

ANTHROPOLOGIE UND PRÄHISTORIE

The fibres in textile remains from the Iron Age salt-mines at Hallstatt, Austria

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with a report on dyes by Penelope WALTON ROGERS²

(With 6 tables)

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Summary

This is the fifth and final paper of a 12-year investigation of cloth and skin remains from the Eastern Group of the prehistoric salt-mines at Hallstatt, Austria, dated 6th to 8th century BC. It deals solely with the cloth which yielded 315 yarn samples. Of these only one was spun from plant fibre (flax); there were two single filaments that appeared to be pig bristles or possibly horse mane hair. The remainder of the yarns were of wool from sheep with four main fleece types: 55% of the yarns were of Hairy-medium (primitive hairy) type and 31% were of the more highly developed Generalised-medium (primitive woolly) type. There were two "modern" fleece types: 4% true Medium wools and 10% Semi-fine (shortwools). Three yarns had wool of true Hairy type, a fleece type that is thought to have developed during the Iron Age. Over half of the wools had no natural pigment and so were white; 20% had pigment in all the fibres and would have appeared black or brown, while 29% had a mixture of coloured and white fibres, giving a grey appearance. Dyes on the fibres were often visible with the microscope and an analysis showed that a blue dye was indigotin possibly from woad. It was not possible to identify a red dye. There appeared to be no pattern in the cloth construction in that there was no consistent difference in yarn thickness or of fleece types between the warp and weft. Neither was there a difference in the spinning twist between the two systems. A cursory inspection revealed that most yarns were Z-spun and often S-plied.

Zusammenfassung

Fünfter und abschließender Bericht über eine zwölfjährige Untersuchung von Textilien und Fellen aus der Ostgruppe der prähistorischen Salzbergwerke in Hallstatt, Österreich, datiert in das 8. - 6. Jh. v. Chr. Er beschäftigt sich ausschließlich mit den Textilien, die 315 Garnproben lieferten. Nur eine davon war aus Pflanzenfasern (Flachs) gesponnen; zwei Fäden stellten sich als Schweineborsten oder möglicherweise Pferdehaare von der Mähne heraus. Die restlichen Garne sind aus Schafwolle von vier Hauptvliestypen: 55% sind vom "Hairy-medium (primitive hairy) type" und 31% vom höher entwickelten "Generalised-medium (primitive woolly) type". Es gibt zwei "moderne" Vliestypen: 4% echte "Medium wools" und 10%

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"Semi-fine (shortwools)". Drei Garne bestehen aus Wolle vom echten "Hairy type", einem Vliestyp von dem angenommen wird, daß er sich während der Eisenzeit entwickelt hat. Mehr als die Hälfte der Wollen hat kein natürliches Pigment und war daher weiß; 20% haben Pigment in allen Fasern und müssen schwarz oder braun gewesen sein, während 29% ein Gemisch von färbigen und weißen Fasern aufweisen und daher grau erschienen. Oft war Farbe unter dem Mikroskop an den Fasern erkennbar und eine Analyse ergab, daß blaue Farbe Indigo ist, möglicherweise aus Färberwaid. Rote Farbe konnte nicht identifiziert werden. In der Konstruktion der Stoffe konnte keine Regelmäßigkeit festgestellt werden: Bei Kette und Schuß besteht kein Unterschied in der Dicke der Garne oder im Vliestyp. Auch in der Drehrichtung des Spinnens fand sich kein Unterschied. Eine kursorische Überprüfung ergab, daß die meisten Garne z-gezponnen und s-gezwirnt sind.

Introduction

The important Iron Age site of Hallstatt in Austria has yielded much organic material, which has been well-preserved by the salt of the mines in which it was found (SCHAUBERGER 1960, STÖLLNER 1999). These have been excavated over 30 years by Dr F. E. BARTH (BARTH 1982, 1993/4). Preliminary results of a microscopic study of samples of the skin and wool remains found were given by RYDER (1990a) and descriptions of the haired animal skins were given by RYDER (1992a&b). The present account covers the textile remains excavated subsequently and these have been grouped with the earlier ones to give a total of 315 yarns for analysis. When this investigation began in 1987 it had been possible to study few remains of skin and wool from the Iron Age compared with the preceding Bronze Age and the succeeding Roman period. The Hallstatt finds now comprise one of the largest collections ever found which allows detailed analysis. Details of fleece changes after domestication were given by RYDER (1983) and these were summarised by RYDER (1987). The development of a fleece during the Neolithic period was discussed, and the nature of Bronze Age fleeces was described, by RYDER (1988). One of the few previous sources of Iron Age wool was the Scythian site of Pazyryk in Siberia, and a study of more remains from this site was published by RYDER (1990b).

Materials and methods

The material, which was supplied by Dr F. E. BARTH of the Natural History Museum, Vienna, came from several sites of the Eastern Group of the prehistoric salt mines at Hallstatt and has been dated by C-14 as from the sixth to the eighth centuries BC. RYDER (1990a) measured 56 yarns taken from 28 pieces of cloth; to these have been added 259 samples measured in the present study, two of which were single filament bristles, to give a total of 315 yarns. The approach changed during the long period of study; latterly the yarn colour observed by eye was recorded and the thickness of the yarn was measured and the direction of spin (whether S or Z). Each yarn sample was cut up and the fibres were separated to make a whole mount microscopic preparation in Euparal. The diameter of 100 fibres in each sample was measured using the International Wool Textile Organisation's standard method with a projection microscope at a magnification of 500 X. The fleece types were defined from wool fibre diameter distributions using the skewness of the distribution and the maximum diameter as criteria (RYDER 1969). Also recorded were the percentages of fibres with a central medulla (hollow core) which give a measure of hairiness and the percentages of pigmented fibres, which give an indication of fleece colour. The results are summarised in Table 1. The HUNDT number is that given to the textiles in his publications (1960 & 1967).

Results and discussion

(a) Fibre and fleece type

The fleece types determined from the fibre diameter measurements are summarised in Table 1 from which it can be seen that almost all of the yarn samples were wool (from sheep). The data are given in full to allow different analyses in future. There were two single filament "bristles" (89.832 and 89.844) about 200 microns in diameter that appeared to be pig bristles (pig bristles having been used to make lace in the French Alps in recent time, Earnshaw, 1989) but they could possibly be horse mane hair. There were only two examples of plant fibres: 90.180 was the bast fibre flax and 90.138 was a seed fibre that appeared to be cotton. However, according to BARTH (1998) the latter thread could be a modern intrusion and so must be discounted. Table 2 shows that as with the study of RYDER (1990a) there were no Fine wools, but there were three fleeces of true Hairy type that were previously found only on skins (RYDER 1992a & b) and have been omitted from the table. The other four main fleece types were represented. The 144 Hairy-medium wools included 16 of Primitive type; these have finer underwool and lack medium fibres and so lie in an intermediate position between the Neolithic coat (found on skins, RYDER 1992a & b) and the Hairy-medium type (RYDER 1992c). The 69 Generalised-medium wools included 10 Fine Generalised-medium wools and the 12 Medium wools include 10 of hairy Medium type, which was not recognised as a distinct type in the previous investigations. This type has the symmetrical fibre diameter distribution of the Medium wool plus some hairy fibres. The percentages in the present, larger sample show a greater preponderance of Hairy-medium wools in relation to Generalised-medium wools, while the percentages of the Medium and Semi-fine wools are roughly as before (in RYDER 1990a). The explanation for this difference could be that later samples were from a different part of the site, or from a different period. But there are too few yarn samples to allow any analyses of such possibilities. The best way to present these data is to combine the two groups, as in Table 2, to give a single large sample. When this is done the preponderance of Hairy-medium wools is not quite so high. The fibre measurements of the different fleece types are shown in Tables 4, 5 and 6.

b) Natural pigment and dye

The existence of white as well as coloured sheep is shown by some cloth from the site on display in the Natural History Museum, Vienna. The bulk of this had been woven from non-pigmented yarns, but into this had been woven a rectangular pattern of bands of black or dark brown wool, which was reminiscent of a Scottish tartan. Woolled-sheepskin caps with the cloth indicated that the coloured animals included brown as well as black individuals. The gross observations reported by (RYDER 1992a) showed that only 5% of the sheepskins were from grey animals. In the present study the percentage of naturally-pigmented fibres was recorded in each yarn sample. The colour of the fleece expected from these percentages is listed in the penultimate column before the percentage in Table 1. The system used is a modification of one used in Sweden by breeders of grey Gotland sheep. Samples with less than 5% pigmented fibres are regarded as white (W). Up to 20% pigmented are "white-grey" (WG), from 20% to 40% "light-grey" (LG), from 40% to 60% "medium-grey" (MG), from 60% to 80% "dark-grey" (DG),

from 80% to 95% "black-grey" (BG) and over 95% pigmented fibres is regarded as black (B). For analysis only three categories were used: white, grey and black (Table 3). It is possible that some of the samples with 100% pigmented fibres were in fact brown

