A STUDY OF FLEECES EXHIBITED AT A NATIONAL MERINO FLEECE WOOL COMPETITION

by

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I hereby declare that this treatise or part of it submitted by me for the degree of MSc. Agric. at the University of the Orange Free State has not been submitted previously for a degree at any other University.

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CHAPTER I

INTRODUCTION

Selection to improve livestock can be based on either a subjective or an objective evaluation of breeding animals. Selection, however, will not bring about any significant progress unless the factors influencing it, are taken into account in the breeding programme.

For the breeder the factors influencing the price of wool must form the primary basis of selection while due attention must be paid to fertility and body weight. (Young & Turner, 1965).

The relative economic importance of the different factors having an influence on the price of wool was indicated by Engela, Wessels & Havenga (1948) and Young & Dunlop (1955, quoted by Turner 1956). They concluded that the amount of scoured wool is the predominant characteristic, followed in turn by length and spinning count. Attention must also be paid to quality and other factors but only to maintain a minimum acceptable standard and without inhibiting the amount of wool, spinning count or length.

Selection for wool weight, length and spinning count thus seems to be the obvious criteria. However, in practice problems will arise with the visual and tactile evaluation of these characteristics. Bogart (1959) mentioned that selection in farm animals had so far been done on eye appraisal but it does not appear very successful in the selection for certain important traits. The C.S.I.R.O. (1955) compared efficiency of selection between visual and measured evaluation of wool production and found efficiency in increasing total wool weight on eye appraisal only 30 percent compared to 100 percent when measured. In terms of financial returns, visual methods were 50 percent efficient compared to 100 percent when measured.

An evaluation of the methods in use today in the selection of sheep and the classing of wool, and possibly, the improvement of some criteria thus seems of major importance. Duerden (1929) laid down certain standards for the determination of fibre thickness from crimps per inch for South African Merino wool. According to this work there is a definite relation between fibre thickness and the number of crimps per inch, the finer fibres having more crimps per inch. Barker & Norris (1930) favoured a relationship between crimp and fibre thickness; the square of the diameter being inversely proportional to the number of crimps per inch. Work on the crimp-fibre thickness relationship showed, however, that while the Duerden standards hold true for the judging of spinning count from crimps per inch, the crimp-fibre thickness relationship may vary from strain to strain as well as from one area to another. (Bosman,1937; Lang,1947, and Roberts & Dunlop,1957).

There seems to be a tendency in South African wool to be undercrimped (Venter 1964) and estimating the fibre thickness of the wool on crimps per inch will result in an underestimation of spinning count.

The question now arises whether the Duerden scale for crimp-fibre thickness relationship, is still valid for South African Merino wool and if not, whether any of the existing scales offer a better criterion.

As a result of the importance of the amount of wool produced by the animal, success in selection will depend on effectiveness of selection for the different production components. Of the wool components described by Turner (1958) only length and fibre thickness will be discussed in this study. Since results definitely show a positive correlation between length and weight of wool produced (Terrill, Kyle & Hazel 1950), the production of excessively long wool causes various problems.

While it is generally accepted that spinning count is negatively correlated with staple length, Turner (1956) mentioned the possibility of producing long fine wool. Selection for clean fleece weight is not practical and the use of greasy fleece weight as a selection measure, will be of value to the producer. Turner op. cit. mentioned that fleece weight should respond to selection in all breeds except in the case of the Romney Marsh.

While quality is not of major importance, poor quality can result in low prices. Knowledge of the relationship between quality and production characteristics will simplify selection for quality because quality cannot be evaluated objectively, and in the majority of cases quality evaluation will differ from one school of woolmen to another. Le Roux (1960) is of the opinion that quality differences are a result of differences in chemical composition, but as yet no definite conclusion is possibl

The relationship between different production characteristics and the chemical composition of wool seems to be a new field for research. Horio & Kondo (1953), Mercer (1953), Mercer (1954) and Louw (1960b) investigated the origin of fibre crimp and came to the conclusion that it is caused by differences in the cortex of the fibre. Feugelman & Reis (1967) found differences in mechanical properties between high- and low sulphur wool. Preliminary research seems to indicate that differences in the chemical composition of fibres may be responsible for different properties in fibres, but at present this cannot be proved.

The aim of this study is to determine:

(a) The accuracy of estimating production characteristics and whether or not the Duerden standards for the crimp - fibre thickness relationship are still applicable to South African Merino wool.

(b) the interrelationships between different wool traits with special reference to the production characteristics *viz.* amount, length and spinning count of wool.

(c) the relationship between quality and physical- and chemical properties.

(d) the relationship between chemical composition (in terms of disulphides and thiol groups) and the different wool characteristics and whether chemical differences in wool result in differences in physical properties.

CHAPTER 2

EXPERIMENTAL PROCEDURE

2.1 Experimental material

Wool samples from 42 rams and 65 ewes were obtained from the fleeces exhibited at the South African Merino Fleecewool Competition held in Bloemfontein during 1966.

Whole fleeces from which only "locks" had been removed were entered in the following classes according to spinning count:

RAMS:	
Overstrong...........	$58^s/56^s$ - $58^s/60^s$
Strong...............	$60^s/58^s$ - $60^s/64^s$
Medium...............	$64^s/60^s$ and finer
EWES:	
Overstrong...........	$60^s/58^s$
Strong...............	$60^s/64^s$
Medium...............	$64^s/60^s$ - $66^s/70^s$
Fine.................	70^s and finer

The judges interchanged fleeces between classes whenever they considered them incorrectly entered. After receipt at the exhibiting hall, the fleeces were weighed and this weight, corrected to 12 months growth, was regarded as the official greasy fleece weight for all analyses.

2.2 Estimating procedure

Estimation was done in the exhibiting hall in two phases.

During the first phase two judges from the "trade" scored the following properties:

Spinning count
Length
Yield
Evenness of length
Uniformity for class.

During the second phase one representative each of the South African Wool Board, the Department of Agricultural Technical Services and the Merino Sheep Breeders Association scored the following properties:

Soundness (tensile strength)
Quality
Substance, staple formation and tip
General appearance.

2.3 Subjective evaluation of properties

From the score card, (Appendix I) used asabasis for the estimation, it is clear that a large number of the properties were estimated subjectively, some measurable and others not. For this study only the measurable properties, apart from quality, were used in the statistical analyses and estimation based only on these properties will be discussed.

2.3.1 Spinning count (Fibre thickness)

Spinning count was used as the criterion for estimating fibre thickness, which is the normal procedure.

Duerden (1929) and Duerden & Bell (1931) found a definite correlation between fibre thickness and the number of crimps per inch and it is general practice to estimate the fibre thickness on this basis. In Table 1 the relationships between spinning count, crimps and fibre thickness are illustrated.

Crimps per inch can be misleading at times and judges in practice frequently take other factors like quality into consideration when estimating fibre thickness.

2.3.2 Length

Length was estimated visually. The length of wool was corrected for period of growth by conversion to 12 months growth.

2.3.3 Yield

The estimation of yield was based on the presence or absence of foreign matter as well as the amount of yolk present in the wool. Yield was expressed as a percentage of the greasy fleece weight.

TABLE 1:- The relationship between spinning count, crimp and fibre thickness

SPINNING COUNT (hanks)	CRIMPS PER INCH	FIBRE THICKNESS (μ)
150^{s}	28 - 30	14.0 - 14.7
120^{s}	25 - 27	14.7 - 15.4
100^{s}	22 - 24	15.4 - 16.2
90^{s}	20 - 21	16.2 - 17.0
80^{s}	18 - 19	17.0 - 17.9
70^{s}	16 - 17	17.9 - 18.9
66^{s}	14 - 15	18.9 - 20.0
64^{s}	12 - 13	20.0 - 21.3
60^{s}	10 - 11	21.3 - 23.0
58^{s}	8 - 9	23.0 - 25.5
56^{s}	6 - 7	25.5 - 29.0

2.3.4 Quality

This property can be evaluated subjectively only. Various definitions of this property are offered by different workers, but for this study the following definition, as described in the competition rules, was taken as the basis for estimation: "Softness (kindness) of handle and a well-defined even crimp are characteristic of a true Merino wool and are indicative of uniformity of characteristics. Merino wool can be divided into classes according to quality, namely: very good, good, fairly good, ordinary to common and common". (Grootfontein College of Agriculture, 1952).

In estimating quality the judges awarded points on the basis of a possible total of 20 points but for analysis these scores were converted to a scale of a possible total of 10 points. Points were thus allotted on the following basis described by Labuscagne & Steyn (1956).

Ideal..........	9 - 10
Very good......	7 - 8
Good...........	6
Fair...........	4
Common.........	0

2.3.5 Calculation of amount of scoured wool

$$\text{Amount of scoured wool} = \frac{\text{Greasy fleece weight} \times \%\ \text{yield}}{100}$$

2.4 Objective evaluation of properties

Some properties evaluated subjectively were also determined objectively.

2.4.1 Length

Staple length (in inches) was determined with a ruler by measuring the wool in a normal unstretched position. (Bosman & Botha 1939)

2.4.2 Yield

The following method described by Kruger (1966) was used to determine the yield of wool.

Wool samples were conditioned in a humidity room with a relative humidity of 65± 2 percent and a temperature of 20± 2°C. All analyses were done in this room.

Samples of 100 gm.each were weighed accurately and this weight taken as the greasy wool weight. After weighing the samples were washed in a solution of sodium carbonate and commercial soft soap. Two stock solutions, one of 15 percent commercial sodium carbonate and the other 30 percent commercial soft soap, were made and used to make up the different washing solutions used in the determination of the yield. The wool was washed in four different containers, each holding 22.7 litres of washing solution and according to the condition of the wool the stock solutions, given in Table 2, were added to the different containers.

TABLE 2:- Amount of stock solution, added to distilled water, for washing wool samples (gm)

CONDITION	STOCK SOLUTION	CONTAINER			
		1	2	3	4
1. Light	Soap	680	540	450	0
	Na_2CO_3	540	400	250	0
2. Medium	Soap	750	540	450	0
	Na_2CO_3	600	400	250	0
3. Heavy	Soap	840	630	450	0
	Na_2CO_3	660	450	250	0
4. Very heavy	Soap	990	660	450	0
	Na_2CO_3	800	490	250	0
5. Greasy	Soap	1200	750	450	0
	Na_2CO_3	1000	540	250	0

The temperature and time of washing in the solutions varied as illustrated in Table 3.

Washing started in solution one and progressed through solutions two and three to solution four which was pure distilled water. Washing was done by limited agitation of the wool in the washing solution. After washing in a solution for the specified time the excess washing solution was removed from the samples before the samples were

TABLE 3:- Temperatures and time of washing in the different washing solutions.

	SOLUTION			
	1	2	3	4
Temperature °C	52°	49°	46°	46°
Time (minutes)	4	3	3	1.5

transferred to the next solution.

Only ten samples were washed in each bath after which bath number one was cleaned and filled with distilled water. This bath replaced bath number four and the concentration of washing solutions in the other baths was adjusted by the addition of stock solutions making bath number two number one and number three number two. Temperatures were adjusted accordingly.

After washing, the wool was dried and hand-carded to remove plant material, after which it was conditioned in the humidity room before weighing. This last weight was taken as the clean wool weight.

Yield was calculated as follows:

$$\% \text{ Yield (M)} = \frac{\text{Clean wool weight}}{\text{Greasy wool weight}} \times 100$$

The remaining determinations were done on these clean wool samples after the final weighing.

2.4.3 Spinning count (Fibre thickness)

Spinning count was determined by two methods. Firstly the number of crimps per inch as described by Duerden loc. cit. was determined and from this scale spinning count was obtained.

The National Fleece Testing Centre at Grootfontein determined fibre thicknesses of the samples by flowmeter according to the method of Anderson (1954), based on the flow of air through a certain weight of compressed wool.

2.4.4 Amount of scoured wool

$$\text{Amount of scoured wool} = \frac{\text{greasy fleece weight} \times \% \text{ determined yield}}{100}$$

2.5 Chemical analyses

Chemical analyses were done on the samples to determine the degree of weathering and the amount of disulphide linkages and thiol groups.

2.5.1 Alkali solubility test

The method described by the International Wool and Textile Organisation (1960) was used to determine the alkali solubility of the wool samples.

Three sub samples of 1 gm. each were weighed, one for a moisture determination and the other two samples for the duplicate determination of alkali solubility.

Each sample was treated in 100 ml. of 0.1 N sodium hydroxide solution for one hour at 65° C after which it was washed six times in distilled water, twice in 1.0 percent acetic acid solution, and again six times in distilled water. It was then dried for 24 hours in a drying oven at 105° C, cooled in a de~~s~~siccator and weighed.

Calculation:

$$\text{Alkali Solubility} = \frac{W\,1 - W\,2}{W\,1} \times 100\%$$

where W 1 = dry weight of sample before reaction with sodium hydroxide.

and W 2 = dry weight of sample after reaction with sodium hydroxide.

2.5.2 Determination of disulphides (SS) and thiols (SH) in the wool samples

The determinations of the disulphides and thiols in the samples were carried out according to a polarographic method based upon those described by Leach (1960 a, 1960 b) and Swanepoel (1964). According to these methods the disulphides or thiols are blocked with an excess amount of methyl mercury iodide solution and the excess methyl mercury iodide is determined polarographically.

2.5.2.1 Reagents

2.5.2.1.1 Methyl mercury iodide (Me Hg I)

Methyl mercury iodide was prepared according to the method described by Leach (1960 a). A mixture of mercury and methyl iodide was exposed to direct sunlight for six weeks in a stoppered flask whereafter the formed methyl mercury iodide was washed, recrystallised and stored in an air tight bottle left in the dark.

A 0.1 M stock solution of methyl mercury iodide in 30% Formdimethyl amide ~~0.1 N potassium chlorid~~e was prepared and stored in the dark. This solution was used to prepare the working solutions (Leach *op. cit.*).

2.5.2.1.2 Solution R-SH, used in the determination of thiol groups

This solution was prepared by dissolving 12.1 gm. of tris buffer (tris- (hydroxymethyl) amino methane) and 7.5 gm. of potassium chloride in 800 ml. of distilled water. The pH was adjusted to 7.3 by the dropwise addition of 1.0 N hydrochloric acid. 15 ml. of a 1.0 percent gelatine solution and enough methyl mercury iodide stock solution to obtain the desired concentration of 5×10^{-4} M, were mixed and made up to 1.0 litre.

