THE SWEAT GLANDS AND HAIR FOLLICLES OF EUROPEAN CATTLE

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Abstract

Measurements were made on the skins of 1363 cattle from different European breeds. The mean values of these measurements have been tabulated for each breed and the skin types present in each breed or group of breeds have been determined using sweat gland shape (L/D) and hair follicle depth (FD) as the principal bases of comparison.

Two extreme skin types, I, with an $L/D < 8 \cdot 0$ and $FD < 1 \cdot 5$ mm, and II, with an $L/D > 12 \cdot 0$ and $FD > 2 \cdot 0$ mm, were distinguished. Type I was found in almost all the cattle in the Jersey breed while type II was present in relatively high proportion in the Scottish Highland breed. Varying proportions of animals with these types and others with intermediate skin types were found in the other European breeds. About $0 \cdot 5\%$ of the cattle population studied exhibited "follicle giantism" which was characterized by a low hair follicle density, long thick hairs, and large sweat glands. No simple relationship between skin type and habitat was found.

I. Introduction

Jenkinson and Nay (1968), in a preliminary communication, examined the effects of age, sex, and habitat on various cattle skin measurements. Their results and those of previous workers led to the conclusions (1) that sweat gland shape, defined as the ratio of sweat gland length to sweat gland diameter, is a reliable indicator of cattle skin type when measured on skin samples from the neck or midside of adult animals and (2) that hair follicle depth, defined as the perpendicular distance between the base of an active hair follicle and the skin surface, may be of use in the subclassification of a skin type based on sweat gland shape. Other skin measurements were found to be of restricted value as indicators of skin type.

The purpose of the present investigation was to compare the skin structures of different breeds of European cattle using sweat gland shape and hair follicle depth as the principal bases of comparison. A knowledge of the differences in the anatomy of the skin of different cattle breeds could be of value not only to the anatomist and physiologist but also of practical value to the leather industries in different countries. Such information could perhaps also be of use in the selection of cattle for tolerance to different environments and in determining evolutionary trends in sweat gland development as suggested by Nay (1959).

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II. Materials and Methods

Over the past 12 years duplicate post-mortem or biopsy skin specimens from the neck or midside of cattle were generously supplied by scientists and veterinarians in a number of European countries. Whenever possible at least 10 animals over 2 years old from each breed and on a good plane of nutrition were sampled. The skin samples were taken either with a trephine 1 cm in diameter or using a biopsy punch of known diameter and were processed and measured as described by Jenkinson and Nay (1968). Measurements were made of hair follicle depth (*FD*), length (*FL*), and diameter (*FDM*) and of sweat gland length (*L*) and diameter (*D*) as defined by Jenkinson and Nay (1968). From sweat gland length and diameter, sweat gland shape (*L*/*D*) and volume (*V*) were calculated. Hair follicle shape (*FL*/*FDM*) was also determined from hair follicle length and diameter and the mean angle of slope of the hairs was determined by trigonometry. Details of the breeds which were investigated and the number of animals sampled are given in the Appendix.* The specimens from each breed were in general obtained from different herds.

Care was taken to standardize the conditions of processing and measurement and as far as possible those of sampling. In some instances, however, only a few animals were available for sampling and in others some of the skin samples were obtained from animals which had not completely matured. Frequency distribution histograms showed that the distribution of sweat gland shape was not normal in many of the breeds and when the data were tested on a computer the results obtained showed that they were not homogeneous. Consequently it was not possible to apply statistical techniques to the data save for breeds from which large numbers of samples were obtained, and transformation of the data also failed to provide a form suitable for statistical analysis.

The data have therefore been divided into groups based on an independent classification of cattle breeds (Mason 1969) and these groups and some of the breeds within them have been compared using sweat gland shape and hair follicle depth as the principal bases of comparison. For ease of illustration the continent has been divided geographically into three main categories: (1) northern and western Europe (Britain, Eire, and Scandinavia); (2) remainder of northern and western Europe; and (3) southern and eastern Europe. In addition the Simmental, Friesian, and Brown Mountain groups, varieties of which are found throughout the continent, have been considered separately.

