

## A survey of European primitive breeds of sheep <sup>(1)</sup>

M.L. RYDER

*A.R.C. Animal Breeding Research Organisation, West Mains Road  
Edinburgh EH9 3JQ, Scotland*

### Summary

This paper surveys the primitive (i.e. unimproved) sheep of Europe using data (notably the fleece type) from surviving breeds in place of the more commonly-used skeletal and textile remains.

Only bone evidence exists for the Neolithic sheep, and its coat is assumed to have been little different from that of the undomesticated wild ancestor. Textile remains show that Bronze Age sheep had less hairy, but still brown, fleeces like those of the *Soay* sheep that survives feral in the Saint Kilda islands off north west Scotland. Within this less hairy fleece type both textile remains and surviving sheep show a range of variation from relatively hairy to woolly animals.

Textile remains show that white sheep appear in the Iron Age. Much wool was, however, still coloured, having either 100 p. 100 pigmented fibres (black or brown) or some pigmented fibres and others not (grey or roan). Surviving breeds of this type (often with a primitive short tail) have a similar fleece structure to the *Soay* but with a range of colours, white, black and grey, in addition to the brown of the Bronze Age *Soay*. The present paper concentrates on this type which was probably the predominant sheep in Europe until after the Middle Ages when modern, improved breeds began to emerge.

The breeds considered to be of Iron Age type described are divided into groups as follows. The *Northern Short-tail* which comprises the *Romanov* of Russia, the *Fynish Landrace*, the Swedish *Goth*, the Norwegian *Spaelsau*, *Faroe*, *Iceland*, *Orkney-Shetland*, *British Four-horned* and Irish *Cladagh*. The *Corsican* and *Ushant* breeds of France are placed with the *Guirra* of Spain in a South Western group, and three *Heath* breeds are described from the north European plain, the *Drenthe* of the Netherlands, the *Heidsnucke* of Germany and the *Wrzosowka* of Poland.

On *Alpine* group comprises the *Bundner* of Switzerland, the *Steinschaf* of Austria, and the *Della Roccia* of Italy, and two other Italian breeds and the *Massa* and *Carapelle*. The Balkan group includes the *Racka* of Hungary, the *Dubrovnik* of Yugoslavia with the *Karakachan* and *Karnobat* of Bulgaria, and the *Drama* and *Chalkidiki* of Greece. It was possible to include only two breeds of the Soviet Union, the *Karachaev* of the Caucasus, and the *Kulunda* of Siberia, which is included for completeness although it is not a European breed.

---

(1) Revised version of a paper read at the 3rd *International Archaeozoological Conference*, Poland, 1978.

### Introduction

Skeletal remains provide the most common source of evidence in archaeozoology, supplemented by remains derived from skin, e.g. RYDER (1962, 1973). The present paper utilises descriptions incorporating tail length, horn, colour and fleece type data of surviving unimproved breeds, and incidentally provides a compelling argument for the preservation of such breeds (RYDER, 1976).

A synthesis of biological and historical evidence on the origin of British breeds made it relatively easy to group modern breeds into broad types, and to postulate waves of introduction (RYDER, 1964 a, 1968 a). It is less easy to discern the same patterns on the continent of Europe because the affinities are less obvious, and the greater number, and wider distribution, of breeds makes it difficult for one person to see them all (RYDER, 1968 b; BROOKE & RYDER, 1977, 1979).

There is no conclusive evidence for wool textile manufacture in Neolithic Europe, and it is probable that the coat of domestic sheep then had outer kemps and fine underwool, showing only a gradual change from that of the wild ancestor. Textile remains from the Bronze Age, however, coupled with skeletal remains, indicate that the sheep of this period was comparable with the *Soay* which now remains feral only in the Saint Kilda islands, which are outliers of the Hebrides on the very edge of the continent (fig. 1). The *Soay* shares with the wild ancestor : large horns in the ram, a short tail, and a moulting fleece. It also has a coloured fleece with white belly, which sets it apart from other primitive breeds. The fleece of the *Soay* is, however, much less hairy than the coat of the wild ancestor (see below).



FIG. 1

*The Soay breed of Saint Kilda, a survivor of the Bronze Age type*  
*Le mouton Soay de Saint Kilda, un survivant de l'Age du Bronze*

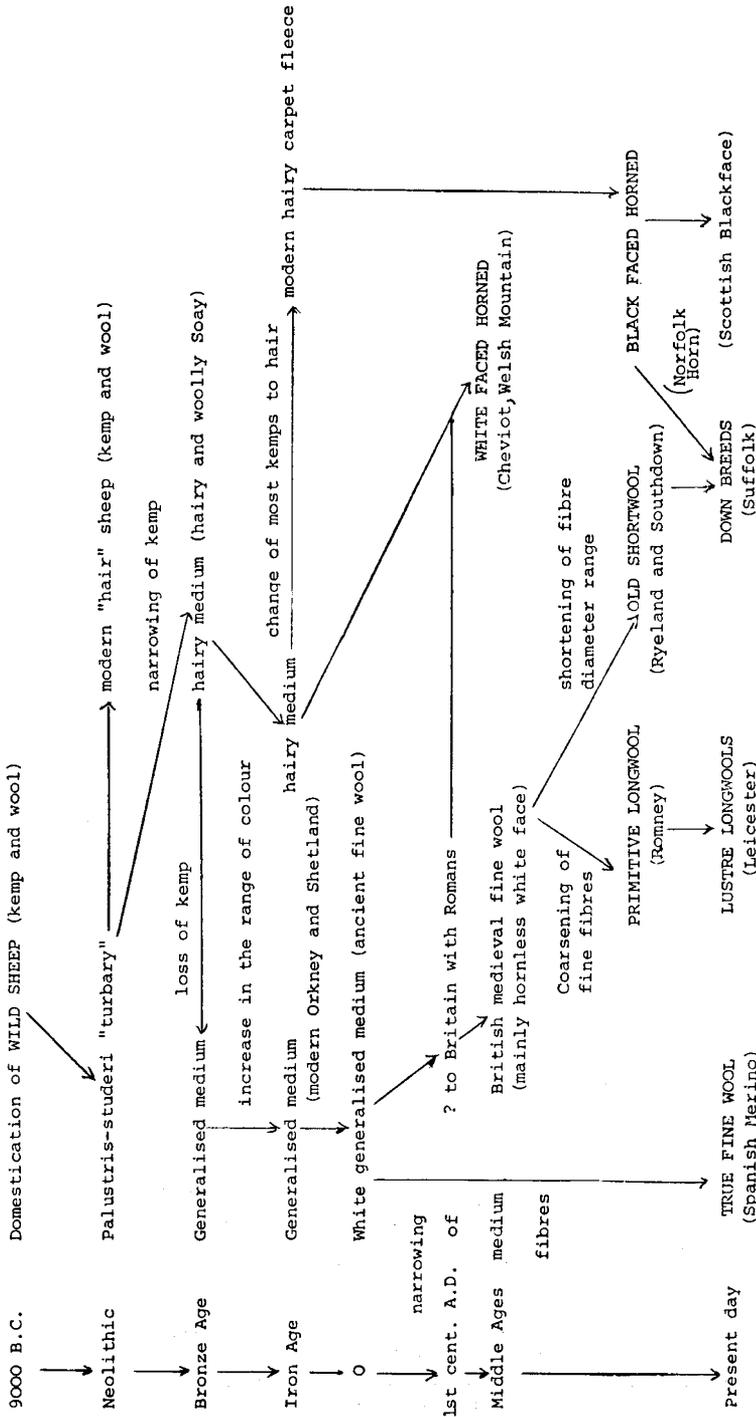


FIG. 2

The broad picture of suggested lines of fleece evolution with particular reference to British breeds  
 Vision schématique des lignes d'évolution possible de la toison principalement pour les races anglaises

Revised version of the diagram that first appeared in RYDER (1964 b), from RYDER(1982).  
 Version remaniée d'un diagramme paru chez RYDER (1964 b), à paraître in RYDER(1982).



Textile remains indicate that most *Roman* sheep were white, and illustrations suggest that only the rams were horned. The suggestions of RYDER (1964 a) summarised in fig. 2, were that crosses between white, *Roman* sheep, and the brown, native *Soay* could have produced types that later emerged as breeds such as the *Cheviot* and *Welsh Mountain* to the north and west. These are horned in the rams only, and any pigment is brown rather than black. Such a derivation is no doubt too simplified if only because by the time the Romans arrived the *Soay* was no longer the dominant type. On its own in Britain, however, the *Roman* sheep could have given rise on the one hand to the primitive longwool and on the other to the shortwool. These types were found among Roman textiles (see below) but they did not become common until after the Middle Ages. On the continent the true fine wool was the more important type, emerging later in Spain as the *Merino* breed.

The third main type in Britain is the horned and hairy black-faced type. There are suggestions linking this with the *Heath* sheep of the North European Plain via a Danish introduction, but one need not postulate an exotic origin for every British type, although it is not yet clear how much evolution took place within Britain. The British representatives of the European vari-coloured type — the *Orkney* and *Shetland* breeds — have been associated with Norse settlers, but if this type goes back to the Iron Age they may have introduced a similar breed and not a distinct type. Fig. 3 summarises the probable origins and relationships of modern British breeds from historical records over the last 200 years.

Changes in the fleece following domestication are shown in fig. 4. The big difference in diameter between the coarse kemps of the outer coat, and the fine, woolly under coat in the wild *Mouflon* (top) is very striking. Fleeces of existing sheep have been used in fig. 4, but all diameter distributions (fleece types) except that of the wild animal at the top have been found in ancient textiles. The evolutionary changes that appear to have taken place are, first, a narrowing of the coarse, bristly kemp fibres forming the outer coat of the wild sheep to produce much the less-coarse, hairy fibres (fine kemps) of the hairy *Soay*. The underwool became a little coarser, few, if any, domestic sheep having wool as fine as that of the wild sheep. Further narrowing of the hairy fibres, presumably as a result of selective breeding by man, changed them into wool fibres of medium diameter to give the fleece of the woolly *Soay*. These two fleece types occur as hairy medium and generalised medium fleeces, with the same natural pigmentation as the *Soay*, in Bronze Age wools.

The evolutionary term generalised is used for the latter fleece type because it formed an important link. Not only was it apparently derived from a more primitive hairy type, but it was able to give rise to several more-highly evolved fleece types as follows. A continued narrowing of the medium fibres by breeding could have resulted in a fine fleece with a symmetrical diameter distribution like that of the modern *Merino* (fig. 4 bottom, right). If, on the other hand, the finer fibres had become coarser, then the medium wool diameter distribution of the modern longwool would have been obtained (top right). Thirdly, if both changes had taken place together, and the range of fibre diameter had become shortened, the distribution would have been comparable with that of the modern shortwool (right, middle). In this the mean fibre diameter has a value between that of the fine and medium values.