2.5.2.1.3 Ammonium hydroxide/Ammonium chloride solution

An ammonium hydroxide/ammonium chloride solution was prepared by adding, to 500 ml of water the amount of NH_4OH to make a 1.0 N solution. NH_4Cl was formed by adding 1.0 N HCl until the pH was 9.3. This solution was made up to 1.0 litre and consisted of NH_4OH and NH_4Cl.

2.5.2.1.4 Solution R-SS, used in determination of Disulphides + thiols

To 480 gm,urea, 7.5 gm.potassium chloride and 50 g. hydrous sodium sulphide ($Na_2SO_3.7H_2O$), 100 ml 1.0 N solution of ammonium chloride/ammonium hydroxide solution of pH 9.3 and 400 ml of water were added.

The mixture was shaken until all reagents had dissolved and 10 ml. of a 1.0 percent gelatine solution and enough methyl mercury iodide stock solution to obtain the desired concentration of 10^{-3}M, were added and made up to 1.0 litre with distilled water.

NOTE:-

All mercuric solutions were stored in the dark and methyl mercury iodide was added to the buffer solutions (R-SS and R-SH) just before the reagent was added to the wool.

2.5.2.2. Apparatus

A registering polarograph, Metrohm Polarecord Type R271 and a direct reading polarograph, Metrohm Polarimeter Type E356 with a dropping mercury electrode, Metrohm Type E354 were used.

Forced dropping of six drops per minute was used. Current sensitivety was $10^{-9}/5$ A/mm when using the Polarecord and $10^{-8}/1$ A/mm when the Polarimeter was used. Damping and compensation current settings were 3 and 50 respectively for both sets.

When the polarecord was used the starting voltage was -0.25 volts and the end voltage -1.0 volts. The paperfeed and voltage increase were done rapidly with the speed settings both at "fast".

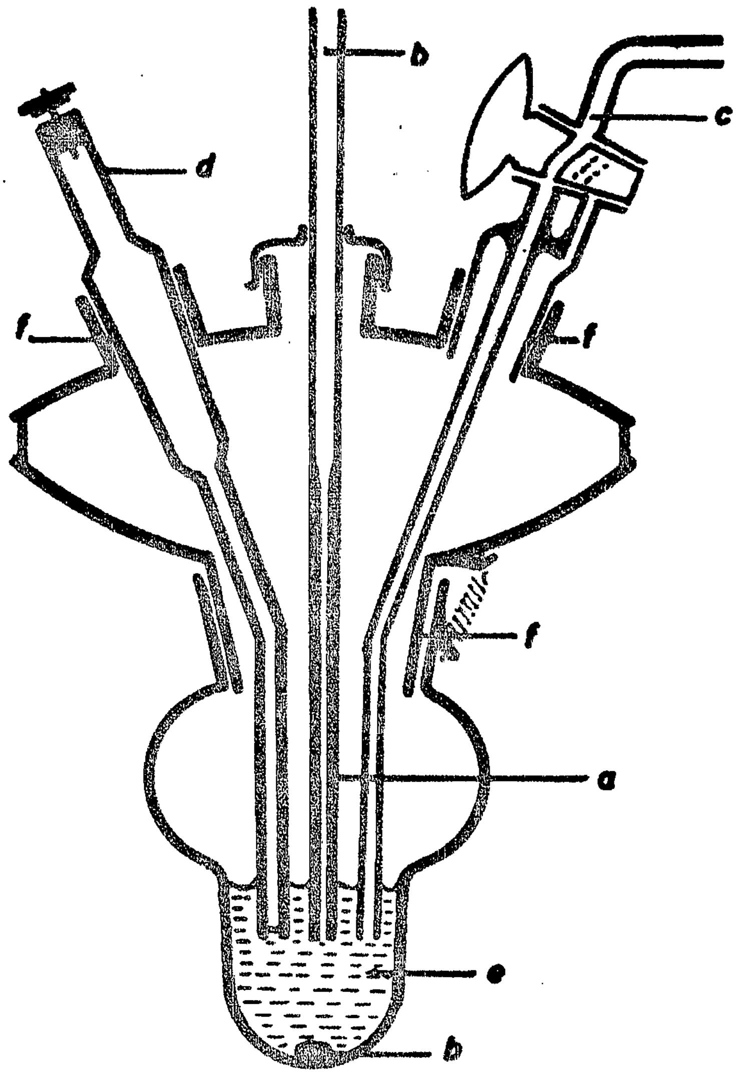
An Ag/Ag Cl-reference electrode connected to the solution with a KCl - 1.0 percent agar-bridge was used.

Oxygen was removed by bubbling nitrogen through the solution and blown over the solutions when recordings or readings were taken. The determination bowl, with dropper, Ag/Ag Cl reference electrode and Nitrogen inlet is shown in Figure 1.

2.5.2.3 Procedure

All rubber corks used in the determination were boiled in 1.0 percent sodium hydroxide solution for three hours and thereafter left overnight in distilled water.

Duplicate samples of 0.0225 gm.for disulphide- and 0.0750 gm.for thiol determinations were weighed accurately and were exposed to the reaction with 15 ml. solutions R-SS or R-SH for at



a. dropper

b. mercury

c. N_2 inlet

d. Ag/AgCl reference electrode

e. solution R-SS or R-SH

f. ground joints

Fig.1 Determination bowl of the dropping mercury electrode set.

least 12 hours. Polarographic determinations were done after nitrogen had been bubbled through the solution for seven minutes. A few blank solutions R-SS or R-SH containing no wool, were shaken with each batch of samples. This blank sample was determined polarographically simultaneously with the other samples.

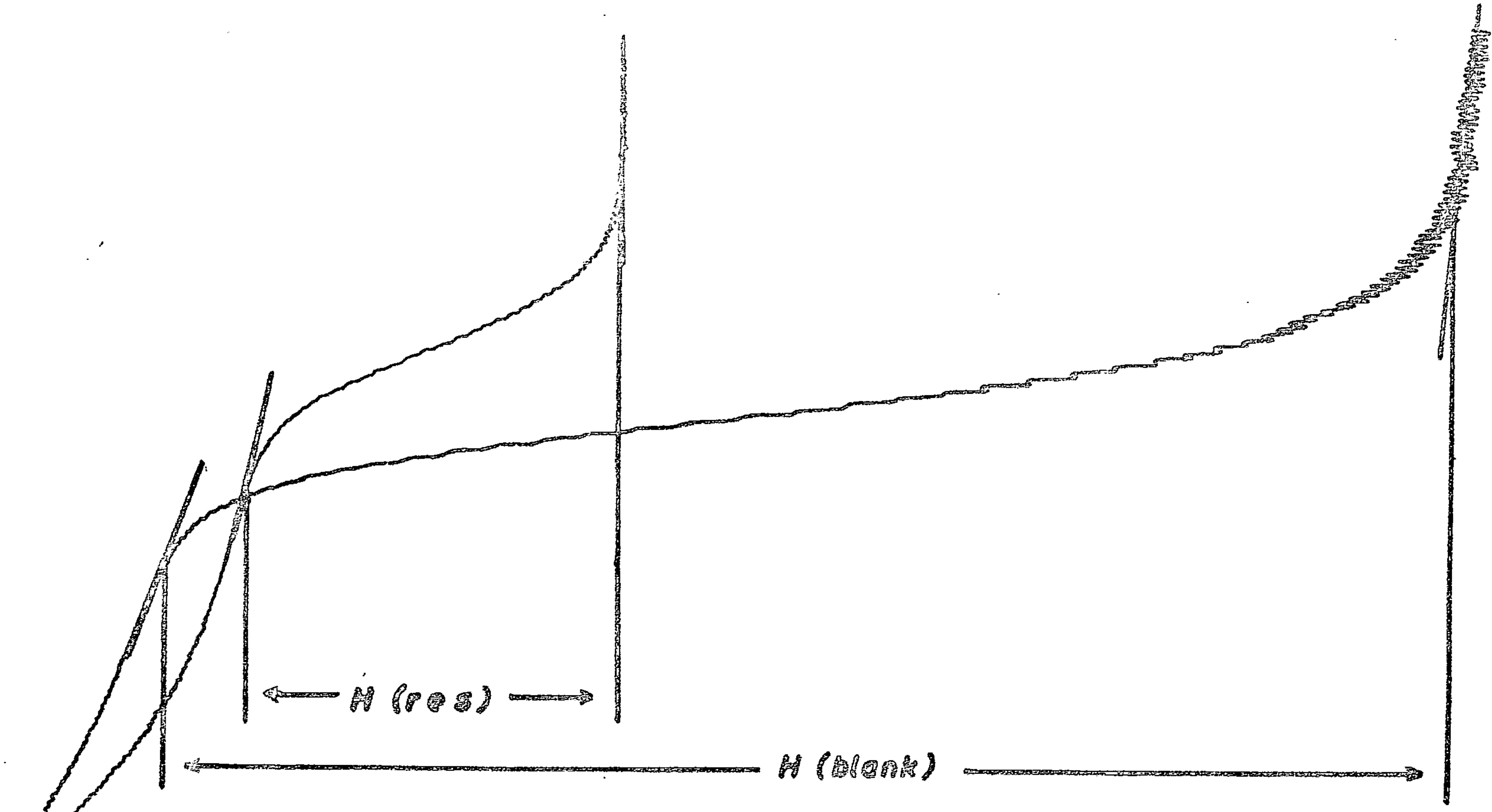
Samples for the determination of moisture were weighed simultaneously with the samples used for chemical analyses.

When the Polarecord was used the height of the curve was determined as shown in Figure 2.

Direct readings are obtained by means of the Polarimeter. A method based on the method of Leach (1960 b) was used. This method proved to be faster and just as accurate for routine determination.

Normally curves are not plotted because a direct reading is obtained. However, in order to compare this method with the Polarecord described above a few general curves, which are given in Figures 3 and 4, were drawn from Polarimeter readings.

It was found that for the determination of thiols the best results were obtained when the Polarimeter was zeroed at -0.420 volts and the reading taken at -0.500 volts while the values



$I = (\text{sensitivity} \times H)\, 10^{-6}\, \mu V.$

Fig. 2. Measurement and calculation of diffusion current for polarographic determinations.

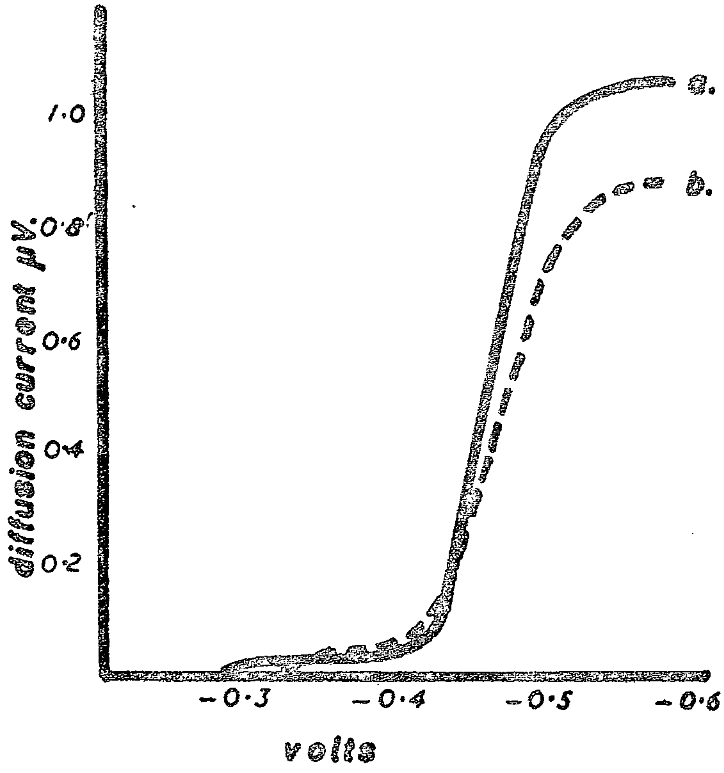


Fig.3 The reaction of thiols with 5×10^{-4}M MeHgI(a)before-(b)after reaction.

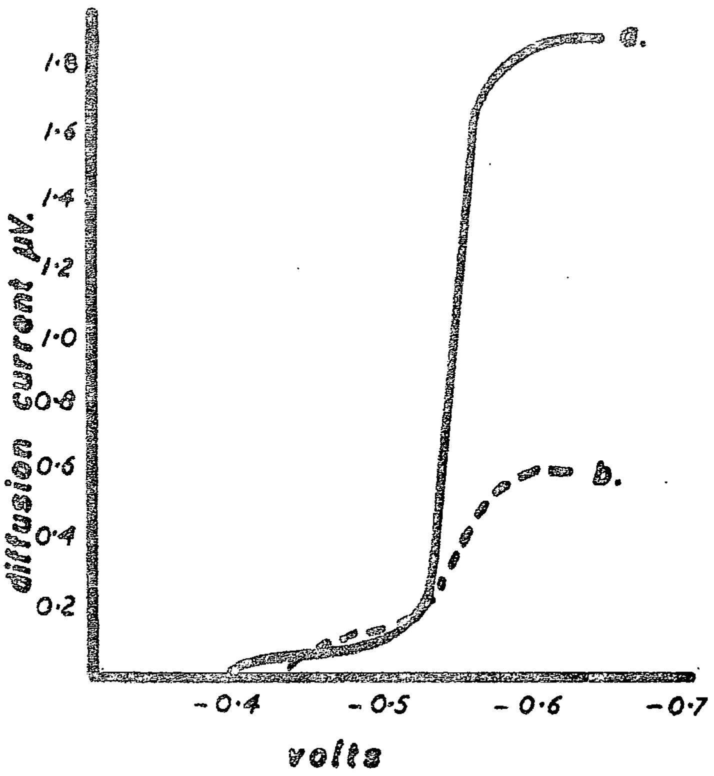


Fig.4 The reaction of disulphides+thiols with10^{-3}M MeHgI(a)before-(b)after reaction.

were -0.520 and -0.560 for the total disulphide + thiol group determination.

The diffusion current was determined as follows for both the Polarecord and Polarimeter:

Id = Sensitivity x (measured length of curve)
or
(direct reading value)

Identical values were obtained by means of the Polarecord and the Polarimeter. Since the Polarimeter ensures faster analysis it is recommended for routine analyses.

Methyl mercury iodide reacts as follows with the thiols in wool:

$$\mathrm{R{-}S^- + MeHgI \rightarrow MeHgSR + I^-}$$

In solution R-SS, apart from the abovementioned reaction with thiols, the following reaction with disulphides also takes place:

$$\mathrm{R{-}SS{-}R + MeHgI + SO_3{}^{=} \rightarrow R{-}SHgMe + RSSO_3{}^{-} + I^-}$$

The total disulphides + thiols is therefore determined with solution R-SS while only the thiols in the wool ~~is~~ are determined by means of solution R-SH.