Towards the end of the investigation the yarn colour as observed by eye was recorded and is listed in Table 1 before the yarn thickness (from the end of page 3 onwards). The apparent colour to the eye was not always borne out under the microscope. This is because brown discoloration can be confused with natural pigment, which usually occurs in granules. Hints of a dye were sometimes seen even in wool with about 30% naturally-pigmented fibres which would have appeared light grey. Cloths 89.844 & 845 are of interest in having one system that was black (100% pigmented fibres) and the other system with blue dye but no natural pigment (Table 1). The apparently black yarn of sample 89.271 had a blue-dyed yarn plied with a red-dyed yarn. In many samples blue dye was restricted to only parts of the fibres; the remaining parts appeared yellow. It is tempting to suggest that, as in more recent times, to produce green, this had been dyed with the yellow dye from Dyer's Greenweed (*Genista tinctoria*) or the weld plant (*Reseda luteola*) (which was known to the Romans) as well as blue indigotin from woad (*Isatis tinctoria*). However, according to Penelope WALTON ROGERS fibres dyed only with woad can appear like this and it is difficult to distinguish a yellow dye from the common yellow discoloration under the microscope

The natural pigment analysis was done initially in error on only about two thirds of the samples and the results are given on the second line of Table 3. When the analysis was repeated to include those samples excavated later, the proportion of white wools had increased from 43% to 51%. Attention is drawn to this difference because it could be that the later excavations involved a different area or a later period. Overall, compared with the 1990 investigation, there were more white wools and wools in which most fibres were pigmented, and fewer grey wools.

(c) Cloth construction

1. Yarn thickness

Ideally one would expect warp (Kette) yarns to be thin (tightly spun) and straight, and weft (Schuss) yarns to be thicker and wavy. In order to ascertain to what extent this was true (or could be discerned) the thickness of the yarns was noted when the fibres were being mounted and in the later stages of the investigation an estimate of the actual thickness was made using a mm scale (Table 1). Of 35 textiles in which the warp and weft had been identified by the textile investigator, in 11 the warp was in fact thinner than the weft, but in as many as 9 the warp was thicker than the weft, and there were 15 textiles with no difference in thickness between warp and weft. Of 67 textiles in which the yarn system could not be determined, 50 had yarns of different thickness and 17 had yarns of similar thickness. There was therefore little evidence that warp yarns are necessarily thinner than weft yarns, but overall over twice as many textiles had yarns in which the thickness differed between the systems as there were in which the the yarns were the same thickness. However, yarns had often become untwisted and so it is possible that a change had occurred at some stage since being woven.

2. The fleece types in each system

There is evidence in more recent times that a coarser wool (e.g Hairy-medium) was used in the warp than in the weft (e.g Generalised-medium) although the wools were probably chosen on the differences in staple length rather than fibre diameter. Although in the previous investigation no evidence was found for coarser wool in the warps (RYDER 1990a) the question was looked at again in the present study. Of 101 entire cloths, 55 had the same kind of wool in the warp and the weft: of these 37 were Hairy-medium wools, nine Generalised-medium wools, seven Semi-fine and one each of hairy Medium type and Hairy type. In 25 cloths the fleece type in one system was different from that in the other. On one "side" there were eight Hairy-medium wools, 12 Generalised-medium wools, one Medium wool two hairy Medium wools and two Semi-fine wools, while on the other there were 13 Hairy-medium wools, nine Generalised-medium wools and three Medium wools, with no indication that one system had coarser wool than the other. In 21 cloths in which the system had been identified the warps comprised 12 Hairy-medium wools and the weft of each of these was finer (i.e. Generalised-medium and including five Semi-fine wools). The remaining warps comprised one Medium wool, the weft of which was Generalised-medium, and eight Generalised-medium wools, the wefts of which were coarser (i.e. Hairy-medium) except for one Semi-fine wool. Therefore only 12 of the cloths clearly had a warp with coarser wool so confirming the previous observations.

3. Spinning twist

In the later samples an attempt was made to investigate the possibility that the two systems (warp and weft) had a different spinning twist, but this was abandoned because of the difficulty of determining the twist in the short lengths of yarn I received. Where the twist could be determined, however, there appeared to be no pattern; most yarns appeared to have a Z spinning twist and were often S-plied.

(d) General microscopic observations

The Semi-fine fleece 78.552 (K) had a fragmentary medulla in some of the finest fibres. This is a primitive feature observed previously in Primitive Hairy-medium wools; fine fibres in modern fleeces are never medullated. In fine pigmented fibres the pigment granules were frequently concentrated on one side of the fibre in keeping with the known bilateral structure of wool. The Hairy-medium fleece 88.892 (K) had fibre loops as seen in felted wool. RYDER (1990a) noted that many fibres had rounded ends indicating abrasion wear like that seen in carpets in keeping with the use of the textiles as cleaning cloths/rags. In the present study there were almost as many frayed fibre ends as rounded ends indicating flexing wear as seen in clothing.

General discussion

The rarity of textiles from Hallstatt made with plant fibres is surprising. HUNDT (1960) described only three such fabrics which were bast fibres, but whether flax or hemp could

not be decided. The only plant fibre found since then is some flax (90.180). This contrasts with the nearby Durnberg salt mines of the Early La Tene period, which had a number of bast fibre textiles (RYDER 1999).

The predominance of the primitive Hairy-medium and Generalised-medium fleeces, (which first appear in the Bronze Age), confirms the findings of RYDER (1990a) and the expectations for Iron Age wool from the findings at the Roman site of Vindolanda in northern England, and from surviving unimproved breeds in various pockets throughout Europe (RYDER 1983). The larger sample of the present study has increased the percentage of the primitive hairy (Hairy-medium) fleeces from 46% to 55% and reduced the percentage of the primitive woolly (more highly evolved Generalised-medium) fleeces from 45% to 31%. The true Medium and Semi-fine (Shortwool) types remain in roughly the same proportions (Table 2). The presence of three true Hairy fleeces in the textiles (as opposed to the skins) raises the question of the origin of the Hairy fleece, which apparently developed from the Hairy-medium type by a change in which many of the short, moulting kemp-hairs changed into long, continuously-growing hairs. It has been postulated that such a change might have been associated with selective breeding for a continuously-growing fleece following the invention of iron shears (in Anatolia about 1000 BC) which allowed sheep to be clipped and so avoided the loss of wool during the spring moult (RYDER 1983; 1992c). Whereas the vast majority of the textiles were made from Hairy-medium wool or finer, the skins comprised Hairy-medium wools and coarser (RYDER 1992a). This does not mean that the cloth was made elsewhere, it merely means that the people had sheep with a range of coat types, and that they used the finer wool for cloth and the hairy skins as skins, just as we would today. The cloth was made from finer wool because that on the skins was too hairy for textiles. As today, whereas fine wool can be used as skins and also as cloth, coarse wool can only be used in skins and rugs.

The skin samples without a fleece that were coloured with a white belly like the Mouflon are of interest since the Mouflon sheep of Mediterranean islands is now thought to be not truly wild, but a feral domesticate from the Neolithic period. The Hallstatt skins with a Mouflon colour pattern confirm not only that a non-fleeced sheep persisted into the Iron Age, but indicate that some did so with the primitive Mouflon colour pattern, perhaps being like the Mouflon sheep of Corsica.

Having ruled out the possibility that a truly wild Mouflon survived, then they are likely to be non-fleeced domestic sheep with a Mouflon pattern. If it appears unlikely that a primitive breed lacking a fleece was still kept in the Iron Age one can say that the animals people keep today are often illogical. On the other hand the non-fleeced sheep could be feral Mouflon (i.e feral Neolithic) like those on the Mediterranean islands. The sheepskins with long wool and short hairy fibres (RYDER 1992a & b) are like the offspring of ordinary goats with the Angora goat and so one wonders whether these could be a cross of non-fleeced sheep with a woolly sheep.

