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Studies on the Variation within the Fleece of the Characteristics of South African Merino Wool. I.—Tensile Strength.

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INTRODUCTION.

IN experimental practice, workers often select samples from one or more regions of a sheep for estimating the characteristics of the wool grown by that sheep, or the influence of various treatments on such characteristics.

Systems of sampling have already been established for some of the fleece characteristics but the variability in tensile strength does not appear to have received attention.

Joseph (1926) used shoulder samples for determining the effect of feed and management of sheep on the tensile strength and elasticity of the wool. Wilson (1931) determined the breaking strength of samples from the shoulder and thigh, and found that the fibres from the thigh were stronger than those taken from the shoulder, a fact which he attributed to the greater degree of coarseness of the fibres growing on the thigh.

Kärrner (1932) and Doehner (1935) determined the breaking strength at three points, viz., shoulder, side and thigh, but gave no indication of the relative values of the tensile strength at these regions. Swart (1937) used shoulder samples for investigating the influence of calcium and phosphorus in the ration on the growth and properties, including tensile strength, of the wool. Bosman, Waterson and van Wyk (1940), in a study of the tensile strength of South African Merino wool, used representative samples from the selected fleeces or lots for their determinations.

The practice of selecting only a few samples may be justifiable in the case where samples are taken from the same area on the same sheep after successive treatments, but not when an estimate of the tensile strength of the wool grown by particular sheep is desired, as in genetical studies, unless the degree of variability is known.

The present investigation deals with the variation of tensile strength over the body of the sheep.

MATERIAL.

Eight four year old Merino sheep were selected from a group which had been on a controlled sufficiency ration since they had been weaned, and had been reared together. A brief description of each sheep is given in Table 1, the body weights in the second column being those obtained immediately after shearing, two months after the samples had been taken.

TABLE 1.

A Description of the Sheep Used in the Investigation.

Sheep No.	Body Weight.	Sex.	Description.
	(lb.)		
45114	107	Ewe	Exceptionally plainbodied. Measurements showed the variability in fibre fineness over the body of the sheep to be exceptionally small. The wool had a soft handle.
45059	98	Ewe	Extremely developed. The wool had a good crimp definition, but results of measurements showed a high variability in fibre fineness.
45100	147	Ram	Plainbodied. The wool had a shallow type of crimping.
45297	162	Ewe	Exceptionally large and plainbodied. The ewe was described as a good flock type.
45250	116	Ewe	Plainbodied. The fleece was extremely hairy, crimping was almost entirely absent, and the wool felt harsh.
45308	125	Ram	Extremely developed. The wool had a well-defined crimp, but was rather short. Measurement showed considerable variability in fibre fineness over the body of the sheep.
45129	184	Ram	Plainbodied. The wool was long and loose.
45135	138	Ram	Plainbodied. An extremely hairy fleece, crimping almost absent. The wool had a harsh feel.

(The term "developed" indicates the presence of skin folds.)

The eight sheep included widely different types, and for the group at least might be expected to show extreme values.

Samples of approximately 100 gm. weight were taken from the shoulder, back, side, neck, thigh and belly of the sheep, and the tensile strength of each sample determined by the method described by Bosman, Waterson and van Wyk (1940). Each value given is the mean of tests on three bundles of a hundred fibres each. The standard error of the values given was calculated to be $\pm 0{\cdot}046 \times 10^6$ gm./sq. cm.

RESULTS.

The results of analyses are given in Table 2.

TABLE 2.

The Tensile Strength (in 10^6 gm./sq. cm.) and Fibre Fineness (in Microns) Determined at Different Regions on the Sheep.