The amount of disulphides is calculated as follows:

$$\mathrm{SS = R{-}SS \rightarrow R{-}SH}$$

The amount of MeHgI which reacted with thiols or thiols + disulphides is given by the following formula:

$$\frac{(\mathrm{Id(blank)}-\mathrm{Id(res)}) \times \text{volume of reagent} \times \text{concentration of reagent}}{\mathrm{Id\ (blank)}}$$

Where Id = diffusion current measured by means of the Polarecord or Polarimeter.

While MeHgI is a monofunctional reagent, this value thus gives the stoigiometric concentration of the different determined groups.

2.6 Statistical analyses

All data were transferred to punchcards and the computations done by electronic computer (I.B.M. 1130).

Correlation coefficients were calculated for all possible combinations and polynomial regressions of the first and second degree were done with spinning count and length as variables to the other production factors.

CHAPTER 3

EXPERIMENTAL RESULTS

3.1 General

The subjective evaluation of the various samples in respect of spinning count, length, yield, amount of scoured wool and quality is given in Appendix II.

Particulars of physical analyses on individual samples are given in Appendix III.

Chemical analyses are given in Appendix IV.

The frequency distribution of all measured traits, as well as estimated spinning count is given in Appendix V. It will be observed that spinning count in the ram sample group varies only between 54^s and 64^s while that for the ewes varies between 56^s and 80^s. The larger variation in the ewe samples may be the reason for the higher number of significant results obtained in the ewe sample group.

Crimp, fibre thickness and spinning count relationships of Duerden and A.S.T.M. are given in Appendix VI.

The analysis of variance for polynomial regressions of the first and second degree is given in Appendix VII.

Abbreviations and character numbers are given in Table 4.

TABLE 4:- Abbreviations and code numbers used for analysed characteristics.

CHARACTERISTIC	ABBREVIATION	NUMBER
Alkali solubility	Alk. sol.	1
Total disulphide bonds + thiol groups	Tot. SS+SH	2
Disulphides	SS	3
Thiol groups	SH	4
Spinning count (measured)	S.C. (M)	5
Quality	Qual.	6
Length (measured)	Length (M)	7
Length (estimated)	Length (E)	8
Spinning count (estimated)	S.C. (E)	9
Spinning count from crimps per inch	S.C. (c.p.i.)	10
Amount of scoured wool (estimated)	A.S.W. (E)	11
Amount of scoured wool (measured)	A.S.W. (M)	12
Yield (estimated)	Yield (E)	13
Yield (measured)	Yield (M)	14
Greasy fleece weight	G.F.W.	15
Measured	M	
Estimated	E	
Significant P <0.05	*	
Highly significant P < 0.01	**	
Non significant	N.S.	

3.2 Means and variances

Means, standard deviations and coefficients of variation for the different analysed characteristics are given in Table 5.

TABLE 5:— Mean values, standard deviation and coefficient of variation for all characteristics analysed. (Rams n = 42, Ewes n = 65)

CHARACTERISTIC	MEAN		STANDARD DEVIATION		COEFFICIENT OF VARIATION %	
	RAMS	EWES	RAMS	EWES	RAMS	EWES
1. Alk. sol. (%)	13.4502	13.6844	4.0616	2.8180	30.19	20.59
2. Tot. SS+SH (µM)	502.8809	505.7230	18.1621	19.6822	3.61	3.89
3. SS (µM)	480.7857	478.7384	18.0223	20.5177	3.74	4.29
4. SH (µM)	22.0952	26.9846	3.9743	7.2918	17.98	27.02
5. S.C. (M) (hanks)	57.8571	62.8615	2.0430	5.7442	3.53	9.14
6. Qual. (score/10)	5.0952	5.4923	2.1505	2.1368	42.20	38.91
7. Length (M) (inches)	4.3142	4.0461	0.4956	0.4531	11.49	11.20
8. Length (E) (inches)	3.4523	3.4215	0.4734	0.4738	13.11	13.84
9. S.C. (E) (hanks)	57.5714	61.4770	1.0511	4.8380	1.82	7.87
10. S.C. (c.p.i.) (hanks) ..	58.7142	60.8923	2.2007	3.9843	3.75	6.54
11. A.S.W. (E) (~~pd~~ lb)	13.3237	9.5538	3.4296	2.5706	25.74	26.91
12. A.S.W. (M) (~~pd~~ lb)........	13.5737	9.2984	3.4270	2.7915	25.25	30.02
13. Yield (E) (%)	52.5714	60.6769	4.4946	3.7918	8.55	6.25
14. Yield (M) (%)	53.6737	58.4983	4.8089	4.9785	8.96	8.51
15. G.F.W. (~~pd~~ lb)	25.4452	15.7630	6.5100	4.4192	25.58	28.04

The largest coefficient of variation occurs within quality values (rams 42.2 percent, ewes 38.91 percent) while practically no variation was found for the determinations of disulphides + thiols (rams 3.61 percent; ewes 3.89 percent).

Variation in the ewe sample group is generally higher than the variation of the ram sample group.

3.3 Phenotypic correlation coefficients

Phenotypic correlation coefficients for all possible combinations are given in Tables 6 (rams) and 7 (ewes).

From the above-mentioned tables it is evident that the ewe sample group gives considerably more significant values than the ram sample group with the highest and most frequent correlations obtained between either spinning count, amount of scoured wool and greasy fleece weight with the other characteristics.

3.4 Coefficients for accuracy of estimation

Correlation coefficients for accuracy of estimation are given in Table 8. The r^2-values are also given to ensure more accurate conclusions. Percentage accuracy, which can be described as the percentage of the measured values, taken into consideration for estimation of the estimated values, are given.

TABLE 6:— Correlation coefficients between all estimated, measured and chemical analysed properties: (Rams, 42 pairs).

		2	3	4	5	6	7	8
Alk. sol.	1	-0.2988	-0.2729	-0.1279	0.1187	0.1509	-0.0996	-0.3330*
Tot. SS+SH	2		0.9759**	0.1444	0.0718	-0.1714	-0.0225	0.1864
SS	3			-0.0749	0.0296	-0.1391	-0.0430	0.1318
SH	4				0.1939	-0.1523	0.0921	0.2540
S.C.(M)	5					0.1252	0.1128	-0.0201
Qual.	6						0.1474	0.1114
Length (M)	7							0.5987**
Length (E)	8							
S.C. (E)	9							
S.C.(c.p.i.)	10							
A.S.W. (E)	11							
A.S.W. (M)	12							
Yield (E)	13							
Yield (M)	14							
G.F.W.	15							

$P < 0.05$ $r = 0.3044^{*}$ $P < 0.01$ $r = 0.3932^{**}$

TABLE 6 Continued.

		9	10	11	12	13	14	15
Alk. sol.	1	-0.1391	-0.0328	-0.1436	-0.0784	-0.3347^{*}	-0.0515	-0.0480
Tot. SS+SH	2	0.1608	0.1315	0.1810	0.0685	0.1493	-0.1681	0.1435
SS	3	0.1532	0.1564	0.1867	0.1007	0.0671	-0.1780	0.1767
SH	4	0.0401	-0.1083	-0.0193	-0.1436	0.3778^{*}	0.0390	0.1456
S.C. (M)	5	0.5083^{**}	0.5006^{**}	-0.5592^{**}	-0.5343^{**}	0.1897	0.1733	-0.6196^{**}
Qual.	6	0.1082	-0.0662	-0.1226	-0.0406	-0.1874	0.0625	-0.0590
Length (M)	7	-0.1532	-0.2689	0.2851	0.3326^{*}	0.0696	0.1568	0.2857
Length (E)	8	-0.0463	-0.1679	0.3101^{*}	0.3054^{*}	0.3975^{**}	0.3066^{*}	0.2002
S.C. (E)	9		0.6969^{**}	-0.2538	-0.4124^{**}	0.4775^{**}	0.0423	-0.4173^{**}
S.C.(c.p.i.)	10			-0.5018^{**}	-0.5795^{**}	0.1648	-0.0336	-0.5555^{**}
A.S.W. (E)	11				0.9094^{**}	0.1513	-0.1767	0.9434^{**}
A.S.W. (M)	12					-0.0667	0.0826	0.9303^{**}
Yield (E)	13						0.3360^{*}	-0.1757
Yield (M)	14							-0.2797
G.F.W.	15							

$P < 0.05 \quad r = 0.3044^{*}$ $\qquad$ $P < 0.01 \quad r = 0.3932^{**}$

TABLE 7 :– Correlation coefficients between all estimated, measured and chemical analysed properties: (Ewes, 65 pairs).

		2	3	4	5	6	7	8
Alk. sol.	1	-0.3735^{**}	-0.3529^{**}	-0.0149	0.0661	0.1557	0.0298	-0.0836
Tot. SS+SH	2		0.9350^{**}	0.0682	0.1970	-0.0074	-0.2355	-0.0767
SS	3			-0.2899^{*}	0.2814^{*}	0.1116	-0.2526^{*}	-0.0509
SH	4				-0.2600^{*}	-0.3344^{**}	0.0749	-0.0637
S.C.(M)	5					0.1049	-0.4381^{**}	-0.3591^{**}
Qual.	6						-0.0835	0.0998
Length (M)	7							0.5882^{**}
Length (E)	8							
S.C. (E)	9							
S.C.(c.p.i.)	10							
A.S.W. (E)	11							
A.S.W. (M)	12							
Yield (E)	13							
Yield (M)	14							
G.F.W.	15							

$P < 0.05$ $r = 0.2500^{*}$ $P < 0.01$ $r = 0.3250^{**}$

TABLE 7 Continued.

		9	10	11	12	13	14	15
Alk. sol.	1	0.0332	0.0393	-0.2203	-0.1574	0.1308	0.2510*	-0.2574*
Tot. SS+SH	2	0.2242	0.1920	-0.1117	-0.1629	-0.0389	-0.3290**	-0.0611
SS	3	0.3379**	0.3121*	-0.1992	-0.2524*	-0.0211	-0.3567**	-0.1571
SH	4	-0.3456**	-0.3598**	0.2588*	0.2704*	-0.0453	0.1156	0.2770*
S.C.(M)	5	0.7765**	0.7468**	-0.7011**	-0.6666**	0.3530**	-0.1088	-0.7240**
Qual.	6	0.1069	0.0540	0.1071	0.1321	0.0989	0.2130	0.0721
Length (M)	7	-0.5318**	-0.4506**	0.4335**	0.4221**	-0.0730	0.1717	0.3863**
Length (E)	8	-0.3133*	-0.3125*	0.3898**	0.3729**	0.1171	0.2648*	0.3156*
S.C. (E)	9		0.8674**	-0.6788**	-0.6957**	0.3636**	-0.2382	-0.7071**
S.C.(c.p.i.)	10			-0.7006**	-0.7187**	0.3564**	-0.2620*	-0.7207**
A.S.W. (E)	11				0.9664**	-0.1788	0.2525*	0.9575**
A.S.W. (M)	12					0.2375	0.4055**	0.9377**
Yield (E)	13						0.4127**	-0.4218**
Yield (M)	14							0.1046
G.F.W.	15							

$P < 0.05$ $r = 0.2500^{*}$ $P < 0.01$ $r = 0.3250^{**}$

TABLE 8:- Correlation coefficients, r^2 values and percentage accuracy of estimation.

CHARACTERS	Correlation coefficient	r^2	% accuracy
RAMS:			
S.C. (M , E) (5,9).....	0.5083^{**}	0.2580	26
S.C. (M , c.p.i.) (5,10)	0.5006^{**}	0.2506	25
S.C. (c.p.i. , E) (9,10)	0.6969^{**}	0.4857	49
Length (M , E) (7,8)....	0.5987^{**}	0.3584	36
Yield (M , E) (13,14)...	0.3360^{*}	0.1129	11
A.S.W. (M , E) (11,12)..	0.9094^{**}	0.8270	83
EWES:			
S.C. (M , E) (5,9).....	0.7756^{**}	0.6016	60
S.C. (M , c.p.i.) (5,10)	0.7468^{**}	0.5607	56
S.C. (c.p.i. , E) (9,10)	0.8674^{**}	0.7524	75
Length (M , E) (7,8) ...	0.5882^{**}	0.3460	35
Yield (M , E) (13,14) ..	0.4127^{**}	0.1703	17
A.S.W. (M , E) (11,12) .	0.9664^{**}	0.9339	93

Table 8 shows that the accuracy of estimation is relatively low for the majority of characteristics while that for the amount of scoured wool is fairly high (rams 83 percent; ewes 93 percent), the reason being that both the estimated and measured values are derived from the greasy fleece weights; the one via estimated yield to the amount of scoured wool and the other via measured yield to the measured amount of scoured wool. Accuracy of estimating yield is very low (rams 11 percent; ewes 17 percent).

3.5 F-values

Tables 9 (rams) and 10 (ewes) give a summary of the F-values obtained from the analyses of variance for the polynomial regressions. The (a) F-value is for the analyses of variance for the first degree polynomial while the second (b) F-value is the value for the second degree polynomial. The third (c) F-value indicates whether the second degree curve fits better than that of the first degree.

From Tables 9 and 10 it is evident that the regressions of most of the other characteristics on measured spinning count give a significant F-value in the ram sample group while in the ewe sample group the regression of other wool properties on both spinning count and length measured give significant F-values.

In the ram sample group the second degree curve was superior to the first degree curve (F=8.03665**), Only with regard to the regression of quality on spinning count, while in the ewe sample group the second degree curve fits better than the first in the regression of greasy fleece weight on length.

3.6 a- and b-values for the polynomial regression

A summary of a- and b-values for the polynomial regression is given in Tables 11 (rams) and 12 (ewes)

TABLE 9:- F-values for first and second degree polynomial regression of some wool properties on spinning count and length: Rams.

CHARACTERISTICS x , y	F-value (a) F-value (c) F-value (b)	CHARACTERISTICS x , y	F-value (a) F-value (c) F-value (b)
5 , 6	0.63798 8.03665 ** 4.39342 *	5 , 14	1.23968 0.76348 0.99791
5 , 7	0.51609 0.13184 0.25827	5 , 15	24.93590 ** 0.01168 12.16673 **
5 , 12	20.74261 ** 0.04218 10.14405 **	7 , 15	3.55683 0.74166 2.13775

F-value (a) = value for 1st degree polynomial.

F-value (b) = value for 2nd degree polynomial.

F-value (c) = value to test whether 2nd degree is superior to 1st degree.

