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Methods for Determining Length in the Merino Fleece.

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THE importance of length as a characteristic of the merino fleece has often been stressed. It has been shown (Bosman 1937) that, in a stud ram producing 40,000 fibres per square inch of skin, every half an inch increase in staple length adds ·9 pounds of wool to the scoured fleece, when it is a fine woolled fleece, and 1·4 pounds when it is a coarse* woolled fleece.

The wool farmer considers length and uniformity of length as a basis for classification when his wool clip is being prepared for the market (Cowley 1928; National Wool Growers' Association, 1934; Wilson, 1935, *et alia*), and several authors have referred to the importance of length in the manufacturing processes of wool (Barker 1931; Stanbury, 1935; Speakman and Sun, 1936, *et alia*).

Since length is an important attribute both from the wool producer's and wool manufacturer's points of view, it is necessary that suitable methods for its determination be available. In practice, and in merino experimental work, the methods should be as quick and simple as possible so that they can be applied to large numbers of fleeces and should be applicable for use on the live sheep as well as on the shorn fleece. Those that have been evolved and are used on the merino, are here outlined.

STAPLE LENGTH, STRAIGHT FIBRE LENGTH, CRIMP RATIO.

The staple length does not give a true measure of the actual length of wool, this depending on the type of crimping, (Duerden and Bosman, 1931) whether it is shallow or deep. In the latter case the straight length may bear a ratio of 1·8 to 1 with the staple length and in the former case the ratio may be only 1·2 to 1. In practice it is therefore possible that two wools of the same staple length say 8 centimetres, may differ in straight fibre length to the

* Among South African Woolmen the term coarse is synonymous with strong and signifies a thick fibred wool.

extent of the difference between 14·4 cm. and 9·6 cm. or a 50 per cent. difference. Even greater differences than these have been recorded by Roberts (1938), who asserts that a 4 inch straight fibre length can be reduced to a 1⅝ inches staple length or a crimp ratio of 2·4 to 1.

In practice, both the wool farmer and the wool buyer take into account staple length, rather than straight fibre length, the latter being a refinement that is not so readily determined. In experimental work where length is studied from such aspects as breeding, nutrition, environment, wool growth and spinning, it is often necessary that determinations on straight fibre length be made, or alternately, on staple length in conjunction with the crimp ratio.

Variability in the Merino Fleece.

The merino, unlike other breeds of sheep, has a distinctive covering of fine wool growing at a constant rate from month to month and from year to year (Duerden and Maré, 1931; Bosman, 1937) at approximately 8 cm. staple length or 12 cm. straight length per annum. The rate of growth varies on the same animal (Duerden and Palmer, 1923) and also among individual fibres constituting a staple (Duerden and Bosman, 1931) so that the length of any one fleece must be expressed in terms of the mean value of several measurements. This depends on the extraction of a representative sample of the fleece which is controlled by the variability of the fleece.

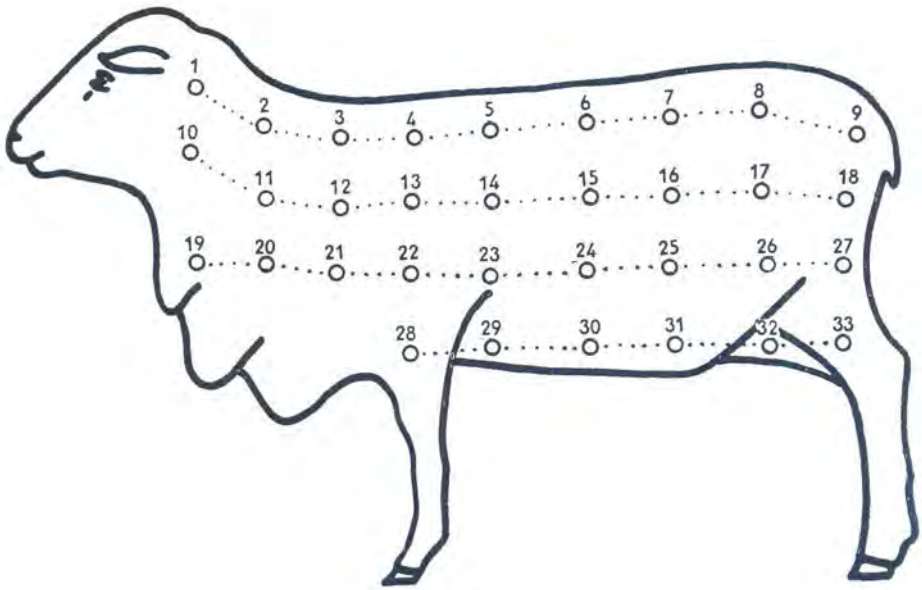

Figure 1.