III. Results

The general structure of the skin was similar in all the breeds of cattle studied. Each hair follicle had associated with it an arrector pili muscle, a sweat gland, and a sebaceous gland which was generally bilobular. Although the hair follicles within the skin of any given animal varied in length and diameter no secondary hair follicles were observed in cattle skin. Therefore, the differences between cattle breeds were in the dimensions of the skin and its component organs. The means and standard deviations of the skin measurements for each breed are tabulated in the Appendix* and the mean values and standard deviations of the skin measurements for all 1363 European cattle are given in the following tabulation:

Sweat gland		Hair follicle	
Length *L* (μm)	928±276	Length *FL* (mm)	2·00±0·31
Diameter *D* (μm)	107± 21	Diameter *FDM* (μm)	44·2±8·1
Shape (*L*/*D*)	8·80±2·51	Depth *FD* (mm)	1·76±0·31
$10^{-6}\times$Volume *V* (μm³)	9·00±5·21	Shape (*FL*/*FDM*)	46·4±9·7
		Mean angle of slope of hair 61° 39′	

L/*D* for European cattle ranged from about 4 to 20 and *FD* from about 1 to 3 mm.

* Copies of the Appendix may be obtained on application to the Editor-in-Chief, Editorial and Publications Section, CSIRO, 372 Albert St, East Melbourne, Victoria 3002.

These ranges, however, were not characteristic of every breed as can be seen by examination of different groups formed from the different European breeds of cattle studied.

(*a*) *Breeds from Northern and Western Europe* (*Britain, Eire, and Scandinavia*)

For ease of comparison the breeds of cattle from this region of Europe were divided into 11 groups (Fig. 1, key) according to the classification of Mason (1969).

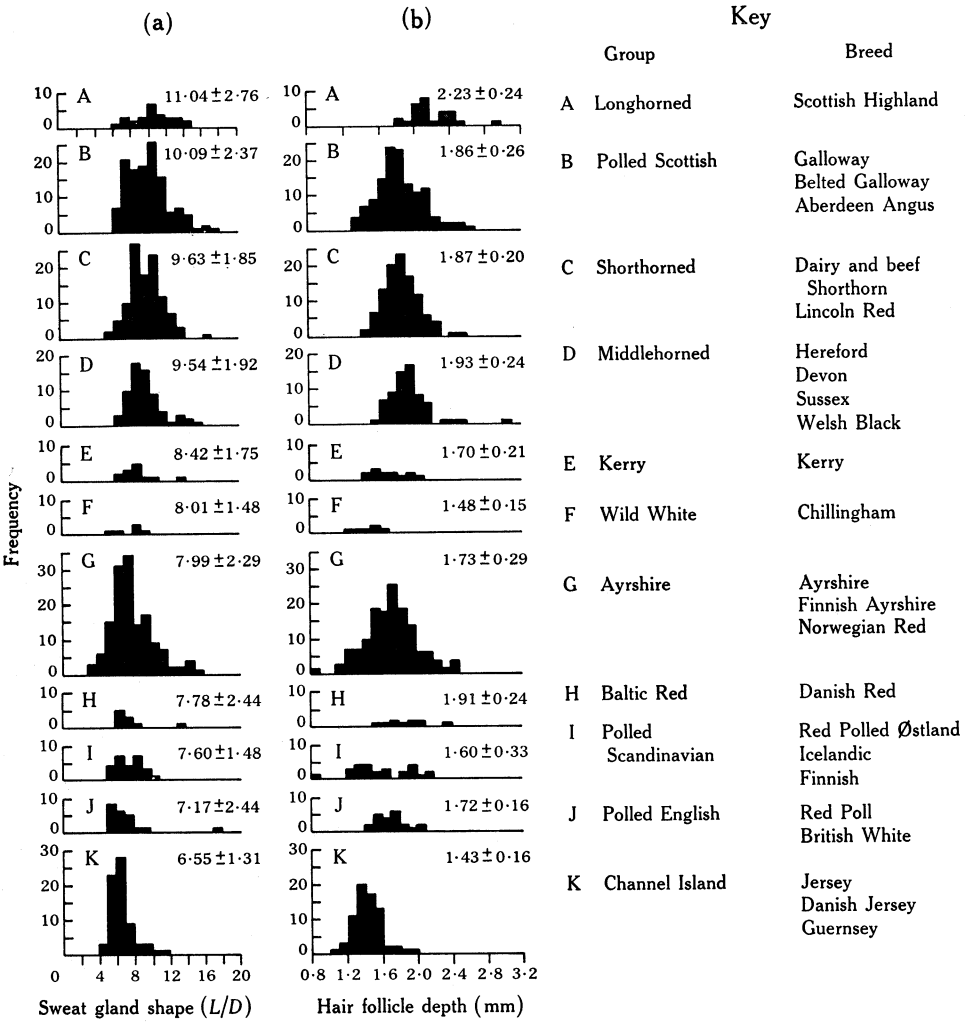

Fig. 1.—Distributions of (*a*) sweat gland shape and (*b*) hair follicle depth for the cattle groups A–K from Britain, Eire, and Scandinavia as detailed in the key. The mean value and standard deviation for each group are also given.