	$P < 0.05$	$P < 0.01$
1st degree polynomial	F = 4.08	F = 7.31
2nd degree polynomial	F = 3.25	F = 5.21
test between 1st and 2nd	F = 4.10	F = 7.35

TABLE 10:- F-values for first and second degree polynomial regression of some wool properties on spinning count and length: Ewes.

CHARACTERISTICS		F-value (a) F-value (c) F-value (b)	CHARACTERISTICS		F-value (a) F-value (c) F-value (b)
x ,	y		x ,	y	
5 ,	6	0.70134 3.81130 2.27197	5 ,	14	0.75606 0.23578 0.49134
5 ,	7	14.96486** 1.10811 8.04932**	5 ,	15	69.42243** 3.82079 38.17578**
5 ,	12	50.38204** 3.72822 28,14603**	7 ,	15	11.05638** 7.43223** 9.80873**

F-value (a) = value for 1st. degree polynomial.
F-value (b) = value for 2nd. degree polynomial.
F-value (c) = value to test whether 2nd. degree is superior to 1st. degree.

	$P < 0.05$	$P < 0.01$
1st. degree polynomial	F = 3.99	F = 7.04
2nd. degree polynomial	F = 3.15	F = 4.98
test between 1st. and 2nd	F = 4.00	F = 7.08

TABLE 11:— Summary of a- and b-values for significant polynomial regression analyses: Rams.

CHARACTERISTICS y , x	a.	b_1.	b_2.
6 , 5	-462.62225	15.75645	-0.13244
12 , 5	70.28633 116.19863	-0.98021 -2.53925	0.01321
15 , 5	139.68649 94.65696	-1.97454 -0.44529	-0.01296

First degree polynomial regression equation: $y = a + bx$

Second degree polynomial regression equation:

$$y = a+b_1x + b_2 x^2$$

TABLE 12:— Summary of a-and b-values for significant polynomial regression analyses: Ewes.

CHARACTERISTICS y , x	a.	b_1.	b_2.
7 , 5	6.21871 0.78937	-0.03456 0.12845	-0.00120
12 , 5	29.66277 79.51507	-0.32395 -1.82081	0.01110
15 , 5	50.77947 124.66621	0.55704 -2.77555	0.01645
15 , 7	-85.38110	46.99264	-5.36970

First degree polynomial regression equation: $y = a+ bx$

Second degree polynomial regression equation:

$$y = a+ b_1x + b_2 x^2$$

From Tables 11 and 12 the following significant regression equationscan be deduced:-

3.6.1 Rams

3.6.1.1 Quality = y on spinning count (M) = x

(6 on 5)

$$y = -462.62225 + 15.75645\,x - 0.13244\,x^2$$

3.6.1.2 Amount of scoured wool (M) = y on spinning count (M) = x

(12 on 5)

$$y = 70.28633 - 0.98021x$$

or

$$y = 116.19863 - 2.53925x + 0.01321\,x^2$$

3.6.1.3 Greasy fleece weight = y on spinning count (M) = x

(15 on 5)

$$y = 139.68649 - 1.97454x$$

or

$$y = 94.65696 - 0.44529x - 0.01296\,x^2$$

3.6.2 Ewes

Length (M) = y on spinning count (M) = x

(7 on 5)

$$y = 6.21871 - 0.03456x$$

or

$$y = 0.789_{3}7 + 0.12845x - 0.00120\,x^2$$

3.6.3 Amount of scoured wool (M) = y on spinning count (M) = y

(12 on 5)

$$y = 29.66277 - 0.32395x$$

or

$$y = 79.51507 - 1.82081x + 0.01110\,x^2$$

3.6.4 Greasy fleece weight = y on Spinning count (M) = x

(15 on 5)

$y = 50.77947 - 0.55704x$

or

$y = 124.66621 - 2.77555x + 0.01645\ x^2$

3.6.5 Greasy fleece weight = y on length (M) = x

(15 on 7)

$y = -85.38110 + 46.99264x - 5.36970\ x^2$

CHAPTER 4

DISCUSSION OF RESULTS

4.1 The accuracy of subjective evaluation of certain wool characteristics

Evaluation of certain specific characteristics of the animal is the basis of selection. It is, therefore, clear that an accurate evaluation of economically important characteristics is important in breeding practices.

Laboratory methods of evaluating characteristics are often too tedious, and in practice eye appraisal is used in the majority of cases. The breeder estimates the breeding value of an animal from appearance. The rejection of this method as non-scientific would not solve any problem. However, it can be endeavoured to determine the accuracy of this subjective evaluation of characteristics and to recommend modifications of the methods in use today. Development of more scientific methods of evaluation of characteristics which are of economic importance, is needed.

Riches & Turner (1955) found the efficiency of selection by visual appraisal to be only approximately 30% at any stage in increasing total wool production when compared with selection on wool weight at the same age. It will be shown that similar results were obtained by other workers. It is, however, unrealistic to give too much attention to accuracy of estimation of the characteristics of minor importance. If only the accuracy of appraisal of characteristics of major importance can be increased, considerable progress in breeding may be ensured. According to Engela et al. loc. cit., who made an analysis of the British Woolbuyers Table used as a basis for the purchasing of wool during the Second World War, the following characteristics are of major importance:

Amount of scoured wool	60 percent
Staple length	20 percent
Spinning count	10 percent
Other properties (quality, soundness, etc.)	10 percent

Young & Dunlop (1955, quoted by Lockart 1958) have shown that, apart from yield of clean wool, crimps per inch is the most important fleece property due to its influence on the price of Merino wool. The accurate evaluation of amount of wool, spinning count and length must therefore be emphasised to increase the effectiveness of selection.

4.1.1 Amount of scoured wool.

As was previously mentioned the amount of scoured wool appears to be the most important characteristic influencing the total income of a wool-grower. In this study the greasy fleece weight was not estimated and both the estimated and measured amount of scoured wool was calculated from the greasy fleece weight obtained at the exhibiting hall.

Correlations found in this study between partly estimated and measured amount of scoured wool, were $r_{11,12} = 0.9094$ ** for rams and $r_{11,12} = 0.9664$** for ewes, with r^2 -values of 0.8270 and 0.9339 respectively. The correlations between estimated and measured values of yield is very low: $r_{13,14} = 0.3360^*$ for rams and $r_{13,14} = 0.4127^{**}$ for ewes with r^2 values of 0.1129 and 0.1703 respectively.

It seems that, while accuracy of estimating yield is as low as 11 percent in the ram- and 17 percent in the ewe sample group, the influence on amount of scoured wool is not of any importance (accuracy of estimation for amount of scoured wool is 82 percent in the ram- and 93 percent in the ewe sample group), and that selection on greasy fleece weight will increase clean wool production.

The low values for accuracy of estimating yield can be misleading, considering the fact that in the ram sample group the error was 0 to 2 percent for 33.3 percent of the samples and more than 5 percent for 26.8 percent of the samples. In the ewe sample group 44.6 percent had an error of 0 to 2 percent and only 27.7 percent differed from the actual value by more than five percent. In view of the above-mentioned values it is evident that while the accuracy of estimating may be low, an error of 2.5 percent made in estimating yield results in a quarter of a pound error on a greasy fleece weight of ten pounds. About 50 percent of the fleeces showed an error of only 0-3 percent. It is thus evident that the low accuracy of estimating yield does not have a pronounced effect on the amount of scoured wool and it therefore seems ad~~a~~equate for buying and classing purposes.

However, it must be emphasised that the accuracy of judging wool production is very low and that at least greasy fleece weight must be used in the selection of sheep.

A point of interest in estimating yield was the fact that the judges tended to underestimate the yield of strong wool, while they overestimated that of fine wool. No possible reason for this could be found in the literature and no definite conclusion on this point can be made.

4.1.2 Length.

While length is of economic importance it is also the basis for classing wool into different classes. (Regulations 1965). A sound estimate of length is of importance to the wool-grower and promotes confidence in the buyer.

Correlations between estimated and measured values for length were $r_{7,8} = 0.5987^{**}$ for rams and $r_{7,8} = 0.5882^{**}$ for ewes with r^2 values of 0.3584 and 0.3460 respectively. These values give an average accuracy of 35.5 percent for the estimation of staple length. Venter (1964) found a positive correlation between the score for length and evenness of length, and length measured. This value is somewhat lower than the values obtained in this study but considering the fact that evenness of length can considerably affect the score for estimated length, it seems that the above-mentioned values may be nearer to values found in this study if length only had been taken into account. The above-mentioned values found in this study seem very low but when the final effect of the inaccuracy is analysed only 4.8 percent of the ram fleeces and 1.5 percent of the ewe fleeces would be classed within two grades of the grade determined by actual measurement, while 23.8 percent of the ram and 24.6 percent of the ewe fleeces would differ one grade and 71.4 percent of the ram and 73.9 percent of the ewe fleeces would not be classed in any other grade according to measured length.

Thus, although the accuracy of estimation is very low, the final effect of the error is of little practical importance and considering the extra time needed to measure the length, it seems that the visual estimation of length is still the only practical method of classing wool into the different length classes.

A point of interest in the estimating of length is that in all cases except two, the estimated length was either shorter or the same as the measured length. It thus seems that judges tend to underestimate the length of wool. From a production point of view this is useful, because too many classers tend to push length in classing, which is responsible for loss of confidence in buyers. It must be emphasised that a classer should not use the minimum length of the class as a criterion in classing the wool but rather the average of the class. For example - only wool longer that three inches should be classed into the A-length group. This will minimize the inclusion of short wool in various length classes.

4.1.3 Spinning count or fibre thickness.

While spinning count evaluation is used in nearly all classing and judging of wool, the accuracy of estimating spinning count is therefore of major importance. In the trade spinning count is also a basic factor in quality evaluation.

Roberts (1961) has shown that the average fibre diameter has a far more important effect on the softness of handling than any other fibre characteristic, while O'Connell & Lundgren (1954) and O'Connell & Yeiser (1954) showed that fibre crimp influences the mechanical properties of wool.

Dunlop & Young (1960) found in price studies that apart from the effect of length and colour which was minimal, the count (commercial count or quality number, spinning count) alone was responsible for nearly 80 percent in the variation of the price. In the absence of count they found that either crimp or diameter assumed major importance though both were less effective than count. Crimp alone was responsible for 70 percent and diameter alone for 63 percent of the variation in price.

A large proportion of stud wool in South Africa has a spinning count of 60^s and lower. According to the Woolclassing Regulations <u>loc. cit.</u> wool with a spinning count of 58^s is classed as overstrong Merino wool while wool of a spinning count of 56^s is considered as cross-bred wool.

The rules for this specific competition laid down minimum spinning counts of 58^s - 56^s for rams and 60^s - 58^s for ewes. All fleeces having spinning counts below this, were disqualified.

According to the above-mentioned rules 45 percent of the ram- and 32 percent of the ewe fleeces were disqualified by the judges, while 36 percent of the ram and 29 percent of the ewe fleeces were disqualified when the actual fibre thickness was measured.

The question now arises whether the estimation of spinning count is sufficiently accurate and to what extent the basis laid down by Duerden in 1929 is still applicable in the estimation of spinning count in the South African wool clip and whether the percentage overstrong wool produced by stud sheep is as high as indicated above.

4.1.3.1 Accuracy of estimating spinning count.

The correlations between estimated and measured spinning counts found in this study are $r_{5,9} = 0{\cdot}5083^{**}$ for ram- and $r_{5,9} = 0.7756^{**}$ for the ewe sample group, with r^2-values of 0.2580 and 0.6016 respectively. From the r^2-values it is evident that the accuracy of estimated spinning count values is 25 percent for rams and 60 percent for ewes.

The reason for the higher accuracy in the ewe sample group is not apparent but even the maximum of 60 percent accuracy is insufficient for spinning count evaluation.

Correlation coefficients between estimated spinning count and spinning count determined from crimps per inch were much higher ($r_{9,10} = 0{,}6969^{**}$ for rams and $r_{9,10} = 0.8674^{**}$ for ewes) with resulting r^2-values of 0.4857 and 0.7524 respectively.

From these values it is evident that the accuracy of estimation is very low when compared with actual measured spinning count values and it appears that the estimated value is much more dependant on crimps per inch than on actual fibre thickness.

This is in accordance with the results obtained by Venter <u>loc.cit</u>. Roberts (1957) also mentioned that quality numbers (spinning counts) assigned by wool buyers are largely based on crimp.

The smallest correlation between different methods of spinning count evaluation was found between spinning count derived from crimps per inch and the measured spinning count. The values were $r_{5,10} = 0.5006^{**}$ for rams and $r_{5,10} = 0.7468^{**}$ for ewes. The r^2-values were 0.2506 and 0.5607 respectively which are relatively low compared to the r^2-values between estimated spinning count and spinning count from crimps per inch. Values for r^2 found by Venter loc.cit. between actual fibre thickness and spinning count derived from crimps per inch were as low as 0.09.

When measured spinning count was compared with spinning count determined from crimps per inch it was found in this study that 64 percent of the ram samples corresponded, ten percent were finer and 26 percent coarser than indicated by crimp. It seems therefore that the Duerden standard may be used for ~~estimating~~ judging the ram samples although the samples tend to be slightly overcrimped. The fact that the ram wool was overcrimped may possibly be explained by the fact that these rams were kept on a very high plane of nutrition.

Maré & Bosman (1934) found a definite decrease in fibre thickness with a low plane of nutrition. They found that a high plane of nutrition results in thicker fibres. Henderson (1953), Lockart loc.cit., Short, Fraser & Carter (1958), and Coetzee (1965) found the same decrease in fibre thickness with a low plane of nutrition. Kruger & de Wet (1965 a) concluded that a high plane of nutrition keeps thickness constant while a low plane results in a decrease in fibre thickness. The effect of a high plane of nutrition on the crimp - fibre thickness relationship is, however, still unknown.

The position was different, however, in the ewe sample group where 61 percent of the samples corresponded, 34 percent were finer than indicated by the crimp and five percent were coarser. The results of Venter loc. cit. showed the same tendency viz. 38.8 percent corresponding, 37.8 percent finer and 23.4 percent coarser than indicated by the crimp.

Work by Kruger & de Wet (1966) showed that 27 percent corresponded, 58 percent were finer and 15 percent coarser than the crimp indicated.

These values seem to indicate that in general South African wool tends to be undercrimped and that the woolman who estimates spinning count on number of crimps per inch alone will underestimate the spinning count in the majority of cases.

The whole problem of spinning count estimation was summarized by Lang (1947) as follows: "It is emphasised that while Duerden's scale values for crimp-quality numbers and fineness quality relationship are an important quide to the scientific worker, it is an error to consider that the values for the various quality numbers are discrete." His work also underlined the fact that woolclassers' assessments must not be taken as completely authoritative and final as has been done in many studies, without due attention being paid to their sensory character and to the limitations of such empirical estimations.