Diagram showing the points from which measurements were taken from Sheep A and B. The results are analysed in Table 1.

Experimental.

Sampling on the Live Sheep.

In sheep experiments dealing with breeding, nutrition, wool growth, and also where breeding records for farmers are concerned, the length of the fleece must often be determined on the live animal before shearing. With this object in view, studies on the methods of sampling on the live sheep were undertaken. Two animals, chosen as typical representatives of the type of merino sheep that are usually subjected to measurement, were studied. A large number of measurements was taken from each animal, 66 on the one and 64 on the other, half of the measurements being made on the left hand side, and half on the right hand side of each sheep. The points from which measurements were taken are those shown in figure 1. The wool is a twelve months growth.

The method of measuring was that of placing a suitable ruler, graduated in centimetres and tenths of centimetres, along the staples and measuring their lengths from base to tip.

The measurements, taken from the two fleeces, were used for establishing whether the selection, taken from the left hand side of the fleece, was similar to that taken from the right hand side of the fleece. A summary of the results is given in Table 1.

Table 1.

Staple length measurements of two merino sheep taken on the left and right hand sides of each animal.

Sheep and region.	Type of sheep.	Number of regions measured.	Mean staple length (cm.).	Standard deviation.	Standard error of mean.	Remarks.
A.—Right-hand side	Showing medium body development*	33	6·7	·782	± ·136	Not significantly different.
Left-hand side	...	33	6·7	·620	± ·108	,,
Entire fleece	...	66	6·7	·700	± ·086	,,
B.—Right-hand side	Showing excessive body development	32	7·9	·844	± ·149	Not significantly different.
Left-hand side	...	32	7·8	·936	± ·165	,,
Entire fleece	...	64	7·9	·844	± ·106	,,

* Among South African and Australian Sheepmen the term "development" has reference to skin folds on the body of the sheep.

TABLE 2 (*a*).

Analysis of Staple Length Measurements of Sheep A. Left Hand Side. (On live animal.)

Region.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1	6·6	6·6	6·6	—	—	—	—	—	—	—
2	7·0	—	—	—	—	—	—	—	—	—
3	7·0	7·0	—	—	—	7·0	—	—	—	—
4	6·5	—	6·5	6·5	—	—	—	—	6·5	—
5	6·6	6·6	—	—	6·6	—	—	—	—	—
6	6·6	—	—	—	—	6·6	—	—	—	—
7	6·5	6·5	6·5	6·5	—	—	—	—	—	—
8	7·1	—	—	—	7·1	7·1	—	—	7·1	—
9	4·6	4·6	4·6	4·6	—	—	—	—	—	—
10	6·7	6·7	—	—	—	—	—	—	—	—
11	6·2	—	—	—	—	—	—	—	—	—
12	7·3	7·3	7·3	—	—	—	—	7·3	—	7·3
13	6·8	—	—	—	—	—	6·8	—	—	6·8
14	7·1	7·1	—	—	—	—	—	—	—	7·1
15	7·3	—	7·3	—	—	—	—	7·3	7·3	7·3
16	7·1	7·1	—	—	—	—	7·1	—	—	7·1
17	6·4	—	—	—	—	—	—	6·4	—	6·4
18	6·6	6·6	6·6	—	6·6	—	6·6	—	—	—
19	5·8	—	—	—	—	—	—	—	—	—
20	7·0	7·0	—	—	—	—	—	—	—	—
21	7·6	—	—	—	—	7·6	—	—	—	—
22	7·0	7·0	—	7·0	—	—	—	—	7·0	—
23	7·0	—	—	—	7·0	—	—	—	—	—
24	7·4	7·4	—	—	—	—	—	—	—	—
25	6·7	—	—	—	—	6·7	—	—	—	—
26	6·7	6·7	—	6·7	—	—	—	—	6·7	—
27	6·9	—	—	—	6·9	—	—	—	—	—
28	7·1	7·1	7·1	—	—	—	7·1	—	—	—
29	5·9	—	—	—	—	5·9	—	5·9	—	—
30	6·6	6·6	6·6	6·6	—	—	6·6	6·6	6·6	—
31	6·6	—	—	—	6·6	—	—	6·6	—	—
32	7·2	7·2	—	—	—	—	7·2	—	—	—
33	6·7	—	6·7	—	—	—	—	—	—	—
Means	6·7	6·8	6·6	6·3	6·8	6·8	6·9	6·7	6·9	7·0
Number of regions	33	17	10	6	6	6	6	6	6	6
Standard error	± ·0959	± ·1517	± ·2417	± ·3516	± ·0931	± ·2330	± ·1095	± ·2212	± ·1203	± ·1414
Standard deviation	± ·5509	± ·6253	± ·7642	± ·8612	± ·2280	± ·5707	± ·2683	± ·5419	± ·2946	± ·3464
Coefficient of variability	8·2%	9·2%	11·6%	13·7%	3·4%	8·4%	3·9%	8·1%	4·3%	4·9%

