres
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	2b
Further comments	The fibre distribution in the warp corresponds to sample 1 in H72A. It is possible that the observed differences are due the randomness of sampling
No. of micrographs	180

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	57	34	9	2	14-39, 41-43, 46, 48, 55, 67, 69	CD	122
Weft	72	23	5	1	13-37, 39, 41-42, 44, 46, 49, 51, 64	CD	165
Spelsau Fl. 3	57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256

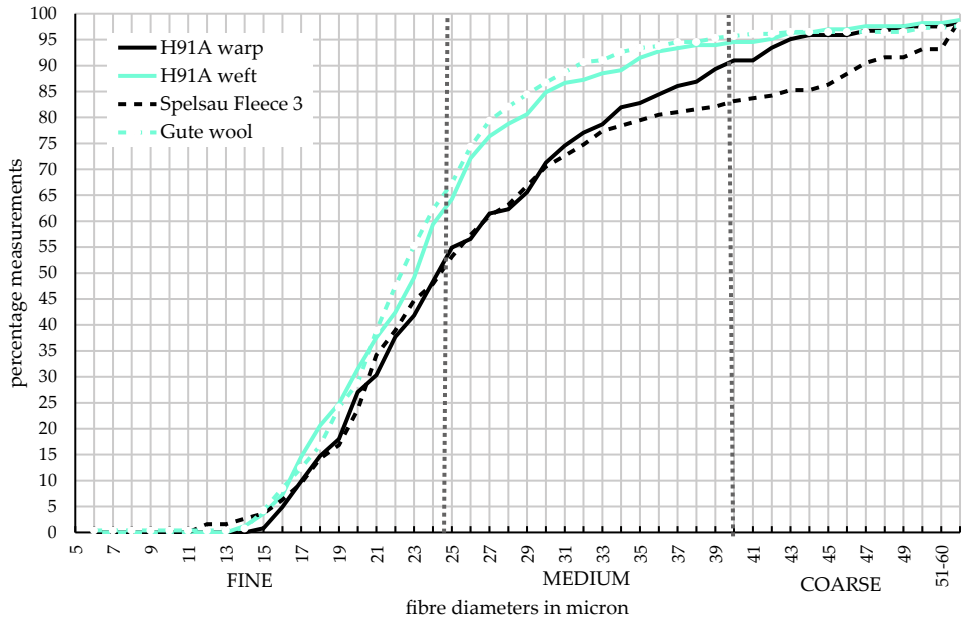
► Fig. 12.49: Textile H91 A. Part of H72 A-B. Tabby.

Photo: Charlotte Rimstad

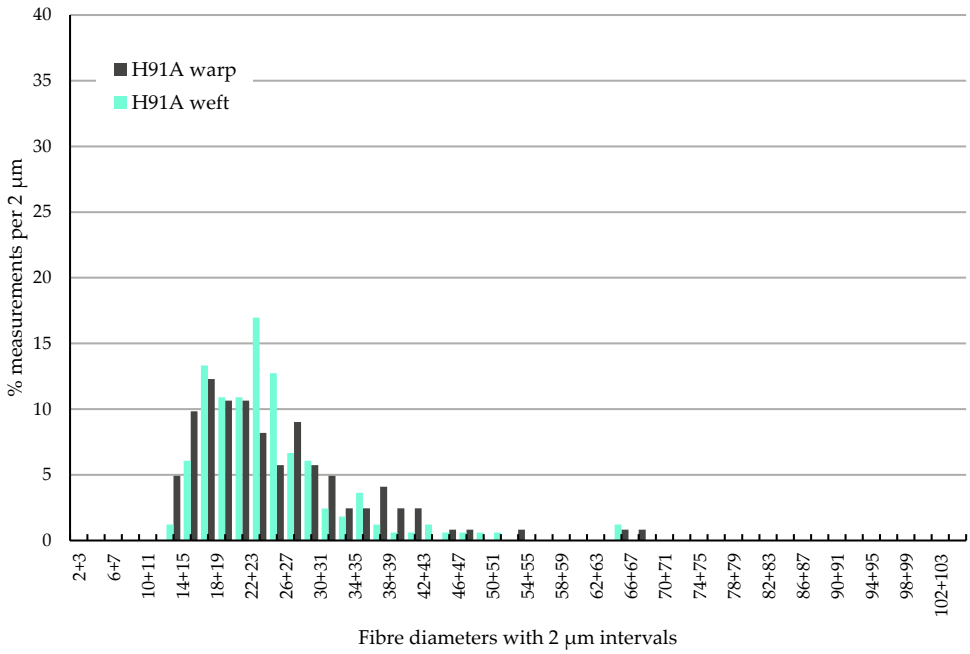


◄ Fig. 12.50: Enlarged detail of the yarns.

Photo: Charlotte Rimstad



◄ Fig. 12.51: Both warp and weft have a majority of fine and medium fibres but differ in regards to the specific contents resulting in a slightly steeper weft curve. Although these differences seem small they have most likely been decisive for the choice of yarn for warp and weft. Spelsau 3 correlates well with the warp and Gute wool with the weft.



◄ Fig. 12.52: Almost identical sizes of the bars representing the two yarns are seen excepting one tall weft peak above 15%. They both increase and decrease evenly ending in a few scattered bars. Based on this diagram the results do not indicate major differences in warp and weft.

Hedeby Settlement, S3. 2/2 twill with nap

► Table 12.14: Analyses of samples from the warp and the weft

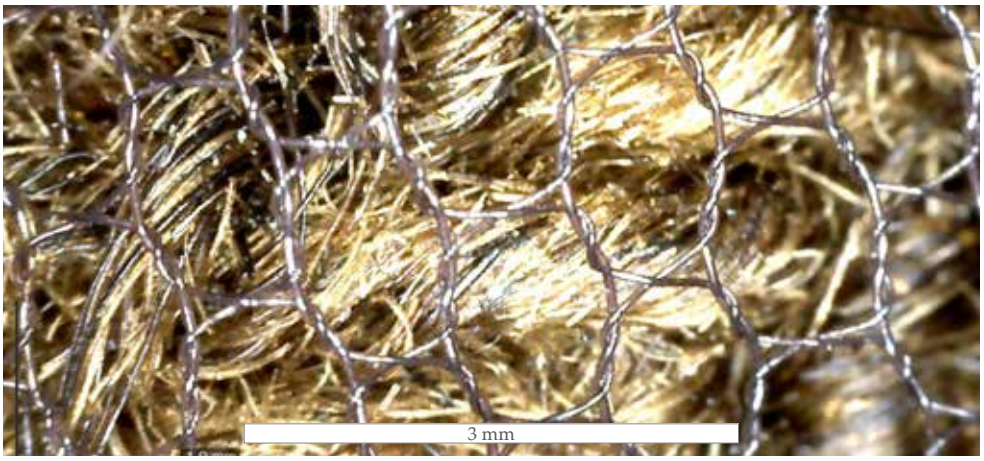
Fibre colour	A mixture of white/unpigmented and different shades of brown
Fibre distribution	The two yarns in this textile have similar percentages of medium fibres. The warp has a low percentage of fine and a high percentage of coarse fibres and this is reversed in the weft
Resemblance to modern primitive sheep	The overcoat Spelsau Fleece 1 has closest resemblance to the warp in respect to the coarse fibres but deviates in the exact amounts of the three fibre types. The Värmland Fleece 0 corresponds well with the weft
Comments to diagrams	Cumulative frequency diagram: The large gap between the warp and weft is indicative of their differences. The differences between the warp and the modern wool appear more distinct than the calculations suggest Histograms: The warp has a wide range, many low and uneven peaks. The large amount of fine and medium fibres in the weft is indicated by higher peaks centered around c. 25 microns
Category definitions	The fibre distribution in the warp and the Spelsau Fleece 1 do not match any of the categories CD: 80% below 40, 20% above 40, 2% above 60 microns
Warp/weft fibre combination	2A
Further comments	-
No. of micrographs	197

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	7	32	61	10	19, 21-59, 61, 63-64, 66, 68, 70-71, 74-75	no	118
Weft	58	35	7	2	15-34, 36-39, 44-45, 48-50, 53, 57, 61, 63, 81	CD	187
Spelsau Fl. 1 OC	4	21	75	20	21, 23, 26, 30-35, 37-38, 40-41, 43-54, 56-58, 60-64, 66-67, 72, 79	no	75
Värmland Fl. 0	60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

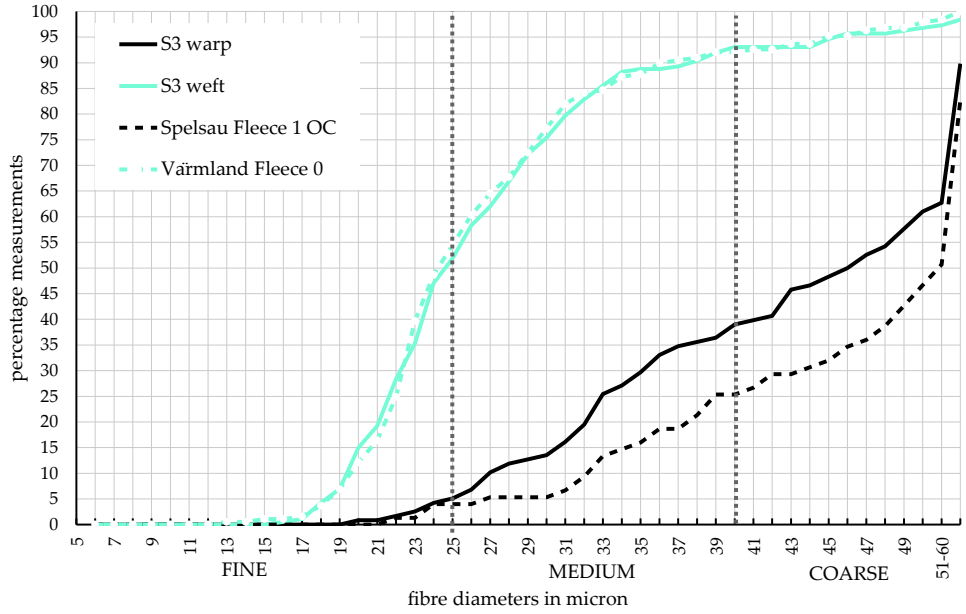
► Fig. 12.53: Textile S3. Liripipe hood. 2/2 twill.

Photo: Roberto Fortuna

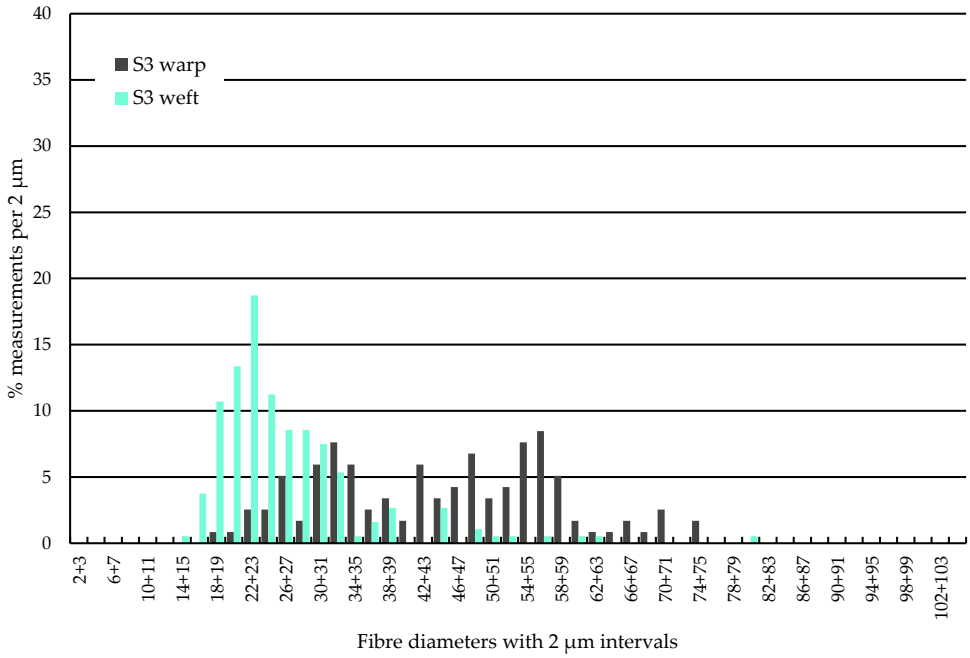


◄ Fig. 12.54: Enlarged detail of the yarns visible behind a protective net.

Photo: Charlotte Rimstad



◄ Fig. 12.55: The warp has a majority of coarse fibres, the weft of fine fibres while the contents of medium fibres are equal. This results in a large gap between the two curves. The two yarns could be from similar raw material. The warp is compared to the overcoat from Spelsau 1 differs in the medium and fine ranges. The weft and Värmland 0 have identical curves.



◄ Fig. 12.56: Both yarns have broad ranges but the fibre content in the warp creates several low bars of uneven heights while the size of the weft bars increase and decrease evenly and continues towards the right with low and scattered bars.

Hedeby Settlement, S26. 2/2 herringbone twill

► Table 12.15: Analysis of one sample from the warp

Fibre colour	Mostly white/light and some with different shades of brown
Fibre distribution	A large majority of medium fibres and only few coarse fibres have been recorded
Resemblance to modern primitive sheep	The Svärdsjö wool has comparable results with minor deviations
Comments to diagrams	Cumulative frequency diagram: The deviations of the modern wool cause the two curves to separate in the fine range and towards the coarse range Histograms: The concentrations of fine and medium fibres give a short range to the histogram and a relatively even outline
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The yarn appears made from wool with predominately medium fibres from which coarser fibres have been removed. Equivalent fibre distribution is seen in the felt item H14D
No. of micrographs	92

Calculations of fibre measurements in microns

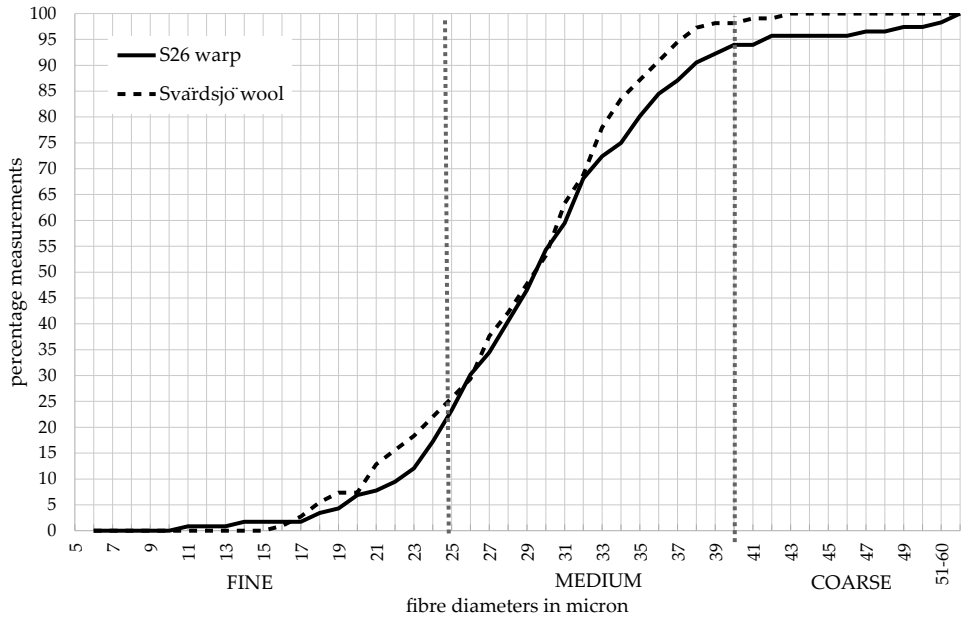
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	30	64	6	0	10, 13, 17-39, 41, 46, 48, 50, 53	CD	116
Svärdsjö	29	69	2	0	15-18, 20-38, 40, 42	CD	109

► Fig. 12.57: Textile S26. Band. 2/2 herringbone twill.