The appearance of a range of colours, including white, but with a high proportion of grey, in contrast to the almost universal brown of Bronze Age sheep is also confirmed. The larger sample of the present study has increased the percentage of black/brown fleeces from 7% to 20%, and the percentage of white wools from 45% to 51%, with a

corresponding decrease in the proportion of grey wools from 48% to 29%. With this proportion of grey wools in the cloth, it is surprising that only 5% of the skins were grey; 31% were black or brown and 56% white (including 9% tan) (RYDER 1992a). Part of the explanation for the discrepancy could be that some of the grey wools with few pigmented fibres as seen under the microscope would have appeared (dirty) white to the eye. Another explanation could be that the wool from piebald (spotted) sheep would be carded to give grey, although only 5% of the skins were spotted. Also quite likely is that black and white wool was mixed together to give grey, which was done in 16th and 17th century England for socks as a way of utilising black wool.

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Table 1: Yarn details and summary of fleece types

Identity	System	Thickness	Fleece type	Colour	% pigment
73.297-Hundt 79	a	thin (? Kette)	Hairy-medium	DG	63%
	b	thick (? Schuss)	Hairy-medium	BG	80%
73.336-Hundt 11	Kette (warp)	thin	Semi-fine	WG	16%
	Schuss (weft)	thick	Semi-fine	MG	52%
73.343-Hundt 1	Kette (warp)	thin	Hairy-medium	W	0%
	Schuss (weft)	thin	Hairy-medium	BG	95%
73.344-Hundt 19	Kette dark		Hairy-medium	BG	95%
	Kette light		Genl.-medium	W DYE	2%
	Schuss dark		Hairy-medium	BG	82%
	Schuss light		Hairy-medium	W DYE	0%
73.345-Hundt 20	Kette	thick 2-ply	Hairy-medium	red "red"	100%
	Schuss	thin	No DYE detected by PWR ? Genl.-medium	genetically tan BG	95%
73.346-Hundt 30	K	dark thick	Hairy-medium	BG	94%
		light thick	Genl.-medium	LG	30%
	S	dark thick	Hairy-medium	BG	94%
		light thin	Hairy/HM	W	0%
73.347-Hundt 31	K	thin	Hairy-medium	W DYE	0%
	S	thin	Genl.-medium	W DYE	0%
note warp (K) coarser (HM)					
75.977-Hundt 67	a	dark thin straight	Hairy-medium	LG	29%
	a	light thick straight	prim. HM	W	0%
	b	dark thick) less	Genl.-medium	DG	69%
	b	light thin) straight	Hairy-medium	W	0%
77.569-Hundt 80	a	light thin	Hairy-medium	W	9%
	b light	thicker	Hairy-medium	W	0%
	c dark	thicker	Genl.-medium	BG	96%
77.740-Hundt 81	a)	similar	Hairy-medium	LG	32%
	b)	thickness	Hairy-medium	DG	71%
77.741-Hundt 82	a	medium thick	Hairy-medium	BG	88%
	b	medium thick	prim. HM	B	100%
77.765-Hundt 83	a	thick	Hairy-medium	BG	91%
	b	thick	Hairy-medium	BG	90%
above two could be same fleece					
77.776-Hundt 84	K	medium thick	Genl.-medium	Br	99%
	S	thin	Genl.-medium	BG	89%
77.776-Hundt 85	a)	similar	Hairy-medium	Br/tan	100%
	b)	thickness	Genl.-medium	Br/tan	100%
since both have the same diffuse "red" pigment it could be dye					
77.776-Hundt 86	a	thin black	Fine GM blue	W DYE	0%
	b	med. thick black	Genl.-med. blue	W DYE	0%
78.526-Hundt 87	a	thin	Genl.-medium blue	W DYE	0%
	b	thicker ? warp (K)	Hairy-medium blue	W DYE	0%
78.551-Hundt 88	a	thick dark	Genl.-medium	brown	100%
	b	thick dark	Hairy-medium	brown	100%
78.552-Hundt 89	a	thick dark	Hairy-medium	brown	100%
	b	thick dark	prim. HM	brown	99%
78.552-Hundt 90	K	not recorded	Semi-fine	W	0%
	S		Semi-fine	W	0%
78.552-Hundt 91	a	dark	Hairy-medium	brown	98%
		light	HM/hyM	WG	5%

Table 1: continued

Identity	System	Thickness	Fleece type	Colour	% pigment
78.552-Hundt 91	b	dark	Genl.-medium	MG	59%
		light	Medium	W	0%
79.144-Hundt 92	a		Hairy-medium	DG	75%
	b		Genl.-medium	MG	50%
79.153-Hundt 93	K	light	Hairy-medium	WG	4%
	S	dark	hairy Medium	B	100%
79.153-Hundt 94	K	not recorded	Genl.-medium	B	98%
	S		Hairy-medium	B	100%
79.407-Hundt 95	a		Hairy-medium	B	99%
	b	? same wool	Hairy-medium	B	94%
79.429-Hundt 96	a	thin	Hairy-medium	W	0%
	b	thick ? same wool	Hairy-medium	W	0%
79.436-Hundt 97	a	thin straight	Hairy-medium	BG	80%
	b	thicker wavy	Hairy-medium	DG	78%
79.441-Hundt 98	a	thin wavy	Genl.-medium	W	0%
	b	thicker wavy	hairy Medium	W	0%
79.442-Hundt 99	a	thin	Genl.-medium	blue W DYE	0%
	b	thicker	Hairy-medium	blue W DYE	0%
79.442-Hundt 100	a	similar	Fine GM	blue W DYE	0%
	b	thickness	Hairy-medium	blue W DYE	0%
79.443-Hundt 101	a	thin	Semi-fine	W	0%
	b	thick	Semi-fine	W	0%
	same fleece type				
79.448-Hundt 102	a	similar	Semi-fine	W	1% ? contamin.
	b	thickness	Semi-fine	W	0%
80.672-Hundt 103	a	similar	Hairy-medium	BG	96%
	b	thickness	Hairy-medium	BG	95%
	same fleece type				
81.160-Hundt 104	a	similar	Genl.-medium	W	0%
	b	thickness	Hairy-medium	W	1%
81.449-Hundt 105	K	thick	Genl.-medium	W	0%
	S	thin	hairy-Medium	WG	0%
81.463-Hundt 106	a	thick	Hairy-medium	B/BG	94%
	b	thicker	Hairy-medium	DG	83%
85.811-Hundt 107	K	thick wavy	Genl.-medium	DG	75%
	S	thicker straight	Hairy-medium	B	99%
85.819-Hundt 108	K	similar	Genl.-medium	B	100%
	S	thickness	Hairy-medium	BG	93%
85.915-Hundt 109	a	similar	? primitive HM	WG	5%
	b	thickness	? same HM	W	1%
	a & b same fibre distribution cf. skins 35.718, 75.906, 88.918				
	eye colour				
89.040	?K	brown 0.5 mm	Hairy-medium	W	0%
	?S	blue 1.0 mm	Genl.-medium	W	0%
89.841 Gewebe 1 Gewebe 2 Gewebe 3	-	0.5 mm	HM	hint of dye WG	6%
	-	1.0 mm	HM	hint of dye LG	34%
	-	0.5 mm	HM	hint of dye LG	33%
89.842	-	0.5 mm	hairy Medium	MG	58%
89.843	-	0.5 mm	hairy Medium	W	2%
89.844 Brettchenkante Gewebe	K	1.0 mm	Genl.-medium	B	100%
	?S	0.5 mm	GM blue dye	W	0%