TABLE 2 (*b*).

Analysis of Staple Length Measurements of Sheep B. Left Hand Side. (On live animal.)

Region.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1	6·8	6·8	6·8	—	—	—	—	—	—	—
2	6·9	—	—	—	—	—	—	—	—	—
3	8·5	8·5	—	—	—	8·5	—	—	—	—
4	8·2	—	8·2	8·2	—	—	—	—	8·2	—
5	7·5	7·5	—	—	7·5	—	—	—	—	—
6	7·8	—	—	—	—	7·8	—	—	—	—
7	7·6	7·6	7·6	7·6	—	—	—	—	—	—
8	7·8	—	—	—	7·8	7·8	—	—	7·8	—
9	6·7	6·7	6·7	6·7	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—	—
11	9·0	—	—	—	—	—	—	—	—	—
12	6·7	6·7	6·7	—	—	—	—	6·7	—	6·7
13	8·6	—	—	—	—	—	8·6	—	—	8·6
14	8·9	8·9	—	—	—	—	—	—	—	8·9
15	8·3	—	8·3	—	—	—	—	8·3	8·3	8·3
16	8·2	8·2	—	—	—	—	8·2	—	—	8·2
17	6·6	—	—	—	—	—	—	6·6	—	6·6
18	7·8	7·8	7·8	—	7·8	—	7·8	—	—	—
19	6·7	—	—	—	—	—	—	—	—	—
20	9·0	9·0	—	—	—	—	—	—	—	—
21	6·7	—	—	—	—	6·7	—	—	—	—
22	8·1	8·1	—	8·1	—	—	—	—	8·1	—
23	9·3	—	—	—	9·3	—	—	—	—	—
24	8·4	8·4	—	—	—	—	—	—	—	—
25	8·5	—	—	—	—	8·5	—	—	—	—
26	9·6	9·6	—	9·6	—	—	—	—	9·6	—
27	6·6	—	—	—	6·6	—	—	—	—	—
28	8·7	8·7	8·7	—	—	—	8·7	—	—	—
29	7·8	—	—	—	—	7·8	—	7·8	—	—
30	7·4	7·4	7·4	7·4	—	—	7·4	7·4	7·4	—
31	7·5	—	—	—	7·5	—	—	7·5	—	—
32	6·6	6·6	—	—	—	—	6·6	—	—	—
33	8·2	—	8·2	—	—	—	—	—	—	—
Mean	7·8	7·9	7·6	7·9	7·8	7·9	7·9	7·4	8·2	7·9
Number of regions	32	16	10	6	6	6	6	6	6	6
Standard error	± ·1571	± ·2307	± ·2296	± ·3997	± ·3585	± ·2692	± ·3250	± ·2651	± ·3041	± ·3661
Standard deviation	± ·8886	± ·9227	± ·7260	± ·9791	± ·7871	± ·6595	± ·7961	± ·6494	± ·7448	± ·8969
Coefficient of variability	11·4%	11·7%	9·6%	12·4%	11·3%	8·3%	10·1%	8·8%	9·1%	11·4%