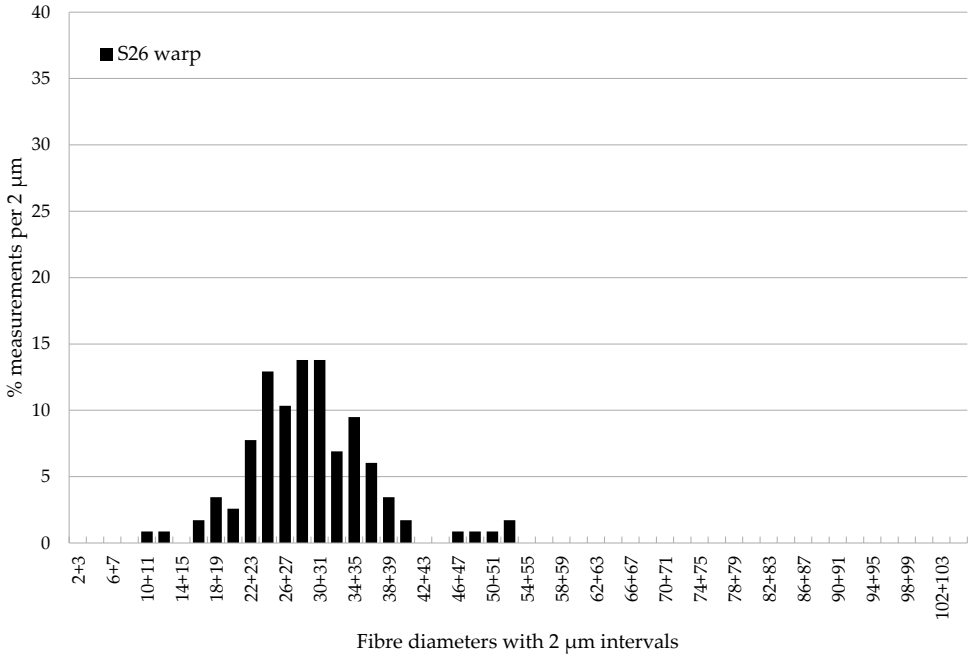
Photo: Roberto Fortuna

► Fig. 12.58: Enlarged detail of the yarns visible behind a protective net.

Photo: Charlotte Rimstad



◄ Fig. 12.59: This warp has a large majority of medium and fine fibres resulting in a steep curve.The results correlate well with the Svärdsjö wool.



◄ Fig. 12.60: The heights of the bars increase and decrease almost symetrically around the tallest peaks reaching almost 15% of the results.

Hedeby Settlement, S28. 2/2 twill

► Table 12.16: Analyses of samples from the warp and the weft

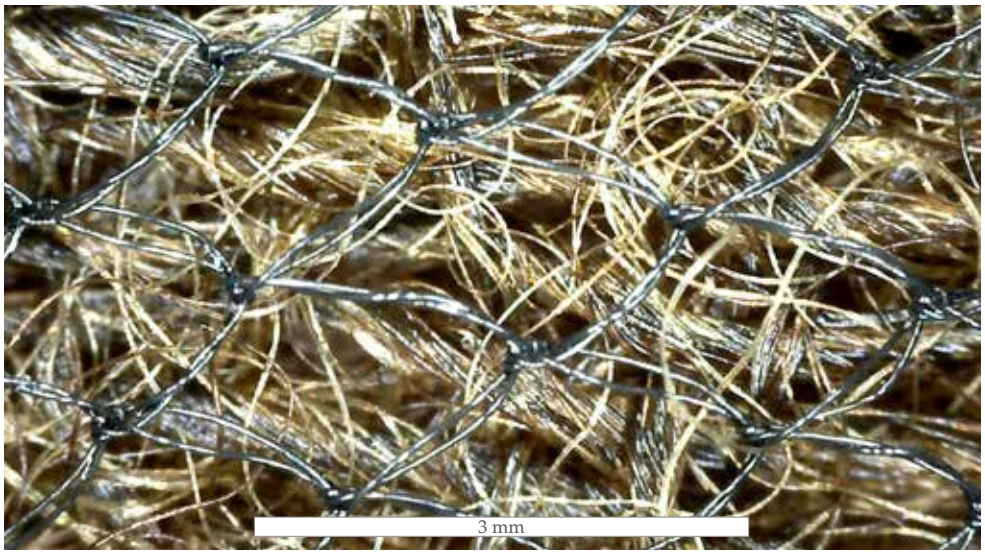
Fibre colour	Mainly white, few with light shades of brown
Fibre distribution	In both warp and weft, the majority of fibres are fine. The warp also has a large content of medium and coarse fibres while fewer of these fibre types are recorded in the weft
Resemblance to modern primitive sheep	The Klövsjö wool is comparable to the warp but has slightly fewer medium and more coarse fibres. The Gute wool has almost as many fine fibres as the weft and is as such the most comparable of the modern wool samples
Comments to diagrams	Cumulative frequency diagram: The weft has a steeper curve because of the large content of fine fibresalso causing the seperation of the Gute wool curve in this range. The Klövsjö wool separates from the warp towards the end of the curve Histograms: The two yarns appear quite similar in the distribution of the peaks
Category definitions	AB: 80% below 30, 15% above 30, 2% above 40, max. 60 microns CD: 80% below 40, 20% above 40, 2% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns
Warp/weft fibre combination	1b
Further comments	-
No. of micrographs	189

Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Warp	50	34	16	1	13-30, 32-42, 44-45, 47-52, 61	CD	124
Weft	80	19	1	0	11-38, 43, 46-47	AB	228
Klövsjö	52	25	23	7	11-40, 42-52, 54, 56-60, 62-66, 68, 70, 73, 77	E	204
Gute	74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256

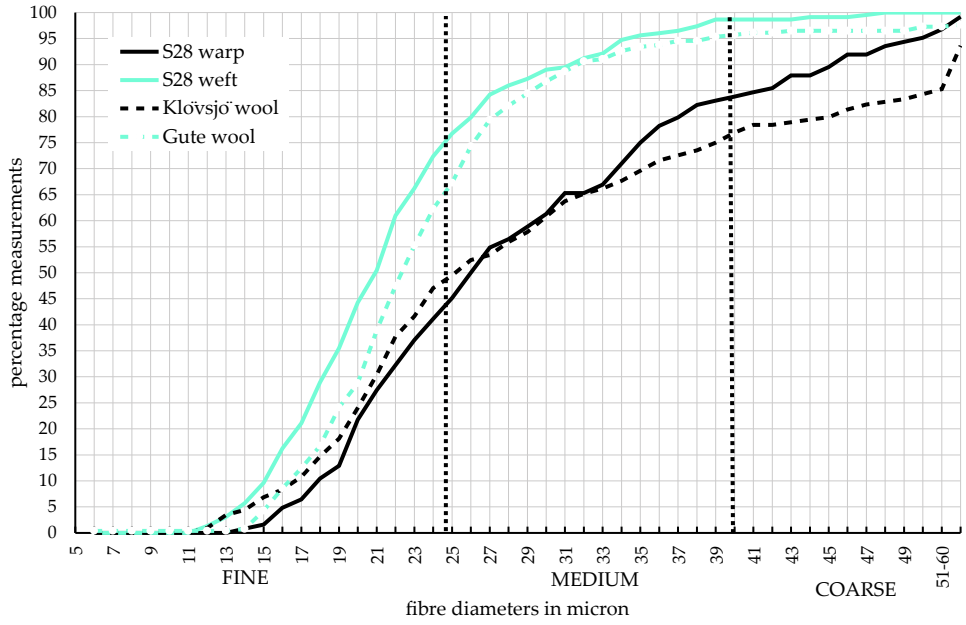
► Fig. 12.61: Textile H 28. Upper garment. 2/2 twill.

Photo: Roberto Fortuna

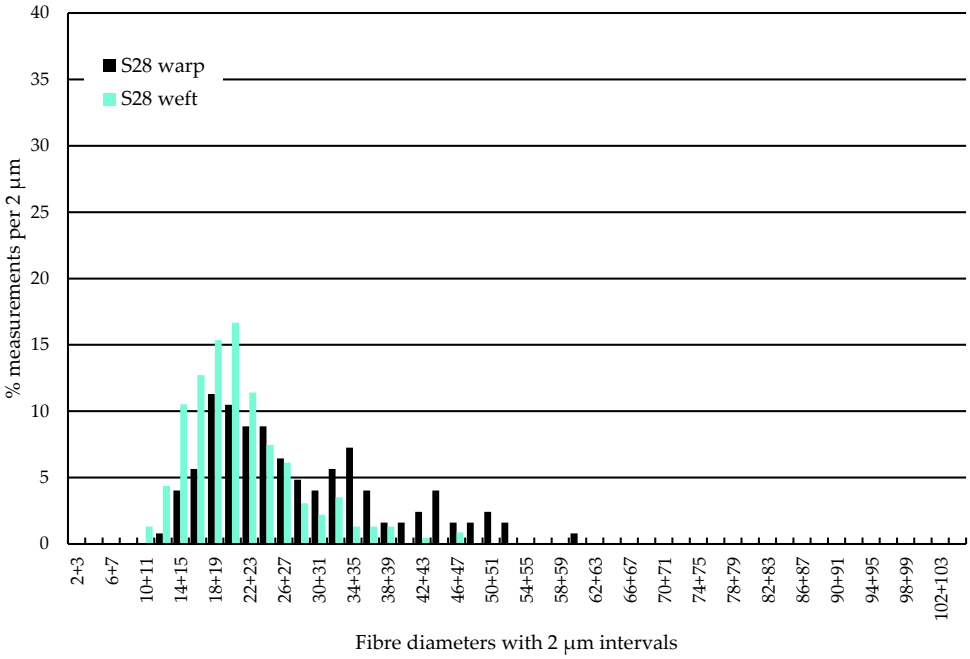


◄ Fig. 12.62: Enlarged detail of the yarns visible behind a protective net.

Photo: Charlotte Rimstad



◄ Fig. 12.63: The majority of fibres consist of fine and medium fibres in both warp and weft, but the specific contents are larger in the weft resulting in a gap between the two curves. These factors must have been decisice for the choice of yarn for warp and weft. Gute wool has the closest resemblance to the weft although not as many fine fibres. Klövsjö wool correlates with the warp.



◄ Fig. 12.64: The cohesive ranges are similar and the contents of similar fibres increase evenly until slightly above 10 and 15% in the case of the warp and weft respectively

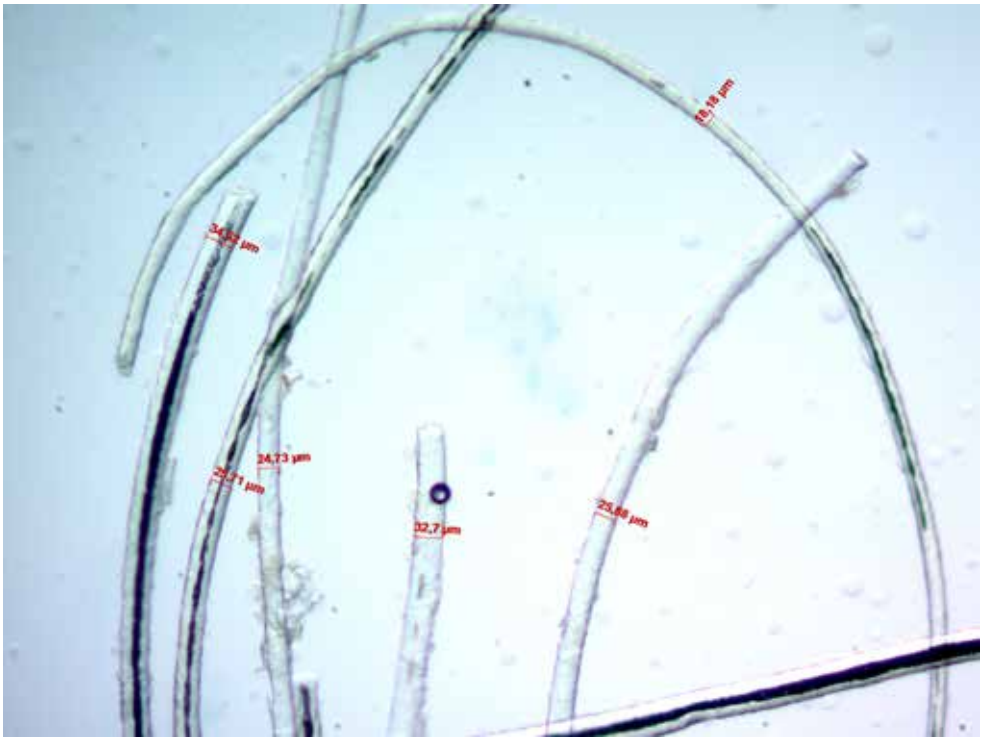
Appendix modern sheep breeds

Blue-Faced Leicester sheep

► Table 13.1: Fibre analysis results.

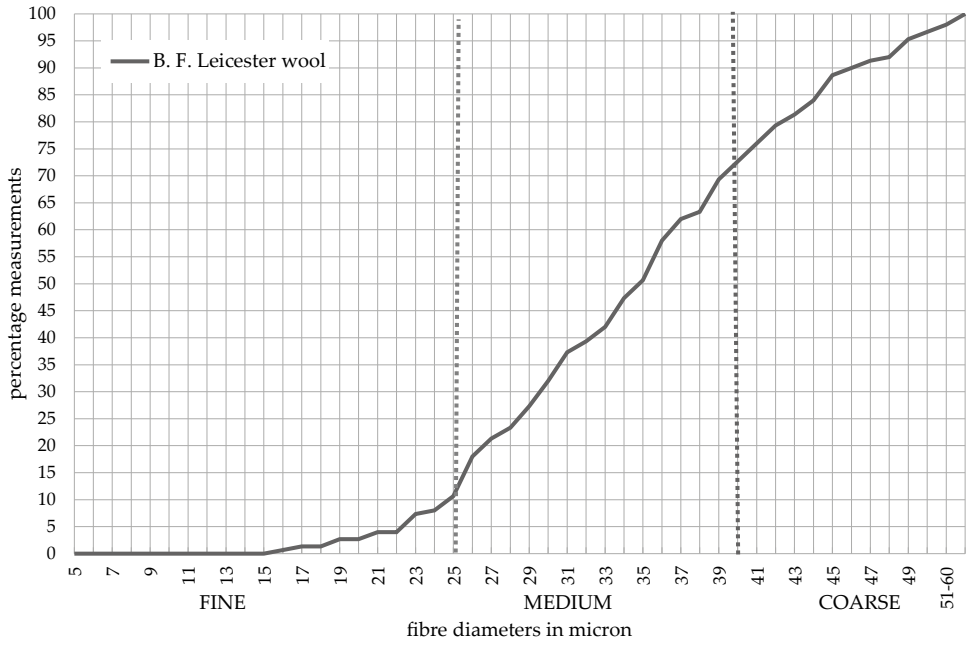
Fibre colour	White. Many fibres with distinct medulla
Fibre distribution	Medium fibres constitute the majority of the measurements, and the content of coarse fibres is slightly larger than the fine
Comments to diagrams	Cumulative frequency diagram: The large amount of medium fibres gives steepness to the curve in that range Histograms: The bars form a nice curve centered around 36 microns with only a few irregular peaks
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns
Further comments	The fibre combination resembles the Roslag wool
No. of micrographs	63

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
18	55	27	0	15-16, 20, 22-52, 57	D	150

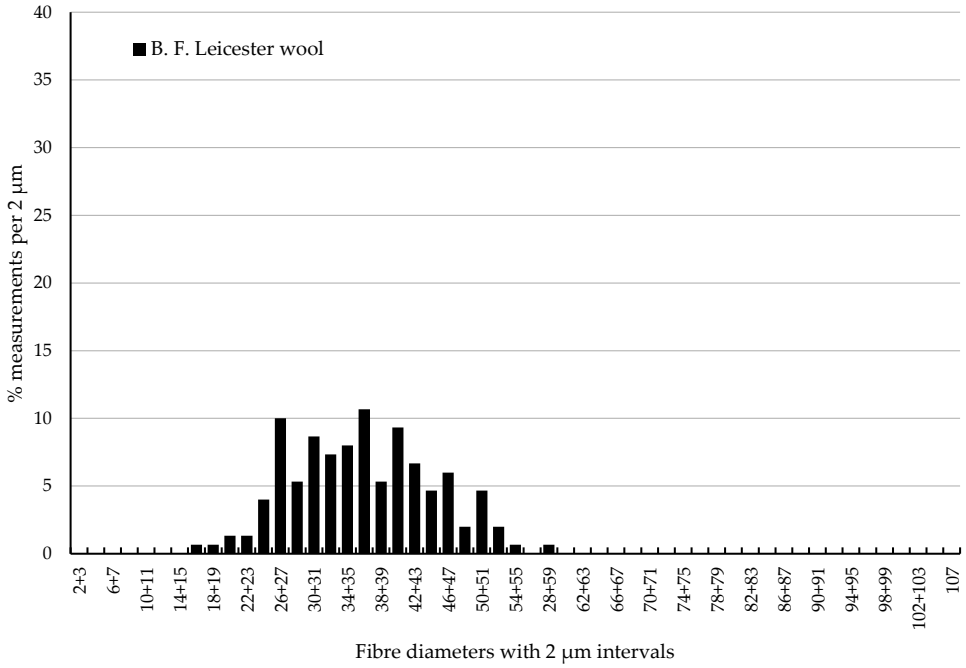


► Fig. 13.1: The Blue-Faced Leicester fibres are unpigmented. The dark lines indicate that the fibres have hollow centers.