Table 1: continued

Identity	System	Thickness	Fleece type	Colour	% pigment
89.845 Nähfaden	-	3.0 mm	Hairy-medium	B	96%
89.845 Körpergewebe	-	0.5 mm	GM blue dye	W	0%
89.846 Gewebe 1	-	0.5 mm	Genl.-medium	W	0%
2	-	1.0 mm	Hairy-medium	W	0%
3	-	1.0 mm	Hairy-medium	W	0%
89.060	-	2.0 mm	Hairy-medium	MG	53%
89.067	K	1.0 mm	Genl.-medium	WG	8%
	S	1.0 mm	hairy Medium	W	0%
89.088 Gewebe 1	-	0.3 mm	Semi-fine	W	0%
Gewebe 2	-	0.5 mm	Semi-fine	W	0%
89.101	-	1.5 mm	Hairy-medium	W	0%
89.102	K	1.0 mm	Hairy-medium	DG	63%
	dark S	2.0 mm	Hairy-medium	DG	79%
	light S	2.0 mm	Semi-fine	W	0%
89.107		2.0 mm	Genl.-medium	B	97%
89.709	K	>2.0 mm	Hairy-medium	LG	37%
	S	<2.0 mm	Genl.-medium	DG	79%
89.718	K	0.5 mm	Hairy-medium	DG	71%
	S	0.5 mm	Hairy-medium	DG	75%
89.724	K	1.0 mm	Hairy-medium	MG	45%
	S	>1.0 mm	Hairy-medium	WG	17%
89.725	K	1.0 mm	Hairy-medium	W	0%
	S	1.0 mm	Hairy-medium	W	0%
89.832 angenähertes Gewebe		1.5 mm	Hairy-medium	WG	18%
	K blue	1.0 mm	Hairy-medium	blue dye	0%
	K white	1.0 mm	Semi-fine	W	0%
	S single filament, 0.2 mm, pig bristle/horse mane				
89.844	Band, S single filament, 180 microns, pig bristle/horse mane				
89.833	K	<0.5 mm	Fine Genl.-medium	W	0%
		1.0 mm	Hairy-medium	W	0%
89.833 Kante (edge)	K light	0.5mm	Fine GM	W	0%
	K dark	1.0 mm	Genl.-medium	W	1%
	K red	>1.0 mm	hairy medium	B/Br	93%
	S dark	>1.0 mm	Semi-fine	B	99%
89.834	K black	1.0 mm	Genl.-medium	B	99%
	S black	1.0 mm	Hairy-medium	BG	80%
89.835	?K dark	>1.0 mm	Hairy-medium	B	98%
	?S dark	>1.0 mm	Semi-fine	B	99%
89.836	K black	2.0 mm	Hairy-medium	B	99%
	S black	1.5 mm	primitive HM	B	100%
89.837	pale, lustre	>1.0 mm	Semi-fine	W	0%
89.838	black & white	<1.0 mm	Semi-fine	LG	21%
89.839 Gewebe 1.	light brown	1.0 mm	Hairy-medium	W	2%
Gewebe 2.	light brown	<1.0 mm	Hairy-medium	LG	5%
Gewebe 3.	(a) light	>1.0 mm	Hairy-medium	W	0%
	(b) dark	0.5 mm	Hairy-medium	LG	37%
89.840	K (a) light	>1.0 mm	Hairy-medium	W	3%
	(b) dark	>1.0 mm	Genl.-medium	B	98%
89.840	S dark	<1.0 mm	Hairy-medium	W	2%
89.847	black	1.0 mm	Hairy-medium	MG	51%

Table 1: continued

Identity	System	Thickness	Fleece type	Colour	% pigment
89.848	grey	1.0 mm	primitive HM	LG	29%
89.849	dark	0.5 mm	Hairy-medium	B	97%
89.850	brown	<1.0 mm	Genl.-medium	LG	22%
89.851	brown	<1.0 mm	Genl.-medium	W	0%
89.852	brown	<1.0 mm	Genl.-medium	DG	64%
89.853	dark	>1.0 mm	Genl.-medium	B	100%
89.854	brown	2.0 mm	Semi-fine	W	0%
89.855	dark brown	1.0 mm	Hairy-medium	MG	50%
89.870	K light	0.5 mm	Genl.-medium	W	1%
	dark	0.5 mm	Hairy-medium	BG	86%
	S black	0.5 mm	Genl.-medium	B	99%
89.871	light	not clear loose	Hairy-medium	W	3%
	black	0.3 mm	red-dyed HM plied with blue-dyed GM	W	0%
89.872	dark	0.2 mm	Hairy-medium	W	0%
89.873	light	2.0 mm	Hairy-medium	W	0%
	dark	2.0 mm	Hairy-medium	BG	93%
89.891 coarse, lustre lustrous	K cream	2.0 mm	Hairy-medium	W	0%
	S cream (few dark)	2 mm	prim. HM	W	2%
89.892	K brown	1.0 mm	Hairy-medium	WG	9%
	lustrous S ginger	1.5 mm	Fine GM	WG	9%
89.893	black	1.5 mm	Genl.-med.	B	99%
89.894	cream	2.0 mm	Hairy-medium	W	0%
	green	1.0 mm	Fine GM	W (blue dye)	0%
89.895	coarse black	3.0 mm	Hairy-medium	B	97%
90.067	(a) brown	1.5 mm	Semi-fine	LG	24%
	(b) brown	1.5 mm	Semi-fine	WG	8%
90.067 Rep border	K blue	1.0 mm	Generalised-medium	W	0%
	K brown	>1.0 mm	Hairy-medium	WG	18%
	S blue	<1.0 mm	Primitive HM	W	0%
90.126 basket tabby	(a) med. brown	1.0 mm	Generalised-medium	MG	45%
	(b) dark brown	<1.0 mm	Hairy-medium	MG	50%
	(a) dark brown	1.0 mm	Hairy-medium	B/Br	100%
	(b) dark brown	<1.0 mm	Hairy-medium	B/Br	98%
90.127 basket tabby	(a) light brown	<1.0 mm	Hairy-medium	W	0%
	(b) light brown	0.5 mm	Hairy-medium	W	0%
	(a) light brown	0.5 mm	Generalised-medium	W	2%
	(b) light brown	0.5 mm	Fine GM	W	0%
90.128 twill 1a 1b 2a 2b	dark red	>1.0 mm	Hairy-medium	W	0%
	blue		Generalised-medium	B	100%
	discolored	<1.0 mm	Hairy-medium	W	0%
	dark brown		Generalised-medium	B	100%
90.129 tabby	(a) light brown	<1.0 mm	Semi-fine	W	4%
	(b) light brown	2.0 mm	Hairy-medium	LG	28%
90.130 twill	(a) light brown	0.5 mm	Hairy-medium	W	0%
	(b) light brown	1.0 mm	Primitive HM	W	0%
90.134 twill twill	(a) brown	1.0 mm	Hairy/HM	MG	51%
	(b) brown	<0.5 mm	Hairy/HM	WG	20%
90.135 tabby tabby	(a) pale	1.0 mm	Hairy-medium	W	1%
	(b) pale	2.0 mm	Semi-fine	W	0%

Table 1: continued

Identity	System	Thickness	Fleece type	Colour	% pigment
90.136 twill twill	(a) pale	2.0 mm	Semi-fine	W	0%
	(b) pale	1.0 mm	Semi-fine	W	0%
90.137 tabby tabby	(a) blue	<1.0 mm	Hairy blue & yellow dye	W	0%
	(b) blue	0.5 mm	Hairy some green	WG	6%
90.137 twill twill	(a) brown	>1.0 mm	Fine GM blue & yellow	W	0%
	(b) blue	<1.0 mm	Hairy-medium blue dye	W	0%
90.139 thread	tan	2.0 mm	Prim. Hairy-medium	W	1%
90.180 twill twill	(a) black	2.0 mm	typ. Hairy-medium	B	100%
	(b) dark brown	>2.0 mm	typ. Genl.-medium	B	99%
90.180 repp wa border wa wa we	(a) maroon	1.0 mm	Hairy-medium	W	0%
	(b) blue	no record	prim. Hairy-medium	W	0%
	(c) khaki	0.5 mm	Semi-fine	W	1%
	blue	<1.0 mm	Hairy-medium wool paler	BG	100%
90.180 thread thread	(a) pale (plant)	<1.0 mm	FLAX	n/a	n/a
	(b) blue	0.5 mm	Hairy-medium	W	0%
90.181 twill wa we border we	dark	0.5 mm	Generalised-medium	BG	91%
	brown	<1.0 mm	Fine Genl.-medium	W	0%
	dark	1.0 mm	Genl.-medium bimodal wool paler	BG	94%
90.182 check twill	1a dark	2.0 mm	Hairy-medium	BG	sic 94%
	1b light	1.0 mm	Generalised-medium	W	0%
90.182 check twill	2a dark	1.0 mm	Hairy-medium	B	99%
	2b light		Hairy-medium	W	1%
90.182 border	wa light	2.0 mm	Hairy-medium	W	1%
	we dark	2.0 mm	Hairy-medium	BG wool paler	99%
90.183 twill	(a) black	1.0 mm	Genl.-medium blue dye	W	4%
	(b) black	1.0 mm	Hairy-medium blue dye	W	1%
90.184 twill	K light brown	1.0 mm	Medium	W	0%
	S lustre buff	<1.0 mm	Generalised-medium	W	0%
90.185 twill	(a) hairs black	1.0 mm	Hairy-medium	WG	1%
	(b) light	<1.0 mm	Hairy-medium	W	1%
90.186 band	K	1.0 mm blue ply	Primitive HM blue dye	W	0%
		brown ply	Hairy-medium	WG	13%
	S black	1.0 mm	Primitive HM	B	
90.187 twill	(a) light brown	<1.0 mm	Generalised-medium	W	0%
	(b) light brown	<0.5 mm	Fine Genl.-medium	W	0%
	sewing thread dark	>2.0 mm	Hairy-medium	B	100%
90.214 twill	K light brown	<1.0 mm	Generalised-medium	W	0%
	S light brown	<1.0 mm	Generalised-medium	W	0%
90.215 twill	K no record	>1.0 mm	Hairy-medium	W	0%
	S no record	<1.0 mm	Semi-fine	W	0%
90.216 twill	(a) purple straight	1.0 mm	Hairy-medium	? dye	100% diffuse
	(b) purple wavy	1.0 mm	Hairy-medium	? dye	100% diffuse
90.217 twill	(a) brown straight	1.0 mm	Primitive HM	DG	73%
	(b) brown wavy	<1.0 mm	as above	BG	88%
90.218 twill	(a) light brown	<1.0 mm	hairy Medium	W	1%
	(b) same both wavy	1.0 mm	Generalised-medium	W	0%
90.252 twill	(a) dark brown	st. 1.0 mm	hairy Medium	W	0%
	(b) med. brown	st. 1.0 mm	primitive HM	W	0%
90.253 twill	(a) blue	<1.0 mm	Genl.-med. blue dye	W	0%
	(b) blue	0.12 mm	Genl.-med. blue dye	W	0%