This relationship between staple crimp and fibre thickness was investigated by many workers (Reimers & Swart, 1929; Bosman, 1937; Lang 1947, 1961; Roberts & Dunlop,1957) and they all agreed that while the Duerden standards can be used for estimation of spinning count, the crimps - fibre thickness relationship may vary from strain to strain as well as from one area to another. Paynter (1967) found that the efficiency of wool classing by spinning count, as a means of separating fleeces of different fibre diameter, varies from flock to flock and may be influenced by such factors as the strain, the nutritional level, the environment and the age of the sheep.

It thus seems quite possible that the wool of the South African Merino may be classed as undercrimped resulting in a wool clip which seems stronger than it actually is.

In the estimation of the ram samples according to crimps per inch, 52 percent corresponded, seven percent were finer and 41 percent stronger than the crimp indicated while in the ewe sample group 80 percent corresponded, 11 percent were estimated finer and nine percent coarser than indicated by the crimp.

Venter loc. cit. found 44.9 percent correspondence, 53.1 percent finer and two percent stronger than indicated by crimp.

The reason for the difference between the ram and ewe samples is not at all clear but it seems that in this study the judges considered only crimps per inch in the estimation of spinning count while in the case of Venter op. cit. they took factors like quality and handle, which can compensate for the error made as a result of undercrimping, into consideration. This is indicated by the fact that the r^2 -values obtained in this study were 0.4357 for rams and 0.7524 for ewes while Venter op. cit. obtained a value of 0.36.

Venter op. cit. explained his results on the basis of the work of van Wyk (1946) and van Wyk & Venter (1954) who showed that undercrimping resulted in a lower resistance to deformation and thus softer handling which caused overestimation of spinning count.

Kruger & de Wet (1965 a) also stated that undercrimping results in a low resistance to compressibility and found a significant positive correlation between crimps per inch and compressibility.

The reason, however, for the high percentage underestimation (41 percent) in the ram sample group is not clear while the ram wool tends to be slightly overcrimped, the judges correctly underestimated the spinning count. This can possibly also be explained by the results of van Wyk op. cit., van Wyk & Venter op. cit. and Kruger & de Wet op. cit. in that overcrimping can result in poor handling qualities and consequently the wool is estimated stronger than the crimp indicates.

The question now arises why the judges apparently considered only crimps per inch in the estimation of the ewe sample group while they also took quality into consideration when estimating the ram samples.

This may possibly be explained by the fact that the quality of the ewe wool was on the average better than that of the ram wool. Furthermore it is a well known fact that in practice judges tend to put more emphasis on quality when estimating the spinning count of strong and overstrong wool.

This study indicates that the Duerden standard laid down in 1929 is still used in South Africa in the estimation of spinning count. It was found that spinning count estimation is based on crimps per inch rather than on actual fibre thickness.

As early as 1934, Bosman warned that the woolman who estimates fibre thickness on crimps per inch may err in 72 percent of his judgement by one, two or even three quality numbers. He found in 334 samples that 36 percent were coarser and 36 percent finer than the crimp indicated.

4.1.3.2 Overstrong wool.

It was previously mentioned that in this specific competition 45 percent of the ram- and 32 percent of the ewe fleeces were disqualified by the judges for being too strong and 36 percent of the ram- and 29 percent of the ewe fleeces were disqualified when measured fibre thickness was taken into account.

On the basis of measured fibre thickness more fleeces qualified for competition as a result of the tendency of the wool to be undercrimped.

This result clearly underlines the fact that while Duerden's standard is still used, it must be at least revised for South African conditions because, as was shown previously, the crimp fibre thickness relationship can vary from strain to strain as well as from one area to another.

From this study and work by Venter loc. cit. it is clear that the crimp fibre thickness relationship should be investigated with the purpose to get a more realistic scale for South African conditions. More research, however, is necessary for better standardisation.

If the internationally accepted A.S.T.M. standards for crimp - fibre thickness relationship were used only 21.4 percent of the ram- and 6.2 percent of the ewe samples would have been disqualified for being overstrong. The estimating of spinning count according to A.S.T.M. standards thus seems more accurate and realistic.

Uys (1964 b) came to the same conclusion when he analysed 6,000 samples collected at different ports. He found that 15.9 percent were below 60^s when spinning count was based on the Duerden standard while 10.8 percent were below 60^s when based on actual fibre thickness. He concluded that the Duerden standard for the relationship between crimps per inch and diameter was more applicable for

South African Merino wool. Furthermore, when A.S.T.M. standards for spinning count evaluation were used only 2.6 percent of his samples would be considered overstrong. He came to the conclusion that the Republic is still producing a fine wool clip.

These results are in accordance with the results obtained in this study and underline the fact that a re-evaluation of the basis for estimating spinning count is necessary for the benefit of the wool producer in South Africa. A more accurate basis of estimating spinning count must be developed. At present, however, the only practical method for determining the spinning count in a large flock of sheep is to base judgement on the number of crimps per inch.

4.2 The interrelationship between different wool characteristics.

4.2.1 Interrelationship between objectively determined physical properties.

Correlation studies between the physical properties of wool were carried out by several workers. (Duerden loc. cit; Duerden, Murray & Botha, 193~~4~~2; Bosman loc. cit; Bailey, 1940; Pohle & Keller, 1943; Terril, Pohle ~~&~~ Emik, + Hazel, 1945; Morley, 1955 a, 1955 b; Turner, 1958; Young & Chapman, 1958; Bosman, 1958; Beattie, 1961; Venter loc. cit. and Kruger & de Wet, 1966).

4.2.1.1 Woolproduction.

4.2.1.1.1 Greasy fleece weight.

The weight of wool is the largest single factor influencing the total income of the producers. The tendency, therefore, is to produce more wool and selection practices consist basically of the separation of the uneconomic from the economic producer. Up to a few years ago wool production was estimated subjectively for selection purposes. The farmer, however, realised that visual estimation of wool weight is inaccurate and though the number is small, some are today basing their selection on the actual weight of wool produced.

The most accurate method of selection would be on clean wool weight but as a result of the practical problems involved, greasy fleece weight is used.

In this study highly significant correlations between greasy fleece weight and clean fleece weight were obtained ($r_{12,15} = 0.9303^{**}$ rams; $r_{12,15} = 0.9377^{**}$ ewes). Similar results were found by Ali, Neale & McFadden (1953), Morley (1955 a), Sidwell, Jessup & McFadden (1956) and Venter loc.cit.

In greasy fleece wool, however, a large percentage of foreign matter, consisting of woolwax, suint, plant material and sand, is present. The percentage of the foreign matter varies from one area to another depending on climatic conditions, level of feeding and other factors.

In this study no significant correlations was found between greasy fleece weight and yield while Venter loc.cit. found a significant negative correlation. However, divergent results were obtained by different workers. Malan, van Wyk & Botha (1935); Bosman loc.cit. and Morley (1955 a) obtained negative correlations while Beattie *loc. cit.* obtained a positive correlation. No definite conclusions can therefore, be made but it seems that greasy fleece weight is negatively correlated with yield.

A highly significant negative correlation was found in this study between spinning count and greasy fleece weight ($r_{5,15}$ = 0.6196** rams; $r_{5,15}$ = -0.7240** ewes) which corresponds with the results obtained by Venter *loc. cit*.

A highly significant positive correlation was found between weight of greasy fleece wool and staple length in the ewe sample group ($r_{7,15}$ = 0.3863**) which corresponds with work done by Terril, Kyle & Hazel (1950), Ali *et al*. *loc. cit.*, Morley (1955 a), Sidwell *et al*. *loc. cit.* and Beattie *loc. cit*.

In the ram sample group, however, no significant correlation was found. This may possibly be explained by the fact that the ram wool contained relatively larger amounts of impurities. (yield: rams = 53.6 percent, ewes = 58.5 percent).

From the majority of data it is clear that there is a significant relationship between staple length and greasy fleece weight.

4.2.1.1.2 Clean fleece weight or amount of scoured wool.

The buyer is interested in the amount of clean wool. It must be possible for him to determine yield as accurately as possible and in general he is capable of estimating the yield to within one or two percent.

In the ewe sample group a significant pos~~s~~itive correlation between yield and amount of scoured wool ($r_{12,14} = 0.4055^{**}$) was found while in the ram sample group no significant correlation was obtained. Venter *loc. cit.* found a highly significant negative correlation of ($r = -0.398^{**}$). Therefore no definite conclusions can be drawn from these results.

In this study a highly significant negative correlation between the amount of scoured wool and spinning count was obtained ($r_{5,12} = -0.5343^{**}$ for rams and $r_{5,12} = -0.6666^{**}$ for ewes). This is in accordance with the results of Bosman (1958) and Venter *loc.cit*.

Morley (1955 a) found in genetic correlation studies that if selection is entirely for clean fleece weight, fineness will decrease. It is a fact that in practice strong woolled sheep produce more wool than fine woolled sheep.

In this study a highly significant positive correlation was found between staple length and amount of scoured wool in the ewe sample group ($r_{7,12} = 0.4221^{**}$) while in the ram sample group a significant positive correlation was found ($r_{7,12} = 0.3326^{*}$). While Venter *loc.cit.* did not find any significant correlation between amount of scoured wool and staple length, Terrill, *et al.* (1945), Ali *et al.* *loc.cit.*, Bosman (1958) and

Coetzee (1967) found positive correlations. Turner (1956) obtained similar results in genetic studies.

4.2.1.2 Spinning count.

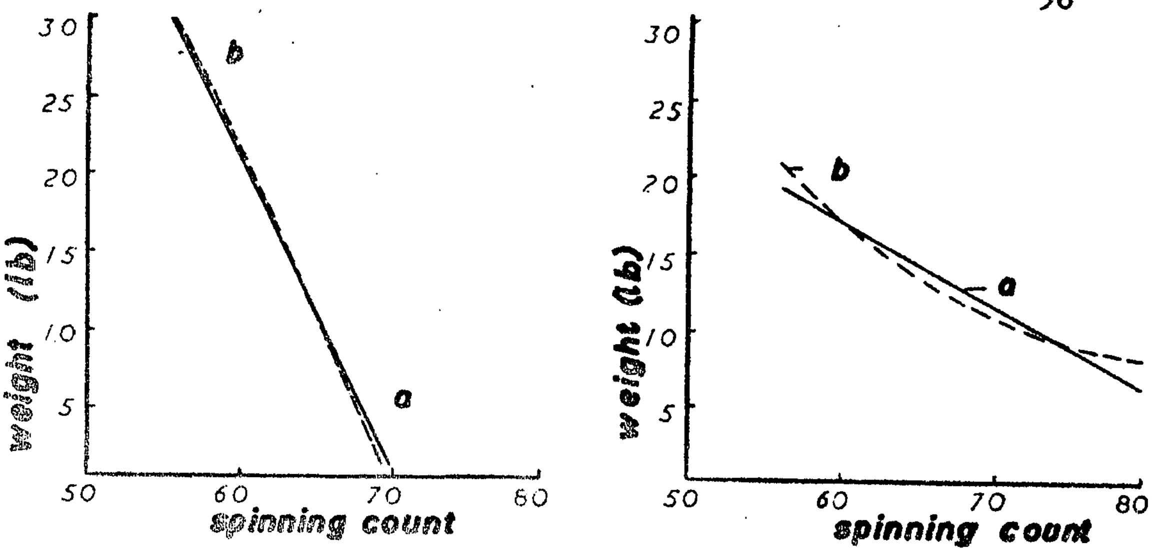
According to Engela *et al.* *loc. cit.* and Young & Dunlop *loc. cit.* spinning count is, apart from clean wool weight and length, the most important factor determining the price of wool. Together with length it is also the basis for classing wool.

Highly significant negative correlations between spinning count and greasy fleece weight were obtained. ($r_{5,15} = -0.6196$ **, rams; $r_{5,15} = -0.7240$** ewes) and with amount of scoured wool, ($r_{5,12} = -0.5343$ **, rams; and $r_{5,12} = -0.6666$ ** ewes). These results correspond with results obtained by Morley (1955 a), Bosman (1958) and Venter *loc. cit.*

Linear and curvilinear regressions of greasy fleece weight on spinning count are demonstrated graphically in Figure 5, while the regressions of amount of scoured wool on spinning count are demonstrated in Figure 6. Statistical analyses indicate that the curves fit the data and are highly significant ($P<0.01$) in all the cases demonstrated.

There seems to be a definite increase in greasy fleece weight and amount of scoured wool with a decrease in spinning count in both the ram- and ewe sample groups. Increase in greasy fleece weight and amount of scoured wool with a decrease in spinning count is much faster in the ram sample group.

No significant correlation was found between spinning count and yield.



(a) $y=139\cdot68649-1\cdot98021x$

(b) $y=94\cdot65696-0\cdot44529x+0\cdot01296x^2$

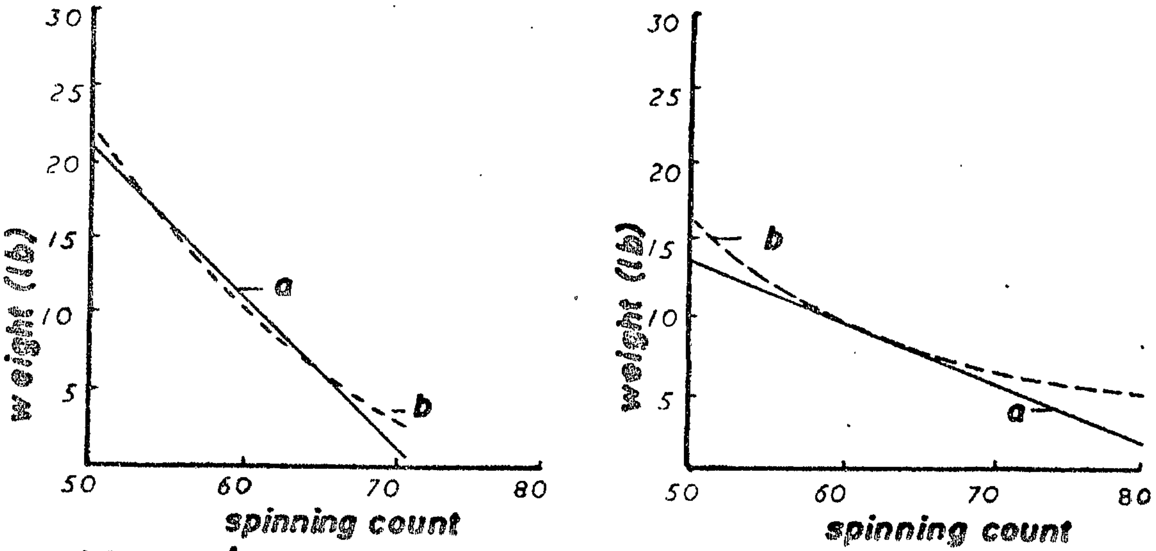
r a m s

(a) $y=50\cdot77947-0\cdot55704x$

(b) $y=124\cdot66621-2\cdot77555x+0\cdot01645x^2$

e w e s

Fig.5 Regression of greasy fleece weight on spinning count



(a) $y=70\cdot28633-0\cdot98021x$

(b) $y=116\cdot19863-2\cdot53925x+0\cdot01321x^2$

r a m s

(a) $y=29\cdot66277-0\cdot32395x$

(b) $y=79\cdot51507-1\cdot82081x+0\cdot01110x^2$

e w e s

Fig. 6 Regression of amount of scoured wool on spinning count

In the ewe sample group a highly significant, negative correlation was found between spinning count and length ($r_{5,7} = -0.4381^{**}$). This correlation corresponds with work of Duerden & Bosman (1931 a) ($r = 0.96^{**}$) and Demiruren & Burns (1955) ($r = 0.869611^{**}$) on the relationship between fibre thickness and length.