Photo: Irene Skals



◄ Fig. 13.2: The large content of medium fibres gives a steep curve in that range.



◄ Fig. 13.3: The distribution of fibres gives a narrow cohesive range and varying concentrations of similar fibres below 10%.

Gotland sheep

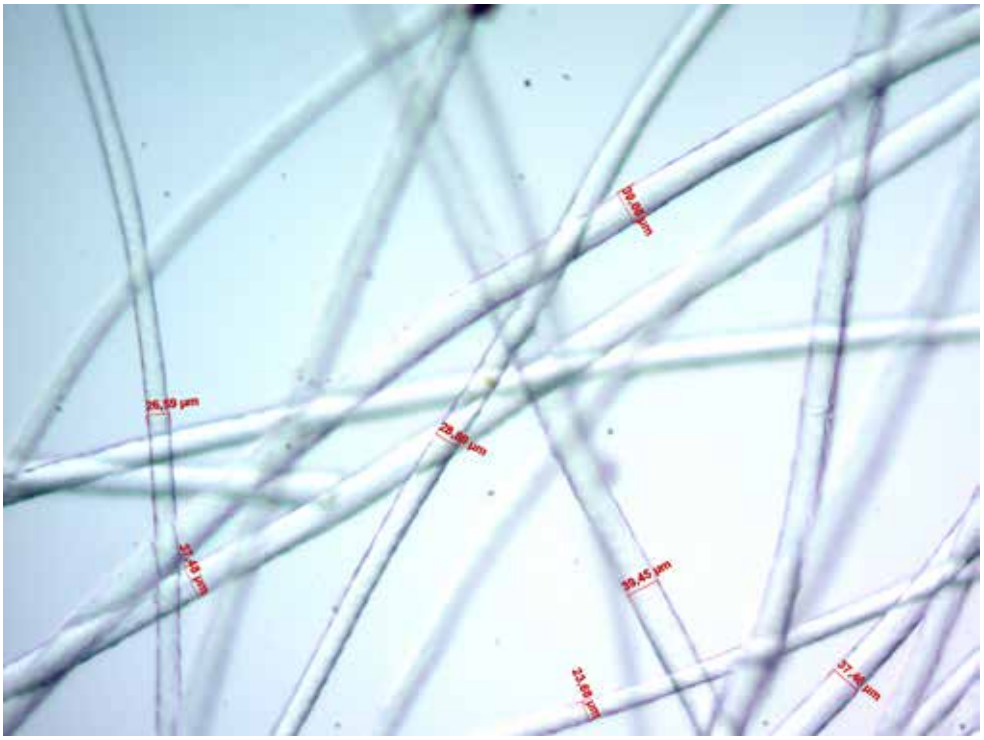
► Table 13.2: Fibre analysis results

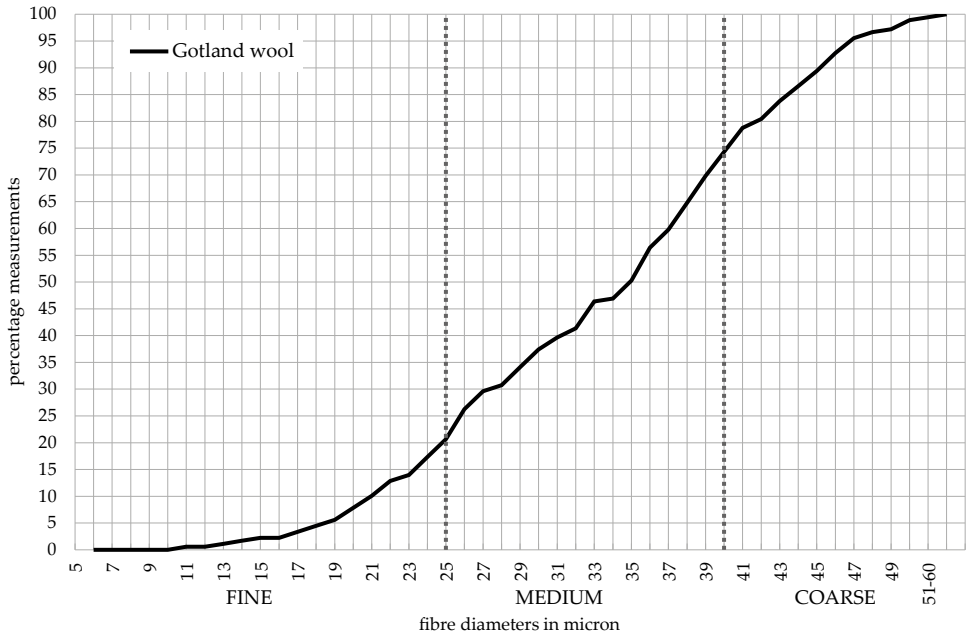
Fibre colour	White
Fibre distribution	Medium fibres constitute the majority and equal amounts of fine and coarse fibres are recorded
Comments to diagrams	Cumulative frequency diagram: The curve has a gentle slope with similar start and finish Histograms: The bars create a curve slightly skewed toward the right with fibre concentrations around 30-40 microns
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The results resemble the samples from the undercoats of the Spelsau Fleeces 1 and 4
No. of micrographs	65

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
26	48	26	0	10, 12-14, 16-51	CD	179

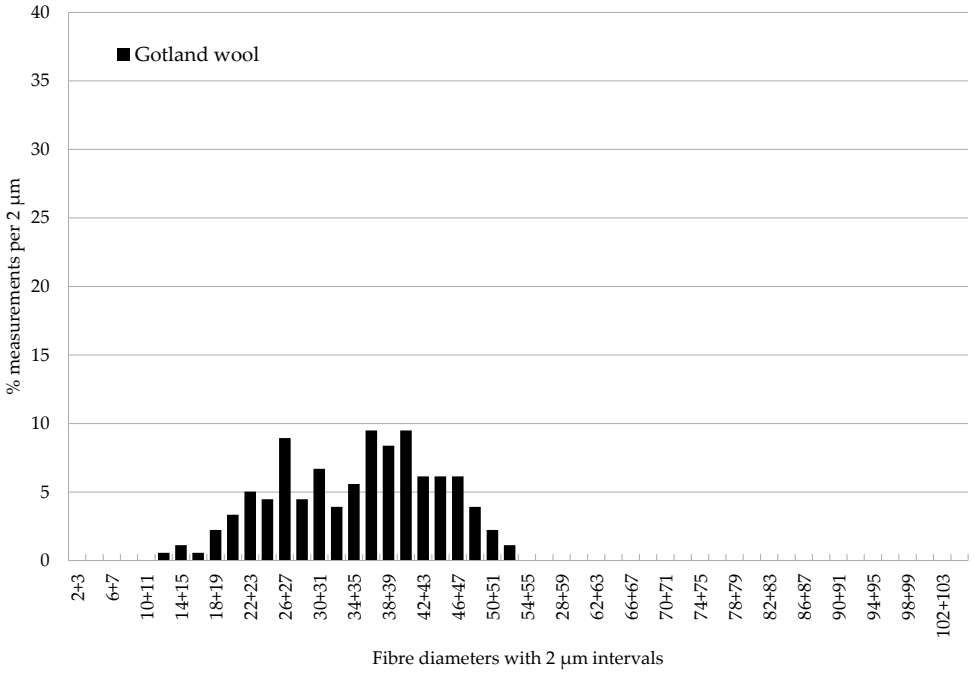
► Fig. 13.4: Gotland fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.5: A majority of medium fibres starting at 20% of the results and ending at 75% and similar contents of fine and coarse fibres give the curve a gentle slope.



◄ Fig. 13.6: The distribution of fibres gives a narrow cohesive range and varying concentrations of similar fibres below 10%.

Gute sheep

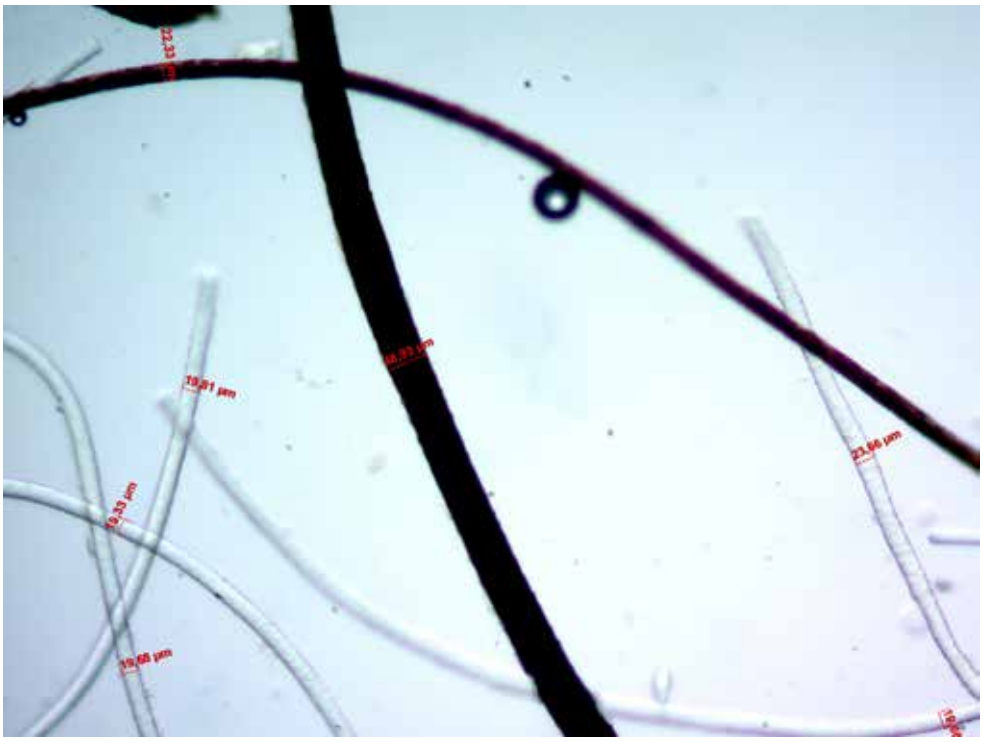
► Table 13.3: Fibre analysis results.

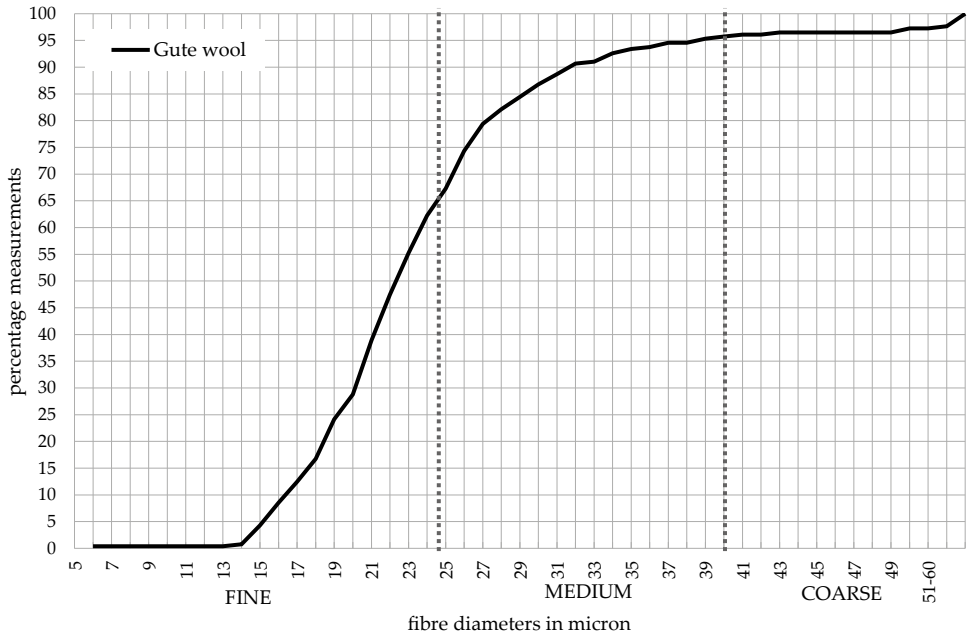
Fibre colour	White and pigmented fibres
Fibre distribution	A large majority is fine with very few coarse fibres
Comments to diagrams	Cumulative frequency diagram: The curve is steep through the fine range and has almost reached 100% before the coarse range Histograms: High peaks are formed between c. 22-29 microns and the random coarse fibres give low peaks towards the end
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	None of the other primitive wool samples have similar large content of fine fibres
No. of micrographs	76

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
74	21	4	2	13-36, 38-40, 42, 49, 57, 64, 75, 80, 82, 85	CD	256

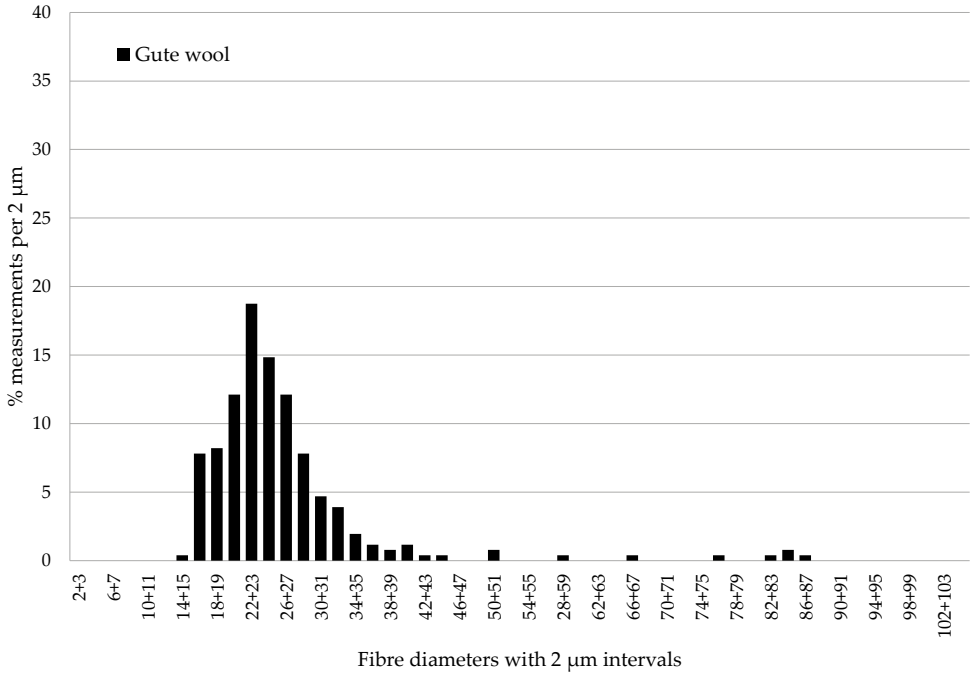
► Fig. 13.7: Gute fibres are white or heavily pigmented.

Photo: Irene Skals





◄ Fig. 13.8: A large majority of fine fibres not ending until c. 65% of the measurements gives the curve a rounded shape.



◄ Fig. 13.9: The distribution of fibres gives a narrow cohesive range with scattered low bars towards the right. The largest concentration of similar fibres is just below 20%.