The true hairy (carpet wool) type of fleece seems to have arisen from the hairy medium wool by a change of most of the kemps into hairs (fig. 4, bottom, left). The

origin of hairs, which are coarse and kemp-like in summer, but lack a medulla and appear like wool fibres in winter, appears to have been associated with the change from a moulting fleece to one of continuous growth (see below). The hairy, carpet fleece first appeared in the Iron Age, but was uncommon until after the Middle Ages. Most Roman wools, although white, were of either hairy medium, or generalised medium type (RYDER, 1974 a, 1981) but longwools, shortwools, and fine wools were developing at that time. A range of fleece types from hairy medium through generalised medium to true fine (rarely) has been found in the modern *Orkney* breed, and some *Northern Short-tails* have a true hairy fleece (RYDER, 1968 a).

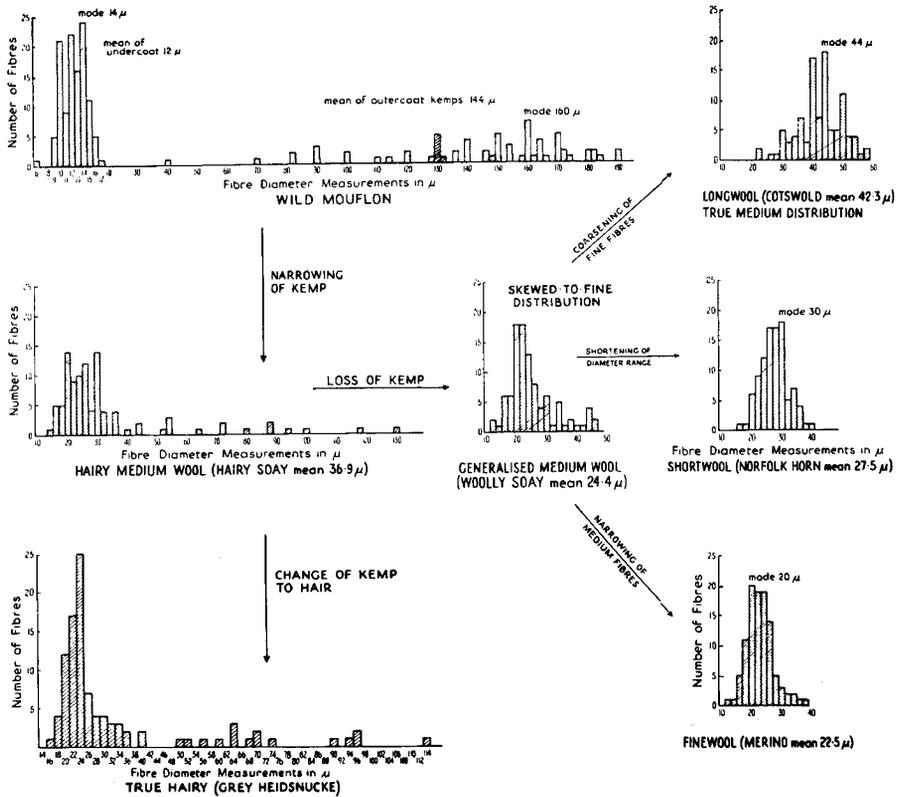


FIG. 4

*Changes in fibre diameter distribution during the domestic evolution of the fleece*

*Changements dans la distribution du diamètre des fibres au cours de l'évolution de la toison après domestication*

In these histograms the fibre diameter is shown on the horizontal axis, and the number of fibres on the vertical axis. Revised version of the illustration in RYDER (1969 a and 1973), from RYDER (1982).

Dans ces histogrammes le diamètre de la fibre est en abscisses, le nombre de fibres en ordonnées. C'est une version remaniée de l'illustration de RYDER (1969 a et 1973), à paraître in RYDER (1982).

In addition to allowing studies of the evolution of fleece structure, the survival of primitive breeds with a high proportion of coloured animals has allowed investigations of colour inheritance. An interpretation worked out by ADALSTEINSSON (1970) with *Icelandic* sheep, apparently also applies to *Soay*, *Orkney* and *Shetland* sheep (RYDER *and al.*, 1974) and may even be universal (RYDER, 1980).

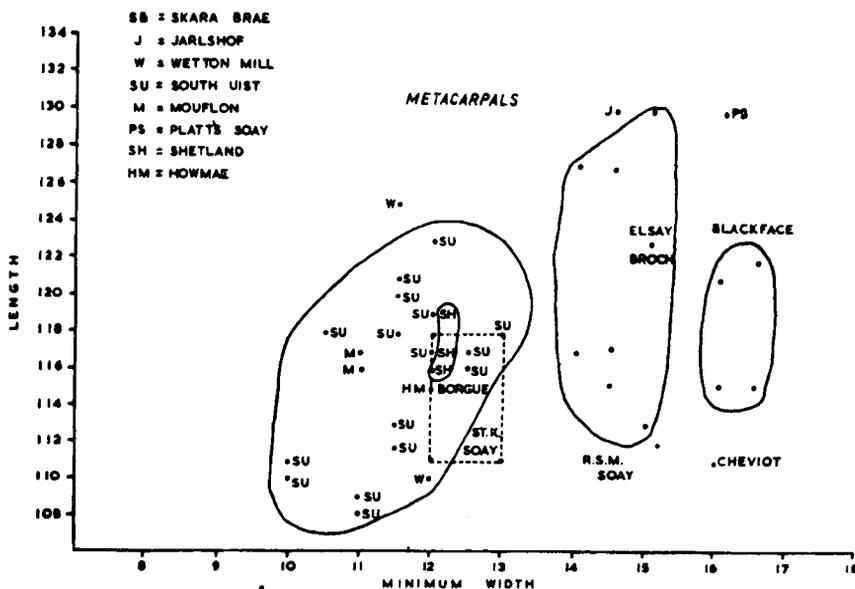


FIG. 5

The length plotted against minimum width at the mid-point of metacarpal bones from Scottish sites, and including primitive and modern breeds for comparison (from RYDER, 1968 a)

La longueur fonction de la largeur minimum au milieu du métacarpe.  
Observations dans des sites écossais avec mesures sur races primitives et races modernes, à titre de comparaison (RYDER, 1968 a)

The *Soay* has light and dark brown individuals, dark animals being genetically black, and most *Soays* have a white belly (fig. 1). There are, however, self-colour *Soays* in which the belly is coloured, and dark self-coloured animals appear all black. The colour genotypes found in the *Soay*, *Orkney* and *Shetland* are shown in table 1. The colour pattern genes of the *A* series are on a different chromosome from the colour genes of the *B* series, and those higher in the series are dominant over those lower down, thus black (*B*) is dominant over brown (*b*) and the black phenotype can therefore be either homozygous (*BB*) or heterozygous (*Bb*).

Brown (*aabb*) is the simplest (homozygous recessive) genotype; *a* is the gene for self-colour and this is recessive to *A<sup>w</sup>* the gene for mouflon-pattern a term that ADALSTEINSSON use for black with white belly. In the *Soay* there are two genotypes for light mouflon-pattern, and four for dark mouflon-pattern. The all-black and

all-brown genotypes of the Orkney and Shetland (and probably also of other Northern Short-tails) are the same as those in the *Soay*, and provide a link between these Bronze Age and Iron Age types : a polled, self-colour, light *Soay* with a woolly fleece is almost indistinguishable from a brown *Shetland*.

TABLE 1

*Genetic formula for coat colour in the Soay, Orkney and Shetland*  
*Formule génétique pour la couleur du Soay, de l'Orkney et du Shetland*

Phénotype	Génotype		
Brown .....	a a b b		
Black .....	a a B B	a a B b	
Dark Mouflon (black with white belly) .....	A <sup>w</sup> A <sup>w</sup> B B A <sup>w</sup> a B B	A <sup>w</sup> A <sup>w</sup> B b A <sup>w</sup> a B b	
Light Mouflon (brown with white belly) .....	A <sup>w</sup> A <sup>w</sup> b b	A <sup>w</sup> a b b	
Grey .....	A <sup>g</sup> A <sup>g</sup> B B A <sup>g</sup> a B B	A <sup>g</sup> A <sup>g</sup> B b A <sup>g</sup> a B b	
Grey-brown .....	A <sup>g</sup> A <sup>g</sup> b b	A <sup>g</sup> a b b	
White .....	A <sup>wh</sup> A <sup>wh</sup> B B A <sup>wh</sup> A <sup>g</sup> B B A <sup>wh</sup> a B B	A <sup>wh</sup> A <sup>wh</sup> B b A <sup>wh</sup> A <sup>g</sup> B b A <sup>wh</sup> a B b	A <sup>wh</sup> A <sup>wh</sup> b b A <sup>wh</sup> A <sup>g</sup> b b A <sup>wh</sup> a b b

*White* ( $A^{wh}$ ) is dominant to *grey* ( $A^g$ ) and both are dominant to *mouflon-pattern* ( $A^w$ ) and self-colour  $a$ . There are at least nine white genotypes in the Orkney and Shetland breeds. The grey gene ( $A^g$ ) causes a mixture of coloured and white fibres; when the black gene ( $B$ ) is present the mixture is grey, for which there are four genotypes. When there is only the brown gene ( $b$ ) the mixture of brown and white fibres is named grey-brown, which the Norwegians name « brown skimlet », grey being termed « black skimlet ». It is usually the coarsest fibres that are pigmented.

The changes in fleece and other characteristics during successive periods of antiquity are summarised in table 2.

TABLE 2  
 Summary of development of (mainly European) sheep types  
 Résumé du développement des types ovins (pour l'Europe)

Period	Skeleton	Fleece structure	Fleece colour	Evidence
Neolithic . . . . .	Similar to the wild ancestor (short tail)	Assumed to be initially of « hair » type (outer kemp and underwool) like wild ancestor	Assumed to be similar to the wild ancestor	Skeletal remains and surviving « hair » breeds in Africa and India
Bronze Age . . . . .	Limb bones shorter than in wild ancestor (short tail)	Hairy medium type with finer kemps than in wild ancestor plus generalised medium (woolly) type in which kemps replaced by medium wool fibres	Brown with wild-pattern white belly, with a few self-colour brown or black, and occasional piebald animals	Skeletal and textile remains plus surviving <i>Soay</i> sheep
Iron Age . . . . .	Bones still slender, and tail still short, but ewes usually lack horns	As above plus new true hairy (carpet) type in which kemps replaced by long heterotype hairs	White belly rare. Black or brown self-colour plus white and grey (black and white mixture) which now predominate, and a few roan (brown and white mixture)	Skeletal and textile remains plus surviving vari-coloured sheep (e.g. the <i>Orkney</i> and <i>Shetland</i> breeds in Britain)
Roman . . . . .	Tendency to increase in size, and illustrations show a long tail, but bones still slender	The modern medium (diagram), shortwool and fine fleece types begin to appear in small numbers	All white animals more numerous	Skeletal and textile remains, plus illustrations in which different fleece types are sometimes shown

Each change is additional to the preceding types and does not completely replace them.

### Material and methods

Most breeds described in this paper have been seen by the author and the fleece measurements given were made on wool and skin samples taken at the mid-side position (immediately behind the last rib, and half way down the body). Staple length was measured against a ruler, and fibre diameter was measured at the base of the staple on 100 fibres using a projection microscope at a magnification of  $500\times$ . The skin was processed histologically and follicle counts were made on horizontal sections by the method in Appendix I of RYDER & STEPHENSON (1968).