The distributions of L/D and FD for each of these groups are illustrated in Figures 1(*a*) and 1(*b*).

From Figure 1(*a*) it can be seen that in spite of within-group variations the mean shape of the sweat gland in group A (the Scottish Highland) differs from that of group K (the Channel Is. breeds). A variance ratio test on the L/D data from 13 Highland and 44 Jersey cows gave an F value of $7 \cdot 60$ ($P < 0 \cdot 001$) confirming the difference between these groups. These two sweat gland shapes can also be readily distinguished histologically (Fig. 2). The remaining cattle groups have mean sweat gland shapes

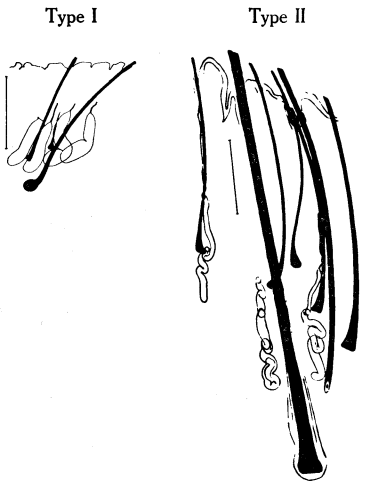

Fig. 2.—Diagram illustrating the two skin types I and II with different L/D and FD values found in European cattle. Type I which is illustrated by a tracing from the skin of a Jersey cow has a thin hair follicle depth and a sac-like sweat gland. Type II which is illustrated by a tracing from the skin of a Highland cow has a thick hair follicle depth and a long serpentine sweat gland. The scale indicates 1 mm.

intermediate between these two extremes. This does not mean, however, that all the animals in the breeds comprising these groups have an intermediate L/D ratio as can be seen from Figure 1(*a*). Since animals with an L/D ratio less than 8 can be distinguished histologically from those with an L/D of more than 12 an indication of the variation within groups can be obtained by study of the number of animals with glands of these two types and those with an intermediate L/D [Fig. 1(*a*)]. It can be seen using this classification that group K (the Channel Is. breeds) consists mainly of animals with an L/D of less than $8 \cdot 0$ and does not appear to contain individuals with an L/D of greater than $12 \cdot 0$. Group A, on the other hand, although clearly different from group K, contains a small percentage of animals with an L/D of less than $8 \cdot 0$. It is evident therefore that the variations in mean L/D between the remaining cattle groups in Britain, Eire, and Scandinavia are due to the presence within them of different percentages of animals exhibiting one or other of the two extreme shapes ($< 8 \cdot 0$ or $> 12 \cdot 0$) as well as to the presence of animals with intermediate sweat gland shapes. Different individuals within a breed therefore may exhibit different sweat gland shapes although in some instances, such as in the Jersey breed, the variability between animals is less marked than in others. The shape of the gland is, however, characteristic of the individual.

From Figure 1(*b*) it is apparent that hair follicle depth (FD) also varies between the different cattle groups. Again group A (the Scottish Highland) varies from group K and a variance ratio test on the FD data from 13 Highland and 44 Jersey cows gave a significant F value of $5 \cdot 01$ ($P < 0 \cdot 05$). The two groups would appear therefore

to have quite different hair follicle depths. The remaining groups have mean *FD* values which range in between. However, as for *L/D*, all the animals in the breeds composing these groups did not have an intermediate hair follicle depth and different individuals within them had different *FD* values which ranged between and included two extreme classes ($< 1{\cdot}5$ mm; $> 2{\cdot}0$ mm) which could be distinguished histologically. Group A, however, did not contain any animals with an *FD* of less than 1·5