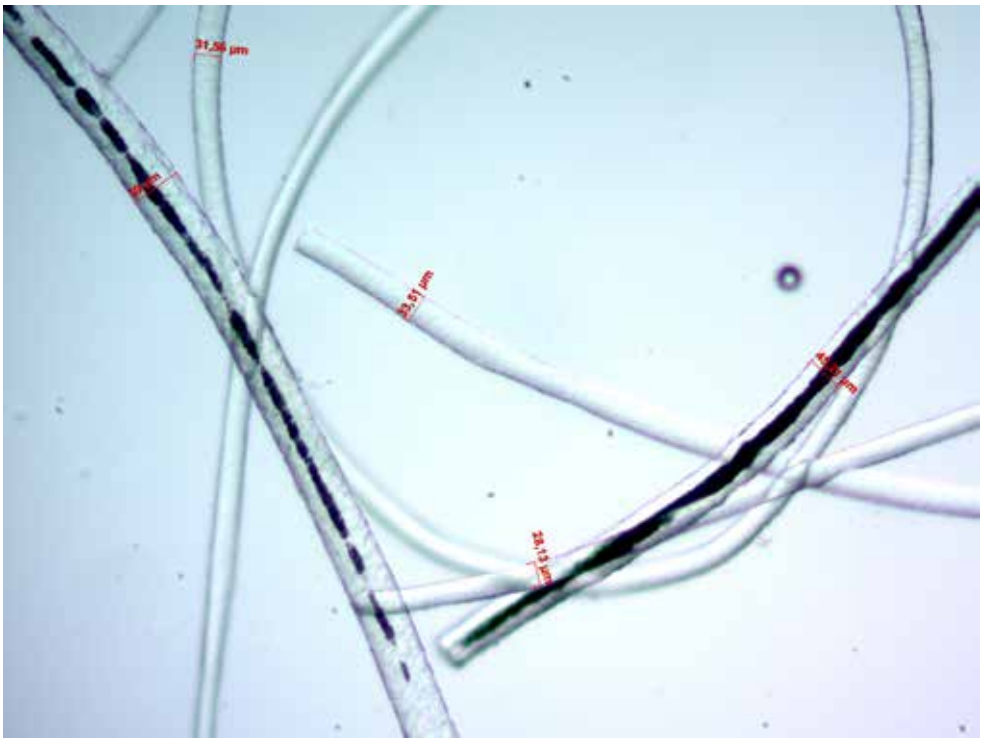
Jacob sheep

► Table 13.4: Fibre analysis results

Fibre colour	Mostly white, some with very distinct medulla
Fibre distribution	Equal amounts of medium and coarse fibres. The fine fibres constitute the smallest group
Comments to diagrams	Cumulative frequency diagram: The small content of fine fibres gives the curve a gentle start Histograms: The bars form a broad range of low, slightly uneven peaks
Category definitions	E: 60% below 40, 40% above 40, 10% above 60 microns
Further comments	The results are comparable to the overcoat sample from the Spelsau Fleece 2
No. of micrographs	90

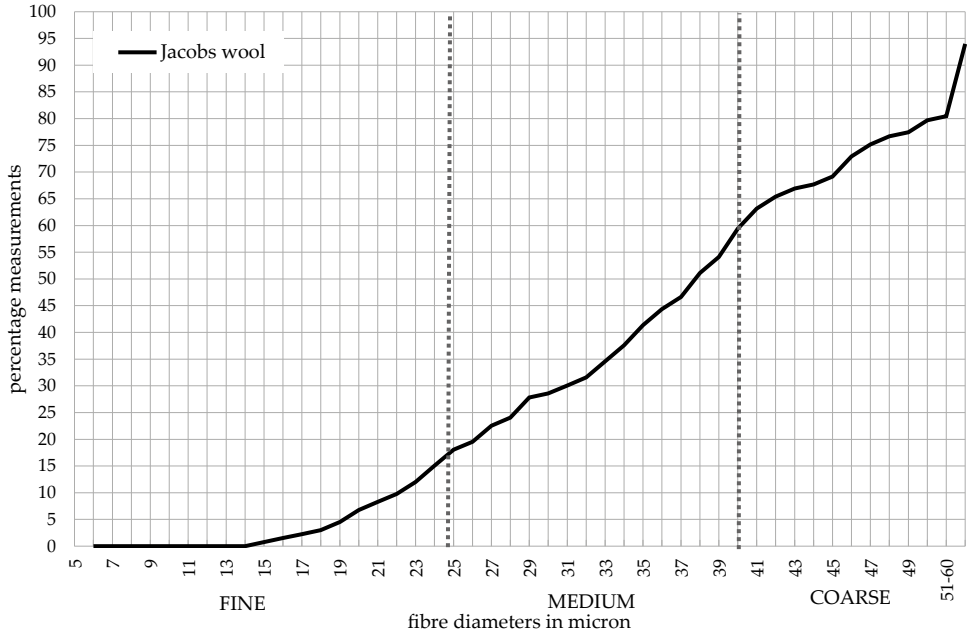
Calculations of fibre measurements in microns

% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
20	40	41	1	14-52, 54-61, 63-64, 67-68, 81	E	133

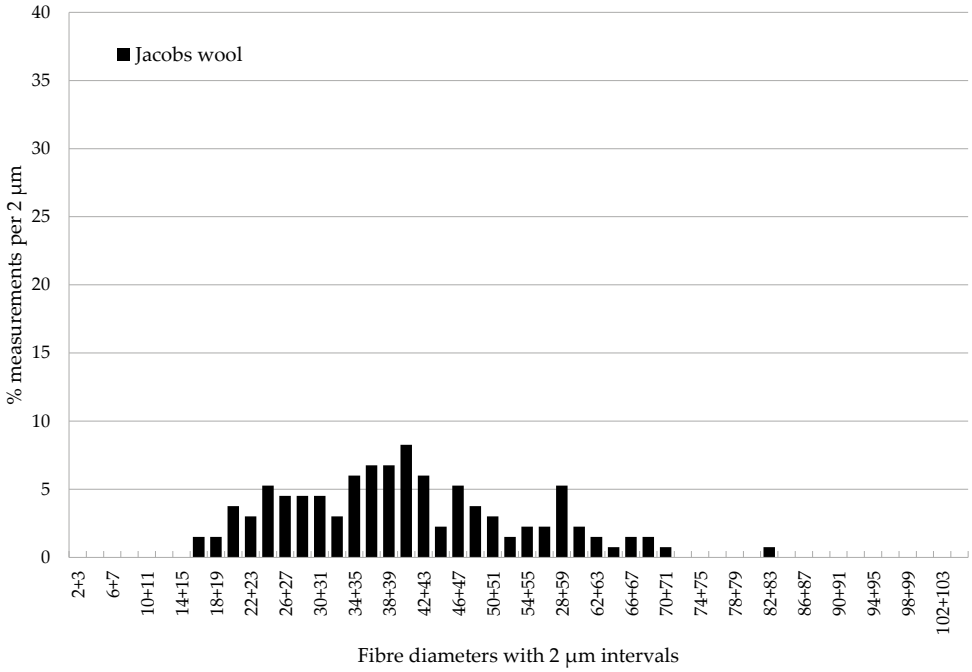


► Fig. 13.10: The Jacobs fibres are unpigmented. Hollow centers are seen in several fibres.

Photo: Irene Skals



◄ Fig. 13.11: Similar contents of medium and coarse fibres and a smaller amount of fine fibres give a slightly downward sloping curve.



◄ Fig. 13.12: The distribution of fibres gives a broad cohesive range and varying concentrations of similar fibres mainly below 5%.

Klövsjö sheep

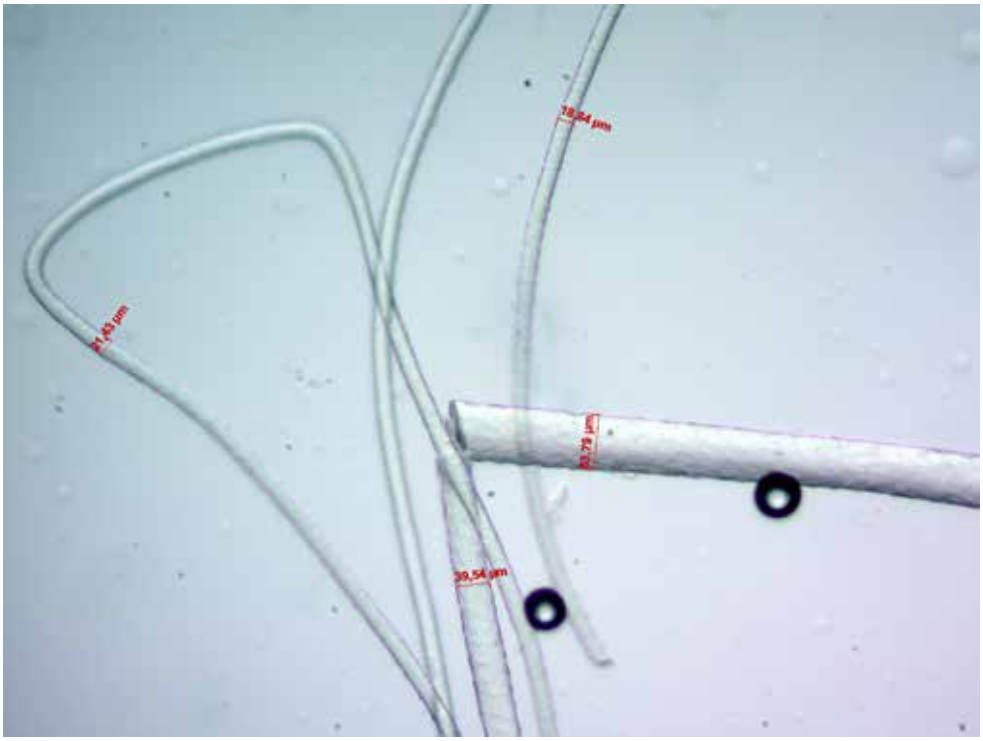
► Table 13.5: Fibre analysis results.

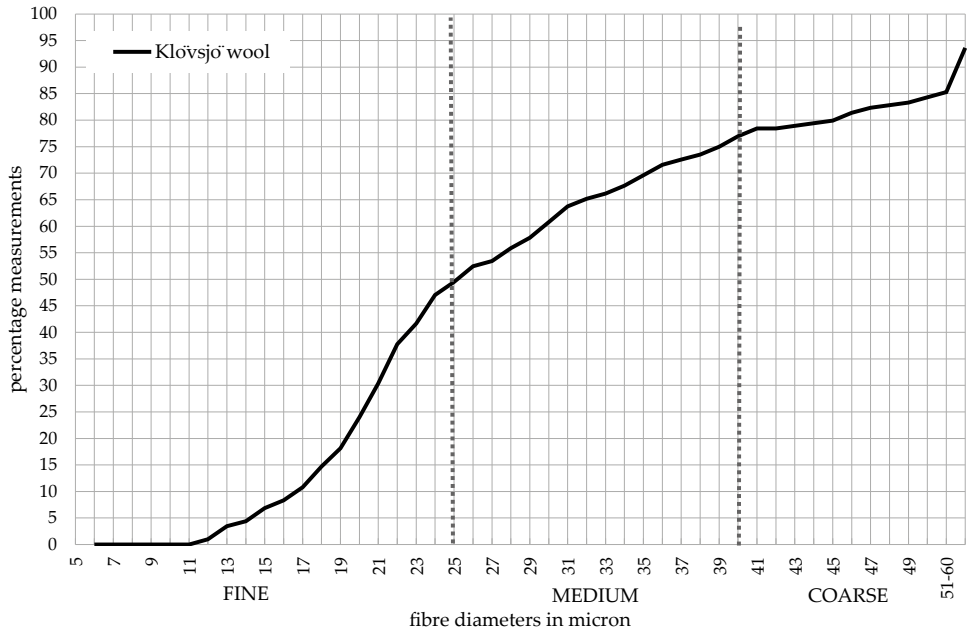
Fibre colour	White
Fibre distribution	Fine fibres constitute about half of the measurements and equal contents of medium and coarse fibres are recorded
Comments to diagrams	Cumulative frequency diagram: The results give a steep start through the fine range after which the curve flattens through the medium and coarse ranges Histograms: The bars make an even upward line until c. 24 microns after which a long, slightly uneven downward slope is formed
Category definitions	E: 60% below 40, 40% above 40, 10% above 60 microns
Further comments	The results are comparable to the Spelsau Fleece 3
No. of micrographs	105

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
52	25	23	7	11-40, 42-52, 54, 56-60, 62-66, 68, 70, 73, 77	E	204

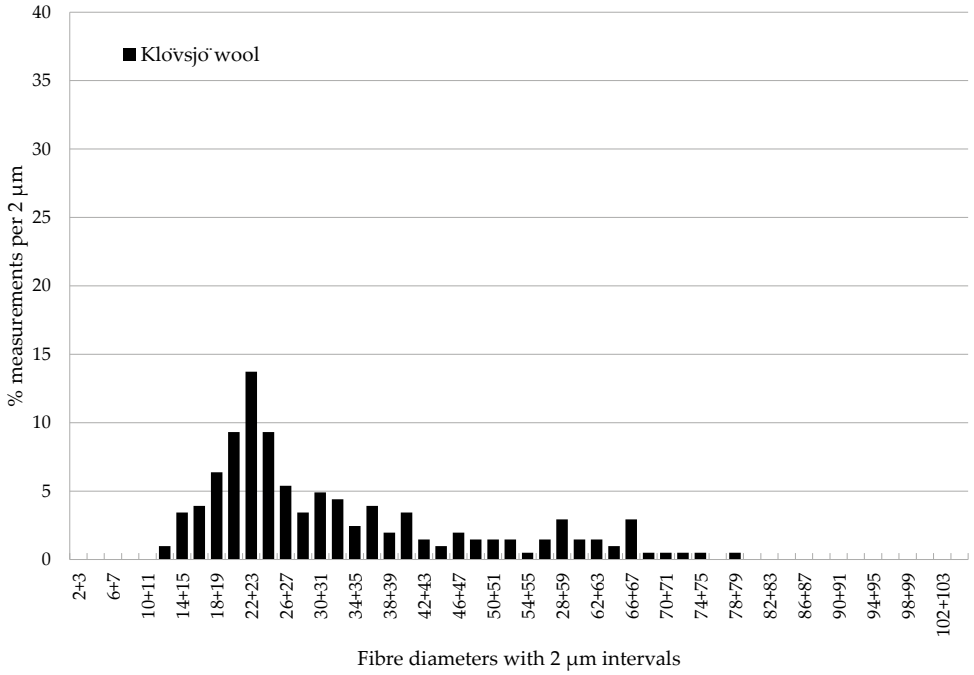
► Fig. 13.13: The Klövsjö fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.14: The majority of fine fibres and similar contents of medium and coarse fibres give the curve a rounded shape



◄ Fig. 13.15: The distribution of fibres gives a broad cohesive range. The concentration of similar fibres increases evenly until just below 15% but is otherwise seen as many low bars below 5%.