#### *Fibre types*

Although all fibres in the fleeces of sheep are collectively named wool, there are three main types : kemps which form the outer coat of wild sheep, wool, which forms the underwool, and intermediate (heterotype) hairs. Kemps are very coarse fibres with a wide internal (hollow) medulla. Kemp is usually short since the fibres do not grow long before shedding. Wool fibres are usually fine, and any medulla is relatively narrow. Hair (in sheep) is usually long and it varies over the length (hence the name heterotype). It is relatively highly evolved (see above), and so hair is uncommon in the primitive breeds of the present paper.

#### *Criteria on which fleece type is decided*

Although the mean diameter, and the diameter distribution are taken into account, the upper limit of the diameter range is the deciding factor (see fig. 4). Thus a fleece with a symmetrical (statistically normal) distribution, and a maximum fibre diameter between 30 and 40  $\mu\text{m}$  [one  $\mu\text{m}$  (micron) = 0.001 mm] would be regarded as a true fine type. The shortwool, too, has a symmetrical diameter distribution, but has a mean diameter of about 25  $\mu\text{m}$  compared with a mean of about 20  $\mu\text{m}$  in the fine wool. A skewed-to-fine diameter distribution (in which most of the fibres are fine) appears to be a primitive feature and if this occurred in a fleece with an upper limit above 35  $\mu\text{m}$ , it would be regarded as a fine variety of the generalised medium wool (i.e. fine, generalised medium wool).

The generalised medium wool is characterised by a skewed-to-fine distribution, and a maximum diameter about 55  $\mu\text{m}$ . The true medium wool has a symmetrical diameter distribution with an upper limit of about 60  $\mu\text{m}$ , whereas the hairy medium wool has a skewed-to-fine distribution with a few hairs greater than 60  $\mu\text{m}$  diameter. The hairy type has a continuous distribution, which is at the same time skewed-to-fine, with a relatively high proportion of hairy (i.e. medullated) fibres that are often over 100  $\mu\text{m}$  in diameter.

#### *Secondary/primary follicle ratio*

In wild animals outer coat hairs are grown in primary follicles, and the finer underwool in secondary follicles. Since the secondary follicles produce fine fibres,

the more secondaries a domestic sheep has, the finer will be its fleece. The mean S/P follicle ratio of a breed therefore gives a measure of the relative fineness of the fleece (RYDER, 1962; RYDER & STEPHENSON, 1968).

### Breed survey

The breeds surveyed have been classified into different groups for convenience, and these are listed in table 3.

TABLE 3

*The main breeds surveyed*  
*Les principales races examinées*

Northern short-tail	Alps
<i>Romanov</i> (Russia)	<i>Bundner</i> (Switzerland)
<i>Finnish Landrace</i>	<i>Steinschaf</i> (Austria)
<i>Goth</i> (Sweden)	<i>Della Roccia</i> (Italy)
<i>Spaelsau</i> (Norway)	
<i>Faroe</i>	Italy
<i>Iceland</i>	<i>Massa</i>
<i>Orkney/Shetland</i>	<i>Carapelle</i>
<i>Four-Horn</i> (Britain)	
<i>Cladagh</i> (Ireland)	Balkan
	<i>Racka</i> (Hungary)
South-west	<i>Dubrovnik</i> (Yugoslavia)
<i>Ushant</i> (France)	<i>Karakachan</i>   (Bulgaria)
<i>Corsican</i> (France)	<i>Karnobat</i>
<i>Guirra</i> (Spain)	<i>Drama</i>   (Greece)
	<i>Chalkidiki</i>
Heath	USSR
<i>Drenthe</i> (Netherlands)	<i>Karachaev</i> (Caucasus)
<i>Heidsnucke</i> (Germany)	<i>Kulunda</i> (Siberia)
<i>Wrzosowka</i> (Poland)	

#### 1. Northern Short-tail

This group of sheep has a predominantly hairy medium/generalised medium fleece type, and coloured animals are almost invariably self-coloured.



FIG. 6

*Some primitive breeds of Northwestern Europe  
Quelques races primitives de l'Europe du Nord-Ouest*

- a) Unimproved *Goth* Sheep, Lilla Karlsö, Gotland, 1976.  
Mouton *Gotlandais* non amélioré, Lilla Karlsö, Gotland, 1976.
- b) Native *Orkney* breed, North Ronaldsay, Orkney, Scotland.  
Race *Orkney* indigène, North Ronaldsay, Orkney, Ecosse.
- c) *Schoonebeker* flock of *Dutch Heath* Sheep, at Ruinen, the Netherlands, 1974.  
Troupeau de moutons des *Landes de Bruyères de Hollande*, type *Schoonebeker*, à Ruinen (Pays-Bas).
- d) *Heidschnucke* (*German Heath* Sheep), 1964.  
*Heidschnucke* (mouton des *Landes de Bruyères allemand*), 1964.

a) *Romanov and Finnish Landrace*

These hornless breeds are noted for their large litters. Most modern *Romanov* sheep are grey owing to a mixture of black hairy fibres and white wool, but EWART (1919) imported some all brown (presumably *bb*) sheep into Britain from



Leningrad. Most *Finnish* sheep are white, with 10 p. 100 black and 10 p. 100 grey. Fleece and skin measurements from RYDER (1968 b) are shown in tables 5 and 6. In the *Romanov* the white wool was longer than the black hairy fibres which were kemps rather than heterotype hairs, so that the fleece type was hairy medium and not true hairy. The *Finnish* sheep mostly have relatively fine, lustrous wool with a curl. The uniformity of the group is shown by the grading of Finn wool as Shetland in Britain.

#### b) *Swedish*

Most Swedish sheep today belong to the native *Landrace*, a term which is now used to describe the white, fine-woolled variety that is akin to the *Finnish Landrace*. The majority of the *Swedish Landrace* sheep, however, belong to the *Gotland*, grey furskin variety that became localised on the Baltic island of the same name, and there is a remnant of the ancestral Goth sheep on the small island of Lilla Karlsö of south-west Gotland (see fig. 6 a). The following description is based on a visit to this island by the author in June 1976 (see ADALSTEINSSON *et al.*, 1978).

The sheep are mainly horned (horns having been bred out of the *Gotland* variety) and grey, the face and legs usually being black. The fleece colour is, however, very variable; there are light and dark grey individuals, as well as piebald animals, and many have a light-coloured belly giving them a superficial mouflon-pattern. The grey colour usually derives from a mixture of black and white fibres, and some sheep have tan fibres in addition. Others had white kemp fibres that are more usual in true hairy breeds.

The rams have a height of about 72 cm and the ewes 68 cm (the sheep being characteristically long legged) and the weights are 75 kg and 45 kg respectively

TABLE 4

*Fleece measurements of Northern short-tail sheep*  
*Fibre Diameter (microns—1  $\mu\text{m}$  = 0.001 mm)*

Breed	No.	Mean Length (mm)	Overall Range	Mean Mode	Breed Mean
<i>Romanov</i> .....	(1)	160	18-38 60-150	22	38
<i>Finnish Landrace</i> .....	(2)	130	14-40	24	25.5
<i>Finnish Landrace</i> .....	(10)	160			P 39 S 32
<i>Gotland</i> .....	(12)	—	14-52, 70, 80	26	31
<i>Gotland</i> .....	(7)	—	12-70	36	35
<i>Gotland</i> .....	(10 ♂)	—	14-58	31	34
<i>Goth (Gutefar)</i> .....	(23)	111	14-190	HM 30 H 27	40 41
<i>Norwegian Spaelsau</i> .....	(4)	150	12-92	20	27
<i>Orkney</i> .....	(17)	60-160	8-120	17	22
<i>Shetland</i> .....	(8)	100-140	12-60	20	26
<i>Faroe</i> .....	(7)	130	12-112	26	34
<i>Iceland (modern)</i> .....	(2)	yarns	12-80	31	38
<i>Greenland (medieval)</i> .....	(2)	yarns	14-108	44	40

1. RYDER (1968 b).
  2. RYDER (1974 b).
  3. RYDER unpublished.
  4. RYDER (1974 a).
  5. RYDER & WILSON (1972).
- : No measurement.

(EKMAN, 1964). Older ewes usually produce twin lambs (even in the primitive strain on Lilla Karlsö) and 5 p. 100 have triplets.

An appreciable number of fleece measurements have been made in the past on the improved *Gotland* and an overall diameter range of 12  $\mu\text{m}$  to no more than 80  $\mu\text{m}$  was obtained (table 4). The less improved individuals had a skewed-to-fine fibre diameter distribution, being of either hairy medium, or generalised medium type, but the more improved animals had a high proportion of true medium wools. Fleece samples had no more than 5 p. 100 medullated fibres, but skin samples had more than 30 p. 100. A consistent feature in skin samples had been the relatively high secondary/primary follicle ratio.

*Mesures sur des toisons de mouton du Nord à queue courte*

Diameter Distribution		% med.	% pig.	Fleece Type	Ref.
skew fine	1 symmetrical	—	—	HM	[1]
1 skew fine		—	—	F/GM	[1]
					[5]
9 skew fine	3 symmetrical	—	—	M/GM/HM	[1]
2 skew fine	5 symmetrical	5 %	35 %	GM/M	[2]
2 skew fine	8 symmetrical	1 %	10 %	2 GM 10 M	[3]
14 skew fine		7 %	25 %	14 HM	[3]
9 skew fine/ continuous		15 %	32 %	9 H	
skew fine		—	—	GM/HM	[1]
16 skew fine	1 symmetrical	—	17 %	2 F 8 GM 7 HM	[1]
4 skew fine	4 symmetrical	—	—	4 F 3 GM 1 HM	[1]
6 skew fine	1 symmetrical	19 %	38 %	3 GM 4 HM	[3]
1 skew fine	1 symmetrical	22 %	36 %	2 HM	[3]
1 skew fine	1 continuous	34 %	99 %	1 HM 1 H	[4]

**Key**

- H : Hairy (continuous or skew fine/continuous distribution).
- HM : Hairy medium (skew fine).
- GM : Generalised medium (skew fine).
- F : Fine (symmetrical distribution).
- M : Medium (symmetrical distribution).
- P : Primary fibres.
- S : Secondary fibres.

Samples from the primitive variety on Lilla Karlsö comprised nine (39 p. 100) identified as true hairy, and fourteen (61 p. 100) as hairy medium. The overall diameter range was 14 to 190  $\mu\text{m}$ , and as well as having more medullated fibres, the hairy sheep had a greater mean diameter but a smaller mode. Hairy animals also had more pigmented fibres, which is in keeping with the statement of EKMAN (1964) that black hairs tended to be coarser than white ones. The skin indicated that fewer secondaries than primaries were pigmented, and that not only was the intensity of pigmentation lower, but it was concentrated on only one side of the fibre. These unimproved animals already had the unusually high S/P ratio (table 5).