4.2.1.3 Length.

Apart from clean wool weight length is the most important factor determining the price of wool. In the trade it is also a very important factor in the processing of wool. Length is highly significantly, positively correlated with greasy fleece weight ($r_{7,15} = 0.3863^{**}$ for ewes). This compares well with results found by Morley (1955 a), Sidwell *et al*. *loc. cit.* and Beattie *loc. cit.*

Regression analyses in this study indicate a definite relation between length and greasy fleece weight in the ewe sample group. From the highly significant ($P < 0.01$) F-values, in Table 10, it is evident that the regression curves, of both the first and second order for the regression of greasy fleece weight on length fit the data. Further analysis, however, shows the curve of the second order to be superior to the curve of the first order. Only the regression equation $y = 85.38110 + 46.99264\ x - 5.36970\ x^2$ is demonstrated graphically in Figure 7. From Figure 7 it is evident that greasy fleece weight increases with an increase in length. The increase in weight, however, tends to decrease when the fibre gets too long. A possible reason for this can be the decrease in woolwax associated with long fibres resulting in

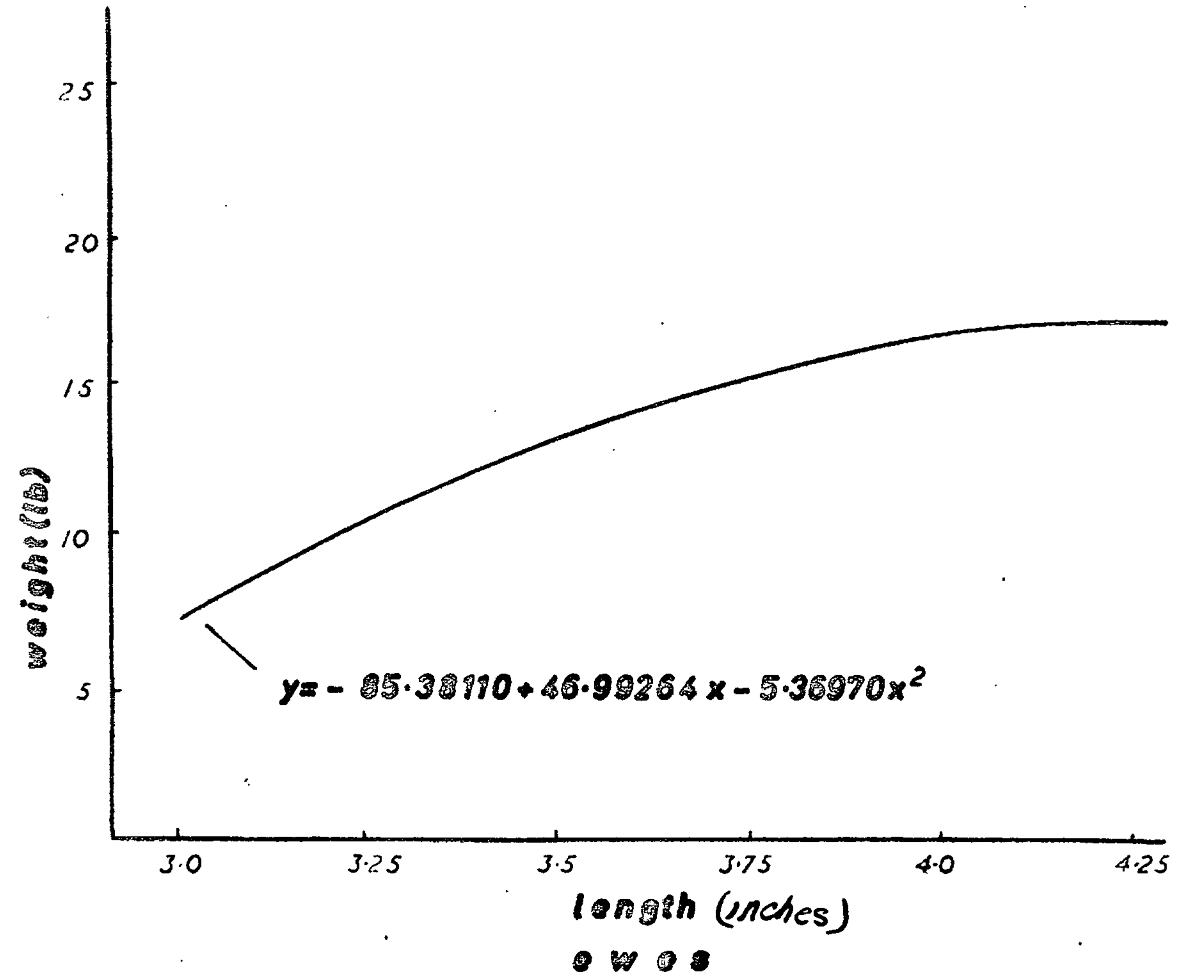


Fig.7 Regression of greasy fleece weight on length

a higher clean yield (Kruger & de Wet, 1966).

Significantly, positive correlations between length and amount of scoured wool were obtained in both the ram- and ewe sample groups. ($r_{7,12} = 0.3326^*$ for rams and $r_{7,12} = 0.4221^{**}$ for ewes) comparing favourably with the results of Bosman (1958). Turner (1956) mentioned that length and fibre thickness can be positively or negatively correlated and selection for long fine wool is possible. The negative correlation between length and spinning count was also highly significant, ($r_{5,7} = -0.4381^{**}$) This corresponds with work done by Duerden & Bosman loc.cit.et al.(1931 b) and Demiruren & Burns loc.cit. In the ram sample group no correlation was obtained. This may possibly be explained by the fact that a considerable number of ram fleeces were overstrong. It would seem that length tends to decrease when fibre thickness exceeds a certain limit. This statement is underlined by the highly significant ($P<0.01$) regression equation of the second order, for the regression of length on spinning count ($y = 0.78937 + 0.12845\,x - 0.00120\,x^2$) in the ewe sample group, demonstrated in Figure 8. While the curves of both the first and second order fit the data, the latter mentioned indicates a decrease in length when spinning count is lower than 58^s. A small, non significant, positive correlation between length and spinning count in the ram sample group was also obtained in this study. A definite, conclusion, however, cannot be made.

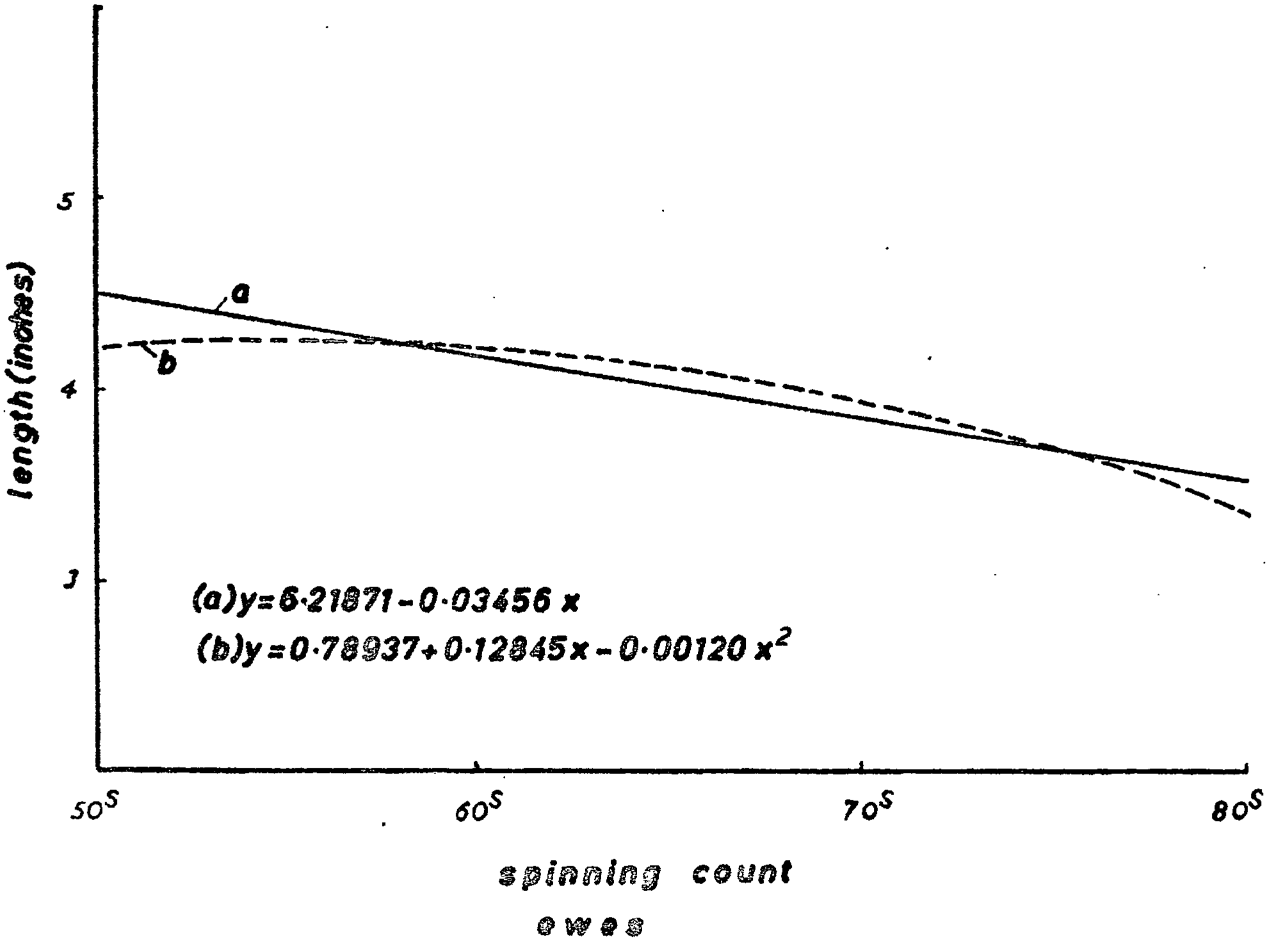


Fig.8 Regression of length on spinning count

4.2.1.4 Practical implications.

It seems that while the use of clean fleece weight is a necessity for the scientific worker, the use of greasy fleece weight as a basis for selection is accurate enough for the wool producer. Moule & Miller (1956) found that the use of fleece measurement as an aid in the selection of stud Merino sheep greatly increases selection differentials for the characters which influence the quality and quantity of wool produced by Merinos in Queensland.

According to Morley, Lockart & Davis (1955) the margin effect on greasy fleece weight comes from 11 months wool weight and this weight will be the most accurate weight to base selection on.

Riches & Turner *loc.cit.* increased wool production by selection on greasy fleece weight. Ford (1961) and Venter (1967) also recommended selection on greasy fleece weight, while Turner (1956) came to the conclusion that fleece weight should respond to selection. Nel (1964) found a repeatability of 0.580 for greasy fleece weight and mentioned the possibility of selecting Merino sheep on their first adult performance in terms of wool production.

Selection for length and lower spinning counts to increase amount of scoured wool holds promise within certain limits. Excessively long fibres are undesirable in Merino wool because it results in a higher degree of contamination and weathering due to the opening of the fleece and, furthermore, the trade is not prepared to pay more for wool exceeding 3½ inches in length (Bosman 1958).

According to Uys (1964 a) the selection for longer wool can be the cause for undercrimping in South African wool.

Kruger & de Wet (1966) found that the increase in yield which is obtained from longer staples is not worthwhile because it may result in an increase in staple tip length with a decrease in appearance.

It thus seems that selection for length to increase the amount of scoured wool is limited to a maximum length of $3\frac{1}{2}$ inches.

Selection for stronger wool to increase the amount of scoured wool is under no circumstances recommended. Excessive emphasis on strong wool in many cases results in poor quality which can decrease the price drastically. Fine wool, further, has an advantage over strong wool in fabrication and consequently it demands a higher price. Overstrong wool is less versatile and it has to compete with other coarser fibres. The drive for overstrong wool will have to be checked in order to preserve the demand for South African wool.

4.2.2 The relationship between quality and other wool properties.

Considerable confusion exists with regard to the term quality. According to the trade, quality is determined by spinning count while the producer regards it as evenness of crimp and softness of handling.

In this study quality is defined as follows: Softness (kindness) of handle and a well defined even crimp are characteristic of a true Merino wool and are indicative of uniformity of characteristics.

The evaluation of quality is done subjectively because no practical objective method is known. Le Roux (1960) described a method for determining quality by the reaction of wool with 0.1 N sodium hydroxide. However, this method has not found any practical application.

The judging of quality thus depends on the experience of the woolman to consider all the elements of quality and award a value accordingly.

As previously shown in this study, the accuracy of estimating is very low and the same could be expected in the case of quality.

4.2.2.1 The relationship between quality and objectively determined physical properties.

In this study no significant correlations between quality and the objectively determined physical properties like spinning count, length, amount of scoured wool, yield and greasy fleece weight were found.

While Venter (1964) found a positive correlation between quality and clean wool weight and quality and yield and a negative correlation between quality and compressibility, size of staple, percentage woolwax and fibres per square centimeter, no correlation was found between quality and length or spinning count. Bosman (1958) found quality positively correlated with yield and negatively correlated with fibre thickness. Morley (1955 b) found positive correlations between handle and yield, clean fleece weight and length and positive correlations between character and yield, clean fleece weight and length while Lockart (1958) found negative correlations between character and crimps per inch, fibre diameter and staple length. These results seem to indicate that quality is positively correlated with yield, clean fleece weight and spinning count.