Fig. 3

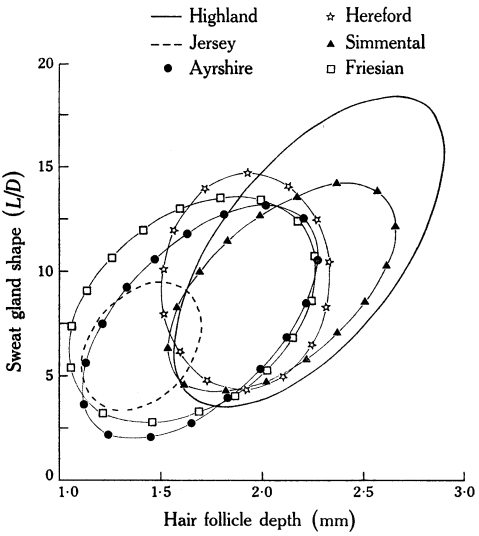

Fig. 4

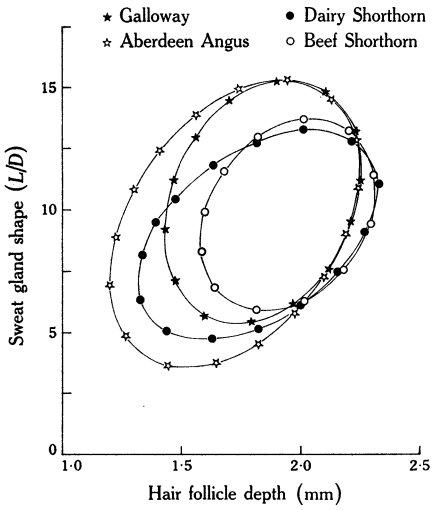

Fig. 3.—Tolerance ellipses illustrating the extent and position of the variation in *L/D* and *FD* among six breeds of cattle. The remainder of the European breeds had *L/D* and *FD* values within the overall range, which can therefore be considered as representative of all European cattle.

Fig. 4.—Tolerance ellipses illustrating the variation in *L/D* and *FD* in four British breeds of cattle. It can be seen that the Galloway and Aberdeen Angus breeds, examples from the Polled Scottish group, have similar skin types. This is true also of the two examples from the shorthorned group—the dairy and beef Shorthorn.

while group K had none with an *FD* greater than 2·0 [Fig. 1(*b*)]. The mean values of *FD* [Fig. 1(*b*)] for the cattle groups between group A, which was characterized by a long thin gland and a large hair follicle depth, and group K, which was typified by a sac-like sweat gland and small hair follicle depth, did not vary in exact sequence with those of *L/D* [Fig. 1(*a*)]. There was a tendency for animals with a large *L/D* ratio also to have a high *FD* value. Correlation of these two parameters in 332 females from nine British breeds gave a value of 0·39 ($P < 0{\cdot}001$) confirming this trend. There was, however, considerable variation between the different breeds in the magnitude of this correlation which was, for example, 0·31 ($P < 0{\cdot}05$) in the Jersey and 0·84 ($P < 0{\cdot}001$) in the Highland breed.

In cattle from Britain, Eire, and Scandinavia, therefore, two extreme and distinct skin types I and II based on the shape of the sweat gland and the depth of the hair

follicle can be distinguished. Type I can be defined as having a sweat gland L/D less than 8·0 and an FD of less than 1·5 mm and type II as having an L/D of more than 12·0 and an FD of more than 2·0 mm. The first type (Fig. 2) is characteristic of almost all the cattle in the Channel Is. breeds while the second is found in varying proportions in a number of breeds but is particularly prevalent in the Scottish Highland. A proportion of the animals in the other cattle breeds from this geographical area exhibit one or other of these types, the remainder in general having skin types intermediate to them.

The extent of the variation in skin type can be illustrated graphically in "tolerance ellipses" comprising 95% of the items (Documenta Geigy 1962) and an indication of the range and position of the variation among cattle from Britain, Eire, and Scandinavia is given in Figure 3 which was compiled using breeds from which more than 20 animals were available for study. The values of L/D and FD for breeds from which fewer than 20 animals were obtained all fall broadly within this total range which can therefore be considered as being representative of the cattle from this region of Europe. Moreover, although the animals were grouped using an existing classification, the breeds within a given group in general showed a similar variation in skin type as can be seen from the examples in Figure 4. There were, however, two notable exceptions as follows:

(1) In group B—the Polled Scottish (Fig. 1, key)—the results from the nine Belted Galloway animals (L/D 7·47; FD 1·76) suggested that this breed was composed mainly of animals with a type I skin with some of an intermediate type. This was in contrast to the Galloway breed (L/D 11·08; FD 1·73) which had a high proportion of animals with a type II skin.