One hundred yarns in textiles from the seventeenth-century Wasa warship wrecked in Stockholm harbour had on overall fibre diameter range of 10 to 140  $\mu\text{m}$  compared with 14-190  $\mu\text{m}$  in the Lilla Karlsö fleeces. There was (1 p. 100) fine wool, 5 p. 100 were shortwools, 19 p. 100 were medium wools, 13 p. 100 were generalised medium wools, 51 p. 100 were of hairy medium type and there were 11 p. 100 hairy fleeces.

The hairy wools had a mean fibre diameter (average of the individual means) of 36.7  $\mu\text{m}$  compared with 41.4  $\mu\text{m}$  in the Lilla Karlsö fleeces, the values for the

TABLE 5

*Percentage of different follicle types in the skin of Northern short-tail sheep*

Breed	No.	Primary follicles			
		Latticed Medulla	Non Latticed Medulla	No Medulla	Inactive Follicle
<i>Romanov</i> .....	(1)	78	—	17	5
<i>Finnish</i> .....	(2)	—	—	94	6
<i>Finnish</i> .....	(10)	—	0.1	96	4
<i>Gotland</i> .....	(7)	12	22	66	—
<i>Goth 9 H</i> .....		32	16	45	8
<i>(Gutefar) 14 HM</i> .....		22	11	44	23
<i>Norwegian Spaelsau</i> ....	(6)	6	2	92	8
<i>Orkney</i> .....	(5)	15	13	71	1
<i>Shetland</i> .....	(4)	—	1	96.5	2.5

The percentage of pigmented fibres varies with the colour type.

1. RYDER (1968 b).
2. RYDER (1974 b).

hairy medium wools being 31.3 and 39.7  $\mu\text{m}$  respectively. Therefore not only did the Wasa wools have fewer hairy fleeces, but those represented were relatively finer than those of the Lilla Karlsö sheep.

The Wasa wools were comparable with a medieval group of yarns mostly from Uppsala which were supplied by D' M. Nockert along with some Swedish Viking wools for comparison. The medieval wools comprised ten hairy medium wools, and

two generalised medium wools having an overall diameter range of 12 to 110  $\mu\text{m}$ , and overall mean fibre diameter of 35.7  $\mu\text{m}$ , and an average mode of 28.2  $\mu\text{m}$ .

These were coarser than the Viking samples which comprised two hairy medium wools, four generalised medium wools, and two of true fine type. The overall diameter range of these was 12 to 80  $\mu\text{m}$  with an overall mean diameter of 29.9  $\mu\text{m}$ , the mean mode being 25.9  $\mu\text{m}$ . These findings contrast with findings from Scotland where the Viking samples were hairy, and the medieval samples relatively fine (RYDER, 1968 a). The observations of ADALSTEINSSON *et al.* (1978) suggested that both the *Goth* and improved *Gotland* sheep had two new grey genes  $A^{gg}$  (Gotland grey) and  $A^{lg}$  (light grey) at the *Agouti* locus.

### c) Norwegian

The native short-tail of Norway is the *Spael*, in which the following colour types are recognised : mouflon-pattern (coloured with white belly), brown, black, some of which fade to grey, and others to brown (as in other *Northern Short-tails*). Then there are « skimlet » sheep with a mixture of coloured coarse fibres, and white (or paler) finer ones, so that a « black skimlet » individual appears grey, as in the *Romanov* or

### Pourcentage des différents types de follicules dans la peau de moutons du Nord à queue courte

Percentage Pigmented	Secondary follicles					S/P Ratio
	Latticed Medulla	Non Latticed Medulla	No Medulla	Inactive Follicle	Percentage Pigmented	
92	—	—	100	—	—	5.2 [1]
83	—	—	73	27	66	4.5 [1]
—	—	—	99	1	—	5.7 [4]
58	0.5	11	88	0.5	22	6.2 [2]
56	0.1	2.3	57	41	8	7.2 [3]
44	0.2	1.4	57	41	8	7.1
85	—	—	86	24	64	4.0 [1]
3	—	—	73	27	65	5.5 [1]
15	—	—	90	10	—	5.5 [1]

3. RYDER unpublished.

4. RYDER & WILSON (1972).

the grey *Orkney* (see fig. 6 b), although the light grey shade in Norway is described as « blue ». The « badger-face » has a white back and a coloured belly. The same range of colours is well represented in Iceland (see below).

There is also variation in coarseness (tables 5 and 6) ; finer fleeces tend, as in the Finn sheep, to be lustrous and to have a shallow curl, and coarse ones tend to be « tippy », i.e. to have staples with a hairy tip (RYDER, 1986 b).





FIG. 7

*a, b, c) Stuffed Sheep from Lille Dimon (Faroe), now extinct : a) ram, b) and c) ewes*  
 (Photographs supplied by Tove HATTING, Zoological Museum, Copenhagen)

*d) The breed of the Island of Ushant (France) (c. 1960)*

*a, b, c) Têtes naturalisées de moutons de Lille Dimon (Faroe) aujourd'hui disparus :*  
*a) bélier, b) et c) brebis* (Clichés fournis par Tove HATTING, Musée Zoologique, Copenhague)

*d) La race de l'île d'Ouessant en France vers 1960*

d) *Danish*

The *Northern Short-tail* still remained in Denmark early in the nineteenth century, but later in that century there was a *Danish Heath* sheep which is said to have been a cross between the *Northern Short-tail* and the *German Heath* breed. The *Danish Heath* has been described as white-faced, hornless and short-tailed, yet a specimen in the Zoological Museum, Copenhagen is black, horned and long-tailed (cf. *German Heath* below).

e) *Faroese*

This group of islands was settled from Norway in the early ninth century and has a breed of *Northern Short-tail*. A feral variety survived on the island of Lille Dimon until the middle of the last century, and there are stuffed specimens of this in the Zoological Museum, Copenhagen (fig. 7 a, b, c) because these are brown self-colour animals one cannot be sure whether or not they are like the *Soay*. There is, however, no reason to believe that they were not *Northern Short-tails*, and so the *Soay* remains unique.

Sheep were introduced from Shetland and Iceland in the eighteenth century, and the modern *Faroese* breed has the same range of colours as other *Northern Short-tails*, with relatively hairy fleeces like those of *Icelandic* sheep (ADALSTEINSSON & WARDUM, 1978). Fleece measurements are shown in table 3. The only skin sample examined had large central primary follicles with a wide latticed medulla, and smaller lateral primaries with either a non-latticed medulla, or no medulla at all. The secondary (underwool) follicles were much smaller, and the S/P follicle ratio was 4/1.

f) *Iceland and Greenland*

Most settlers of Iceland came direct from Norway about AD 900, and present-day *Icelandic* sheep stem from animals introduced at that time. Most sheep today are horned in both sexes, animals sometimes having four horns, but hornless sheep are common. The fleece is hairy, the coarse outer coat having a mean length of 21 cm, and the soft, fine underwool an average length of 6  $\mu\text{m}$ . Despite the hairiness the mean fibre diameter is only 27  $\mu\text{m}$ .

As in Shetland, *Icelandic* sheep were plucked in the past indicating the primitive tendency to moult. In common with the *Soay*, many of the hairy fibres shed at a different time from the wool, so that the wool can be obtained largely free from hair. Although in the *Northern Short-tail* most hairy fibres are kemps, many of those in *Icelandic* sheep appear to be heterotype hairs. Although heterotypes are not typical of this group of sheep, this observation supports the suggested origin of heterotype hairs from kemps (see introduction). Indeed, this occurrence may indicate a stage in the evolution towards the typical carpet type.

Present-day *Icelandic* sheep are mainly white, often with a tan head and feet, and varying proportions of tan fibres in the fleece, although such animals are still genetically white. From 10 p. 100 to 20 p. 100 of the sheep are coloured, black, brown, grey, brown-grey (brown skimlet) and other rare colours such as badger-face

and reverse badger-face another name for coloured with white belly also called mouflon-pattern a term which may cause some confusion. Each colour can be unbroken or broken (e.g. piebald) (ADALSTEINSSON, 1970). Norse settlers took a similar sheep to Greenland, and table 3 shows the measurement of an archaeological specimen from that country.

g) *The British Isles*

A hundred years ago the sheep of the Northern Isles of Britain formed a single population. Since then the *Shetland* has been selected for white, fine wool, so the *Orkney* with hairy and woolly fleeces now represents the ancestral type. These islands were under Norse rule from the ninth to the fifteenth centuries, and the sheep show clear Scandinavian influence in their short tail, and colour range (fig. 6 b). But these sheep as well as those of Scandinavia, may be relics of the Iron Age (see introduction). Fleece measurements and follicle population details are shown in tables 3 and 4. The most primitive sheep remain now only on North Ronaldsay the most northerly island of the group (RYDER, 1986 a and b). The other main feature of these sheep is the retention of a spring moult, so that in the past sheep were plucked instead of being shorn. The same word « roo » is used in Iceland for plucking, indicating the ancestry of the custom.

Other parts of Britain with Norse settlers include the Hebrides, the Lake District and the Isle of Man. The Hebrides formerly had a sheep similar to the Orkney and Shetland, among with four-horned and piebald animals were common. Characters from the *Old Hebridean* sheep probably persist in the *Hebridean Blackface* (RYDER, 1975). The possible relationships between the *Soay*, *Northern Short-tail* and four-horned sheep are shown in fig. 8.

Here it can be seen how selection of black, four-horned sheep could have given rise to the modern black, *Saint Kilda* (Hebridean) breed, and selection of brown, four-horned individuals could have led to the brown *Loghtan* breed of the Isle of Man. Finally, selection of piebald, four-horns could have given the *Jacob* breed, the origin of which has caused much speculation. Unlike the *Saint Kilda* and *Loghtan*, this does not have a short tail, and its fleece is less primitive, so other influence might be involved. But an exotic origin is unlikely when the breed could have originated in Britain.

The *Herdwick* of the Lake District has a hairy fleece like that of the black-faced carpet type, yet it has a white face and dark grey lambs suggesting Scandinavian influence. RYDER (1964 a) thought that the hairy fleece might have been acquired more recently, but it is now realised that such fleeces are found in Scandinavian sheep ; again this does not have a short tail.

Skeletal evidence from prehistoric sites in Ireland indicate an animal similar to the *Soay*, and some four-horned skulls have been found. Textile remains from the first few centuries AD yielded six hairy medium wools in which the coarser fibres were more densely pigmented than the fine ones. Seventeenth century textiles still had this difference in pigmentation between the coarse and fine fibres and comprised 14 hairy medium wools, eight generalised medium wools, four true medium wools, and one fine wool (RYDER, 1969 b).