Table 1: continued

Identity	System	Thickness	Fleece type	Colour	% pigment
repp border	K blue wavy	>1.0 mm	Genl.-med. blue dye	W	0%
	S maroon	1.0 mm	Genl.-med.	B/Br	99%
90.253 basket weave	(a) dark	0.28 mm	Hairy-medium blue dye	W	0%
	(b) dark wavy	0.18mm	Fine GM blue dye	W	0%
90.254 twill	(a) med. brown	>1.0 mm	straight hairy Medium	W	0%
	(b) brown	2.0 mm	Hairy-medium	W	0%
	knot pale	1.0 mm	Semi-fine	W	0%
90.565 twill	(a) dark brown	>2.0 mm	Hairy-medium	BG	94%
	(b) dark brown	1.5 mm	Hairy-medium	BG	93%

same wool in warp and weft.

Key to Table 1.: The "colour" in the penultimate column is the natural fleece colour expected from the percentage of pigmented fibres listed in the final column. Samples with less than 5% pigmented fibres are regarded as white (W). Up to 20% pigmented are "white-grey" (WG), from 20% to 40% "light-grey" (LG), from 40% to 60% "medium-grey" (MG), from 60% to 80% "dark-grey" (DG), from 80% to 95% "black-grey" (BG) and over 95% pigmented fibres is regarded as black (B). In the final part of the table, the colour in the yarn description is the yarn colour as observed by eye. "DYE" indicates that the sample was analysed for dyes by Penelope WALTON ROGERS (see Appendix). Elsewhere the dye description is that observed under the microscope.

Table 2: The percentages of the different fleece types represented

	Hairy-medium	Generalised-medium	Medium	Semi-fine (Shortwool)
1990 sample	46%	45%	2%	7%
Present sample	57%	27%	5%	11%
The two combined	55%	31%	4%	10%

Table 3: Percentages of naturally-pigmented wools

	Black/brown (> 95% fibres pigmented)	Grey (5 to 95% pigmented)	White (< 5% pigmented)
1990 Report	7%	48%	45%
1999 partial analysis	26% (42)	31% (51)	43% (70)
1999 full analysis	20% (50)	29% (74)	51% (128)

Table 4: Hairy-medium fleeces. Fibre Diameter Measurements in Microns

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
Hundt 79					eye	
73.297 a	16 - 48 54 60	28.8+/- 9.5	20	0%	63% DG	Hairy-medium
b	14 - 56 68 82	26.9+/-10.7	20	0%	80% BG	Hairy-medium
Hundt 18						
73.343 K	16 - 50 58 60 70 74	28.0+/-10.4	26	2% DYE	0% W	Hairy-medium
S	16 - 38 44 - 66	33.7+/-14.7	25	obscured	95% BG	Hairy-medium
Hundt 19						
73.344 K	14 - 38 48 70	23.3+/- 7.8	20	obscured	95% BG	Hairy-medium
73.344 dark S	16 - 58 80	30.5+/-12.4	20	obscured	82% BG	Hairy-medium
light S	14 - 60 74 80	27.9+/-11.8	20	2% DYE	0% W	Hairy-medium
Hundt 20						
73.345 K	14 - 44 66 2-ply	26.4+/- 6.6	28	0% red No DYE detected by PWR ?	100% "red" HM genetically tan	
Hundt 30						
73.346 K dark	10 - 56 60	32.1+/-12.5	18	3%	94% BG	Hairy-medium
S dark	12 - 56 60	26.9+/-12.5	16	1%	94% BG	Hairy-medium
light	18 - 50 54-80	32.8+/-15.6	22	13%	0% W	Hairy/HM
Hundt 31						
73.347 K	14 - 58 74 86	30.6+/-12.0	28	12%	100% ?DYE?W	Hairy-medium
Hundt 67						
75.977 a drk	16-28 36-44 48-72	30.3+/-14.6	20	0%	29% DYE LG	Hairy-medium
a light	14-30 38-52 56-74	28.0+/-15.9	16	15%	0% W	prim. HM
b light	14 - 58 64 66	27.0+/-11.4	20	4%	0% W	Hairy-medium
Hundt 80						
77.569 a	18 - 66	34.0+/-13.2	28	0%	9% W	Hairy-medium
b	14-58 64 70 78(2)	26.5+/-13.4	20	10%	0% W	Hairy-medium
Hundt 81						
77.740 a	12 - 66	26.6+/-11.5	20	0%	32% LG	Hairy-medium
b	12 - 54 66	25.8+/- 9.3	20	0%	71% DG	Hairy-medium
Hundt 82						
77.741 a	14 - 54 60	25.7+/-12.5	19	0%	88% BG	Hairy-medium
b	14-46 58 60 76	22.9+/-11.0	17	0%	100% B	prim. HM
Hundt 83						
77.765 a	14-54 58 62 68 70	26.6+/-11.5	21	3%	91% BG	Hairy-medium
b	14 - 50 62 70	27.0+/-10.9	18	3%	90% BG	Hairy-medium
				above two could be same fleece		
Hundt 85						
77.776 a	14-56 68 70(3) 72	31.9+/-13.9	22	18%	100% Br	Hairy-medium
Hundt 87						
78.526 b blue	16 - 60	29.7+/-11.2	20	13%	0% DYE W	Hairy-medium
Hundt 88						
78.551 b	10-50 58 64(2) 76	24.3+/-11.6	20	1%	100% brown	Hairy-medium
Hundt 89						
78.552 a	12 - 50 64	27.0+/- 9.6	20	0%	100% brown	Hairy-medium
b	12-50 54(2) 60	23.6+/-10.8	18	0%	99% brown	prim. HM
Hundt 91a						
78.552 dark	16 - 54 58 68	30.2+/-10.5	24	0%	98% brown	Hairy-medium
light	16 - 54 78	32.3+/-10.6	27	9%	5% WG	HM/hyM +
Hundt 92						
79.144 a	12-38 48 54 70	22.7+/- 7.8	20	0%	75% DG	Hairy-medium