Sheep No.		Shoulder.	Back.	Side.	Neck.	Thigh.	Belly.	Mean per Sheep.
45114	Tensile strength........	1·52	1·57	1·46	1·60	1·51	1·19	1·48
	Fibre fineness..........	19·2	17·9	18·7	19·3	20·2	21·3	19·4
45059	Tensile strength........	1·51	1·62	1·44	1·41	1·32	1·25	1·42
	Fibre fineness..........	23·1	23·1	24·0	24·3	23·8	22·5	23·5
45100	Tensile strength........	1·46	1·47	1·45	1·41	1·40	1·27	1·41
	Fibre fineness..........	24·6	25·7	26·0	27·5	26·8	24·5	25·8
45297	Tensile strength........	1·46	1·42	1·37	1·40	1·56	1·08	1·38
	Fibre fineness..........	22·9	23·4	24·3	24·8	24·0	23·7	23·9
45250	Tensile strength........	1·39	1·42	1·49	1·32	1·38	1·20	1·37
	Fibre fineness..........	27·0	28·4	27·4	28·7	28·0	28·0	27·9

TABLE 2 (*continued*).

Sheep No.		Shoulder.	Back.	Side.	Neck.	Thigh.	Belly.	Mean per Sheep.
45308	Tensile strength........	1·44	1·43	1·42	1·41	1·30	1·08	1·35
	Fibre fineness..........	24·8	22·5	25·3	28·4	27·3	29·0	26·2
45129	Tensile strength........	1·40	1·31	1·34	1·49	1·33	1·13	1·33
	Fibre fineness..........	23·4	22·3	23·9	25·2	23·9	23·2	23·6
45135	Tensile strength........	1·19	1·19	1·23	1·17	1·18	1·08	1·17
	Fibre fineness..........	26·5	26·8	27·7	27·9	27·4	25·8	27·0
Mean per Region	Tensile strength........	1·43	1·43	1·40	1·40	1·37	1·16	—
	Fibre fineness..........	23·9	23·8	24·7	25·8	25·2	24·7	—

An analysis of the variance of the tensile strength determinations is given in Table 3.

TABLE 3.

Analysis of Variance of the Tensile Strength Determinations.

Variance.	D.F.	Standard Deviation. (10^6 gm./sq. cm.)
Between regions of a sheep..	5	0·4986
Between sheep..	7	0·3782
Error..	35	0·1209
Between determinations..	47	—
Within determinations..	96	0·0804
TOTAL..	143	

The variance between regions differed significantly from the error variance, so that definite differences in tensile strength occurred between the various regions of a sheep.

Table 4 gives the mean difference and the standard deviation of the differences between each region and the mean of each sheep.

TABLE 4.

Differences in Tensile Strength Between the Regions and the Means of the Sheep.

Region.	Mean Difference. (10^6 gm./sq. cm.)	Standard Deviation of Differences. (10^6 gm./sq. cm.)
Shoulder..	+ 0·06	0·029
Back..	+ 0·07	0·065
Side..	+ 0·04	0·046
Neck..	+ 0·04	0·071
Thigh..	+ 0·01	0·081
Belly..	− 0·20	0·076

The value obtained for the belly wool is considerably lower than the mean for the sheep, and an examination of Table 2 shows that this is the case in all the sheep. For comparison, the tensile strength values may be adjusted to a certain fineness value by means of the regression coefficient of tensile strength on fibre fineness. In the present study the regression coefficient was found to be $-0 \cdot 025$ and Table 5 shows the result of adjusting the tensile strength value to correspond to the mean fineness obtained for each sheep.

TABLE 5.

Mean Tensile Strength (10^6 gm./sq. cm.) after Adjustment for Fibre Fineness.

Shoulder.	Back.	Side.	Neck.	Thigh.	Belly.	Mean.
1·40	1·41	1·40	1·43	1·38	1·16	1·36

Comparison with Table 2 shows that no essential difference in the relative values for the belly and the other regions has been produced, the belly samples still having a considerably lower value of tensile strength.

The influence of the belly wool can be seen in excluding it from the calculation of the variance between regions, as in Table 6.

TABLE 6.

The Variation in the Mean Tensile Strength of the Various Regions of the Sheep.

	D.F.	Standard Deviation. (10^6 gm./sq. cm.)
Including belly samples	5	0·1018
Excluding belly samples	4	0·0221

The variation between the regions is considerably reduced when the belly samples are omitted.