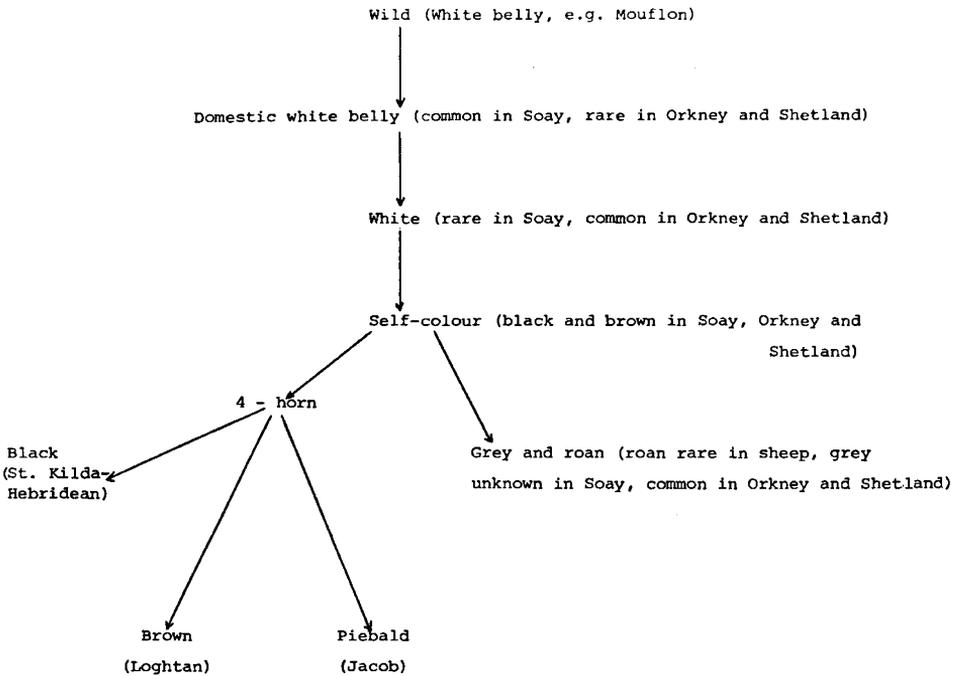


FIG. 8

*Possible relationships of colour types and four-horned breeds*  
*Rapport possible entre les types colorés et les races à 4 cornes*

Descriptions and illustrations of *Irish* sheep do not appear until the nineteenth century, and in the west there was a horned breed known as the *Kerry* with a short tail and coloured as well as white sheep. Here, too, was the primitive *Cladagh*, and descriptions of remnants of this breed were given by NODDLE & RYDER (1974). One fleece samples was of hairy medium type with brown coarse fibres (as in the textile remains) being therefore brown skimlet. The overall diameter range was 12 to 70  $\mu\text{m}$ , with a mean of  $32.8 \pm 12.9 \mu\text{m}$  and a mode of 20  $\mu\text{m}$ . The secondary/primary follicle ratio in the skin was estimated to be 4/1. The identification of the *Cladagh* with the *Northern Short-tail* of Britain (e.g. the *Orkney* and *Shetland*) is supported by the fact that its name means « shore sheep » because it eats seaweed like the *Orkney* sheep on North Ronaldsay.

Attempts have been made recently to collect together remnants of *Cladagh* sheep, and a flock is kept at the *Belclare Research Centre*, Galway. This has mostly hornless, white-faced animals, with few coloured sheep, although at least one coloured with white belly has been recorded. Results from fleece samples (RYDER unpublished) indicate that the sheep are very variable in appearance, and therefore not pure. Three samples appeared hairy and had fibre diameter measurements supporting this identification. Six had pointed staple tips but were fine and lustrous, comprising two

generalised medium wools, two medium wools and two shortwools. Three had a broad wave, two being medium wools, and one a shortwool. Three samples appeared like *British Down* wool, two being shortwools, and one a generalised medium wool. Only one was coloured (grey) and this was of primitive generalised medium type. There was hardly any medullation in the skin, but the proportion of medullated fibres in the fleece samples ranged from zero to 35 p. 100 with a mean of 8 p. 100. The S/P ratio was 3.7/1, and 25 p. 100 of both the primary and secondary follicles were inactive.

### South West Europe

#### *France*

The short-tailed breed of the island of Ushant (Ouessant) off north-west France was linked with the *Northern Short-tail* by RYDER (1968 b). The rams are horned, and the ewes polled, and there is a tendency to moult in spring. The pair with a black lamb described by RYDER (1968 b) as dark brown, are now realised to have been faded black animals. Illustrations of the island, show a predominance of white sheep, some with a tan face, but others appear to be grey, and some white sheep with a black face could be light grey animals (fig. 7 d). More recent breed descriptions list only black and « brown » animals. According to LAUVERGNE (1976) no sheep remain on the island, and in the few flocks preserved on the mainland the colour range has become reduced to all black or all white animals.

A single fleece sample measured by RYDER (1968 b) was over 100 mm long and had a fibre diameter range of 14 to 52  $\mu\text{m}$ , with coarser fibres 56 and 58  $\mu\text{m}$  in diameter, and a mean and mode of 28 and 18  $\mu\text{m}$  respectively.

Illustrations of the native breed of the island of *Corsica* show it to have a hairy, carpet-type fleece, and the sheep appear to have the same colour range as the *Northern Short-tail*. LAUVERGNE & ADALSTEINSSON (1976) found that the colour patterns were determined by a series of six alleles at the *Agouti* locus. Five of these : white, grey, badgerface, black with white belly and black are the same as those in Iceland. The sixth, producing a red patch around the eye has so far only been found in Corsica. In all, six out of nine colour genotypes were the same as in Iceland from which the authors concluded that the sheep of the two islands had a common ancestry. This conclusion supports the theme of the present paper, namely, that during the Iron Age and for some time later, the sheep of Europe were of vari-coloured stock. How this conclusion is affected by the fact that Corsica was never invaded by the Celts (DE BEER, 1965) is not clear.

#### *Spain*

There are references to coloured sheep in Spain going back to antiquity when Pliny mentioned black and brown sheep (*Natural History* VII, 191). In the nineteenth century Majorca in the Balearic Islands had a primitive breed named the *Arta* (SALVATOR, 1897). This was horned, and apparently had a short tail. The body was

white, and the face tan, with two white stripes. One primitive sheep on Ibiza was described as black, and to have small horns and wool of medium quality. Another was said to be polled, and to have a short tail.

Apparently the only coloured breed remaining on the mainland is the *Guirra* kept on the coast opposite the Balearic Islands (BROOKE & RYDER, 1977). All except 5 p. 100 of the animals which are black, are born reddish-brown and become paler with age, the final colour being cream. ADALSTEINSSON (1970) identifies this colour as « red » like that in the French *Sologne* breed which is also born « red » and goes paler with age.

Of the five fleece samples taken, one animal had wool of almost *Merino* fineness, ranging in diameter from 16 to 36  $\mu\text{m}$  with a mean of 24.6 and a mode of 27  $\mu\text{m}$ , but its S/P ratio was only 5.7, lower than expected even for a *Merino* cross. The remaining flour fleece samples had hairy fibres (mean percentage of medullated fibre 14.25 p. 100) in addition to the bulk of the coat which ranged up to about 50  $\mu\text{m}$  in diameter. The mode of each was 24  $\mu\text{m}$ , but the means ranged from 27.3 to 34.8, with an overall mean of 31  $\mu\text{m}$ . The mean S/P ratio in the skin was 5.4/1. By the classification of RYDER (1969 a) these are hairy medium wools.

### Heath sheep

This group of black-faced horned sheep formerly extended from the Netherlands to Poland. Some of the breeds have a short tail, and a hairy fleece, and RYDER (1964 a and 1968 b) thought from their general appearance and fleece type, that they had links with the black-faced, horned group of Britain. The grey fleece and short tail, however, probably indicate a closer association with the *Northern Short-tail*.

### Netherlands

The three breeds of *Heath* sheep of Holland are the *Drenthe* localised in the north east, the *Veluwe* which occurred in belt across the middle of the country, and the *Kempen* breed of the south. The *Drenthe* is mostly horned, and has a straight nose; the fleece is hairy and variable in colour, as is the face which can be black, tan or white. The *Veluwe* breed is larger and related to the German *Bentheim* breed. This sheep is mostly hornless, the nose is convex, and there is black around the eyes and on the legs. The fleece is less hairy. The lambs of both the *Drenthe* and *Veluwe* breeds are piebald to about the age of 6 months.

The *Kempen* breed is hornless and white, as are the lambs, and the hair on the face is « shiny ». Each of the three breeds has a long tail, although some descriptions referred to the *Drenthe* breed as having a short tail. Although the *Kempen* is now rare, the characters of the *Drenthe* and *Veluwe* are retained in the *Schoonebeker* (cf. fig. 6 c) hybrid of which one flock is kept at Ruinen.

This has horned and hornless animals and varying face colours (fig. 6 c). These are black, tan, together with patterns including speckled, black around the eyes, and

badger-face. ADALSTEINSSON (1970) points out that tan-faced sheep are genetically white, the tan fibres being restricted from the fleece since the animals are homozygous for the recessive colour-restricting gene (*ss*), see also the genetic analysis by LAUVERGNE & BOTTEMA (1978) (cf. the rare *Portland* breed in Britain). The colour of the fleece is black, brown, grey, white or piebald, and the wool is generally hairy, but is more akin to that of a hairy *Shetland* sheep (hairy medium type) than the true hairy fleece of the *Scottish Blackface*. Some animals had cast parts of their fleece.

The legs and tail are long and thin, and D<sup>r</sup> A.C.V. VAN BEMMEL pointed out in 1974 that the so called *Drenthe* sheep I had sampled in Amsterdam Zoo in 1964, and published as such (RYDER, 1968 b) were in fact *German Heath* sheep (fig. 6 d).

Fleece measurements of wool samples taken in 1974 are shown in table 6. These can be compared with a group of 17 yarns from *Dutch Terpen* sites dating from throughout the first millenium A.D. These comprised 3 hairy fleeces, 10 hairy medium wools, 2 generalised medium wools, 2 true medium wools, and one fine wool (RYDER, unpublished).

### *Germany*

The *Heidschnucke* of Germany has a black face, horns, and a short tail. The colour is grey, and the lambs are born black, but the sheep frequently have a black belly like the badger-face genotype of the *Northern Short-tail*. There also appear to be some brown animals. The fleece is hairy (table 6) but there is a hornless white variety with a less coarse fleece. The hairy fibres include kemps as well as heterotype hairs. The S/P follicle ratio of 4.4 indicates a greater proportion of fine fibres compared with the *Scottish Blackface* (S/P = 3.7).

### *Poland*

The *Wrzosowka* breed appears to have affinities on the one hand with the *Heidschnucke*, and on the other hand with the *Romanov* of Russia (see table 7). The colour is predominantly grey, but NAWARA (1976) reported 10 p. 100 black animals, with about 50 p. 100 dark grey and 40 p. 100 light grey in an experimental flock at Cracow. Of 20 skin and fleece samples received from the same source 5 were dark grey, 3 medium grey, and 12 light grey. The length of three months growth of wool was about 80 mm. The fibre diameter measurements are shown in table 5 and skin follicles details in table 6. Twelve samples were identified as true hairy type, and eight as hairy medium wools. Another (tailed) breed of Poland is the *Swiniarka*, which is white faced, and horned in the rams only. It appears to have a hairy medium fleece (JANKOWSKI, personal communication).