Roslag sheep

► Table 13.6: Fibre analysis results

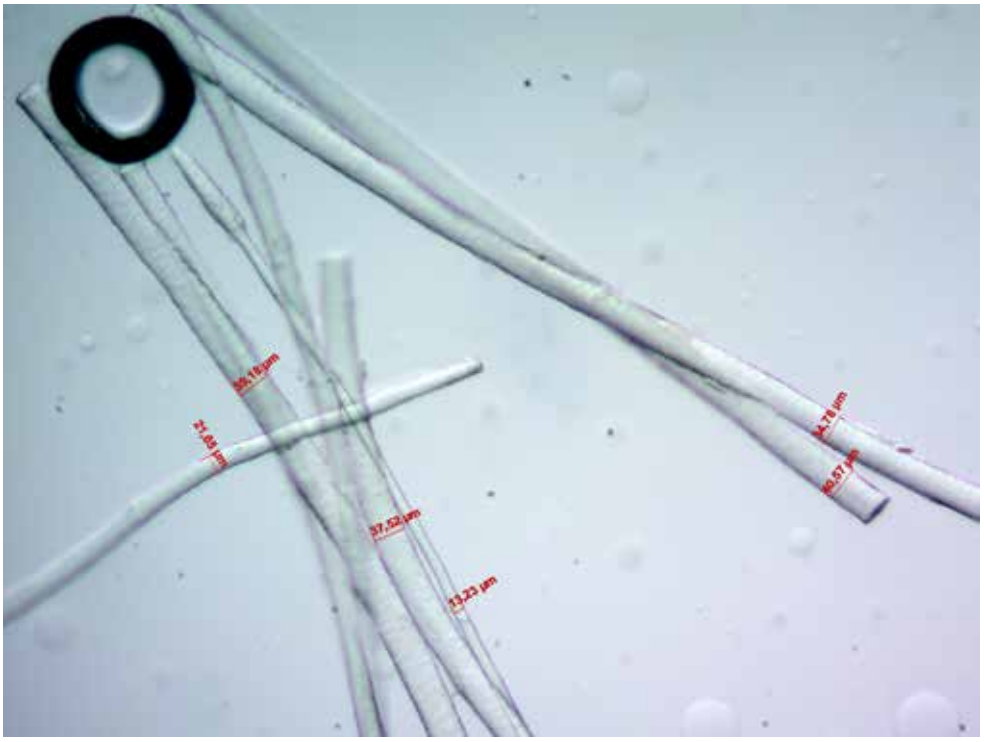
Fibre colour	White
Fibre distribution	Medium fibres constitute the majority followed by coarse and a small amount of fine fibres
Comments to diagrams	Cumulative frequency diagram: Because of the few fine fibres the curve does not start to steepen until shortly before the medium range Histograms: A broad cohesive range with few and low bars at the start several low peaks towards the coarse range
Category definitions	E: 60% below 40, 40% above 40, 10% above 60 microns
Further comments	The results are comparable to the Blue Faced Leicester wool
No. of micrographs	73

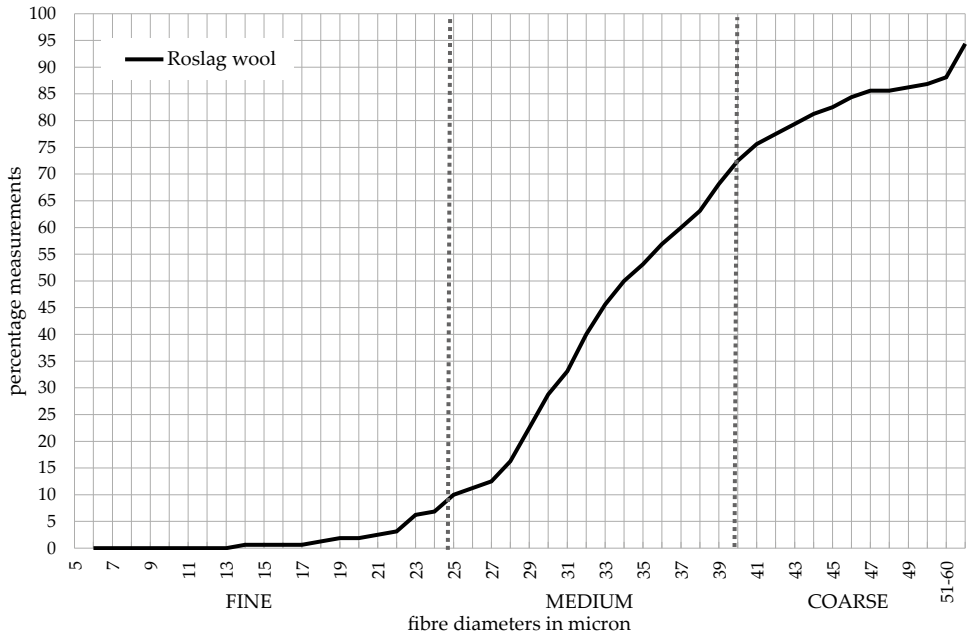
Calculations of fibre measurements in microns

% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
11	61	28	6	13, 17-18, 20-46, 48-53, 55, 57, 63, 65, 67, 72, 75, 78, 89	E	160

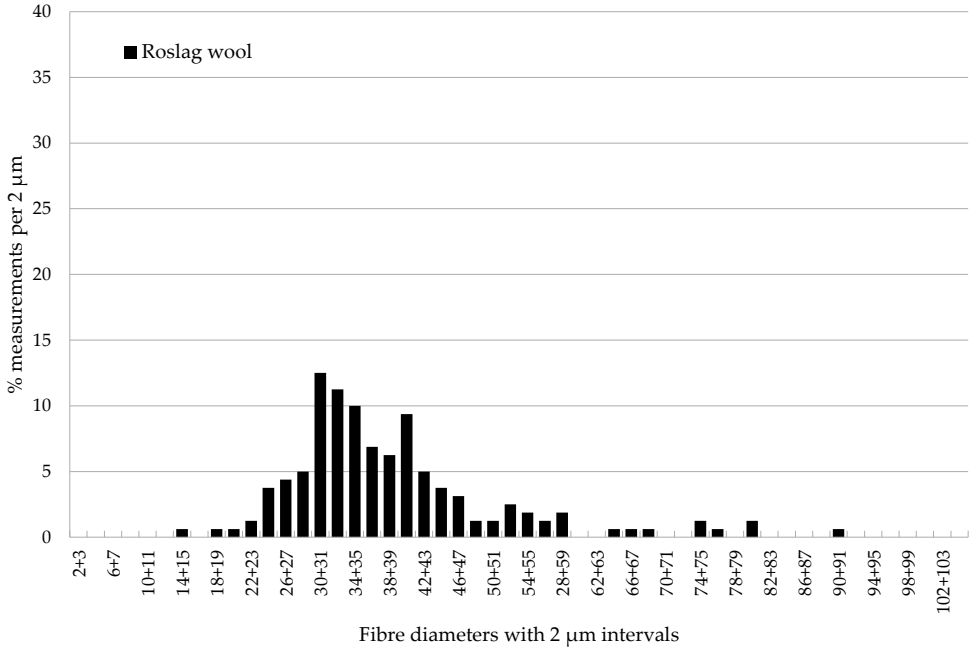
► Fig. 13.16: The Roslag fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.17: The combination of a large amount of medium and course fibres and few fine fibres gives a steep, slightly rounded curve.



◄ Fig. 13.18: The distribution of fibres gives a broad cohesive range and scattered very low bars towards the right. The largest concentration of similar fibres is above 10% and otherwise mainly below 5%.

Rya sheep (lamb)

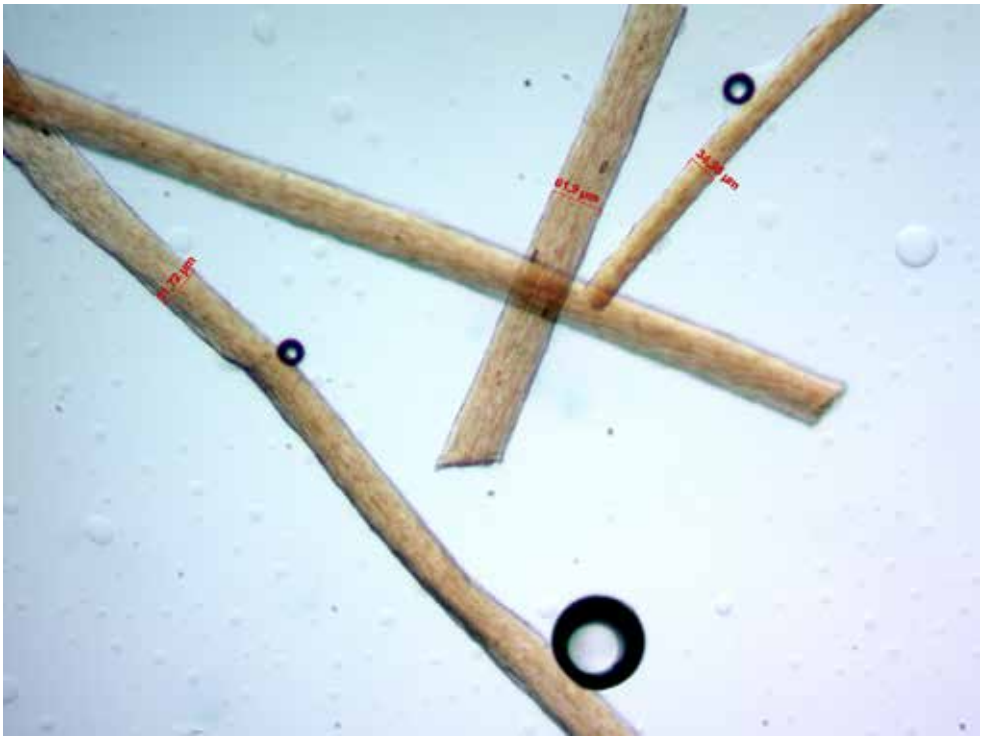
► Table 13.7: Fibre analysis results

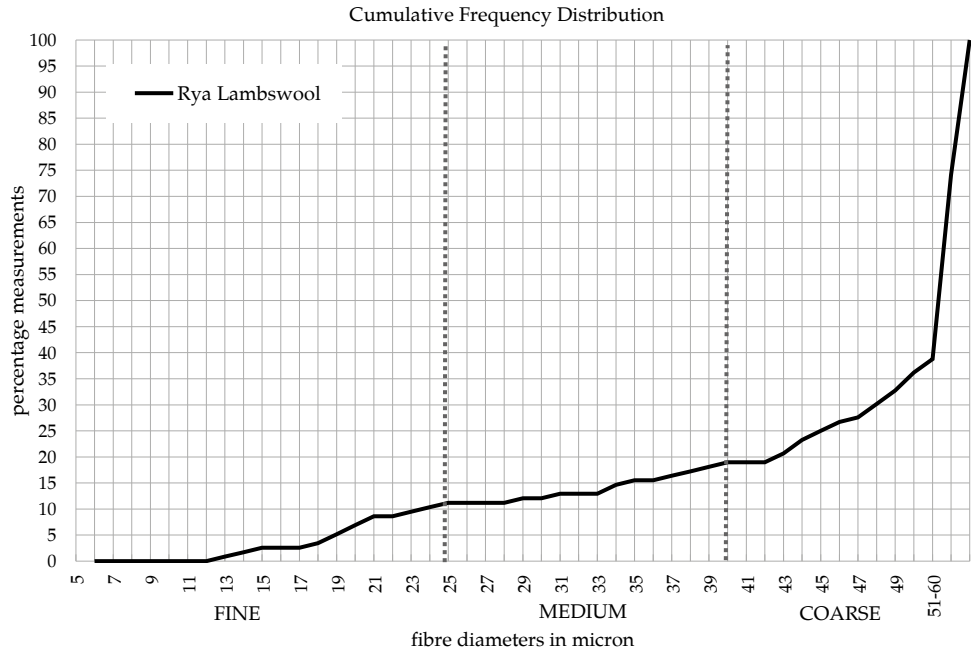
Fibre colour	Lightly pigmented.
Fibre distribution	The coarse fibres constitute a large majority of the measurements, and few fine and medium fibres have been recorded.
Comments to diagrams	Cumulative frequency diagram: The results give a very flat curve until the start of the coarse range. Histograms: The bars form a long cohesive range with an uneven upward slope and the highest peak towards the end.
Category definitions	This fibre combination does not fit any of the categories.
Further comments	The sample was labelled lambswool and a finer fibre distribution was therefore expected. The results resemble the overcoat samples from the Spelsau fleeces 1 and 4.
No. of micrographs	80

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
11	8	81	30	12-14, 17-20, 22-24, 28, 30, 33-34, 36-39, 42-64, 66-70	no	116

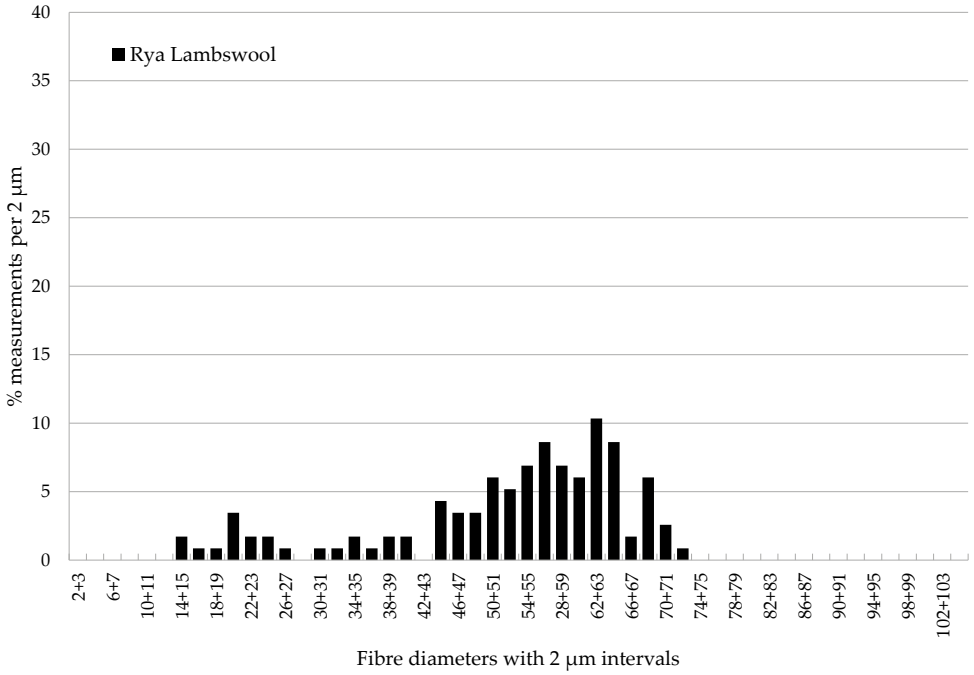
► Fig. 13.19: The Rya fibres are lightly pigmented.

Photo: Irene Skals





◄ Fig. 13.20: The very large content of coarse fibres combined with very few fine and medium fibres creates a very gentle curve well into the coarse range.



◄ Fig. 13.21: The fibre distribution gives a broad range. The concentration of similar fibres starts with several low bars below 5% and the tallest peak is 10%.