(2) In group J—the Polled English—the four Red Poll animals (L/D 11·01; FD 1·82) contrasted with the British White breed (L/D 6·32; FD 1·69) which had a high proportion of animals with skin type I.

In these two instances the group means of L/D and FD may not be truly representative of all the breeds composing the group.

(b) Breeds from Northern and Western Europe except Britain, Eire, and Scandinavia

Details of the breeds comprising the groups of cattle compared for the remainder of northern and western Europe are given in the key to Figure 5, and the distributions of L/D and FD for these groups are illustrated in Figures 5(*a*) and 5(*b*). The ranges of mean L/D (from 6·15 to 10·45) and mean FD (from 1·45 to 1·90) are within the overall range described above for the breeds of Britain, Eire, and Scandinavia. The Kazakh Whitehead had a similar distribution to those of the Channel Is. breeds in contrast to the Red Pied Lowland cattle which had an appreciable proportion of animals with a type II skin. The mean values and standard deviations for L/D and FD appear to be representative of all the breeds composing each group although it was more difficult in this instance, due to paucity of numbers, to detect potential differences between breeds. However, in spite of the small number of animals in some of the groups from

this part of Europe it seems evident from Figures 5(*a*) and 5(*b*) that the range of skin types is similar to that found in Britain, Eire, and Scandinavia and hence is similar throughout the whole of northern and western Europe.

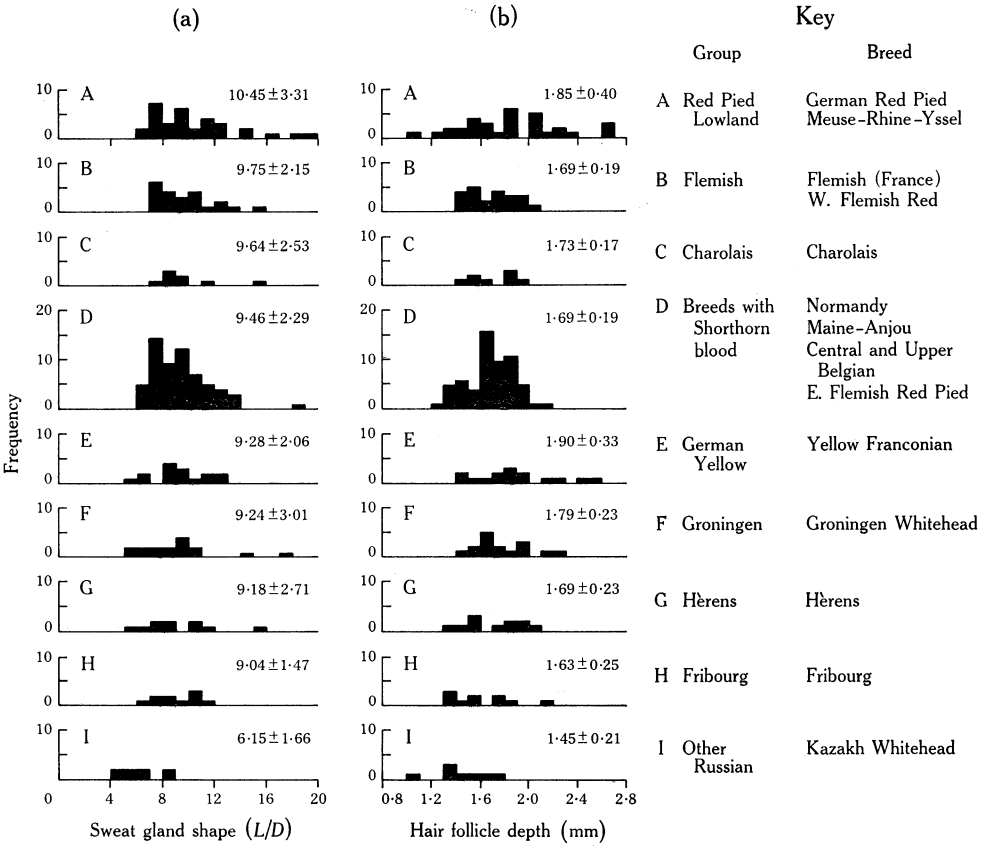

Fig. 5.—Distributions of (*a*) sweat gland shape and (*b*) hair follicle depth for the remaining cattle groups (A–I) from northern and western Europe as detailed in the key. The mean value and standard deviation for each group are also given.