Table 4: continued

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
Hundt 93						
79.153 K light	10 - 54 60	22.2+/-10.4	18	6%	4% WG	Hairy-medium
Hundt 94						
79.153 S	10-44 50 54 66	24.0+/-11.2	18	6%	100% B	Hairy-medium
Hundt 95						
79.407 a	14-46 66(2) 72 76	28.0+/-12.3	20	3%	99% B	Hairy-medium
b	16-50 56 58 68	25.1+/- 9.9	20	0%	94% B	Hairy-medium ? same
Hundt 96						
79.429 a	10 - 46 60	22.8+/- 7.5	18	4%	0% W	Hairy-medium
b	14 - 50 60 70	24.9+/-10.2	19	4%	0% W	Hairy-medium ? same
Hundt 97						
79.436 a	16 - 60 64	28.7+/-11.5	20	2%	80% BG	Hairy-medium
b	14 - 56 60(3) 62	33.8+/-12.6	24	1%	78% DG	Hairy-medium
Hundt 99						
79.442 b	10-34 40-50 66 68	24.0+/-10.1	18	2%	0% DYE W	Hairy-medium
Hundt 100						
79.442 b	16-44 58 60 84 blue	27.1+/-10.3	22	1%	0% DYE W	Hairy-medium
Hundt 103						
80.672 a	12-44 50(2) 54 60	27.8+/- 8.7	20	0%	96% BG	Hairy-medium
b	12-44 50 60	24.2+/- 8.1	20	0%	95% BG	Hairy-medium same fleece type
Hundt 104						
81.160 b	14-36 60	24.1+/- 5.9	20	1%	1% W	Hairy-medium ? same fleece type
Hundt 106						
81.463 a	16 - 48 70 72	27.0+/- 9.4	22	obscured	94% B/BG	Hairy-medium
b	16 - 50 78	24.4+/- 8.5	20	3%	83% DG	Hairy-medium
Hundt 107						
85.811 S	14 - 54 72 86	25.2+/-11.2	20	4%	99% B	Hairy-medium
S	16-58 64 68 78 80	28.8+/-13.7	18	1%	93% BG	Hairy-medium
Hundt 108						
85.819 S	16-58 64 68 78 80	28.8+/-13.7	18	1%	93% BG	Hairy-medium
Hundt 109						
85.915 a	14 - 40 72	26.2+/- 7.4	20	1%	5% WG	? prim HM
	a & b same wool distrib				cf. skins 35.718, 75.906, 88.918	
b	16-40 46 48 52 60	25.5+/- 7.8	20	1%	1% W	? same HM
88.892 S	16-58 62 64	31.8+/-11.4	20	2%	94%	Hairy-medium
89.040 ?K	16 - 56 60	27.1+/-10.2 sic	20	8%	0%	Hairy-medium
89.841 a	14-54 64 66 68	29.0+/-13.0	18	8%	6%	Hairy-medium
89.841 c	14 - 60 66	30.9+/-13.6	18	1%	33%	Hairy-medium
89.845 N	16 - 64 70 80	34.6+/-14.0	23	9%	96%	Hairy-medium typ
89.846 b	8 - 40 112	24.7+/-10.7	20	1%	0%	Hairy-medium?
89.846 c	16 - 72	34.8+/-16.2	20	15%	0%	Hairy-medium
89.060	16 - 50 54 70	26.0+/- 9.0	20	1%	53%	Hairy-medium?
89.101	12-36 44 56 64	21.4+/- 8.6	20	2%	0%	Hairy-medium
89.102 K	10-44 54 58(3) 70	23.5+/-10.4	18	0%	63%	Hairy-medium
89.102 Sd	10-44 54-58 66 78	24.6+/-11.0	20	1%	79%	Hairy-medium SAME
89.107	14 - 44 48(2) 76	23.7+/- 6.3	20	3%	97%	Hairy-medium

Table 4: continued

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
89.709 K	14 - 48 60	22.3+/- 7.8	18	2%	37%	Hairy-medium
89.718 K	12 - 60 64 72	31.0+/-14.5	20	1%	71%	Hairy-medium
89.718 S	14 - 58 64(2)	29.3+/-14.6	20	2%	75% HM	same wool
89.724 K	8 - 32 46 48(2)	21.3+/- 7.3	18	1%	45%	Fine/ prim HM
89.724 S	12-34 48 62 64 82	22.2+/-13.1	18	6%	17%	prim HM same
89.725 K	10 - 60	32.7+/-11.7	20	20%	0%	Hairy-medium
89.725 S	10 - 50 56 60	21.9+/- 9.5	18	2%	0%	Hairy-medium
89.832	10 14 - 60 64	26.7+/-10.0	22	0%	18%	Hairy-medium
89.833 S	14 - 48 66 70(2)	27.9+/-11.9	20	7%	1%	Hairy-medium
89.834 S	12 - 60	32.0+/-11.8	20	6%	80%	Hairy-medium
89.836 K	12 - 56 66	28.9+/-12.4	20	5%	99%	Hairy-medium
89.836 S	14 - 46 58 68	21.2+/- 8.5	18	1%	100%	prim Hairy-med
89.839 a	14-44 52 54 58 72	24.2+/- 9.1	20	3%	2%	Hairy-medium
89.839 b	14-64 74 86 100	31.6+/-15.9	20	9%	5%	Hairy-medium
89.839 light	10-38 48 52 64 70 84	23.9+/-12.4	20	4%	0%	Hairy-medium
89.839 dark	16 - 50 54 60 94	29.7+/-12.0	20	1%	32%	Hairy-medium
light						
89.840 K	14 - 46 60 66 70 80	28.1+/-13.3	20	7%	3%	Hairy-medium
89.840 S	16 - 50 68	29.5+/-10.5	20	6%	2%	Hairy-medium
89.849	14 - 38 42 46 62	25.8+/- 7.4	22	obsc	97%	Hairy-medium
89.847 white	14-54 80	26.6+/-13.6	18	12%	0%	Hairy-medium
color	14 - 56 60 66 74	34.8+/-13.9	40	2%	100%	Hairy-medium
89.848	12 - 42 48(2) 66 68	22.7+/- 9.0	20	1%	29%	prim Hairy-med.
89.855	16 - 36 40(2) 60(2) 90	26.9+/-10.0	20	4%	50%	Hairy-medium
89.870 K dark	ply 14 - 80	28.2+/-16.2	18	10%	86%	Hairy-medium
89.871 (a)	16-54 60(2)	28.8+/- 9.9	20	13%	3%	Hairy-medium
89.871b red ply	14-52 58 64	24.4+/-10.3	20	6%	0%	Hairy-medium
89.872	14 - 54 58 70	25.9+/-10.7	20	2%	0%	Hairy-medium
89.873 light	14 - 44 54 64 116	25.3+/-12.3	20	2%	0%	Hairy-medium
89.873 dark	12 - 52 64 90	24.6+/-12.8	18	4%	93%	Hairy-medium
89.891 K	12 - 54 64 70 74 80	27.2+/-12.6	20	9%	0%	typ Hairy-medium
89.891 S	14 - 34 38 46 52 60	21.4+/- 7.8	18	5%	2%	prim. HM
89.892 K	12 - 46 50 54 58 66	24.5+/-10.4	18	4%	9%	Hairy-medium
89.894 a	14 - 52 60	29.9+/- 9.9	22	4%	0%	Hairy-medium
89.895	14 - 56 64 66 68	29.6+/-12.1	20	0%	97%	Hairy-medium
90.067 Rep border						
K brown	12 - 56 66 88	26.6+/-12.3	18	10%	18%	Hairy-medium
S blue	16-40 52 58 60	24.9+/- 9.2	18	1%	0%	Primitive HM
90.126 ba/2	12 - 48 64 74	26.7+/-11.7	22	2%	50%	Hairy-medium
tabby/1	14 - 56 68 70 84 92	32.3+/-17.5	21	2%	100%	Hairy-medium
tabby/2	16 - 48 62 68	26.7+/- 9.2	24	2%	98%	Hairy-medium
90.127 ba/1	12 - 46 64	26.9+/- 8.0	26	2%	0%	Hairy-medium
ba/2	10 14 - 52 60 78	29.3+/-11.8	18	6%	0%	Hairy-medium
90.128 tw/1a	12 - 44 62 84	28.6+/-15.9	20	8%	0%	Hairy-medium
tw/2a	14 - 40 58 62	28.1+/-11.3	22	6%	0%	Hairy-medium
90.129 tab/2	10 - 36	23.7+/- 7.7	20	2%	28%	Hairy-medium
90.130 tw/1	14 - 54 68	27.6+/-12.1	20	4%	0%	Hairy-medium
tw/2	14 - 28 40 - 58	24.0+/-11.2	18	2%	0%	Primitive HM