### *Alps*

The *Bundner* breed of Switzerland shares the distinction of the *Soay* in Britain of being a sheep whose skeleton was compared with prehistoric remains found during the nineteenth century. It has therefore appeared frequently in the literature (e.g.

TABLE 6

*Fleece measurements of Heath and Balkan sheep*

Breed	No.	Mean Length (mm)	Fibre Diameter ( $\mu$ )		
			Overall Range	Mean Mode	Breed Mean
<b>Heath</b>					
<i>Dutch</i> .....	(5)	138 (Apr.)	12-130	26	32
<i>Heidschnucke</i> grey .....		—	14-114	20	31
white .....		—	16- 80	24	32
<i>Wrzosowka</i> .....	(12)	—	12-150	23	39
	(8)	—	14- 90	25	35
<b>Balkan</b>					
<i>Racka</i> (Hungary) .....	(12)	225	11-115	28	40
<i>Dubrovnik</i> (Yugoslavia) .	(6)	69	14- 88	30	35
	(3)	52 (Dec.)	18- 52	31	32
<i>Karakachan</i> .....	(7)	104 (Sept.)	18-122	34	49
<i>Karnabat</i> (Bulgaria) .....	(5)	38 (Sept.)	14- 70	34	41
<i>Drama</i> .....	(5)	76 (Feb.)	16-112	32	39
<i>Chalkidiki</i> (Greece) .....	(6)	67 (Feb.)	12-124	28	37

1. RYDER unpublished.

2. RYDER (1968 b).

TABLE 7

*Skin follicle details of Heath and Balkan sheep*

Breed	No.	Primary follicles			
		Latticed Medulla	Non Latticed Medulla	No Medulla	Inactive Follicle
<b>Heath</b>					
<i>Heidschnucke</i> grey .....	(3)	75	15	10	0.5
<i>Wrzosowka</i> .....	12 H	5	8	77	10
	8 HM	—	14	77	9
<b>Balkan</b>					
<i>Racka</i> (Hungary) .....	(12)	2 (« medullated »)		87	11
<i>Dubrovnik</i> (Yugoslavia) .	(9)	0	1	97	2
<i>Karakachan</i> .....	(7)	7	31	62	0
<i>Karnabat</i> (Bulgaria) .....	(5)	0	2	92	6
<i>Drama</i> .....	(5)	0	0	87	13
<i>Chalkidiki</i> (Greece) .....	(6)	0	5	64	31

1. RYDER unpublished.

2. RYDER (1968 b).

Mesures sur des toisons de moutons des Bruyères et de moutons des Balkans

Diameter Distribution	% med.	% Pig.	Fleece Type	Ref.
4 skew fine, 1 symmetrical	7 %	25 %	1 H 3 HM 1 M	[1]
skew fine	—	—	H	[2]
skew fine	—	—	HM	
skew fine/continuous	26 %	31 %	H	[1]
skew fine	25 %	30 %	HM	
skew fine/continuous	4 %	not recorded	6 H 6 HM	[3]
skew fine	8 %	0	HM	[4]
symmetrical	3 %	0	F/Short	
skew fine	25 %	38 %	6 H 1 HM	[1]
skew fine	5 %	81 %	HM	[1]
skew fine	5 %	54 %	2 H 3 HM	[4]
4 skew fine, 2 continuous	9 %	61 %	2 H 3 HM 1 GM	[4]

3. RYDER (1974 b).

4. BROOKE & RYDER (1977).

Détails sur les follicules des moutons des Bruyères et des Balkans

Percentage Pigmented	Secondary follicles					S/P Ratio
	Latticed Medulla	Non Latticed Medulla	No Medulla	Inactive Follicle	Percentage Pigmented	
16	0.3	1	97.5	1.2	11	4.4 [1]
22	0	0	92	8	10	4.8 [2]
37	0	0	87	13	16	4.3
not recorded	0	0	70	30	not recorded	2.4 [3]
0	0	0	97	3	0	4.7 [4]
15	0	0	99	1	27	3.9 [1]
83	0	0	99.5	0.5	77	5.0 [1]
15	0	0	96	4	16	3.2 [4]
not recorded	0	0	88	11	not recorded	3.3 [4]

3. RYDER (1974 b).

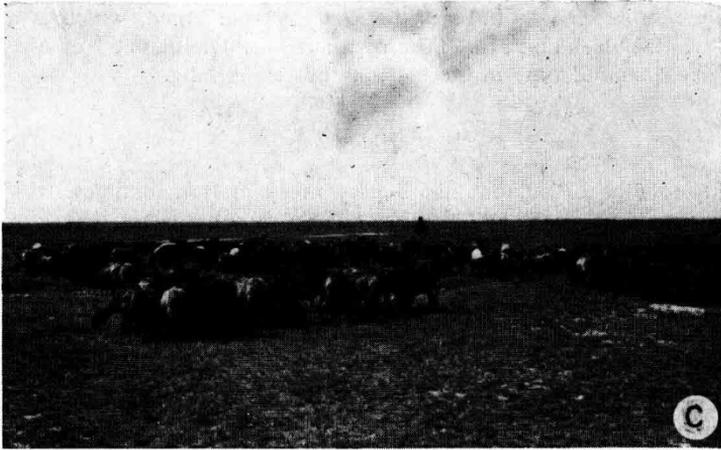
4. BROOKE & RYDER (1977).



FIG. 9

*Some breeds from Switzerland, Italy and the Balkans*  
*Quelques races de Suisse, Italie et des Balkans*

- a) A stuffed specimen of the extinct *Swiss Bündner Sheep*.  
Tête naturalisée du mouton des *Grisons*, aujourd'hui disparu.
- b) The *Carapella* breed of Italy (1975) (photograph C.H. BROOKE).  
La race *Carapella* d'Italie (1975) (cliché C.H. BROOKE).
- c) The *Racka* breed of Hungary (1971).  
La race *Racka* de Hongrie (1971).
- d) The *Karakachan* breed in Bulgaria (1976).  
La race *Karakachan* de Bulgarie (1976).



ZEUNER, 1963) but with inadequate breed description. Sadly the sheep became extinct in 1960. In the Grisons Museum, Chur, in 1976 I saw the stuffed skin of the last (brown) sheep to die. I also saw the grey animal illustrated by previous authors such as ZEUNER (fig. 9 a). The tail was of medium length, but the fleece was of hairy medium/generalised medium type like the Northern short tail, and not as hairy as that of the Heath sheep. The face and legs were black. The small horns described by others as « goat-like » probably indicate the presence of the polling gene (ADALSTEINSSON, 1977).

The *Steinschaf* of Austria seems to be similar to the *Bundner*, and both appear to be representatives of a type that was formerly more widely distributed throughout the Alpine region including Bavaria and Italy (see below). The rams are usually horned and the ewes polled, and there are black, brown, and grey animals in addition white.

The *Steinschaf* is seen in Italy as the *Della Roccia* breed, which in addition to white, has 37 p. 100 black and 3 p. 100 brown animals. The plate 51 of MASON (1967) suggests a hairy *Shetland* type of fleece, but the tail is long.

### Italy

According to Pliny, Piedmont had a grey sheep in Roman times, which accords with the *Della Roccia* above. The *Massa* breed of Tuscany has either dark grey or brown sheep. Illustrations in breed literature indicate a primitive fleece, but the tail is of medium length.

The *Carapelle* of Foggia has been described as a black *Merino*. The survey of BROOKE & RYDER (1977) located only one ewe remaining (fig. 9 b). This was a horned sheep with faded black wool having a mean fibre diameter of 31  $\mu\text{m}$  and an S/P follicle ratio of 5.3. Samples taken from the local fine-woolled *Gentile di Puglia* for comparison had a mean fibre diameter of 25  $\mu\text{m}$  and an S/P ratio of 8.9. This suggested that the *carapelle* has a primitive fleece type like the *Northern Short-tail*, since it is neither a fine wool nor a carpet type. But the tail does not appear to be short.

### Balkan

Previous authors have divided Balkan sheep into the hairy *Zackel* type, and the finer-woolled *Ruda*. The survey of BROOKE & RYDER (1977) obtained evidence that the primitive type might exist among the *Zackels* rather than the *Ruda* sheep.

The *Racka* of Hungary (fig. 9 c) has corkscrew horns in both sexes and there are black and white varieties, the face and legs of the latter being tan (cf. the *Dutch Heath*). The fleece is less hairy than the carpet type, half being hairy medium fleeces, more curly, and sometimes lustrous (RYDER, 1974 b). Fleece measurements are shown in table 5. There was no difference in fibre diameter between black and white animals, nor between the sexes. There were apparently no kemp fibres, and the coarser fibres of the black fleeces tended to be more densely pigmented than the finer ones, which is a common feature in the *Northern Short-tail*. Follicle population details are given in table 6. The S/P follicle ratio of 2.4 was low, being even less than the figure of 3.7. in the *Scottish Blackface*.

The *Dubrovnik* breed of Yugoslavia is hornless and white-faced, and has a long tail; 10 p. 100 of the sheep are coloured. The accepted view is that this breed originated from a fairly recent cross between the *Merino*, and the local hairy *Zackel* type, and some of the fleeces were relatively fine (table 5). But the S/P ratio figure of 4.7 obtained by BROOKE & RYDER (1977) (table 6) was lower than that expected from a *Merino* cross. The *Merinos* that are known to have been introduced are likely to have had an S/P ratio of at least as high as 10, and so the *Dubrovnik* would be expected to have an S/P intermediate (6.6.) between this and the Yugoslav *Zackel* value of 3.3.

It therefore seems more likely that the *Dubrovnik* breed is a relic of an ancient fine wool, which accords with historical evidence of the area in classical times and during the Middle Ages. The fine fleeces, were, however, much closer to the true fine wool, than those found elsewhere in the Balkans (see below).