(*c*) *Breeds from Southern and Eastern Europe*

The groups of cattle from this geographical area which were studied are detailed in the key to Figure 6 and the distributions of L/D and FD for these groups are given in Figures 6(*a*) and 6(*b*). These diagrams show that the groups of cattle in southern and eastern Europe have a similar range of mean L/D (from 6·77 to 9·61) and mean FD (from 1·31 to 2·03) to those from northern and western Europe. The differences in mean L/D and mean FD between groups were again due to differences in the relative proportions of skin types I and II and intermediate skin types in each group. The small numbers of animals in many instances made interpretation of breed differences

within the groups difficult. However, as far as could be determined all the breeds within a group tended to be similar in mean L/D and FD and in their distributions with the exception of group A. Within this group the four Plevna animals sampled all had a type I skin and may consequently differ from the remaining breeds. The Hungarian Grey on the other hand had a proportion of animals with type II skin and had a higher mean L/D and FD than the other breeds.

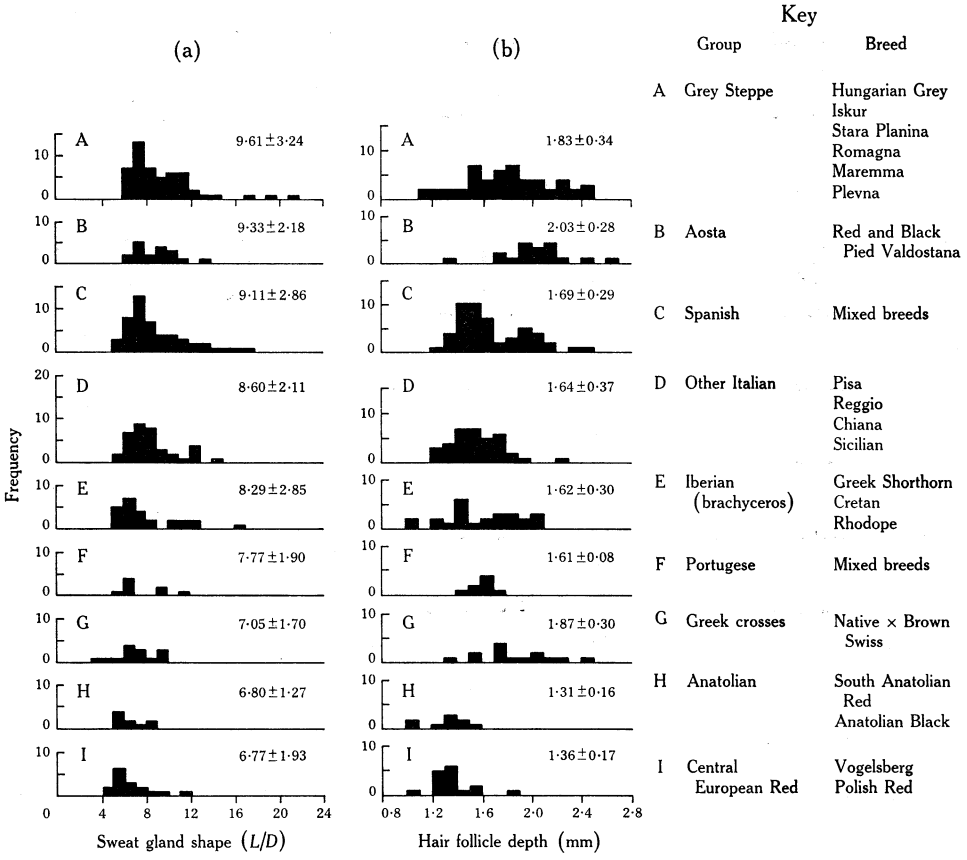

Fig. 6.—Distributions of (*a*) sweat gland shape and (*b*) hair follicle depth for the cattle groups (A–I) from southern and eastern Europe as detailed in the key. The mean value and standard deviation for each group are also given.