Regression analyses in this study indicate a significant relationship between spinning count and quality. Figure 9 demonstrates the regression of quality on spinning count and statistical analyses indicate significance ($P<0.05$) for the second degree curve. From this curvilinear regression curve it is evident that in the ram sample group quality increases with an increase in spinning count to a maximum of ± 60^s, and then decreases. The reason for this decrease is not clear but it is evident that the lower spinning count samples tend to have the poorest quality.

Botha, Hugo & Havenga (1961) found in a study on quality that samples of good quality did not differ from samples of poor quality in respect of the distribution of crimp ratio which justifies their conclusion that other factors also influenced the grading of samples into quality grades.

Divergent results were obtained by different workers on the correlation between quality and length and a definite conclusion at this stage is impossible.

It thus seems that overstrong wool has poor quality and this corresponds with the definition

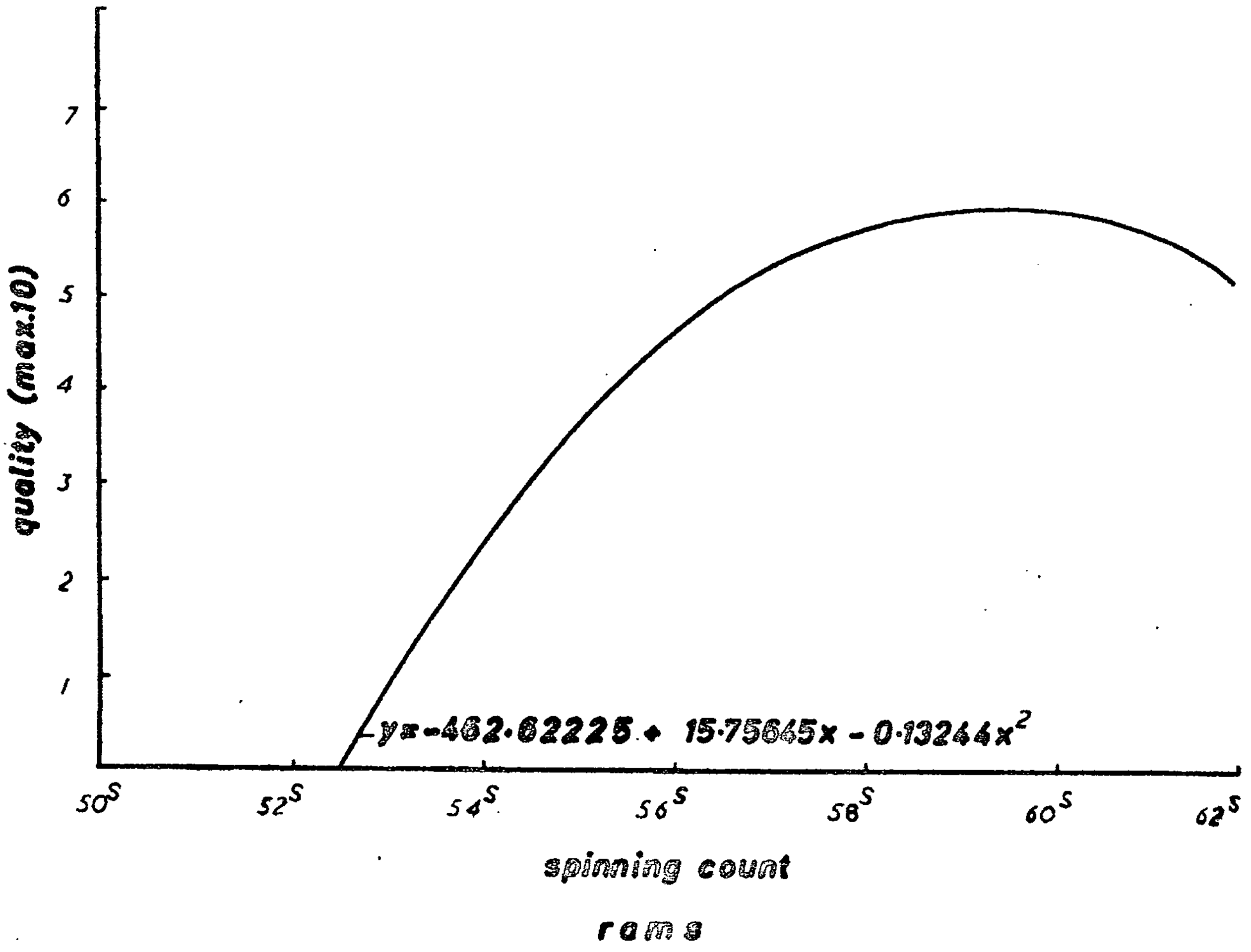


Fig.9 Regression of quality on spinning count

of quality in the trade. It is also evident that a high clean yield and a large amount of clean wool produced will result in a better quality. A possible reason may be that foreign matter in the wool results in mechanical damage of wool fibres which results in poor handling properties in the less dense fleeces.

4.2.2.2 The relationship between quality and some chemical properties.

The possibility that quality variation may be a result of differences in chemical composition was discussed by Le Roux loc. cit. and Speakman (1961). A method to determine quality was suggested by Le Roux & Speakman (1957). They contended that different degrees of wool quality, as estimated by practical woolmen, may be attributed to differences in plasticity which in turn result from differences in chemical composition and molecular structure. Differences in substance affect plasticity and measurement of plasticity may, therefore, be employed to evaluate quality. This method, however, would be too tedious for routine use.

Le Roux op. cit. found that the alkali solubility test, used in determining the dergree of weathering (I.W.T.O., loc. cit.) was a reliable method for routine determinations of quality.

In this study no significant correlation was found between alkali solubility and quality. This is contrary to the results obtained by Le Roux op. cit.

No correlations were found between quality and total disulphides + thiols, disulphide or thiols except in the case of the ewe sample group where a highly significant negative correlation was found between quality and thiol groups. ($r_{4,6}$ =-0·3344**).

Photochemical decomposition in wool takes place especially in the exposed tip section and a portion of the linked sulphur is coverted to hydrogen sulphide and results in the exposed section becoming brittle and weak with harsh handling properties (Le Roux, 1958).

From the negative correlation found between quality and thiol groups it seems that the effect of decomposition in wool influenced the evaluation of quality by the judges. However, as was shown by Louw (1960 b) in studies on steely wool, crimp is ill-defined as a result of incomplete keratinization resulting in a higher amount of residual SH in the wool.

Dusenbury (1963) stated that cystine feeding will result in a better quality in wool because cystine is an integral part of keratin.

Kruger & de Wet (1966) consider knowledge on the relationship between quality and chemical properties at present too limited to come to a definite conclusion. There seems, however, to be an interrelationship between quality and chemical properties. This statement cannot be proved before a reliable objective method for the determination of quality is developed.

4.2.3 The relationship between some chemical properties and objectively evaluated production factors.

Many workers regard the differences in physical properties to be the result of differences in the chemical composition of the keratin fibre. The relationship between chemical and physical properties were investigated by Spöttel (1933), Bonsma & Joubert (1934), Le Roux & Speakman loc. cit., Le Roux (1958, 1960), Louw (1960 a 1960 b), Speakman loc. cit. and Kruger & de Wet (1966). The majority of the workers mentioned investigated only the relationship between physical and chemical properties, however, and not the relationship between differences due to mutual interaction.

4.2.3.1 Wool production.

The amount of scoured wool was positively correlated with thiol group status in the ewe sample group ($r_{4,12} = 0.2704*$) and negatively correlated with disulphide bond status ($r_{3,12} = -0.2525*$). In the same group significant correlations were also found between greasy fleece weight and alkali solubility ($r_{1,15} = -0.2574*$) and greasy fleece weight and thiol groups ($r_{4,15} = 0.2770*$).

From these results it would seem that in wool from ewes the number of thiol groups increase with an increase in clean wool weight and that the disulphide bond status decreases, while an increase in greasy fleece weight also increases the amount of thiol groups.

The negative correlation between greasy fleece weight and alkali solubility is in direct contrast to the above-mentioned results. However, it would seem that the alkali solubility test can be regarded as a criterium of weathering only when staple tip sections are analysed (Le Roux 1967).

The amount of scoured wool and the greasy fleece weight are positively correlated with length and it would seem that the correlations found between chemical and physical properties in this study could be a result of differences in length, with the longer length on the higher producing animals.

Kruger & de Wet (1966) found that an increase in length results in a longer staple tip which is more weathered than the rest of the staple (r staple tip length, cystine =0.389*).

Apart from the longer tip section present in longer wool, a significant negative correlation was found between length and disulphide bond status ($r_{3,7}$ =-0.2526*) in this study which indicates a lower disulphide content in the longer fibres. This result supports the conclusions made above and it seems that longer fibres have a lower cystine content as well as a larger amount of thiols present as a result of the longer tip. Kruger & de Wet (1965 b) found a negative correlation between staple tip length and cystine content.

Louw (1960 a) found that weathering of normal wool on the sheep's back results in a decrease in the cystine content and an increase in cysteic acid and cysteine. While Louw, Swart & Mellet (1963) found in artificial weathering studies that weathering attacks cystine and probably forms sulphur containing compounds which are not amino acids. Hearle & Peters (1963) found a higher cystine content in the root than in the tip sections of wool and Maclaren (1963) found a decrease in cystine content of wool fibres under radiation, while Robbins (1967) reported degradation of dibasic amino acids in the tip sections of human hair as a result of weathering. Bonsma & Joubert <u>loc. cit.</u> found a decrease in the sulphur content with an increase in length. This supports the above-mentioned statements.

The highly significant positive correlation found between alkali solubility and yield ($r_{1,14} = 0.2510^{**}$) and highly significant negative correlations between total disulphides + thiols and yield ($r_{2,14} = -0.3290^{**}$) and disulphides and yield ($r_{3,14} = -0.3567^{**}$) in the ewe sample group could also possibly be a result of chemical differences between different lengths of fibres. Results discussed already showed a positive correlation between length and yield. This was also found by Kruger & de Wet (1966).

The problem is somewhat more complex, however . Yield is not influenced by the length of the tip and degree of weathering only but also by the amount of yolk present. The yolk fulfi~~l~~ls the primary function of protecting the fibre against photochemical decomposition and other weathering factors.

Le Roux (1958) found a highly significant negative correlation between the woolwax content and clean yield (r = -0.9651**). Kruger & de Wet (1966) also found a highly significant negative correlation between woolwax content of the root section and yield (r = -0.677**) while Kruger & de Wet (1965 b) found woolwax of the tip section positively correlated with cystine content.

It, therefore, seems that while yield and length are positively correlated, an increase in length results in a decrease in woolwax with the resulting exposure of the fibre to decomposition (Kruger & de Wet 1966).

It is, therefore, evident that the increase in length and corresponding increase in yield will result in a higher alkali solubility, lower total sulphur and lower disulphide status of the samples as were found in this study.

Kruger & de Wet *op. cit.* found a positive correlation between the cystine and woolwax content of wool (r = 0.416**) which confirms the above statement that it is rather the decrease in woolwax resulting from an increase in length than the increase in length itself, which is responsible for the correlations between yield and chemical properties.

In the ram sample group, however, no significant results were found. This can possibly be ascribed to the larger amount of woolwax present preventing decomposition in the tip section.

4.2.3.2 Spinning count.

Many workers have investigated the chemical composition of the wool fibre and its relation to crimp; among others. Horio & Kondo (1953), Mercer (1953, 1954), Louw (1960 a, 1960 b), Mercer, Golden & Jeffries (1954).

The bilateral structure of wool fibres was investigated by Horio & Kondo loc. cit., who found the one part of the fibre dye accessible, called DA, and the other part non-dye accessible called Non-DA. They also found that single wool fibres show a pronounced tendency to coil though, when movements were restricted by the proximity of other fibres in a lock or mass the result is the formation of crimp. This can be explained as follows:
The resistant particles or short sections of fibrils noted in the cortical cells occur in only half of the cells in cross sections of fine wool. This asymmetry may be related to a relative difference in stability between one half of the cortex (orthocortex) and the other half (paracortex). The ortho-and paracortex from two twisted hemicylinders, and their different response to environmental changes may be responsible for the spontaneous twisting and curling of wool (Mercer, 1953).

Fraser & MacRae (1956, quoted by Louw 1960 b) draw attention to an apparent relation between bilateral structure and crimps in keratin fibres. A larger degree of symmetry of ortho and para components coincides with better defined crimp. One extreme is the fine, highly crimped Merino wool with definite segmentation into approximately equal sections of ortho and para components and the other the straight, human hair which may be regarded as "pure" paracortex. Slightly wavy kid mohair may be regarded as "pure" orthocortex (Menkart & Coe 1958, quoted by Louw 1960 b). Louw (1960 b) regards the crimps in fibres to be the result of catalised keratinization which, proceeding more rapidly in the para- than in the ortho-component probably leads to more and/or different cystine linkages in the former segment. This results in crimp formation while the fibre structure is still relatively unstable and pliable. The paracortex in normal wool is highly keratinized. Keratinization may be defined as the linking of free thiol groups to form disulphide bonds. Mercer et al. loc. cit. stated that the cystine content of the paracortex appeared to be almost twice as high as that of the orthocortex. Dusenbury (1963) stated that a high **cystine content** (15 percent and more) is associated with paracortex fibres and a low cystine content (nine percent and less) with orthocortex fibres while an average value (11-12 percent) indicates fibres which can consist of both.

Louw op. cit. explained the lack of well defined crimp in steely fibres, which show definite segmentation in ortho- and paracortex, to be the result of slower keratinization of fibres due to a deficiency in trace elements as compared to normal wool.

It thus seems that crimp formation results from differences in keratinization between the two segments as well as the relative distribution of the segments in wool. It can thus be expected that with a pronounced difference in the two segments, the fibre will tend to be more crimped than where a smaller difference exists. It could also be expected that the more keratinizated portion, and finer wool, would contain more disulphide linkages as a result of more pronounced differences in keratinization between the ortho- and para-components.

In this study a significant positive correlation was found between spinning count and disulphide bonds status ($r_{3,5}$ = 0.2814*) which supports the statement made above. As early as 1933, Spöttel found a definite correlation between spinning count and sulphur content and he stated that coarse fibres have a lower sulphur content than finer fibres.

Results of Barrit & King (1929) show that the sulphur content of wool from different breeds varies and it seems that the higher sulphur content is found in the fine-woolled breeds. Results of Harris & Smith (1937 quoted by Louw 1960 b) show a decrease in sulphur content from household to carpet wool.