Spelsau sheep Fleece 1

► Table 13.8: Fibre analysis results of samples of over- and undercoat

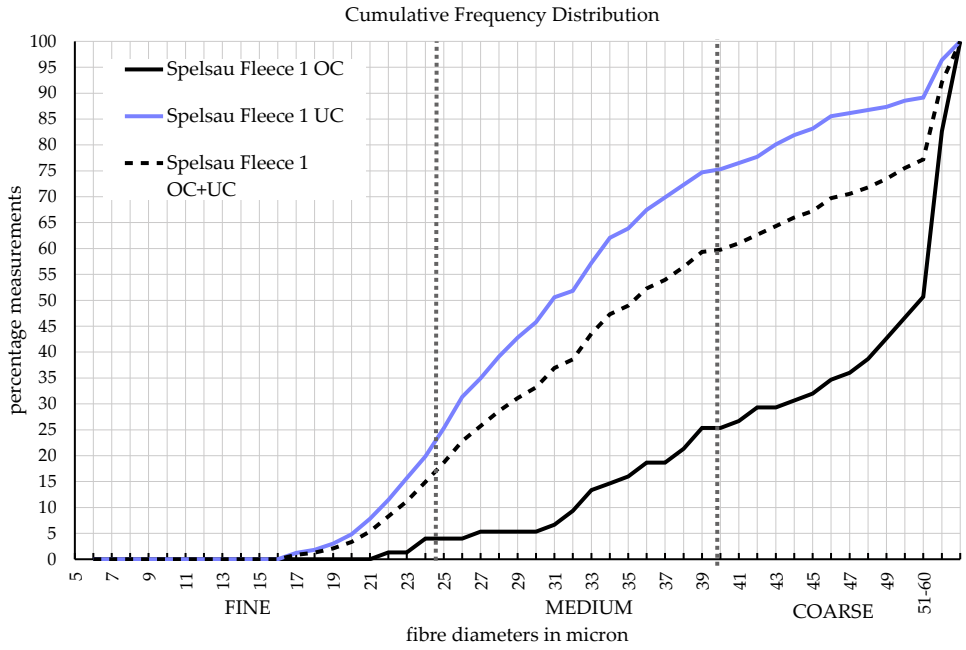
Fibre colour	A mixture of white and pigmented fibres
Fibre distribution	The overcoat has a large majority of coarse fibres and very few fine. The undercoat has a small majority of medium fibres and a slightly larger amount of fine than of coarse fibres. When added together coarse and medium fibres make up the majority
Comments to diagrams	Cumulative frequency diagram: A large gap is created between the over and undercoat. The curve of the combined results is placed in this gap, but closer to the undercoat Histograms: Both samples have broad ranges which overlap. The undercoat has the highest peaks around 28 microns and the overcoat has several slightly lower peaks around 50-60 microns
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns The fibre distribution in the overcoat sample does not fit any of the categories
Further comments	The results from the overcoat correlate with the Rya wool and the overcoat sample from the Spelsau Fleeece 4. The results from the undercoat correlate with the Gotland wool
No. of micrographs	147

Calculations of fibre measurements in microns

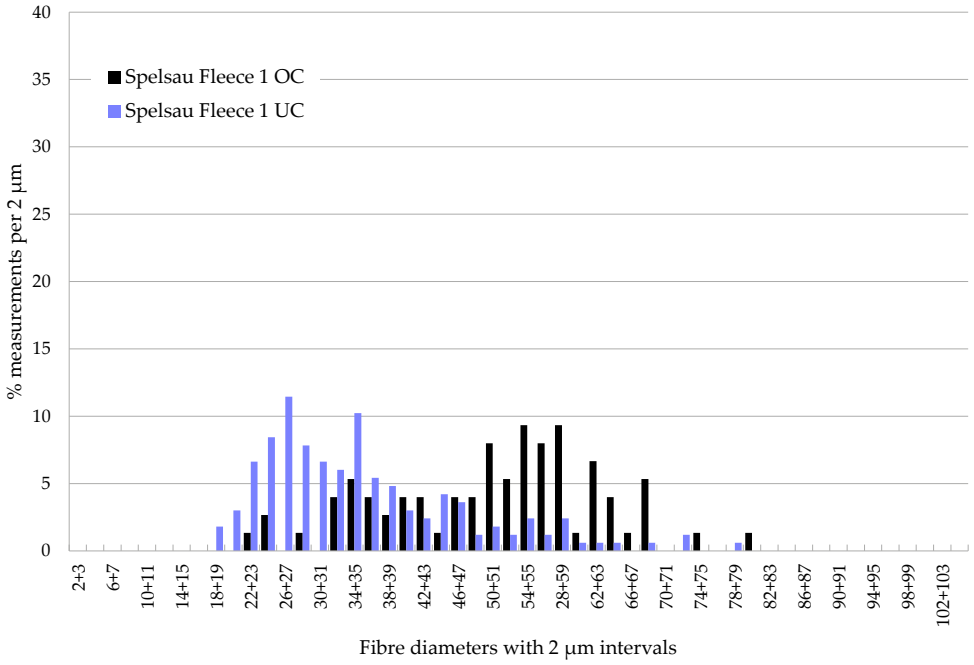
Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Overcoat	4	21	75	20	21, 23, 26, 30-35, 37-38, 40-41, 43-54, 56-58, 60-64, 66-67, 72, 79	no	75
Undercoat	31	45	23	4	16-53, 55-58, 61, 63, 67, 70-71, 76	D	166

► Fig. 13.22: The Spelsau Fleece 1 fibres are white or differently pigmented.

Photo: Irene Skals



◄ Fig. 13.23: A large gap between the over- and undercoat is created because the majority of medium fibres in the undercoat and of coarse fibres in the overcoat both start just around 25% of the measurements.The combined results give a gentle curve between the two.



◄ Fig. 13.24: The fibre distributions give broad cohesive ranges in both the under- and overcoat samples and scattered low bars towards the right. The concentration of similar fibres in the undercoat increses evenly until above 10% and decreases slightly unevenly. The concentration of similar fibres in the overcoat is uneven and the tallest peak is just below 10%.

Spelsau sheep Fleece 2

► Table 13.9: Fibre analysis results of samples of over- and undercoat wool

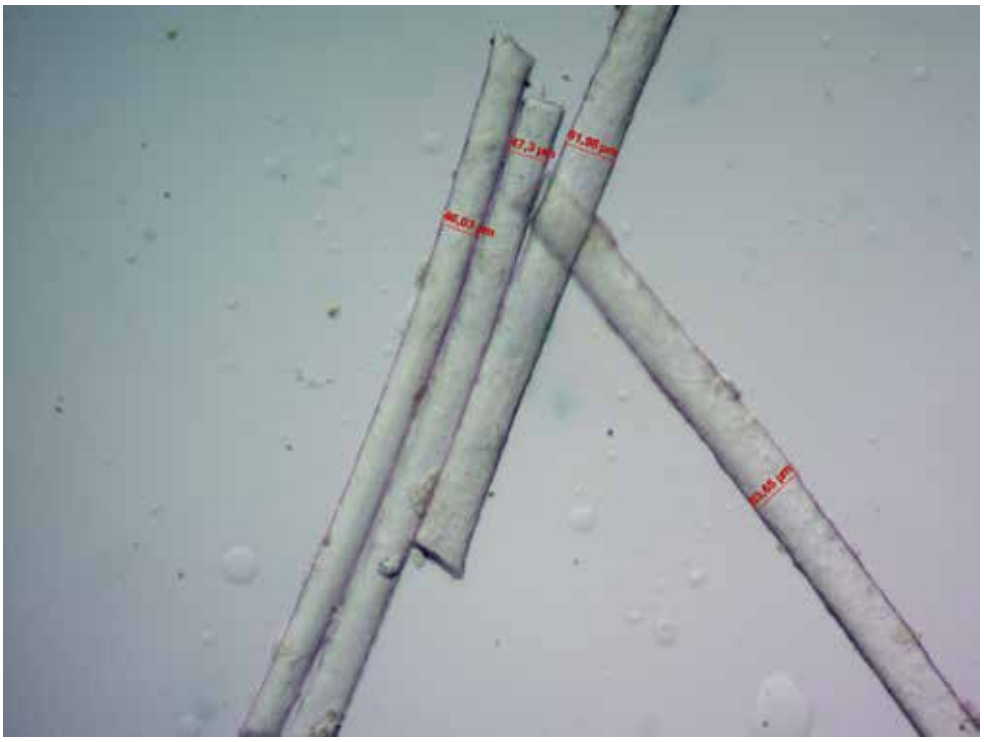
Fibre colour	White
Fibre distribution	The overcoat has almost equal amounts of medium and coarse fibres. The undercoat has a large majority of fine and almost no coarse fibres. The combined results have a small majority of fine fibres and large amounts of both medium and coarse fibres
Comments to diagrams	Cumulative frequency diagram: A large gap separates the two curves, and the combined results are placed between the two, slightly closer to the undercoat Histograms: The overcoat has a broad range with many uneven lower peaks. The undercoat has a narrower cohesive curve with the highest peaks between 22-30 microns and low random peaks in the coarser range
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns E: 60% below 40, 40% above 40, 10% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns
Further comments	The overcoat results are comparable to the combined results from Spelsau Fleece 1 and correlate with the Jacob wool. The undercoat results correlate with the Värmland wool
No. of micrographs	144

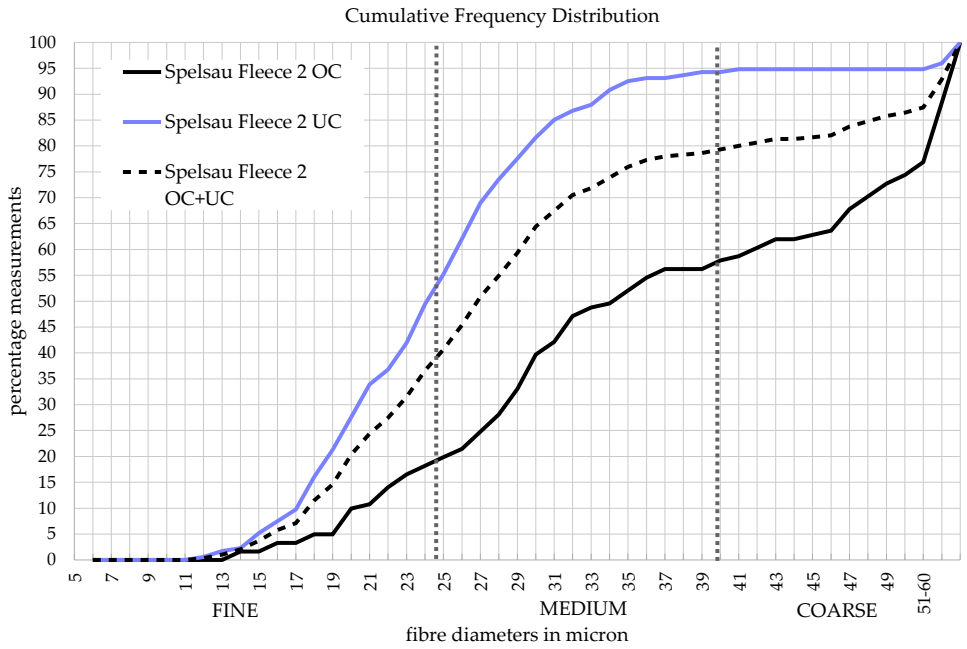
Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Overcoat	21	36	42	12	13, 15, 17, 19-36, 39-42, 44-51, 53-58, 61-66, 68-69, 71, 77	EE	121
Undercoat	62	32	6	4	11-35, 37-38, 40, 52, 58, 61, 64, 68, 74, 76, 83, 88	D	174
OC + UC	45	34	21	7	11-42, 44-58, 61-66, 68-69, 71, 74, 76-77, 83, 88	E	295

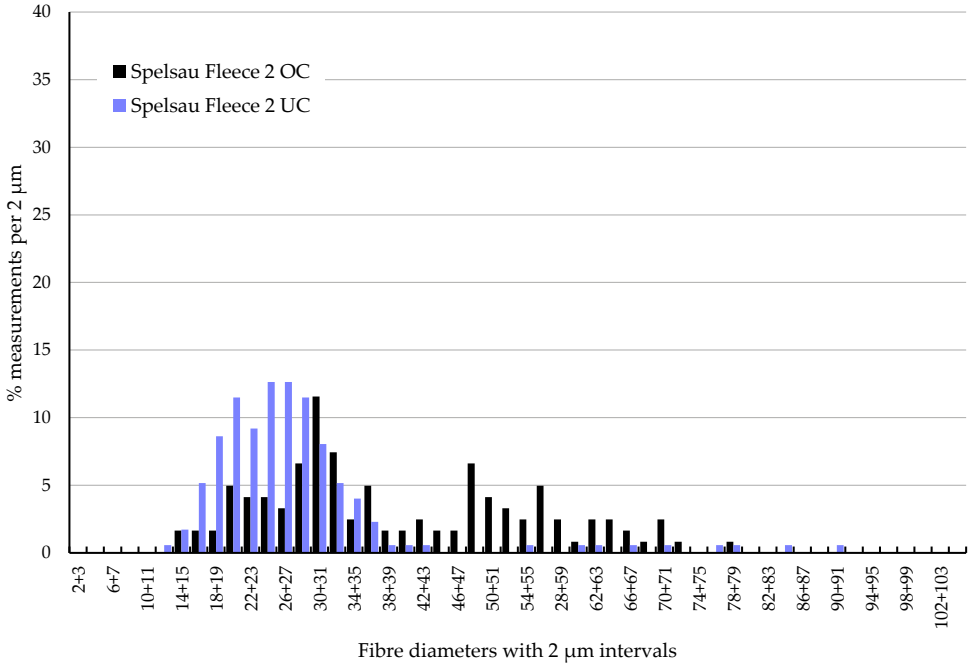
► Fig. 13.25: The Spelsau Fleece 2 fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.26: The over- and undercoat have similar contents of medium fibres but different contents of fine and coarse fibres. This results in the rounded curves in both cases although much more ditinct in the undercoat. The curve of the combined results between the two resembles the undercoat.



◄ Fig. 13.27: The fibre distribution in the overcoat gives a broad cohesive range with uneven concentrations of similar fibres reaching above 10% in one case but mainly less than 5%. The undercoat has a narrower cohesive range with scattered low bars towards the right. The concentration of similar fibres increases evenly until above 10%.

Spelsau sheep Fleece 3

► Table 13.10: Fibre analysis results.

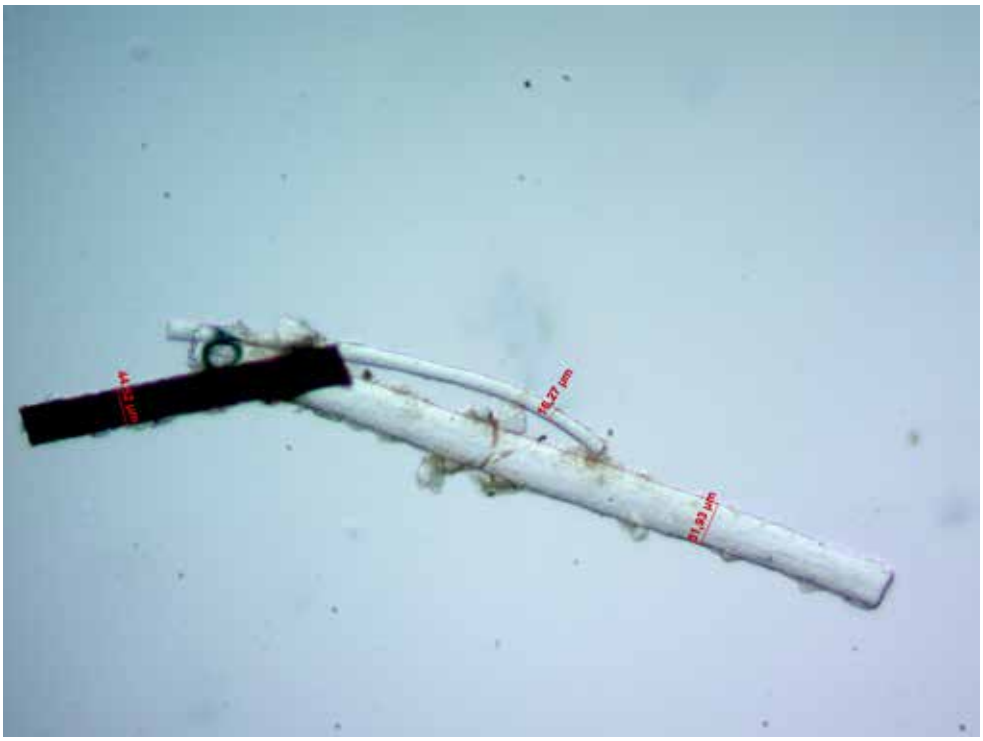
Fibre colour	White mixed with very dark
Fibre distribution	The fine fibres constitute slightly more than half of the measurements and large amount of both medium and coarse fibres have been recorded
Comments to diagrams	Cumulative frequency diagram: The results give a steep curve through the fine and medium ranges Histograms: The bars are arranged around one very high peak at 22 microns and trails off towards the left
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The results correlate with the Klövsjö wool
No. of micrographs	99

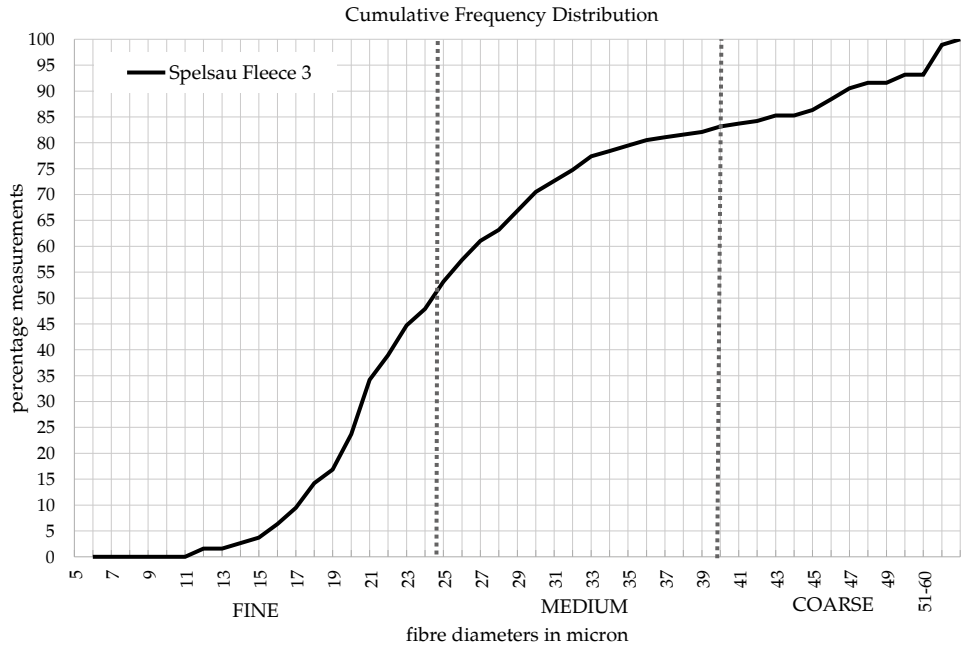
Calculations of fibre measurements in microns

% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
57	26	17	2	11, 13-42, 44-47, 49, 51-55, 59, 61, 74	CD	190

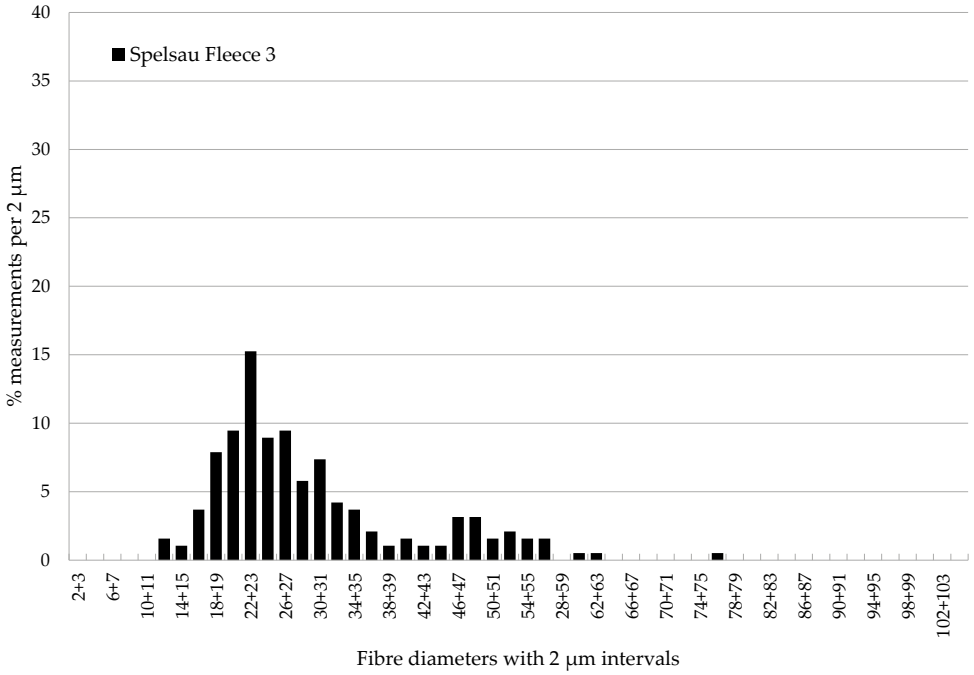
► Fig. 13.28: The Spelsau Fleece 3 fibres are both unpigmented and heavily pigmented.

Photo: Irene Skals





◄ Fig. 13.29: The large content of fine and medium fibres gives the curve a rounded shape.



◄ Fig. 13.30: The fibre distribution gives a broad cohesive range with a few scattered bars towards the right. The concentration of similar fibres increases evenly until 15%.

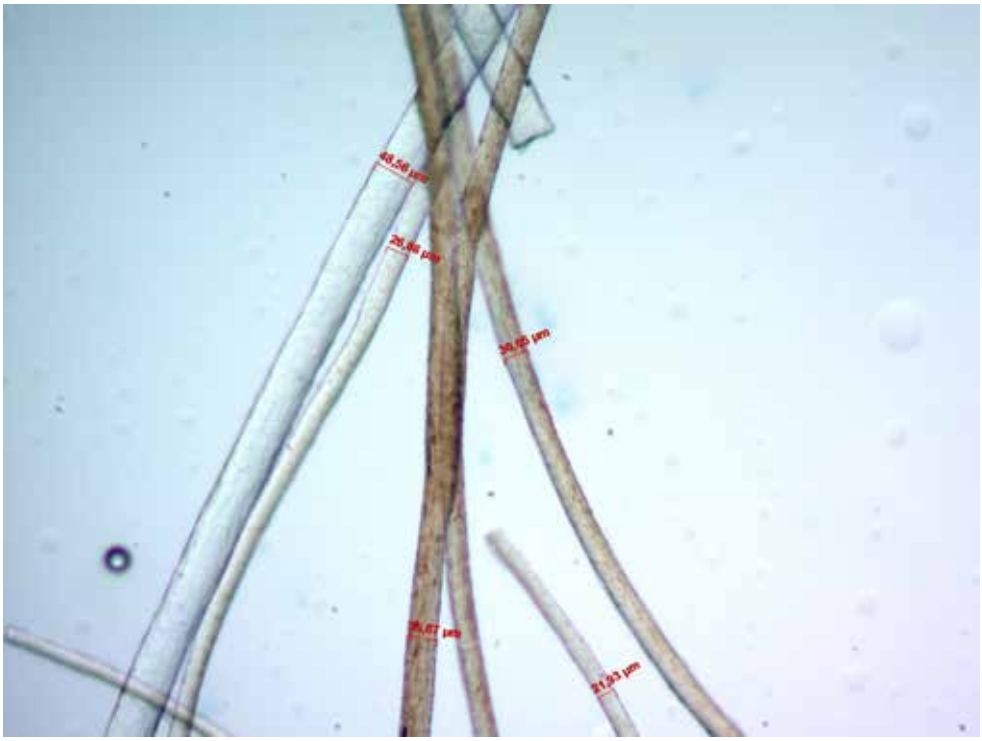
Spelsau sheep Fleece 4

► Table 13.11: Fibre analysis results from the over- and undercoats.

Fibre colour	White and pigmented mixed
Fibre distribution	Only coarse fibres were recorded in the overcoat sample. The undercoat has a majority of medium fibres and larger amounts of both fine and coarse. The combined results have a small majority of coarse fibres
Comments to diagrams	Cumulative frequency diagram: A large gap separates the two curves, and the combined results reflects the large content of coarse fibres and is placed almost centered between them Histograms: The bars representing the two samples only overlap very slightly and in the case of the undercoat they are arranged almost symmetrically around the highest peak and trailing off towards the right. The highest peak in the overcoat creates a broad area in the middle of the range of bars
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns EE: 50% below 40, 50% above 40, 15% above 60 microns The fibre combination in the overcoat does not fit any of the categories
Further comments	The overcoat results correlate with the Rya wool and the overcoat from the Spelsau Fleece 1. The undercoat results resemble the Gotland wool and the undercoat from the Spelsau Fleece 1
No. of micrographs	228

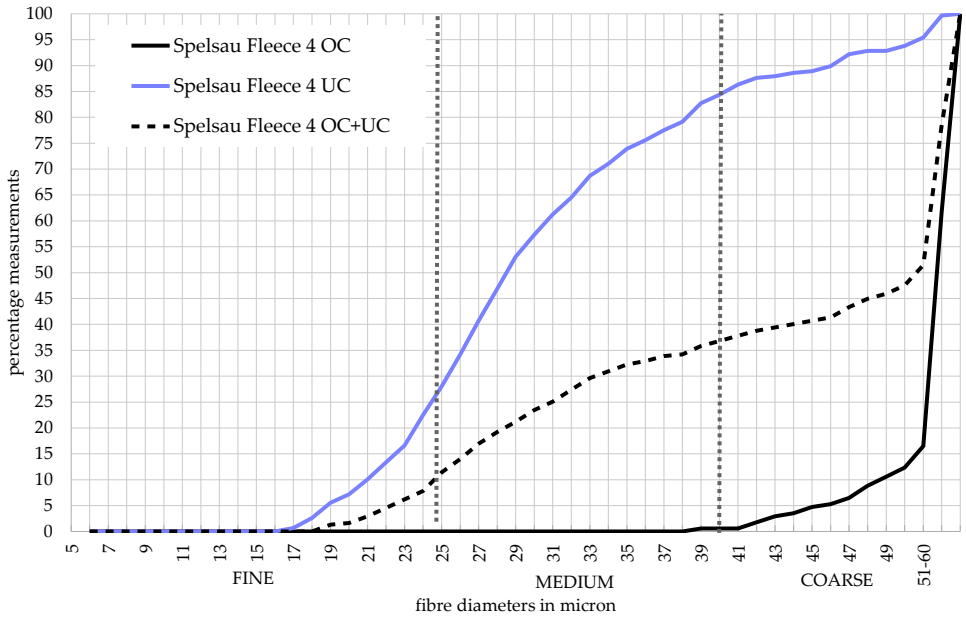
Calculations of fibre measurements in microns

Sample	% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
Overcoat	0	1	99	42	38, 41-75, 79-80, 83	no	170
Undercoat	34	51	15	1	16-47, 49-57, 62	CD	323
OC + UC	23	33	44	14	16-75, 79-80, 83	EE	493

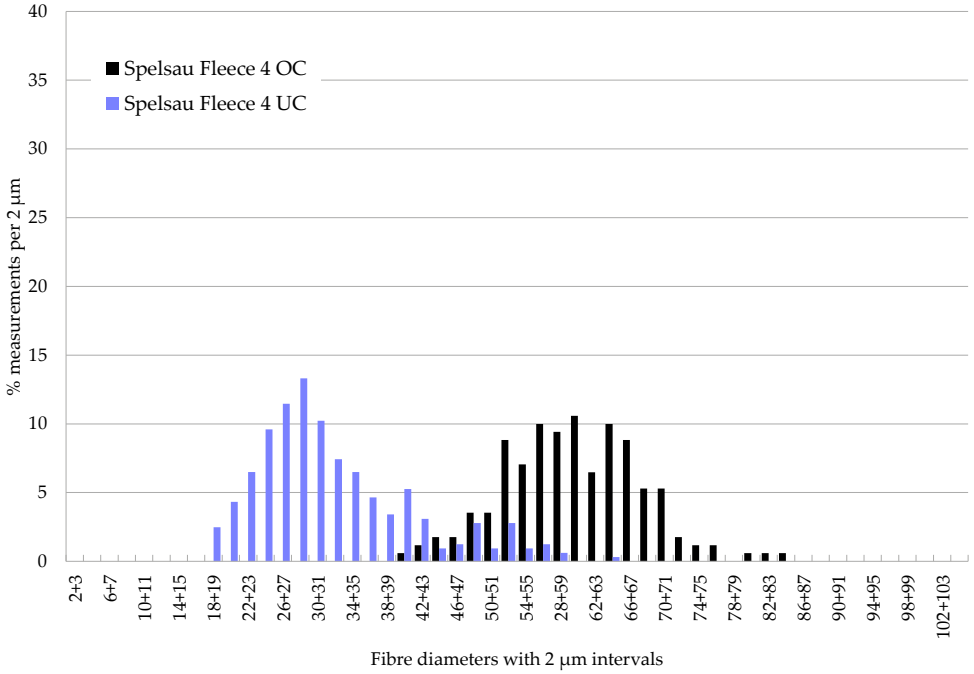


► Fig. 13.31: The Spelsau Fleece 4 fibres are both unpigmented and pigmented.

Photo: Irene Skals



◄ Fig. 13.32: The majority of medium and coarse fibres in the undercoat gives a rounded curve. The overcoat results of only coarse fibres give a very large gap between the two curves and a very steep curve towards the end. The combined results between them has a slightly rounded curve through the medium and most of the coarse ranges.



◄ Fig. 13.33: The fibre distributions give broad cohesive ranges with scattered low bars towards the right in both samples. The content of similar fibres in the undecoat increases evenly until almost 15%. The increase of similar fibres in the overcoat is slightly less even and is in several cases between 5 and 10%.

Svärdsjö sheep

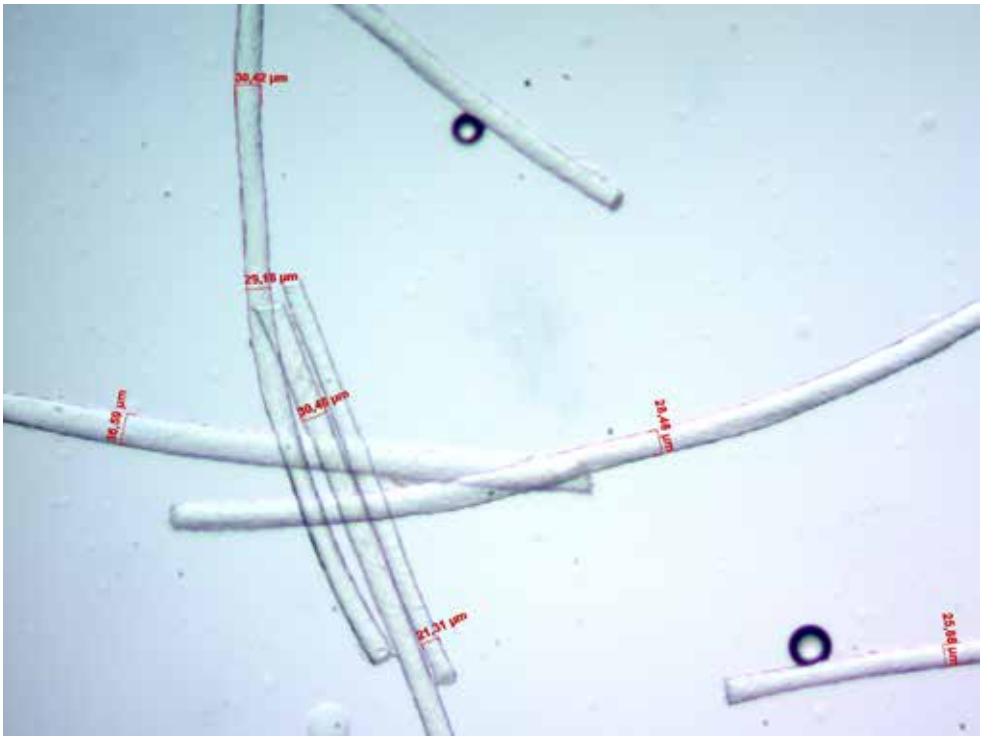
► Table 13.12: Fibre analysis results

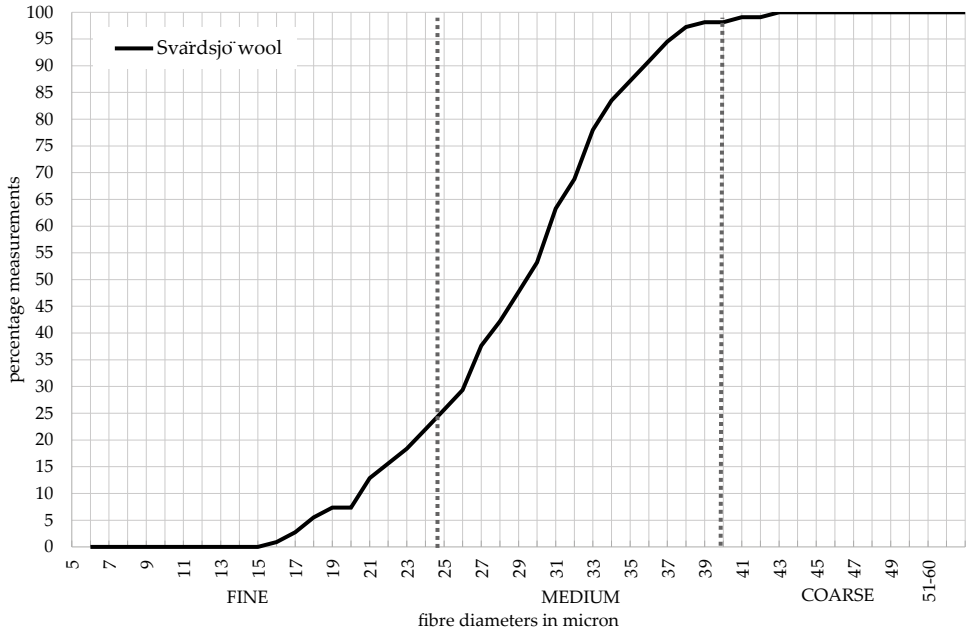
Fibre colour	White
Fibre distribution	Medium fibres constitute a large majority and very few coarse fibres have been recorded
Comments to diagrams	Cumulative frequency diagram: The results form a steep curve through the medium range and reach 100% just around the start of the coarse range Histograms: The bars create a slightly uneven upward motion and stop abruptly after the highest peaks
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The results correspond to the sample from the Värmland Fleece 5
No. of micrographs	68