The Spanish and Portuguese groups (C and F) were composed of data from small numbers of animals from a variety of breeds and the paucity of material prevented classification and breed comparisons. Although 36 different cattle breeds and varieties were sampled in Spain, with one exception (Castellana—six samples) only one or two samples were obtained from each. The data were grouped to give an estimate of the total variation among Spanish cattle for comparison with other European breeds and subsequent comparison with South American cattle.

(*d*) *Simmental, Friesian, and Brown Mountain Groups of Breeds*

The breeds composing these three groups are given in the key to Figure 7. They have been considered separately since varieties of these breeds are found throughout Europe. The distributions of L/D and FD are given in Figures 7(*a*) and 7(*b*). The

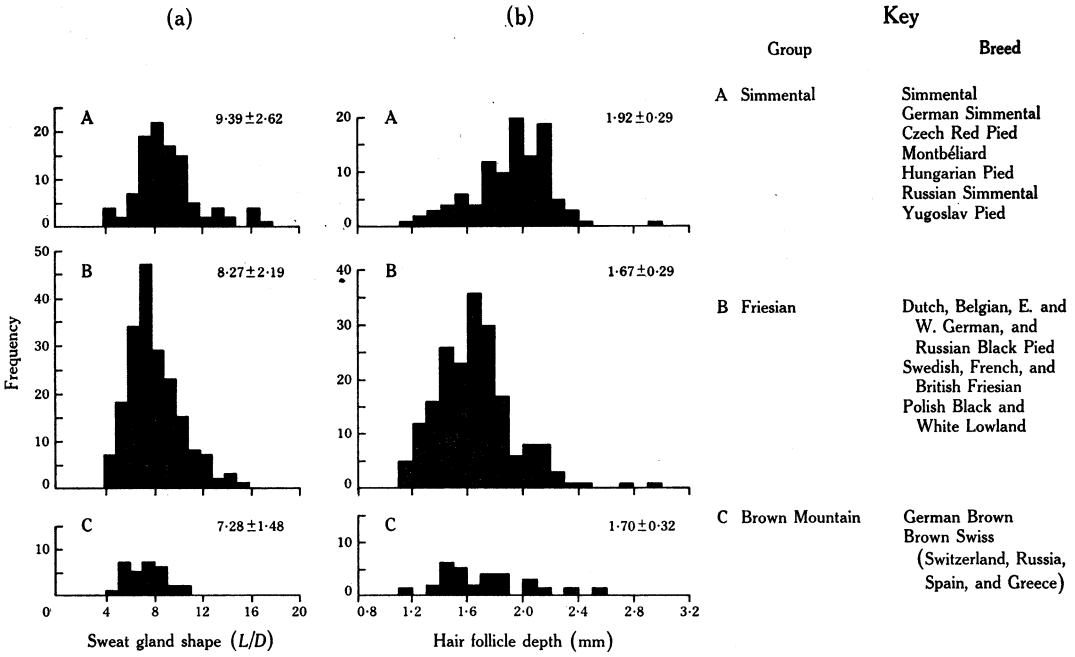

Fig. 7.—Distributions of (*a*) sweat gland shape and (*b*) hair follicle depth for the three cattle groups A, B, and C found generally distributed throughout Europe as detailed in the key. The mean value and standard deviation for each group are also given.

Simmental group, in spite of the wide range of L/D and FD values, has a fairly large proportion of animals with type II skin and resembles the Scottish Highland breed in its distribution (Fig. 3). Individual Friesians also may have a type I skin or a type II skin but the majority of animals in this breed have a skin type intermediate between the two extremes. The Brown Mountain group in contrast has a distribution which tended to be similar to those of the Channel Is. breeds. All the breeds within each of these three groups appear to be representative of their group in mean L/D and FD and have similar distributions to those illustrated for the group in general.

(*e*) *Follicle Giantism*

Seven animals from different European breeds exhibited what can be termed follicle giantism (Table 1). These animals which were not included with their respective breeds had exceptionally long hair follicles which were generally wider and more sparse than those found in other animals of their breeds. They had, for example, only about 380–540 hairs/cm^2 skin compared with the normal 900–1000/cm^2 in European breeds. These animals with one exception also had large L/D ratios characteristic of type II skin.