In sheep A, 33 measurements on the right hand side of the fleece give a mean 6·7 cm. with a Standard error of ± ·136. Those taken on the left hand side give a mean of 6·7 ± ·108, showing no significant difference between the means of the two sides. When the 66 measurements, taken from the entire fleece, are compared with those taken on the left and right hand sides respectively, no significant difference exists between the latter two and those from the entire fleece, indicating that 33 measurements, taken on either the right hand or left hand sides of the fleece, form a representative selection of the fleece. A similar result was obtained from sheep B, which was a more developed type than A and represented an extreme case of development.

Although 33 (or 32) measurements taken on any one side of the fleece form a representative selection of the fleece, it is contended that this number is too large to be applicable in practice. Where the characteristic of length is determined in experiments and breeding work, involving large numbers of animals, the minimum number of measurements that can be used to give a mean, that is representative of the fleece, was determined.

A further analysis of the results of the length measurements of sheep A and B is given in Tables 2 (*a*) and 2 (*b*) where the selection of 33 (or 32) measurements are compared with selections of 17 (or 16), 10, and of 6. In addition, seven differing selections each consisting of 6 measurements, are shown with their means and other statistical constants.

The means obtained from 33, 17, 10 and 6 measurements [given in Table 2 (*a*)] show no significant differences among these. It is therefore concluded that a selection of 6 measurements gives a sufficiently reliable mean for the fleece. A similar result is obtained from sheep B, shown in Table 2 (*b*). It is suggested that, for convenience, the six measurements be taken on a line joining the neck and britch regions of the sheep. Further tests on the reliability of six measurements were also made on the measurements given by Duerden and Palmer (1932) where 12 fleeces are measured for staple length distribution. The results are summarised in Table 3.

The means of staple lengths, obtained from the twelve fleeces, are given with their standard errors, in addition to the means obtained from six places, each a random selection taken on a line between the neck and britch regions of the fleece. It is shown that the means of six measurements do not differ significantly from the means of the whole fleece.

The method of taking six measurements on the live animal, on a line between the neck and britch regions of the sheep, works well in practice since it can be used on large numbers of sheep giving reasonable reliability. The mean of six measurements does not however appear to be indicative of the degree of variability in length of the fleece. It has been found that in stud merinos, and especially so among the wrinkly type, that the variability among staples, even adjacent staples, can give a variability equal in magnitude to that found on regions representing the extremes of the fleece. Furthermore, in this respect there appears to be a

great variability among fleeces, so that it is extremely difficult to obtain a method applicable for general use that gives the mean as well as the variability, unless many more than six measurements are considered for the fleece. It is contended that the latter becomes too cumbersome for practical application on large numbers of animals and practically each type of merino sheep would have to be considered on its own. In general, as stated by Duerden and Palmer (1932), the extremes in staple of the merino are the neck and britch regions and the largest portion of the fleece, conforming to the average, is found on the shoulder and side regions. In stud sheep, that are mostly bred to have large neck folds, the variation between these, the wool grown on the folds and that comprising the rest of the fleece, is often very great, so that each type of sheep would have to be studied separately.

TABLE 3.

An analysis of the staple length measurements given by Duerden and Palmer (1932).

Figure.	Number of regions measured.	Mean of fleece.	Standard error of mean.	Mean of six regions.
1	142	3·53	± ·122	3·60
2	261	4·12	± ·088	4·17
3	294	5·18	± ·128	5·58
4	265	3·60	± ·093	3·57
5	236	3·05	± ·109	3·15
6	225	5·00	± ·115	4·95
7	199	3·29	± ·143	3·40
8	203	3·95	± ·096	4·08
9	161	4·08	± ·123	4·32
10	211	2·60	± ·085	2·63
11	384	3·31	± ·143	3·35
12	220	6·48	± ·146	6·73
AVERAGE	—	4·01	—	4·10

Sampling the Shorn Fleece.

Usually, merino sheep are shorn so that the fleeces can be spread on the skirting table without losing the identity of the regions of the fleece. Under these conditions the method of taking samples from six regions, applicable to the live animal, can also be used.