TABLE 8

*List of Bulgarian sheep breeds according to various authors**Liste des races ovines de Bulgarie selon divers auteurs*

Breed	Listed by MASON (1969)	Recognised by RYDER in 1976	Listed by LAUVERGNE (1980)
<i>Zackel</i>			
<i>Belaslatina</i> (NW) . . . . .	+	+	—
<i>Karakachan</i> . . . . .	+	+	+
<i>Kyustendil</i> . . . . .	+	+	—
<i>Panagyurishte</i> (W) . . . . .	+	+	(Panagor)
<i>Replyan</i> (NW) . . . . .	+	+	+
<i>Rhodope</i> (S) . . . . .	+	+	(Srednorodope)
<i>Sofia-Breznik</i> (SW) . . . . .	+	+	(Brezmik)
<i>Zackel</i> × <i>Tsigai</i>			
<i>Pleven Blackhead</i> . . . . .	+	+	(Černograd Pleven)
<i>Svishtov</i> . . . . .	+	+	+
<i>White South Bulgarian</i> . . . . .	+	(Stara Zagora)	(Stara Zagora)
<i>Rila Monastery</i> (S) . . . . .	+	+	—
<i>Strandzha</i> . . . . .	—	+	+
<i>Tsigai</i>			
<i>Karnobat</i> . . . . .	+	+	+
<i>Shumen</i> . . . . .	+	+	(Mednočerven Šumen)
<i>Type not recorded</i>			
<i>Dăben</i> . . . . .	—	—	+
<i>Katlen</i> . . . . .	—	—	+
<i>Koprivišten</i> . . . . .	—	—	+
<i>Sakav</i> . . . . .	—	RYDER (1974 b)	
<i>Teteven</i> . . . . .	—	—	+
<i>Sredostaraplan</i> . . . . .	—	—	+
<i>Zapadnostaroplan</i> . . . . .	—	—	+

*Bulgaria*

MASON (1969) listed the *Karnobat* and *Shumen* as the only medium wool breeds in Bulgaria along with ten *Zackel* breeds (table 8). The *Karakachan* and *Karnobat* were included in the present survey as the only Bulgarian breeds discovered with a coloured fleece of primitive structure. During a visit in 1980 LAUVERGNE obtained evidence of

more breeds (table 8) but it is not clear to what extent these are varieties of other breeds, or their names synonyms. More details of Bulgarian breeds are given by RYDER (1982). The *Karakachan* breed is associated with the nomadic Sarakatsan shepherd people, and so is found in other Balkan countries, notably Greece. Only two hairy fleece samples were obtained in Greece by BROOKE & RYDER (1977, 1979); another flock was seen and sampled in Bulgaria by the present author in September 1976. The samples comprised 6 hairy fleeces, and one hairy medium wool. There were black, brown, grey and white sheep, the colour being very variable, even over the body, and some of the grey animals appeared to have become so with age (fig. 9 d). The dark grey animals were typically black on the face and legs, while some light ones had a white face or black around the eyes. According to ADALSTEINSON (1977) this pattern is brought about by the effect of the piebald (colour restricting) gene on recessive black, which also makes the body white. The fleece measurements and skin follicle details are given in tables 6 and 7. The hairiness of the fleece is indicated by the high mean diameter and average mode, as well as the high percentage of medullated fibres (table 6).

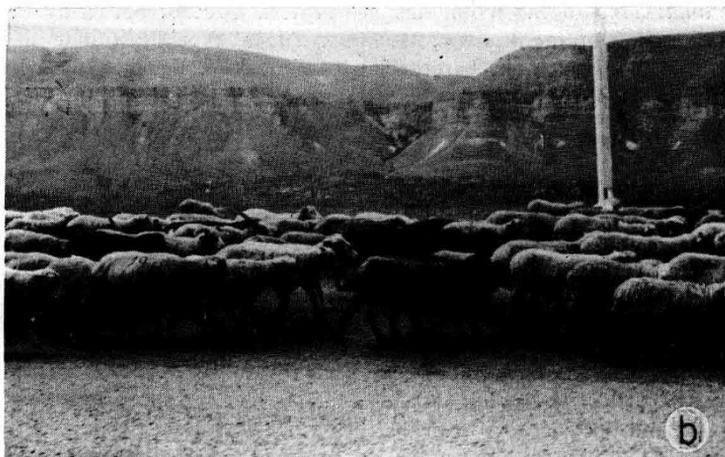
The *Karnobat* breed of Bulgaria is of less-coarse *Ruda* type, and has been thought to have associations with the *Tsigai* (*Ruda*) breed of Romania, which in turn is thought to be related to the *Thraki* breed of Greece and the *Kivircik* of Turkey. My observations in Bulgaria showed it to be similar to the *Drama* of Greece (see below) and the *Panagyurishte* and *Shumen* (Bulgarian) breeds, and BALEVSKA & PETROV (1972) consider from skull measurements that the last two breeds and the *Karnobat* are of *Zackel* rather than *Tsigai* type.



FIG. 10

*Some breeds from Greece and U.S.S.R.  
Quelques races de Grèce et d'U.R.S.S.*

- a) The *Drama* breed of Greece (1975).  
La race *Drama* de Grèce (1975).
- b) The *Karachaev* breed of the Caucasus (1979).  
La *Karachaev* du Caucase (1979).
- c) The *Kulunda* breed of the Altai Steppe in Siberia (1979).  
La race *Kulunda* des Steppes de l'Altai, en Sibérie (1979).



The *Karnobat* sheep I saw were horned in the rams only, and the tail which had been short is now long, or of medium length. The fleece appeared to be of hairy medium/generalised medium type, and not hairy. The animals were brown, but different from the usual brown in that the head and legs were black. The sheep therefore appear to be genetically black, but with a tendency to fade readily to brown (as seen in the black patch of the *Jacob* breed (see also LAUVERGNE *and al.*, 1981 for the fading process). This conclusion is supported by the observation of darker patches on the body, and of a range of shade between individuals from almost black to light brown. Some sheep appeared to have faded to grey, but no true grey animals (with black and white fibres) were observed. The same colour was observed by ADALSTEINSSON, DOLLING, LAUVERGNE & RYDER in *Merinos* in Australia, and may be a different genotype from black and brown (RYDER, 1980). Fleece measurements and skin follicle details are shown in tables 6 and 7.

The *Drama* breed of the mountains in northern Greece bordering on Bulgaria is probably a variety of the *Vlachos Mountain Zackel* type illustrated in Plate 110 of MASON (1967). The black sheep recorded by BROOKE & RYDER (1977) had a relatively finer fleece than the remainder (fig. 10 a) and were also similar to the *Chalkidiki* breed (see below).

As with other Greek breeds the appearance was very variable, there were horned and hornless sheep, black, white and grey fleeces, speckled faces and legs, as well as black around the eyes, and a moderately long tail. Fleece measurements are shown in table 6 and skin follicle details in table 7.

I had hoped to find the remnants of an ancient fine wool in the Balkans, and was looking for a true fine wool. In the event this and the following breed provided the answer with a generalised medium fleece, which was what RYDER (1969 a) identified as the ancient fine wool. It was immediately obvious that the sheep had fleeces similar to the *Shetland*, and this accorded with the theme of the present paper — the primitive type surviving in southern Europe, being the same as that in the North.

The *Chalkidiki* breed of the peninsular of the same name in southern Macedonia has horns in the rams only, and a tail of medium length. Ten per cent of the animals were black, and there were dark and light grey, as well as white sheep. In these the face, legs, and sometimes the belly, were black, although others were white, speckled, or had black around the eyes. Some of the animals had fine kemps as in the hairy *Shetland*; fleece measurements are shown in table 6 skin follicle details are given in table 7. The similarity of the S/P ratio with that of the *Drama* breed suggests a relationship between the breeds.

#### *Soviet Union*

Since it is not known how many truly native breeds remain in the U.S.S.R., and since those known in the west are not well documented, the following coloured breeds recorded during a visit in 1979 will be described.

The *Karachaev* (fig. 10 b) is a mainly black, horned breed with a fat tail and a carpet-wool fleece, and 20 000 are still kept privately in the Caucasus Mountains. Unlike more modern Russian breeds it is kept outside all the year. There is 115 p. 100 lambing, although twins have not been encouraged because of the custom of transhumance in which the sheep are taken to the high mountains during the summer. It is a triple purpose breed, the lambs being killed at one month so that the ewes can be milked. The curly, black lamb skins are used to make hats.

The ewes produce 1.5 kg of wool in two shearings, and weigh 35 kg, while the rams reach 55 kg. Animals seen on the march in a mixed flock (fig. 10 b) were very variable, some apparently being grey. Others seen at a show had wool finer than carpet type, the fleece being more like that of a hairy *Shetland* or the Greek *Chalkidiki* breed. The structure and colour of the fleece suggest a relationship with the European type of the present paper, but the possession of a fat tail implies a different broad grouping, and suggests either that this fleece structure and colour range had evolved before the fat tail developed, or that the same fleece characteristics evolved independently in different broad groups.

The *Kulunda* breed was seen on the steppe of the same name in the Altai region of Siberia. Although located several thousand miles away it appeared superficially similar to the *Karachaev*, being a black, fat-tail Not all the sheep had a fat tail, however, and there were both horned and polled animals. As with the *Karachaev* the fleece appeared to be of hairy medium rather than a true hairy type. Most of the animals were black, but there were a few grey and brown animals, as well as white sheep, which may have been crossbred (fig. 10 c).

### Discussion

Some of the breeds should perhaps have not been included in this survey, and there may well be other known, or more important, unknown, breeds that should have been included. But it is hoped that the present descriptions, however, inadequate, will stimulate more detailed studies of the breeds in question, as well as stimulate the search for little known breeds worthy of being put on record.

Several authors have used a diffusion model not only to study the spread of domesticates, but to estimate the rate of genetic change (e.g. LAUVERGNE, 1979). Such a model may work with plants, but has severe limitations with animals : waves of migration did not radiate outwards in regular fashion, but followed fairly narrow routes which differed in their rate of progress, and evolution was not restricted to the centre of origin.

If one accepts the evidence of POPLIN (1979) that the Mouflon sheep on Corsica are not truly wild but feral domesticates then here we have a survival of European Neolithic sheep that is little, if any, changed from the wild ancestor. Survival has however, depended more on the isolation of an island than on the distance from the centre of domestication.

The next most primitive breed, the Bronze Age *Soay*, is located on the very edge of the continent, but again survival was due to insular isolation. Most of the breeds of the present survey are thought to date from the Iron Age to the Middle Ages, and these are apparently scattered at random throughout Europe, although it is perhaps significant for the diffusion hypothesis that they are universal throughout northern Europe. The criteria on which these were chosen are the possession of a short tail, a primitive fleece structure, and in particular, a range of colour. It is not implied that these have undergone no selective change since the Iron Age (although the *Soay* appears not to have changed) since the colour range of some has been restricted, and they are clearly very variable.

Other factors casting doubt on the diffusion model are the location of the *Merino*, the breed with the most highly evolved fleece, in Spain a long distance from the centre of domestication in the Middle East, while the modern sheep at the centre of domestication appear primitive rather than highly evolved, although the hairy, carpet-type fleeces of these are now thought not to be primitive but relatively highly evolved (see fig. 4). It is however, difficult to define « primitive » and « highly evolved » in this context, and in any case some breeds have both primitive and highly-evolved characters, the carcass in the *Merino* for example not being well developed.

One can speculate that the best fit of a diffusion model to the observed or likely sheep distribution in Europe took place about 1 000 B.C. Then the true fine (*Merino*) fleece was appearing in the Middle East, but had not yet begun to spread around the Mediterranean (RYDER, 1982). The varie-coloured type is likely to have advanced some distance into South East Europe (i.e. assuming that it had not evolved independently in at least one location in Europe itself), and further north and west the *Soay* is likely to have been the main type, while in outlying areas of northern Europe (and islands such as Corsica) the Neolithic « hair » sheep was probably still dominant. But even the most cursory knowledge of the numerous migrations across Europe since that time, must dissuade one from expecting the present distribution to give more than the vaguest hints about movements and evolutionary changes. At the outset of the present survey, for instance, I was expecting to find remnants of the true fine wool that must have existed in South East Europe in classical times, but in the event it was apparently the more primitive vari-coloured type that has survived.