Table 4: continued

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
90.134 tw/1	14 - 40 48 - 70	26.0+/-13.7	20	6%	51%	Hairy/HM
tw/2	16 - 40 46 - 70	28.9+/-11.9	22	1%	20%	Hairy/HM
90.135 tab/1	14 - 50 62	24.0+/- 8.1	21	6%	1%	Hairy-medium
90.137 tw/2	16 - 56 60	28.4+/-10.5	20	4%	0%	Hairy-medium
90.139 thread	16 - 46 54 - 84	26.4+/-12.7	22	7%	1%	prim Hairy-medium
90.180 tw/1	14 - 64	28.9+/-11.5	24	5%	100%	typ Hairy-medium
90.180 wa	16 - 52 68 70	28.0+/- 9.3	20	2%	0%	Hairy-medium
wa	14 - 42 50 68	24.0+/- 7.8	20	2%	0%	prim Hairy-medium
90.180 we	14 18 - 60 64	30.9+/-11.2	24	obsc.	100%	Hairy-medium
90.180 ya	16 - 48 52 62	27.1+/- 8.8	20	0%	0%	Hairy-medium bimodal 90.182
90.181a	12 - 64 90	30.1+/-15.5	20	2%	94%	Hairy-medium
90.182 a	12 - 46 50 72	27.6+/-11.1	16	1%	99%	Hairy-medium
90.182 b	16 - 54 64 70	29.9+/-11.9	20	4%	1%	Hairy-medium
90.182 bwa	10 14 - 64 74	25.6+/-12.2	18	8%	1%	Hairy-medium
90.182 bwe	14 - 60 68	30.0+/-12.2	24	1%	99%	Hairy-medium
90.183	2 14 - 52 56 60	28.4+/-13.2	20	5%	1%	Hairy-medium
90.185 1	14 18 - 44 68 76	24.4+/- 9.9	20	2%	1%	Hairy-medium
90.185 2	14 - 56 68 90 100	29.8+/-13.8	24	5%	1%	Hairy-medium
90.186 band warp						
blue ply	18 - 34 42 72 80	24.3+/-10.0	20	3%	0%	Primitive HM
brown ply	16 - 48 60 70 88 90	32.3+/-15.5	20	7%	13%	Hairy-medium
90.186 bwe	16-34 40 54 60	23.4+/-6.8	18	0%	99%	Primitive HM
90.187 sew	16 - 58	32.3+/-11.6	22	11%	100%	Hairy-medium
90.215 wa	16 - 54 80 88 90	27.2+/-13.4	20	3%	0%	Hairy-medium
90.216 1	18 - 50 54 100	28.2+/- 8.4	24	7%	100%	Hairy-medium
90.216 2	18 - 50 56 72	25.9+/- 9.1	24	0%	100%	Hairy-medium
90.217/1	12 - 32 40 56 90 94	25.3+/-11.7	20	0%	73%	Primitive HM
90.217/2	14 - 30 40 50 82	22.5+/- 8.6	18	0%	88%	as above ? same
90.252/1	14 - 52 56 62	30.3+/-10.3	24	7%	0%	HM/hyM.-SF mixt
90.252/2	16 - 32 38(2) 60	21.8+/- 6.3	18	1%	0%	prim.HM/Fine
90.253/1	12 16 - 46 60	25.6+/- 8.2	22	0% blue	0%	Hairy-medium
90.564/2	16 - 54 60 76 100	32.2+/-15.6	20	5%	0%	Hairy-medium
90.565/1	14 18 - 50 68 100	29.8+/-12.1	20	4%	94%	Hairy-medium
90.565/2	18 - 50 58 64 80	29.1+/-10.4	23	2%	93%	Hairy-medium
						same wool in warp and weft.

Table 5: Generalised-medium fleeces. Fibre Diameter Measurements in Microns

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
73.344 K	16 - 48 54	25.1+/- 8.3	20	1%	2% W DYE	Gen.-med.
73.345 S	14 - 56	28.4+/- 9.3	24	obscured	95%	BG Gen.-med.
73.346 K	10 - 48 54 58	22.7+/- 9.5	20	1%	30% DYE	LG Gen.-med.
73.347 S	16 - 38 44 48	24.1+/- 7.0	20	1%	100% ? dye	W Gen.-med.
75.977 b dark	14 - 58	28.6+/-11.0	22	0%	69%	DG Gen.-med.
77.569 c	16 - 56	29.7+/-10.2	24	0%	96%	BG Gen.-med.
77.776 K	14 - 52	24.2+/- 7.9	20	0%	99%	B Gen.-med.
77.776 S	14 - 50	26.7+/- 6.7	20	0%	89%	BG Gen.-med.
77.776 b	10 16 - 50	27.9+/-10.1	20	0%	100%	Br Gen.-med.
77.776 a blue	10 - 40	21.4+/- 6.3	17	1%	0% DYE	W Fine GM
77.776 b blue	10 - 52	26.8+/- 9.8	20	2%	0% DYE	W Gen.-med.
78.526 a blue	14 - 52	25.6+/- 7.9	20	1%	0% DYE	W Gen.-med.
78.551 a	12 - 48	23.6+/- 7.1	20	0%	100% brown	Gen.-med.
78.552 dark	16 - 50	7.2+/- 9.9	20	0%	59%	MG Gen.-med.
79.144 b	10 16 - 56	27.1+/-10.8	20	0%	50% DYE	MG Gen.-med.
79.153 K	14 - 48	23.0+/- 6.4	20	0%	98%	B Gen.-med.
79.441 a	14 - 54	29.6+/-11.1	18	2%	0%	W Gen.-med.
79.442 a blue	16 - 40 56	24.2+/- 6.7	20	0%	0% DYE	W Gen.-med.
79.442 a blue	14 - 40	22.4+/- 5.9	20	1%	0% DYE	W Fine Gen.-med.
81.160 a	14-36 40 42 58	25.8+/- 6.4	24	0%	0%	W Gen.-med.
81.449 K	14 - 54	26.7+/- 9.4	22	3%	0%	W Gen.-med.
85.811 K	12 - 46 54(2) 58	23.9+/- 8.9	19	3%	75%	DG Gen.-med.
85.819 K	14 - 50 54	24.5+/-10.0	18	3%	100%	B Gen.-med.
89.006 yn	10 14 - 50	25.9+/-10.2	18	3%	91%	Gen.-med.
89.040 ?S	14 - 54	27.2+/-10.5	19	0%	97%	Gen.-med.
89.841 b	12 - 52 58	27.3+/-10.3	20	5%	34%	Gen.-med.
89.844 K1	12 - 38 46 52	22.8+/- 9.6	20	1%	0/diffuse	Gen.-med.
89.844 K2	14 - 42	22.1+/- 6.0	18	1%	100%	Gen.-med.
89.844 ?S	14 - 54	27.9+/- 9.5	20	0%	blue dye	Gen.-med. typ
89.845 tw	14 - 40 44 48	26.5+/- 6.5	22	0%	blue dye	Gen.-med.
89.846 a	10 - 46 50 54 56	24.2+/- 9.4	20	2%	0%	Gen.-med.
89.846 a	14 - 46	24.1+/- 6.2	20	0%	0%	Gen.-med. REP
89.067 K	14 - 46 50	28.3+/- 9.3	20	11%	8%	diff Gen.-med.
89.131	14 - 48 52	25.5+/- 8.3	20	2%	96%	Gen.-med.
89.709 S	12 - 42 50	22.6+/- 6.2	20	0%	79%	Gen.-med.
89.833 K	14 - 48	23.6+/- 8.2	18	1%	0%	Fine Gen.-med.
89.833 K light	18 - 42	25.2+/- 6.7	20	0%	0%	Fine Gen.-med.
89.833 S dark (blue)	14-52 56	29.5+/- 9.9	26	1%	1%	Gen.-med.
89.834 K	14 - 52 56	28.5+/-10.7	18	0%	99%	Gen.-med.
89.840 K	14 - 48	27.3+/- 9.2	21	1%	98%	Gen.-med.
89.850	16 - 50	26.8+/- 8.7	22	5%	22%	Gen.-med.
89.851	10 16-40 44 48 50(2)	24.7+/- 7.7	20	0%	0%	Gen.-med.
89.852	12 - 50 56	26.1+/- 8.5	20	1%	64%	Gen.-med.
89.853	14 - 46	24.5+/- 7.5	20	0%	100%	Gen.-med.
89.870 K light ply	14 - 48	26.3+/- 9.0	20	5%	1%	typic Gen.-med.
89.870 S	16 - 48 52	26.7+/- 8.1	20	0%	99%	typic Gen.-med.

Table 5: continued

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
89.871 b ply blue	14 - 40 56	22.0+/- 8.3	22	0%	0%	Gen.-med.
89.892 S	10-34 38(3) 44	21.8+/- 7.1	18	4%sic	9%	fine Gen.-med.
89.893	14 - 54	28.9+/-11.	18	0%	99%	Gen.-med.
89.894 b blue dye	14 - 48	24.6+/- 7.6	20	0%	0%	fine Gen.-med.
90.067 Rep border K blue16	16 - 54	27.6+/- 6.9	22	0%	0%	Gen.-med.
90.126 ba/1	14 - 50	29.6+/-10.0	22	0%	45%	Gen.-med.
tabby/1	16 - 42 54	24.1+/- 6.4	20	2%	2%	Gen.-med.
tabby/2	12 - 36 44 46	21.4+/- 6.6	20	0%	0%	Fine Gen.-med.
90.128 2 yarns tw/1b	14 - 52	22.7+/- 8.2	18	0%	100%	Gen.-med.
tw/2b	10 - 48	27.4+/- 8.8	22	0%	100%	Gen.-med.
90.137 tw/1	14 - 40	23.7+/- 6.2	18	0%	0%	Fine Gen.-med.(skewed)
90.180 tw/2	16 - 48 54	24.5+/- 7.9	20	2%	99%	typ Gen.-med.
90.181 wa	18 - 58	32.0+/-12.3	20	0%	91%	Gen.-med.
90.181 we	12 - 36 40 44	18.0+/- 5.7	16	0%	0%	Fine Gen.-med.
90.181 bwe	16 - 50 54	33.0+/-11.4	18	0%	94%	Gen.-med.bimodal
90.182 1b	18 - 50 56	29.0+/- 8.2	23	5%	0%	Gen.-med.
90.183 1	12 16-38 46 48	23.4+/- 6.2	20	0%	4%	Gen.-med.
90.184 we	12 - 50 54(3)	25.7+/-10.3	20	2%	0%	Gen.-med.
90.187 1	12 - 48	22.7+/- 8.2	20	0%	0%	Gen.-med.
90.187 2	14 - 44	21.1+/- 6.3	18	0%	0%	Fine Gen.-med.
90.214 wa	12 - 44 50	25.5+/- 6.7	22	0%	0%	M/SF
90.214 we	12 - 44 52 54	26.6+/- 7.3	26	0%	0%	GM/SF
90.218/2	12 - 44 50 58	23.3+/- 8.4	18	2%	0%	Gen.-med.
90.253/1	16-36 44-50 54	25.6+/- 9.8	20	0%	blue 0%	Gen.-med.
90.253/2	12 - 50	23.3+/- 9.4	20	0%	blue 0%	Gen.-med.
90.253 wa	16 - 42 50	26.4+/- 8.0	20	0%	blue 0%	Gen.-med.
90.253 we	14 - 50	26.7+/- 8.0	20	0%	99%	Gen.-med.
90.253/2	14 - 38	23.9+/- 5.6	20	0%	blue 0%	Fine Gen.-med.