It frequently happens, however, that when fleeces are shorn and sent over long distances, the identity of the regions becomes uncertain. In South Africa, where a system of fleece analysis for sheep breeders has been instituted, fleeces such as these are frequently encountered and it has been necessary that methods for sampling such fleeces be considered.

The fleeces of the two stud sheep A and B were shorn so that the identity of the regions of the fleeces was lost.

Each fleece was evenly spread out on the floor in the form of a rectangle and demarcated into ten equal regions by means of a demarcating frame (shown in figure 2). Ten regions were decided on since it was shown that a selection of six measurements, one from each of six demarcated regions, did not give a sufficiently reliable mean for the fleece. Tests were made to establish whether the taking of one measurement from each of the ten regions, demarcated by the frame gave a sufficiently reliable mean for the fleece. Six measurements taken from each region were compared with three and one respectively, giving selections of 60, 30 and 10 measurements respectively from the whole fleece. The results obtained from fleeces A and B are summarised in Table 4. It is shown that there is no significant difference between the means of selections of 60, 30 and 10 samples of the fleece. Several random selections of 10 measurements (taken one from each square) showed no significant differences among them and this number, therefore, gives a reliable mean for the fleece.

TABLE 4.

Staple Length Measurements of two Merino Fleeces A and B, after shearing.

Sheep.	Type of sheep.	Number of measurements taken.	Mean staple length (cm.).	Standard deviation.	Standard error of mean.
A	Medium developed.....	60	6·1	± ·54	± ·07
		30	6·1	± ·54	± ·10
		10	6·2	± ·54	± ·17
B	Extremely developed..	60	7·2	± ·69	± ·09
		30	7·1	± ·81	± ·15
		10	7·2	± ·48	± ·15

Sampling the Broken-up Fleece.

In many sheep experiments, where wool-production is studied, and also where fleeces are analysed for sheep breeders, such as is at present being done in South Africa, factors such as clean yield, fibre fineness etc. are determined in the ordinary course of the work and these require definite methods of sampling. To obtain representative samples, a method of mixing the fleece thoroughly by a fleece breaker is often employed. It has been shown that such broken up fleeces can also be conveniently used for the determination of staple length measurements.

Fleeces A and B were broken up, spread on the floor and demarcated by the frame so that 30, 10 and 6 points were measured.