This result was so striking that a further investigation seemed justified. Since the sheep used in the present study were reared together and received identical treatment, an attempt was made to generalise the results by comparing the shoulder and belly samples of sheep from other sources.

Accordingly six groups of ten sheep each were selected. Care was taken to select only ewes which had not lambed, while the rams' wool used had no visible "breaks" or tender regions.

A composite shoulder sample and a composite belly sample were made up from the ten sheep in each group by drawing 30 fibres at random from each sample. The 300 fibres so obtained were mounted in three bundles of 100 fibres each and the tensile strength of the bundles was determined. Table 7 gives the results obtained.

TABLE 7.

Comparison of the Tensile Strength of Shoulder and Belly Samples taken from Six Groups of Ten Sheep each.

Group.	Description.	Tensile Strength (10^6 gm./sq. cm.).		
		Shoulder.	Belly.	Difference.
I	Karroo Rams	1·38	1·24	0·14
II	Karroo Ewes	1·45	1·17	0·28
III	W. Transvaal Grassveld Ewes (plainbodied)	1·32	1·21	0·11
IV	W. Transvaal Grassveld Ewes (developed)	1·39	1·16	0·23
V	Stud Ewes (long woolled, plainbodied)	1·34	1·02	0·32
VI	Miscellaneous Rams	1·30	1·22	0·08
		1·36	1·17	0·19 ± 0·040

In every case the tensile strength of the shoulder sample was greater than that of the belly sample. The mean difference $0{\cdot}19 \times 10^6$ gm./sq. cm., representing sixty sheep from different sources, was highly significant with a t value of 4·8.

The National Wool Growers' Association (1934) recommended in its schedule of classing standards that belly wools should be baled and marked separately. The present investigation shows this recommendation to be fully justified since the tensile strength of belly wool is appreciably lower than that of the rest of the fleece. It is also advisable that belly wool should be excluded when assessing the tensile strength of the wool of a sheep.

On the average, the wool from the shoulder and back gave the highest values for tensile strength. Wool from the side and neck gave slightly lower values. The order varied slightly from sheep to sheep but it cannot be said that the differences were of material significance. The thigh wool may possibly have a lower tensile strength than the rest of the fleece, but the differences could not be tested with the number of sheep under observation.

The question next arose as to whether it was possible to estimate the tensile strength of a fleece by taking a single sample from a certain region of the sheep. Excluding the values for the belly wool in the calculation of the mean, the following results (Table 8) were obtained for the differences between the value for a region and the mean for each sheep.

TABLE 8.

Differences in Tensile Strength between the Regions and the Means of the Sheep (excluding the Values obtained for Belly Wool).

Region.	Mean Difference. (10^6 gm./sq. cm.)	Standard Deviation of Differences. (10^6 gm./sq. cm.)
Shoulder	+ 0·02	0·021
Back	+ 0·03	0·064
Side	0	0·046
Neck	0	0·071
Thigh	— 0·03	0·081

While the tensile strength of the shoulder samples was on the average $0 \cdot 02 \times 10^6$ gm./sq. cm. greater than the mean of all the samples (excluding the belly samples), the standard deviation of the differences was only $0 \cdot 021 \times 10^6$ gm./sq. cm., and the next smallest standard deviation was twice as large. Even if the belly sample is included in the calculation of the mean for the sheep, Table 4 shows that the same conclusions may be drawn. This means that if the shoulder sample alone is used for estimating the tensile strength of the fleece, the value obtained may be slightly greater than the mean of the fleece but the estimate will be subject to a smaller error than when any of the other regions of the sheep is selected. The tensile strength of the shoulder sample is therefore valuable in comparisons between different sheep.

The correlation between tensile strength and fibre fineness is given in Table 9.

TABLE 9.

The Correlation Coefficient between Tensile Strength and Fibre Fineness.