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
29	69	2	0	15-18, 20-38, 40, 42	CD	109

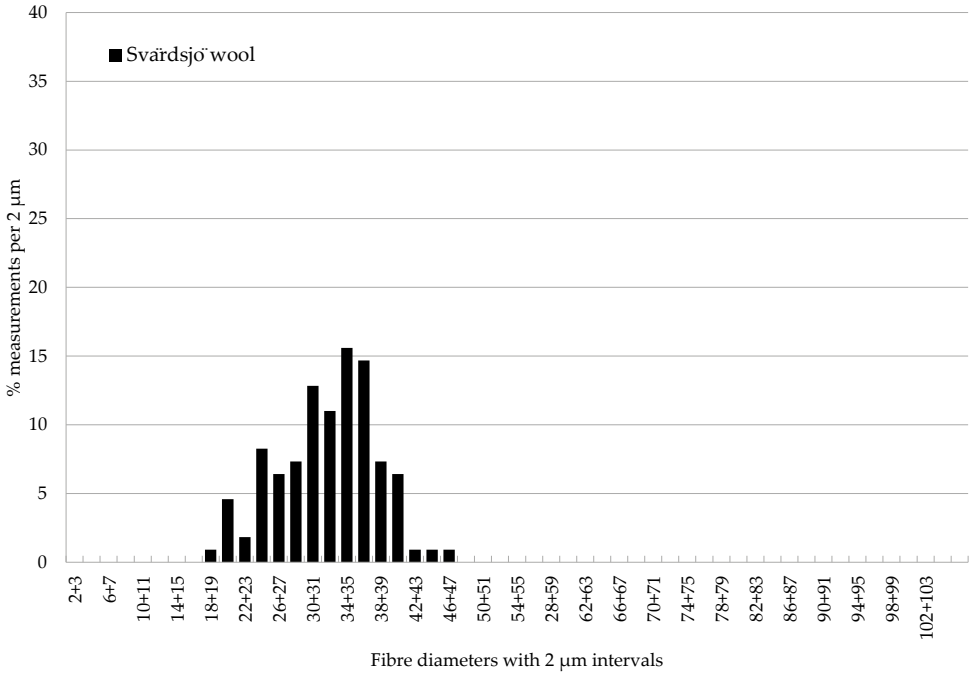
► Fig. 13.34: The Svärdsjö wool fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.35: The very large content of medium fibres and almost no coarse gives a very steep curve in the medium range.



◄ Fig. 13.36: The fibre distribution gives a narrow cohesive range. The concentration of similar fibres increases slightly unevenly until just above 15% and ends abruptly with few bars below 5%.

Värmland sheep Fleece 0

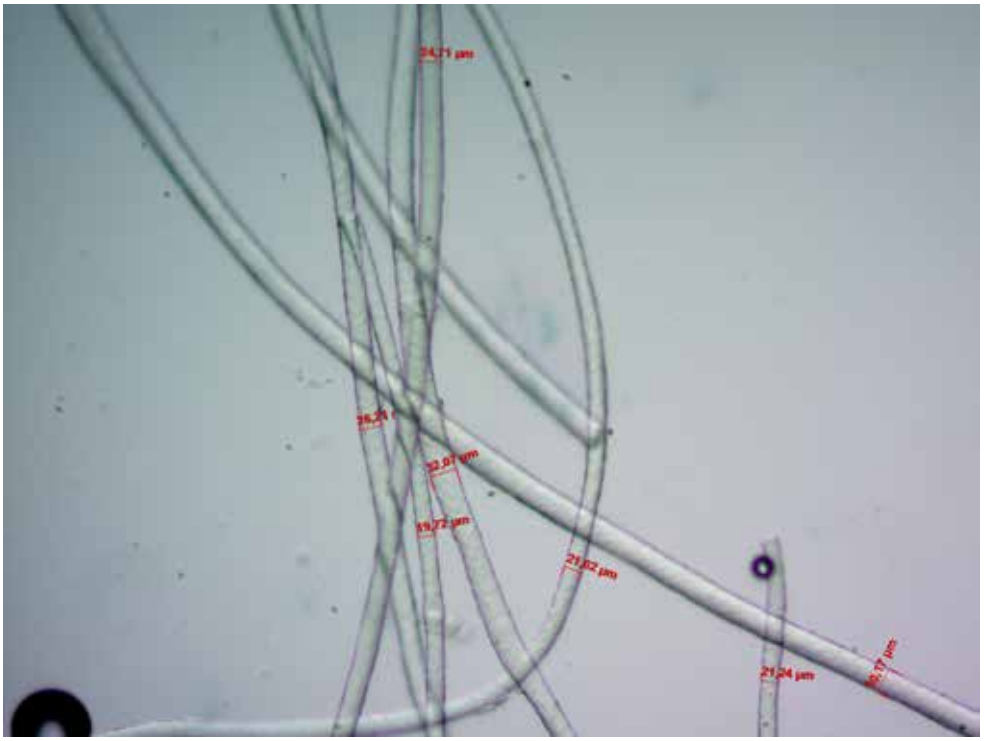
► Table 13.13: Fibre analysis results

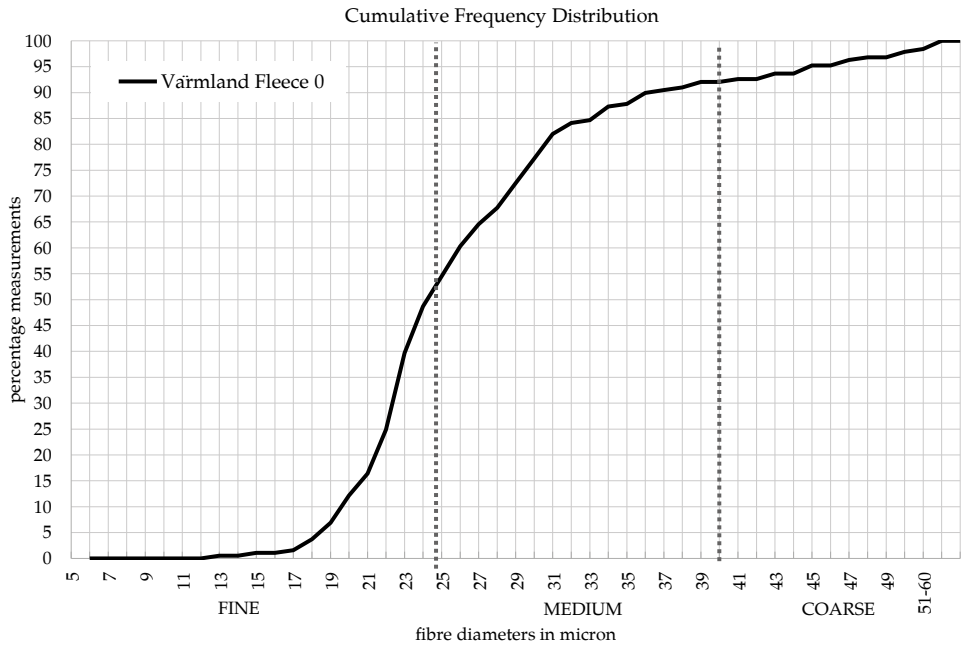
Fibre colour	White
Fibre distribution	A large majority of fine fibres and very few coarse
Comments to diagrams	Cumulative frequency diagram: A steep curve resulting from the large content of fine and medium fibres starts in the fine range and continues through the medium range Histograms: A short upward line towards one very high peak at 24-25 microns trails off towards the right with several low peaks
Category definitions	CD: 80% below 40, 20% above 40, 2% above 60 microns
Further comments	The results correspond to the undercoat sample from the Spelsau Fleece 2
No. of micrographs	79

Calculations of fibre measurements in microns						
% ≤ 24.49	**% ≥ 25.5 ≤ 40.49**	**% ≥ 40.5**	**% >60.5**	**Range**	**Category**	**No. of fibres**
60	32	8	0	12, 14, 16-38, 40, 42, 42, 44, 46-47, 49-51, 54-55	CD	189

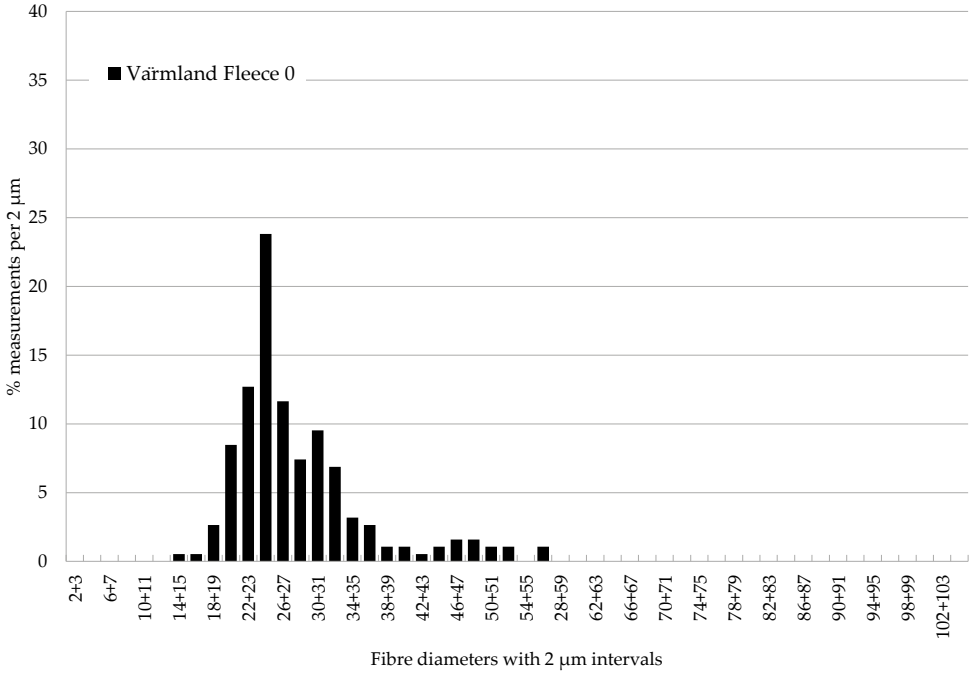
► Fig. 13.37: The Värmland Fleece 0 fibres are unpigmented.

Photo: Irene Skals





◄ Fig. 13.38: The large content of fine and medium fibres and very few coarse gives a steep rounded curve.



◄ Fig. 13.39: The fibre distribution gives a narrow cohesive range. The largest content of similar fibres is in one case almost 25% but otherwise the peak heights are from around 10% to less than 5%.

Värmland sheep Fleece 5

► Table 13.14: Fibre analysis results

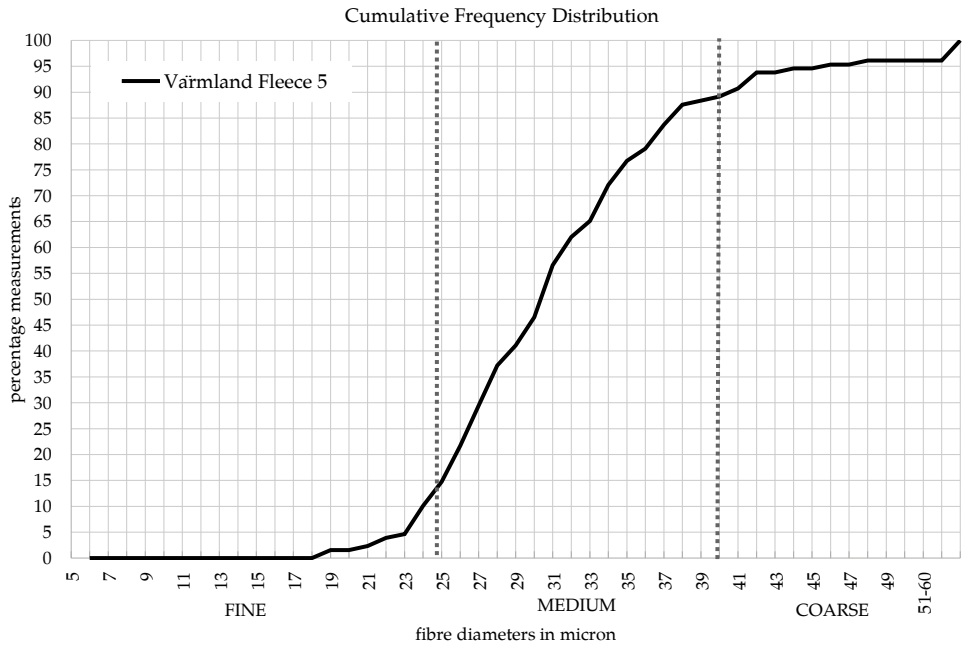
Fibre colour	White mixed with a variety of pigmented
Fibre distribution	The medium fibres constitute a large majority and few coarse fibres have been recorded
Comments to diagrams	Cumulative frequency diagram: The small amounts of fine fibres and coarse fibres result in a very steep curve in the medium range Histograms: The bars form a narrow cohesive range with a couple of high peaks
Category definitions	D: 66% below 40, 34% above 40, 5% above 60 microns
Further comments	The results correspond to the Svärdsjö wool
No. of micrographs	98

Calculations of fibre measurements in microns

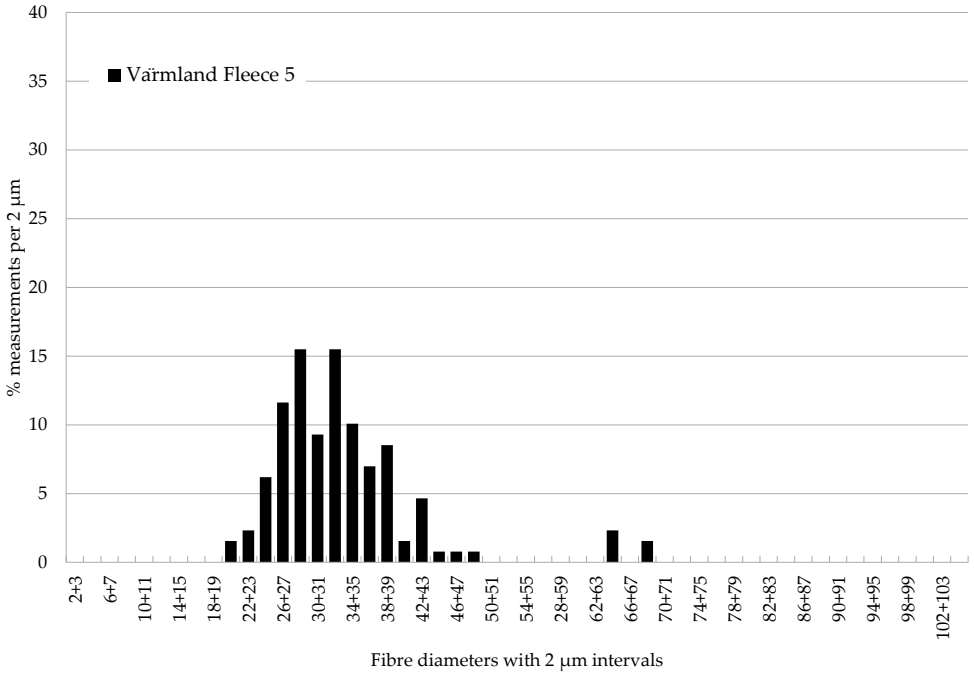
% ≤ 24.49	% ≥ 25.5 ≤ 40.49	% ≥ 40.5	% >60.5	Range	Category	No. of fibres
22	67	11	4	18, 20-41, 43, 45, 47, 62-63, 66	D	129

► Fig. 13.40: The Värmland Fleece 5 have white and differently pigmented fibres.

Photo: Irene Skals



◄ Fig. 13.41: The large content of medium fibres gives a very steep curve through that range.



◄ Fig. 13.42: The fibre distribution gives a narrow cohesive range and a few scattered low bars. The concentration of similar fibres increases evenly until 15%.