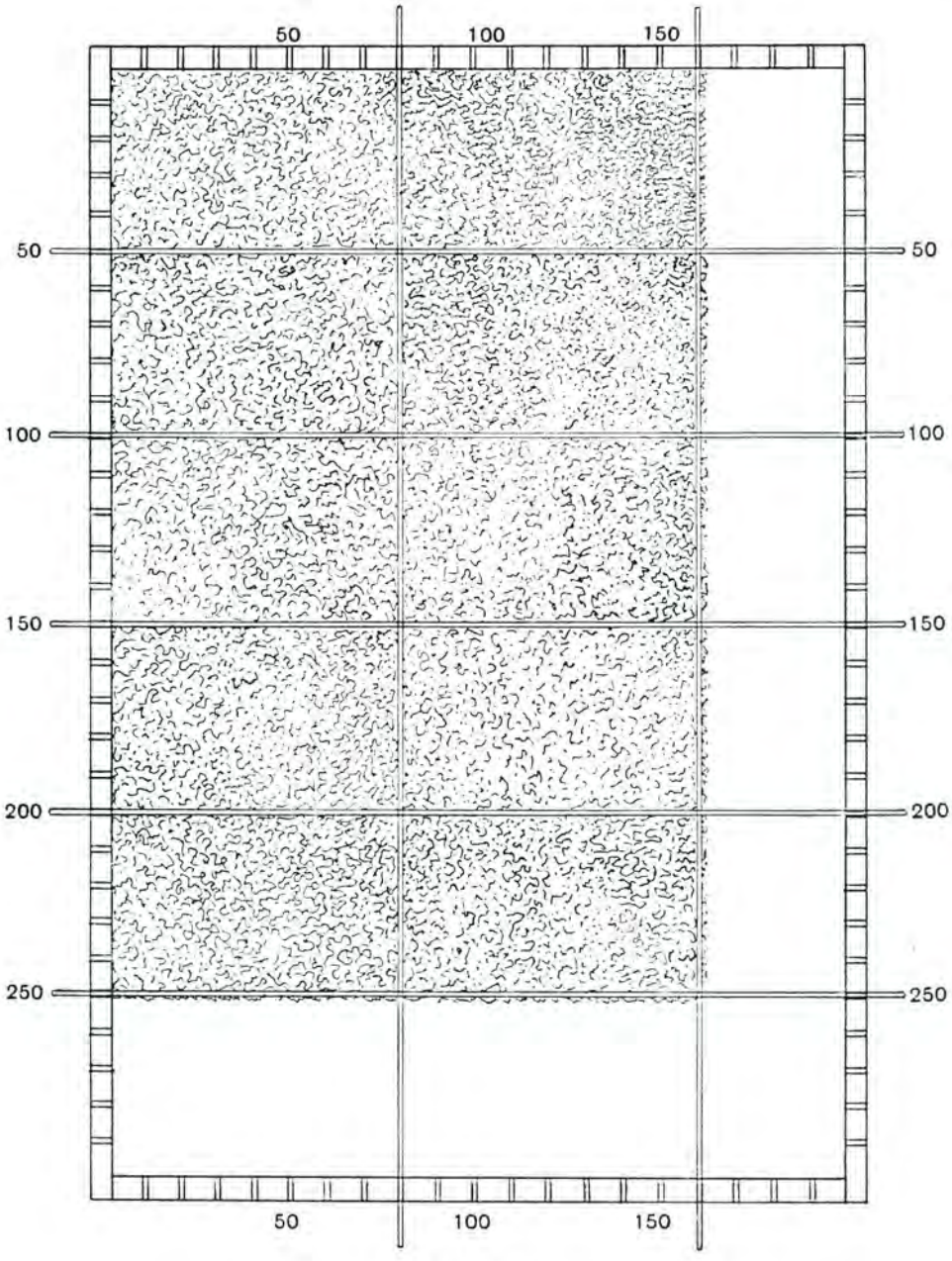

FIGURE 2.

Frame used for demarcating shorn fleeces. The sides of the frame are 300 and 200 centimetres, respectively, and contain grooves for holding the rigid transverse rods, which demarcate the fleece into 10 equal portions.

The means obtained from these selections are shown in Table 5.

TABLE 5.

Staple Length Measurements on two Merino Fleeces A and B after they had been thoroughly broken up and mixed.

Sheep.	Type of sheep.	Number of measurements taken.	Mean staple length (cm.).	Standard deviation.	Standard error of mean.
A	Medium developed.....	30	6·4	± ·42	± ·08
		10	6·3	± ·45	± ·14
		6	6·3	± ·47	± ·19
B	Excessively developed..	30	6·8	± ·67	± ·12
		10	6·9	± ·66	± ·21
		6	6·6	± ·86	± ·35

The measurements of 30, 10 and 6 points on the broken up fleece are shown in Table 5.

There are no significant differences between the means, indicating that a selection of 6 measurements of the broken up fleece gives a sufficiently reliable mean.

When the means, obtained from the fleece on the live animal are compared with the means, obtained from the shorn fleece, there is a difference due to the shearing, since a certain amount of wool is always left on the animal. In general, from a half to one centimetre has been observed to remain on the skin of the sheep.

Sampling for Straight Fibre Length and Crimp Ratio.

Where the determination of straight fibre length and crimp ratio is needed, the number of actual determinations of straight fibre length must necessarily be reduced to a minimum, since they are laborious and not practicable on a large scale, each estimation requiring the straight length measurements of at least 50 fibres. The most suitable method for determining the straight length, is that of straightening each fibre by means of finely pointed forceps against a graduated scale and reading off the length of the fibre.

The crimp ratio is an expression of the ratio of the straight fibre length over the staple length (Duerden and Bosman, 1931). In the measurement of staple length for the purpose of obtaining the crimp ratio, it has been found that more reliable results are obtained by clipping off, at right angles to the length of the staple, small portions at both ends of the staple and then measuring the trimmed staple rather than the untrimmed staple. The straight fibre lengths would also be obtained from the trimmed staple.