	D.F.	r
Between sheep	7	− 0·6264*
Between regions	5	− 0·1806
Error	35	− 0·3005
TOTAL	47	− 0·4168

The total correlation coefficient is significant at the 1 per cent. probability level, showing that on the whole the finer samples had the higher tensile strength. For the available degrees of freedom the other coefficients cannot be regarded as significant, but it is interesting to note that the coefficient between sheep is much greater than that between the regions of a sheep. Bosman, Waterston and van Wyk (1940) found an insignificant correlation between tensile strength and fibre fineness in a random selection of samples, but this may have been to a certain extent counteracted by feeding conditions (Bosman, Waterston and van Wyk(1)). The sheep used in the present investigation received constant feed and the wool was sound, consequently the inclusion of more sheep in the investigation may possibly have rendered the negative correlation between tensile strength and fibre fineness among sheep significant.

The correlation obtained between regions may have been reduced by the presence of wool growing on skinfolds, since several of the sheep showed considerable development, and Bosman, Waterston and van Wyk(2) have found that on the average the wool growing on the folds tends to have a higher tensile strength and a coarser fibre than that growing between folds. Such a tendency would reduce the negative correlation coefficient between regions.

SUMMARY AND CONCLUSIONS.

The tensile strength of the wool grown on six regions on each of eight sheep was determined. Significant differences between the regions were obtained.

In all cases the tensile strength of the belly wool was considerably lower than that of the rest of the fleece.

This point was further investigated with six groups of ten sheep each, and it was found that in the case of every group the shoulder sample had a higher tensile strength than the belly sample, the mean difference being highly significant. This finding strengthens the National Wool Growers' Association's recommendation that belly wool should be baled and sold separately from the rest of the fleece. It was further suggested that the belly wool should be excluded in assessing the average tensile strength of the wool of a sheep.

Differences in tensile strength between the wool from other regions of the sheep were found to be insignificant, but the highest values were obtained on the shoulder and back and the lowest on the thigh.

It was concluded that the shoulder sample should be used for assessing the tensile strength of the wool grown by a sheep, especially in comparisons between different sheep, since differences between the value for the shoulder sample and that of the whole fleece showed the smallest variability.

The total correlation coefficient between tensile strength and fibre fineness was $-0 \cdot 4168$, a highly significant value.

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REFERENCES.

BOSMAN, V., WATERSTON, E. A., AND VAN WYK, C. M. (1940). Studies on the basic characteristics of South African Merino wool. I. Breaking strength and tensile strength. *Onderstepoort J.*, Vol. 15, Nos. 1 and 2, pp. 313-324.

BOSMAN, V. WATERSTON, E. A., AND VAN WYK, C. M.(1). Influence of feed on the characteristics of South African Merino Wool. I. Tensile strength (*In course of publication*).

BOSMAN, V., WATERSTON,: E. A., AND VAN WYK, C. M.(2). The influence of skin folds on Merino wool characteristics. I. Tensile strength (*In course of publication*).

DOEHNER, H. (1935). Die Feinheit und Festigkeit der deutschen Schafwollen. *Paul Parey, Berlin.*

JOSEPH, W. E. (1926). Effect of feeding and management of sheep on the tensile strength and elasticity of wool. *J. Agric. Res.*, Vol. 33, No. 11, pp. 1073-1089.

KARRNER, H. (1932). Weitere Untersuchungen über Tragkraft und Dehnung des Wollhaares mittels des Tänzer-Polikeitshen Dynamometers. *Zeits. f. Zücht. B. Tierz. u. Züchtungsbiol.*, Vol. 23, No. 3, pp. 377-419.

NATIONAL WOOL GROWERS' ASSOCIATION (1934). N.W.G.A. Wool Classing Standards. *Govt. Printer, Pretoria.*

SWART, J. C. (1936). The influence of sulphur in a ration on the growth and properties of wool. *Zeits. f. Zücht. B. Tierz. u. Züchtungsbiol.*, Vol. 36, No. 3, pp. 307-336.

SWART, J.. C (1937). The influence of calcium and phosphorus in a ration on the growth and properties of wcol. *Zeits. f. Zücht. B. Tierz. u. Züchtungsbiol.*, Vol. 37, No. 1, pp. 77-91

WILSON, J. F. (1931). The influence of the plane of nutrition upon various factors related to wool production *The National Wool Grower*, Vol. 21, No. 12.