Table 6: Hairy, Medium and Semi-fine fleeces plus other fibres. Fibre Diameter Measurements in Microns

Identity	Diameter range	Mean+/-SD	Mode	Medull%	Pigment%	Fleece
90.137 tab/1	16 - 52 66 - 108	27.6+/-16.3	22	8%	0%	Hairy
tab/2	14 - 64 72 80	31.5+/-14.4	24	12%	6%	Hairy
92.026 we	16 - 54 58 - 100	29.6+/-16.6	20	17%	1%	Hairy
78.552 light	16 - 54 78	32.3+/-10.6	27	9%	5%	HM/hyM
88-892 K	14 - 58 68 70(2)	40.2+/-14.2	26 & 50	8%	100%	hairy Medium
89.832 K ply	1 18 - 44	30.1+/- 7.5	30	0%	0%	Medium blue ply
89.833 K red	16 - 52 56 70(3)	37.0+/-11.7	39	10%	93%	hairy Medium
90.184 wa	10 16 - 50 56 58	32.0+/-11.2	21 40	0%	0%	Medium/blend
90.218/1	16 - 62 70	39.1+/-10.8	36	17%	1%	hairy Medium
90.254/1	12 - 50 56 64 68	31.9+/-11.1	28	12%	0%	hairy Medium
89.842	16 - 50 54 120	33.3+/-13.0	20 & 36	obsc.	58%	hyM.-SF mixture
89.843	16 - 52 60 62	33.1+/-11.1	20 & 40	7%	2%	hyM.-SF mixture
89.088 a	14 - 40	26.4+/- 6.1	25	0%	0%	Semi-fine
89.088 b	16 - 40	24.9+/- 5.2	24	0%	0%	Semi-fine SAME
89.102 S light	14 18 - 42	24.8+/- 9.4	24	0%	0%	Semi-fine
89.832 K white ply	12 - 40 46(2)	28.3+/- 6.8	26	0%	0%	Semi-fine
89.833 S kante (selvedge)	18 - 36 44(2) 50	27.5+/- 5.4	25	9%	99%	Semi-fine
89.835 S	18 - 40 48	26.8+/- 5.6	28	1%	99%	Semi-fine
89.837	12 - 34 38 48	23.7+/- 6.0	22	2%	0%	Semi-fine
89.838	16 - 42	28.5+/- 6.1	28	3%	21%	Semi-fine
89.854	16 - 40	25.1+/- 5.5	24	0%	0%	typic Semi-fine
90.067 tab/1	14 - 42 48 62	25.7+/- 7.3	22	1%	24%	Semi-fine
tab/2	16 - 36	23.5+/- 4.2	20	0%	8%	Semi-fine
90.129 tab/1	16 - 34	23.9+/- 3.9	24	0%	4%	Semi-fine
90.135 tab/2	12 16 - 34	23.4+/- 5.0	20	0%	0%	Semi-fine
90.136 tw/1	14 - 40	23.2+/- 5.6	20	0%	0%	Semi-fine
tw/2	12 - 40	23.8+/- 5.6	20	0%	0%	Semi-fine
90.180 wa	14 - 40 48	24.5+/- 6.3	24	0%	1%	Semi-fine
90.254 kn	12 16 - 34 (64)	21.7+/- 6.3	20	0%	0%	Semi-fine
90.214 wa	12 - 44 50	25.5+/- 6.7	22	0%	0%	GM/SF
90.214 we	12 - 44 52 54	26.6+/- 7.3	26	0%	0%	GM/SF
90.215 we	12 - 44 48	28.1+/- 9.1	18 & 34	0%	0%	SF/Med.-Fine mixt
89.832 S single filament, 0.2mm, pig bristle/horse mane, no typical pigment						
89.844 band, S, single filament, 180 microns, as above						
90.180 ya	8 - 22 26 28	13.4+/- 4.3	11	n/a	n/a	flax

Appendix

Tests for dyes

by Penelope WALTON ROGER

Introduction

The single threads supplied initially were smaller than the optimum 10 mg required for dye analysis. However, since colour was visible on some of the threads, tests were attempted on seven of them – four dark greenish-blue, two red-brown and one of indeterminate colour. Following conclusive evidence of blue dye in four of the samples further tests were made on larger samples of those appearing red-brown to the naked eye – 73.345 and 73.347.

Method of analysis

Dyes were extracted into a series of solvent systems and the extracts used for absorption spectrophotometry using the methods detailed by WALTON (1988a) and WALTON & TAYLOR (1991) Results

High levels of indigotin were identified in the four greenish-blue samples (Table 1). A trace of a red dye was detected in one of the red-brown threads (73.347), but the first sample yielded too weak a concentration to allow identification. A further test on the larger sample confirmed the presence of a red mordant dye in textile 73.347. The dye was extracted into aqueous sulphuric acid and then worked-up with magnesium salts to give a spectrometer graph showing maximum absorption at 510 nm. No dye was detected in the remaining samples including the repeat of 73.345 (Table 1).

Discussion

The most common sources of indigotin in antiquity were woad (*Isatis tinctoria* L.) and indigo (*Indigofera tinctoria* L.). The most-commonly used red dyes in antiquity were madder, bedstraw and the insect dye kermes. These have maximum absorption at 520 nm, 520 nm and 530 nm, respectively, in the presence of magnesium. The Hallstatt dye is therefore closest to, but not identical with, the madder and bedstraw dyes.

Other Iron-Age samples previously tested include red and blue checked twills from Lonne Hede, Denmark, and a variety of textiles from the prince's grave at Hochdorf, Germany. The Lonne Hede red proved even more difficult to characterise than the Hallstatt red and has remained unidentified, despite a considerable search through the red dyes used by craft dyers (WALTON 1988b). The dyes from Hochdorf proved to include reds and purples based on kermes (WALTON 1992). The Hallstatt sample 73.347 is different from both these red dyes and its identity must remain a mystery, at least for the time being. Nevertheless, it provides clear evidence that a red dye was being used alongside the more common blue (woad/indigo) in Iron-Age Austria.

Appendix References

- WALTON, P. (1988a): Dyes of the Viking Age: a summary of recent work. *Dyes in History and Archaeology* (formerly *Dyes on Historical Textiles*), **7**: 14-2.
- (1988b): Dyes and wools in Iron Age textiles from Norway and Denmark. – *J. Danish Archaeology*, **7**: 144-158.
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- & TAYLOR, G. (1991): The characterisation of dyes in textiles from archaeological excavations. – *Chromatography and Analysis*, **17**: 5-7.

Appendix Table 1

Sample	Colour	Result	Dye source
19-73.344 (K&S)	pale indeterminate	no dye detected	
20-73.345 (K)	red-brown	no dye detected	
31-73.347 (K&S)	red-brown	red mordant dye	not identified
86-77.776 (K&S)	green-blue	indigotin	woad/indigo
87-78.526 (K&S)	green-blue	indigotin	woad/indigo
99-79.442 (K&S)	green-blue	indigotin	woad/indigo
100-79.442 (K&S)	green-blue	indigotin	woad/indigo

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Annalen des Naturhistorischen Museums in Wien](#)

Jahr/Year: 2001

Band/Volume: [102A](#)

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