IV. Discussion

Although the structure of the skin was similar in all the European breeds studied and hair grouping was never observed, it is clear from the results that there is considerable variation in skin L/D and FD in European cattle. Paucity of numbers prevented complete assessment of this variability but two skin types, I and II, based on these measurements, can be distinguished. The first type which is characterized by a sac-like sweat gland and shallow-seated hair follicles contrasts markedly with the second which has a serpentine sweat gland and deeper-seated hair follicles. The results also indicate that animals with a type I skin tend to have shorter, thicker hairs than those of type II and support the suggestion of Jenkinson and Nay (1968) that animals with a greater hair follicle depth tend to have a longer sweat gland. A high percentage of European cattle have skin types intermediate between these two extremes; it was not possible with the present information to further subdivide this group. The main differences between breeds of cattle in Europe appear to depend on the relative proportions of animals within them which exhibit type I, type II, or an intermediate skin type.

Table 1

Details of the skin measurements of seven animals with unusually large hair follicles

Breed	Sex	Sweat gland				Hair follicle				
		L (μm)	D (μm)	L/D	$10^{-6} \times V$ (μm^3)	FL (mm)	FDM (μm)	FD (mm)	FL/FDM	Density
W. Flemish Red	Bull	1892	151	12·56	33·68	2·84	81·5	1·84	34·9	386
Meuse–Rhine–Yssel	Cow	968	51	19·14	1·94	3·31	93·3	2·64	35·5	389
Greek Native × Brown Swiss	Young animal	1103	155	7·10	20·86	3·40	69·3	2·45	49·1	534
Yellow Franconian	Steer	900	78	11·54	4·30	2·81	55·8	2·52	50·4	543
Simmental	Young animal	1445	82	17·73	7·52	3·32	82·6	2·97	40·2	391
Pisa	Cow	1254	89	14·03	7·87	4·04	72·6	3·46	55·6	384
Friesian	Bull	1901	98	19·34	14·40	3·27	93·7	2·52	34·9	—

In the present study the European breeds were grouped for comparison using an independent classification (Mason 1969). It is interesting to note that, with only a few exceptions, the distributions of skin types within the different breeds composing the groups were similar, giving in general a good agreement with known breed relationships. Some of the few exceptions to this finding, as for example the difference between the Plevna and the other Grey Steppe breeds and those between the Kazakh Whitehead and the Hereford (from which it is partly derived), may be a reflection of the paucity of numbers sampled rather than of true differences between the breeds. On the other hand the differences in the distributions of L/D and FD between the young Belted Galloway animals and the other Polled Scottish breeds, including the Galloway, are marked and probably indicate a true breed difference in skin type. This finding is not altogether surprising as the Belted Galloway and Galloway also have different blood transferrin characteristics (Jamieson 1966).

There were no obvious differences in the distributions of the skin types which could specifically be attributed to differences between dairy and beef breeds of cattle.

There was also no simple relationship between skin type and habitat. Breeds which inhabit lowland areas had similar L/D and FD distributions to others which dwell in highland regions. Although Jersey cattle are better suited to hot climates than Highland cattle, breeds with a high proportion of animals with type I skin were found in Scandinavia and Russia as well as in southern Europe and animals with type II skin were found in Spain and Italy as well as in the north. Skin type is therefore unlikely to provide a simple index of heat or cold tolerance for cattle in Europe except perhaps in a few extreme instances. It may be of value, however, to consider further the possibility of a relationship between tolerance to environment and skin type in animals within some breeds such as the Ayrshire, Friesian, and Simmental which exhibit a wide range of skin types.

Follicle giantism, a trait which appears to occur in about 0·5% of the cattle population in Europe, can occur in bulls, cows, or steers and is present in different breeds. Such animals have a low follicle density, long thick hairs, and large sweat glands.

From the evolutionary viewpoint, it is interesting to note that the six British Chillingham Park cows tended to have a type I or intermediate skin type and in this respect resembled the Jersey and some other European breeds. None of them exhibited a type II skin.

V. Acknowledgments

The skin samples studied in this work were very kindly supplied by scientists, veterinarians, and Institutes from all over Europe or obtained from breeds of cattle made available by courtesy of others. Since space prevents individual acknowledgment, the authors express their thanks to all who contributed to the sampling program for this study. They are especially grateful to Mr. I. L. Mason for help and encouragement and to Mrs. Diane Johnston and Miss Penelope Williams for technical assistance.

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