Having cautioned against the over-optimistic use of a diffusion model, one must nevertheless accept that there is still considerable scope for the use as « markers » of such genes as those for colour, as suggested by LAUVERGNE (1979). Mutations observed by ADALSTEINSSON (1970) in *Icelandic* sheep from « mouflon-pattern » to white, from white to self-colour, and from self-colour to grey suggest one way in which the range of colour described in the present paper could have arisen (fig. 8). Another way of obtaining white animals would have been to select for greater and greater areas of white in piebald (spotted) animals (LAUVERGNE, 1975). This would, however, have resulted in recessive-white sheep, and breeds of this type apparently do not exist. Since coloured animals in modern breeds frequently have white markings ADALSTEINSSON (1977) considers that this indicates selection for white in combination with the spotting gene.

Since neither method of selection is likely to have affected the colour genes, these are almost certainly still present in modern breeds, but are masked by the inhibiting white and spotting genes. If therefore the colour genes could be revealed by crossing with homozygous recessive brown rams, breed relationships might be elucidated (RYDER & STEPHENSON, 1968) (see also pp. 321-322 of RYDER, 1980).

*Reçu pour publication en octobre 1981.*

### Résumé

#### *Revue des races ovines européennes primitives*

Cet article considère les moutons primitifs d'Europe (c'est-à-dire non améliorés) en utilisant des données (en particulier pour le type de toison) en provenance de races reliques au lieu des restes osseux et textiles plus communément employés.

Du mouton néolithique il existe seulement des restes osseux et son pelage semble avoir été assez peu différent de celui de l'ancêtre sauvage non domestiqué. Des restes textiles montrent que le mouton de l'Âge de Bronze possédait une toison encore brune mais moins crineuse que celle du *Soay* qui subsiste à l'état marronné sur l'île de Saint Kilda, au nord-ouest de l'Ecosse. Les mesures faites sur les restes textiles, aussi bien que sur les toisons des moutons reliques, montrent que cette toison moins crineuse est en fait très variable, depuis un type relativement crineux jusqu'à une toison lainée.

Les restes textiles montrent que le mouton blanc apparaît à l'Age de Fer. Beaucoup de laines cependant étaient encore colorées ayant soit 100 p. 100 de fibres pigmentées (noires ou brunes), quelques fibres pigmentées (gris ou rouan) ou aucune fibre pigmentée. Les races reliques de ce type (souvent avec une courte queue de type primitif) ont une structure de toison semblable à celle du *Soay* mais avec un éventail de couleurs, blanc, noir et gris en plus du brun du *Soay* de l'Age de Bronze. Dans le présent article, c'est ce type qui est principalement étudié. C'était probablement le type prédominant en Europe jusqu'à ce que, après le Moyen Age, les races améliorées modernes aient commencé à apparaître.

Les races décrites, que l'on pense pouvoir faire remonter à l'âge de fer, sont divisées entre les groupes suivants : le groupe Nordique à queue courte qui comprend le *Romanov* de Russie, le *Finnois*, *Landrace*, l'ancien mouton de *Gotland* en Suède, le *Spaelsau* de Norvège, le *Faroe*, l'*Islandais*, l'*Orkney-Shetland*, le *Quatre cornes* britannique et le *Cladagh* d'Irlande. Les races *Corse* et *Ouessant* de France sont placées, avec le *Guirra* d'Espagne, dans le même groupe Sud-Ouest. Quant aux trois races de bruyère, le *Drenthe* des Pays-Bas, le *Heidschnucke* d'Allemagne, et le *Wrzosowska* de Pologne, on les a rangées dans un groupe des Plaines Nord de l'Europe.

Un groupe alpin comprend le mouton des *Grisons* de Suisse, le *Steinschaf* d'Autriche, le *Della Roccia* d'Italie, ainsi que d'autres races d'Italie, le *Massa* et le *Carapelle*. Le groupe balkanique comporte le *Racka* de Hongrie, le *Dubrovnik* de Yougoslavie, ainsi que le *Karakachan* et le *Karnobat* de Bulgarie et le *Drama* et le *Chalcidique* de Grèce. Il a aussi été possible d'introduire deux races d'U.R.S.S., le *Karachev* du Caucase et le *Kulunda* de Sibérie qui est cité pour être plus complet.

### References

- ADALSTEINSON S., 1970. Colour inheritance in *Icelandic sheep*. *J. agr. Res. Icel.*, **2**, 3-135.
- ADALSTEINSSON S., 1977. Personal communication.
- ADALSTEIN S., LAUVERGNE J.-J., BOYAZOGLU J.G., RYDER M.L., 1978. A possible genetic interpretation of the color variants in the fleece of the *Gotland* and *Goth* sheep. *Ann. Génét. Sél. anim.*, **10**, 329-342.
- ADALSTEINSSON S., WARDUM H., 1978. Frequency of color genes in *Faeroe Islands* sheep. *J. Hered.*, **69**, 259-262.
- BALEVSKA R.K., PETROV A., 1972. *Zackel sheep of Bulgaria and south eastern Europe*. Bulg. Acad. Sci. Sofia.
- DE BEER G., 1965. *Genetics and prehistory*. The Rede Lecture, Camb. Uni. Press.
- BROOKE C.H., RYDER M.L., 1977. Characteristics of some less-common breeds of sheep in southern Europe : a preliminary survey. *Ann. Génét. Sél. anim.*, **9**, 163-180.
- BROOKE C.H., RYDER M.L., 1979. Declining breeds of Mediterranean sheep. *F.A.O. Animal Prod. and Health Paper 8*, F.A.O., Rome.
- EKMAN S., 1964. The *Gotland* sheep. *Z.f. Saugtierkunde*, **29**, 129-145.
- EWART J.C., 1919. The intercrossing of sheep and the evolution of new varieties of wool. *Scott. J. Agric.*, **2**, 159-169.
- LAUVERGNE J.-J., 1975. Génétique de la couleur de la toison des trois races ovines françaises, *Solognote*, *Bizet* et *Berrichonne*. *Ann. Génét. Sél. anim.*, **7**, 263-276.
- LAUVERGNE J.J., 1976. A propos de la coloration du mouton d'Ouessant de type traditionnel. Département de Génétique animale, I.N.R.A., C.N.R.Z., Jouy-en-Josas, 2 p. ronéoté.
- LAUVERGNE J.J., 1980. Compte rendu de mission en Bulgarie : La conservation des stocks génétiques domestiques en Bulgarie. Département de Génétique animale, I.N.R.A., C.N.R.Z., Jouy-en-Josas, 15 p. ronéoté.

- LAUVERGNE J.J., ADALSTEINSSON S., 1976. Gènes pour la couleur de la toison de la brebis Corse. *Ann. Génét. Sél. anim.*, **8**, 153-172.
- LAUVERGNE J.J., BOTTEMA S., 1979. Variants colorés chez le mouton Néerlandais des Landes de Bruyère (*Heideschaap*). *Ann. Génét. Sél. anim.*, **11**, 1-6.
- LAUVERGNE J.J., BURRILL Melinda Jane, DOLLING C.H.S., DENNIS Wendy, 1981. Fading with light and greying with age in the fleece of black Australian *Polwarth* sheep. *Ann. Génét. Sél. anim.*, **13**, 93-110.
- MASON I.L., 1967. *The Sheep Breeds of the Mediterranean*. F.A.O. and Commonwealth Agricultural Bureau Farnham Royal, U.K.
- NAWARA N., 1976. Restitution of valuable characters of the declining Polish sheep breed « *Wrzosowka* » with regard to fecundity and coat utility. Paper presented at the 27th Meeting of the European Assn. for Anim. Prod., Zurich.
- NODDLE B.A., RYDER M.L., 1974. Primitive sheep on the Aran Islands. *J. Arch. Sci.*, **1**, 109-112.
- POPLIN F., 1979. Origin of the Corsican Mouflon in a new palaeontological perspective : by feralising. *Ann. Génét. Sél. Anim.*, **11**, 133-143.
- RYDER M.L., 1962. The histological examination of skin in the study of the domestication of sheep. *Z. Tierzucht. Züchtsbiol.*, **77**, 168-171.
- RYDER M.L., 1964 a. The history of Sheep Breeds in Britain. *Agric. Hist. Rev.*, **12**, 1-12, 65-82.
- RYDER M.L., 1964 b. Fleece Evolution in Domestic Sheep. *Nature*, **204**, 555-559.
- RYDER M.L., 1968 b. The evolution of Scottish Breeds of sheep. *Scott. Stud.*, **12**, 127-167.
- RYDER M.L., 1968 b. Fleece structure in some native and unimproved breeds of sheep. *Z. Teirzücht. Züchtsbiol.*, **85**, 143-170.
- RYDER M.L., 1969 a. Changes in the fleece of sheep following domestication (with a note on the coat of cattle), pp. 495-521, in Ucko P.J. and Dimbleby G.W. (Eds.), *The Domestication and Exploitation of Plants and Animals*, Duckworth, London.
- RYDER M.L., 1969 b. The sheep and wool of Ireland. *J. Bradford Textile Soc.*, 1968-1969, 89-98.
- RYDER M.L., 1970. The rural economy of prehistoric Denmark. *Span*, **13** (2), 98-101.
- RYDER M.L., 1973. The use of the skin and coat in studies of changes following domestication, pp. 163-168 in Matolcsi J. (Ed.), *Domestikationforschung und Geschichte der Haustiere*, Akademie Kiado, Budapest.
- RYDER M.L., 1974 a. Wools from Antiquity. *Text. Hist.*, **5**, 100-110.
- RYDER M.L., 1974 b. Fleece measurements of some miscellaneous native and unimproved breeds of sheep. *J. Text. Inst.*, **65**, 13-19.
- RYDER M.L., 1974 c. The saga of the Orkney sheep. *The Ark*, **1** (5), 12-17.
- RYDER M.L., 1975. Development, structure and seasonal change in the fleeces of unimproved Scottish Blackface sheep from the Hebrides. *J. agric. Sci., Camb.*, **83**, 85-92.
- RYDER M.L., 1976. Why should rare breeds of livestock be saved?, pp. 244-249 in Olney P.J.S. (Ed.), *International zoo yearbook*, vol. 16.
- RYDER M.L., 1980. Fleece colour in sheep and its inheritance. *Anim. Breed. Abstr.*, **48**, 305-324.
- RYDER M.L., 1981. Wools from Vindolanda. *J. Arch. Sci.*, **8**, 99-103.
- RYDER M.L., 1982. *Sheep and Man*, Duckworth, London (forthcoming).
- RYDER M.L., Stephenson S.K., 1968. *Wool Growth*, Academic Press, London.
- RYDER M.L., LAND R.B., DITCHBURN R., 1974. Coat colour inheritance in *Soay*, *Orkney* and *Shetland* sheep. *J. Zool., London*, **173**, 477-485.
- SALVATOR L., 1897. *Balearen in Wrt und Bild*. Würzburg and Leipzig.