Measurements of crimp ratio, taken on a few points on sheep A and B, are shown in Table 6. The points selected are taken on a line between the neck and britch regions of the sheep, this portion of the fleece comprising the bulk of the fleece.

TABLE 6.

Regions.	11.	13.	14.	15.	16.	17.
Sheep A.....	1·5	1·5	1·5	1·5	1·6	1·6
Sheep B.....	1·5	1·4	1·4	1·5	1·6	1·5

It is suggested that, since the work attached to the determination of crimp ratio is too large to be applied for general use, at least one determination of the crimp ratio would give a good indication of the crimp ratio of the fleece. Observations have shown that there is a smaller variability in the same fleece than there is among fleeces and the determination of a sample taken from the shoulder region of the fleece is suggested, this giving a good indication of the crimp ratio of the fleece.

SUMMARY AND CONCLUSIONS.

Methods for determining length in the merino fleece are outlined.

The significance of the staple length, the straight fibre length and the variability of the merino fleece is discussed.

There is no significant difference between the staple length of the left hand side of the merino fleece and that of the right hand side of the fleece.

For sampling the merino fleece on the live animal, a selection of six measurements gives a sufficiently reliable mean for the staple length of the fleece.

When the shorn fleece is spread on a table so that the identity of the regions is preserved, six measurements give a reliable selection for the mean staple length of the fleece.

When the identity of the regions of the shorn fleece is lost and the fleece mixed, the fleece is demarcated into 10 equal regions by a frame, and 10 measurements, one from each region taken for obtaining an average of the fleece.

A correction factor, due to shearing, is necessary when the length of the fleece on the live animal is compared with that of the shorn fleece and in general, a half to one centimetre of staple length has been observed to remain on the live sheep.

It is suggested that, since the complete determination of crimp ratio is too cumbersome for application in general practice, one determination at the shoulder region would give a good indication of the crimp ratio of the fleece.

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BIBLIOGRAPHY.

BARKER, S. G. (1931). Wool Quality. H.M. Stationery Office. London. 328 pp.

BOSMAN, V. (1937). Biological Studies on South African Merino Wool Production. *Reprint from J. Text. Inst.*, Vol. 28, pp. 1-64.

BOTHA, M. L. (Work in progress.)

COWLEY, C. E. (1928). Classing the Clip: A Handbook on Wool Classing. Waterloo (Australia): Eagle Press, Ltd.

DUERDEN, J. E., AND BOSMAN, V. (1931). Staple Length and Crimped and Straight Length of Merino Wool Fibre. *17th Rept. of the Dir. Vet. Serv. and Anim. Indust.*, pp. 781-787.

DUERDEN, J. E., AND BOSMAN, V. (1931). Fibre Lengths, Thickness and Qualities in a Single Wool Staple. *17th Rept. of the Dir. of Vet. Serv. and An. Ind.*, Part 2, pp. 771-779.

DUERDEN, J. E., AND MARÉ, G. S. (1931). Rate of Growth of Merino Wool Month by Month. *17th Rept. Dir. Vet. Serv. and An. Ind.*, Union of S.A., Part 2, pp. 807-811.

DUERDEN, J. E., AND PALMER, E. W. (1932). Staple Length Variation and Distribution in the Fleece of the Merino. *18th Rept. of the Dir. Vet. Serv. and An. Ind.*, pp. 991-1003.

NATIONAL WOOL GROWERS ASSOCIATION (1934). Wool classing standards. Dept. of Agric., Pretoria.

ROBERTS, E. NOEL (1938). Merino development a symbol of success. *The Farmers Weekly*, May 25, 1938, pp. 772-775.

STANBURY, G. R. (1935). The Effect of Quality and Fibre Length on the Strength of Single Worsted Yarns. *The Jour. of the Text. Inst.*, Vol. 26, No. 7, July, pp. Pr. 165-176.

SPEAKMAN, J. B., AND SUN, T. (1936). The Influence of Fibre Length on the Milling Properties of Merino Wool. *Jour. of the Text. Inst.*, June, pp. T. 171-176.

WILSON, R. C. (1935). Classing the Clip. The Queensland Merino Stud Breeders Association Souvenir Book. Jackson and O'Sullivan, Brisbane, Queensland. pp. 189-194.