Nawara & Osikowski (1957) found a negative correlation between cystine content and fibre thickness and they also mentioned the fact that a high cystine content is not always associated with greater fibre strength.

In this study a significant negative correlation was found between thiol status and spinning count ($r_{4,5}$ = -0.2600*), which also supports the above-mentioned theory in so far that the general conclusion can be made that in coarser fibres more free SH groups are present as a result of a lower degree of keratinization and that the difference between the ortho- and para-segments in thicker fibres is not very pronounced.

It,must, however, be emphasised that knowledge on this subject is limited and that no definite conclusions can be drawn. While differences in chemical composition between different lengths were ascribed to yolk and weathering factors, it is quite possible that the differences between the ortho- and paracortex can play a role in so far as degree of keratinization is concerned.

CHAPTER 5

CONCLUSIONS

5.1 Accuracy of estimation

The average accuracy of estimation is very low and the necessity of measurement as an aid to selection must be stressed. While inaccurate estimation of yield has no practical effect on the determination of clean fleece weight, the use of a scale in determining greasy fleece weight is recommended for practical breeding purposes. For analytical work, however, the amount of scoured wool should be used.

The accuracy of judging of length is low but if the fact is taken into account that in practical wool classing one inch difference in the length of wool in the same bale is allowed, the extra time taken to measure length accurately is not justified. At least 70 percent of the fleeces would be classed in the correct class according to length. The argument is further strengthened by the fact that judges tend to underestimate length, rectifying the error made by woolclassers when pushing length to a higher length class in an effort to obtain a better price. For scientific work, however, staple length should be measured and the studfarmer should seriously consider length measurement of wool especially on selected stud sheep.

Spinning count estimation and especially the

Duerden standard laid down in 1929 needs review. The correlation between estimated- and measured fibre thickness is very low and it appears that the estimation of spinning count is much more dependent on crimps per inch that on fibre thickness. It seems that South African wool is undercrimped, resulting in an underestimation of spinning count. The crimp fibre thickness relationship in South African wool needs attention and a new standard is recommended. In this respect the internationally accepted A.S.T.M. standards seem much more realistic and worthy of further study and consideration.

In this study an alarmingly high percentage of fleeces was disqualified when spinning count was estimated according to the Duerden standard. However, when the A.S.T.M. standard was used as a basis for the estimation of spinning count, only a small number of fleeces were disqualified for being overstrong. According to these standards South African stud wool is not overstrong.

5.2 Interrelationship between different wool characteristics

Greasy fleece weight can be used as a basis of selection because there exists a highly significant positive correlation between greasy fleece weight and the amount of scoured wool.

The amount of scoured wool produced can be increased within limits by increasing staple length. Apart from the fact that the trade is not prepared to pay more for wool exceeding the length of 3½ inches, excessively long wool results in the opening of the fleece, longer staple tips and poor appearance.

The production of coarse wool by flock farmers in an effort to increase the amount of scoured wool is not recommended, because this can result in the production of overstrong wool by the studbreeders.

It seems that finer wool has the better quality, corresponding with the definition of quality in the trade. Although present knowledge does not warrant a definite conclusion, it would appear that differences in quality are related to differences in the chemical composition of the fibre.

Although the available data regarding the relationship between the chemical composition of the wool fibre and objective evaluated wool properties are rather limited, the following are indicated:

1) The significant correlations between the amount of scoured wool and the chemical properties (positive with thiol groups and negative with disulphides) and between greasy fleece weight and thiols may possibly be ascribed to length differences in so far as longer wool is positively correlated with the amount of scoured wool and greasy fleece weight and that longer wool tends to be more weathered than shorter wool. Weathering results in longer tip sections in long wool with a resulting increase in thiols and a decrease in disulphides.

2) The significant correlations between yield and chemical properties can also be ascribed to length differences. In this study yield was positively

correlated with length and from the literature the conclusion can be drawn that longer wool tends to contain a lower percentage of woolwax. This results in the weathering of the tip section as indicated by the positive correlation between yield and alkali solubility and the negative correlations between yield, and total disulphides + thiols and thiols.

3) Because crimp is a result of the bilateral structure of the cortex of the wool fibre, it seems that finer fibres are more highly keratinized in the paracortex than coarser fibres. This results in a more pronounced difference between the components with the formation of more crimps per inch.

4) The non significant results obtained in the ram sample group between chemical and physical properties could possibly be a result of the smaller variation in the ram- than in the ewe sample group. While chemical differences are very small it is evident that it could more easily be observed in a study where extreme samples are used.

CHAPTER 6

SUMMARY

Samples obtained from fleeces exhibited at a National Merino Fleece Wool Competition were analysed for physical and chemical properties.

Standard methods of analyses and a modified method for determining disulphides and thiols polarographically with methyl mercury iodide are described.

The accuracy of judging was calculated through r^2-values from correlation coefficients. The interrelationship between different characteristics was estimated by correlation coefficients.

The accuracy of calculating clean wool weight from greasy fleece weight by means of the estimated yield value, was very high (83 percent). The low accuracy of estimating yield seems to have a negligible effect and for practical breeding and classing purposes it can be disregarded.

While the accuracy of judging length is low, in practice the error is negligible because a length difference of one inch is allowed in wool from the same bale. Judges tend to underestimate length.

Spinning count estimation seems to be more dependent on crimps per inch than on fibre thickness. Judges tend to underestimate spinning count as a result of the undercrimping in the wool. While the Duerden standard, laid down in 1929, is still used, it is emphasised that a re-evaluation of the crimp fibre thickness relationship in the South

African Merino wool must be made. The internationally eccepted A.S.T.M. standards seem a much more accurate basis for judging spinning count of South African Merino wool.

The large number of fleeces disqualified for being overstrong is alarming. If disqualifications had been based on measured fibre thickness, a smaller percentage of the fleeces would have been disqualified while the use of A.S.T.M. standards seems a more realistic basis and only 13.8 percent of the fleeces would have been disqualified in comparison with the actual 38.5 percent.

The greasy fleece weight is positively correlated with the amount of scoured wool and staple length and negatively with spinning count.

The amount of scoured wool is positively correlated with greasy fleece weight and staple length and negatively correlated with spinning count.

Spinning count is negatively correlated with length.

The use of greasy fleece weight as a selection criterium is recommended.

The use of length and a lower spinning count as a selection measure to increase the amount of scoured wool is discussed. Selection for length to a maximum of 3½ inches is recommended while a decrease in spinning count as a method to increase the amount of scoured wool is strongly disapproved of.

While no significant correlations were found between quality and other physical wool properties, it would seem from the literature that finer wool has the better quality. This corresponds with the definition of quality in the trade.

Although data are limited, it would seem that differences in quality can be ascribed to differences in the chemical composition of the keratin fibre and that chemical decomposition of the tip sections affected the estimation of quality.

An increase in wool production as a result of an increase in length may be the reason for the positive correlation between the amount of scoured wool and the thiol content and the negative correlation between the amount of scoured wool and the disulphide bond status. A positive correlation was also found between greasy fleece weight and thiol content.

Highly significant correlations were found between yield and alkali solubility (positive), total disulphides + thiols and thiols (negative). This may possibly be due to the amount of yolk present in the wool. Longer fibres tend to contain less yolk than short fibres. This results in the decomposition of the exposed tip section of long fibres and consequently the production of thiols from disulphides.

The bilateral structure of wool is responsible for crimp formation and the paracortex contains more and/or different disulphide linkages than the orthocortex.

A significant positive correlation between spinning count and disulphide bond status and a negative correlation between spinning count and thiol content were found. Although data are rather limited it would seem that finer fibres contain more disulphide bonds than coarser fibres, possibly as a result of a higher degree of keratinization in the paracortex.

Accuracy of judging is dicussed and a re-evaluation of crimp fibre thickness relationship for South African standards is recommended.

Interrelationship between different wool traits is summarised and the practical applications thereof are discussed.

A possible reason for the non-significant correlations in the ram sample group between physical and chemical properties seems to be the lower variation in the ram sample.

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APPENDIX 1 The Merino Wool Score-card.

SCORE-CARD.

Properties.	Definition.	Description	Maximum Points	Points Alloted
1. Soundness (tensile strength)	Well nourished, free from tenderness and/or wastiness		10	
2. Length	Length (points according to scale) and evenness of length		10	
3. Fineness	Uniformity of count for class		10	
4. Quality	Softness of handle, a well defined and even crimp; free from hairy type fibres (hair kemp, etc.)		20	
5. Substance (body) staple formation and tip	Full handling wool, absence of ropy and/or watery staple formation and pointed tips (hoggety)		10	
6. General condition and appearance	Sufficient amount, fluidity and colour of yolk; freedom from vegetable and other undesirable foreign matter		10	
7. Amount of scoured wool	Amount of scoured wool. (Points according to scale)		30	
		Total	100	

APPENDIX II The subjective evaluation of quality, length, spinning count, amount of scoured wool and yield.

N°.	CHARACTERISTIC				
	6	8	9	11	13
RAMS:					
R 1	4	3.2	56	16.2	53.0
R 2	4	3.5	56	14.8	52.0
R 3	6	3.0	56	15.8	50.0
R 4	4	3.0	54	15.6	51.0
R 5	4	3.8	58	18.6	61.0
R 6	6	3.2	50	14.4	44.0
R 7	6	4.0	58	17.1	56.0
R 8	4	3.8	58	18.7	58.0
R 9	8	4.0	56	15.3	51.0
R 10	6	3.0	56	15.3	51.0
R 11	0	3.5	54	14.2	49.0
R 12	4	3.5	56	16.8	48.0
R 13	0	3.0	50	12.5	52.0
R 14	7	4.0	54	15.6	50.0
R 15	6	4.0	56	10.6	55.0
R 16	0	4.0	54	14.7	53.0
R 17	6	3.8	60	10.2	59.0
R 18	7	3.5	58	20.0	52.0
R 19	6	3.0	54	11.1	44.0
R 20	7	3.5	56	12.4	57.0
R 21	8	3.5	58	17.1	56.0
R 22	7	4.0	56	9.9	58.0
R101	4	3.0	60	15.9	52.0
R102	6	3.0	60	13.3	53.0
R103	4	3.2	60	14.4	56.0
R104	4	3.5	60	15.3	52.0
R105	4	4.0	58	19.2	56.0

Appendix II (continued)

No.	6	8	9	11	13
R106	9	4.0	56	10.6	46.0
R107	0	3.0	58	12.9	56.0
R108	6	2.5	58	9.2	48.0
R109	4	2.5	60	6.5	49.0
R110	6	3.2	58	10.7	47.0
R111	7	2.8	60	6.6	50.0
R112	7	2.8	56	9.5	44.0
R113	4	4.0	60	10.2	60.0
R114	6	4.0	58	13.4	56.0
R115	7	4.0	56	14.2	45.0
R116	6	3.2	58	7.2	53.0
R201	6	3.0	64	13.4	56.0
R202	4	3.0	66	9.0	55.0
R203	4	4.2	64	10.0	57.0
R204	6	3.5	64	11.2	57.0
EWES:					
0 1	6	3.0	60	12.8	58.0
0 2	8	3.8	60	11.8	62.0
0 3	8	3.8	58	9.6	60.0
0 4	6	4.0	56	11.8	62.0
0 5	7	4.2	58	10.6	59.0
0 6	6	3.0	60	9.9	55.0
0 7	6	5.0	60	10.8	56.0
0 8	4	4.5	56	14.0	61.0
0 9	6	2.8	54	11.3	63.0
0 10	6	3.8	58	11.8	62.0
0 11	4	3.5	60	12.0	60.0
0 12	7	3.5	54	9.3	58.0
0 13	4	3.2	60	12.9	56.0

N°.	CHARACTERISTIC				
	6	8	9	11	13
0 14	6	3.5	60	12.0	52.0
0 15	7	3.0	56	13.0	57.0
0 16	4	2.8	58	10.8	52.0
0 17	4	2.8	60	10.6	52.0
0 18	7	3.0	58	9.0	55.0
0 19	0	3.8	58	7.4	57.0
0 20	0	3.0	56	8.4	63.0
0 21	0	3.2	60	8.6	60.0
0 22	4	3.2	60	7.7	58.0
0 23	6	3.8	60	9.3	62.0
0 24	6	3.5	60	8.8	59.0
0 25	6	2.8	58	8.0	61.0
0 26	6	3.5	58	15.6	65.0
0 27	7	3.2	60	9.4	60.0
0 28	6	4.0	56	12.5	64.0
0 29	6	4.0	58	10.1	62.0
0 30	6	3.5	58	10.8	61.0
0 31	6	3.2	58	10.3	63.0
0 32	0	3.2	58	8.0	61.0
0 33	4	3.5	56	12.4	54.0
0 34	6	3.2	56	12.3	56.0
0101	6	3.5	54	12.5	66.0
0102	8	3.8	60	15.1	63.0
0103	7	3.8	60	11.4	60.0
0104	6	4.0	64	10.2	64.0
0105	9	3.5	60	9.4	59.0
0106	8	4.0	64	9.8	65.0
0107	7	3.8	60	9.9	66.0
0108	6	3.2	64	10.6	56.0
0109	7	3.0	60	8.1	57.0

Appendix II (continued)

	CHARACTERISTIC				
N°.	6	8	9	11	13
0110	6	3.2	60	10.0	61.0
0111	6	4.0	60	9.3	61.0
0112	7	3.0	66	5.2	65.0
0113	7	3.0	64	4.9	64.0
0114	6	4.0	64	8.4	63.0
0115	4	3.8	64	9.2	66.0
0116	6	3.5	64	9.5	68.0
0117	6	3.2	64	9.5	61.0
0118	4	3.8	64	5.5	61.0
0119	0	3.8	60	10.5	60.0
0120	7	3.2	64	9.2	66.0
0201	8	3.0	66	8.4	60.0
0202	6	3.2	70	7.4	62.0
0203	6	2.8	70	7.2	65.0
0204	8	3.5	66	7.1	59.0
0205	7	3.8	66	9.6	67.0
0206	4	3.2	70	4.4	58.0
0251	4	2.8	74	4.7	67.0
0252	4	3.0	74	5.7	63.0
0253	6	2.5	74	5.1	64.0
0254	6	3.0	70	5.3	59.0
0255	6	3.0	70	4.3	62.0

APPENDIX III Objective evaluation of physical properties, spinning count (M), length, spinning count derived from crimps per inch, amount of scoured wool, yield and greasy fleece weight.

N°.	CHARACTERISTIC					
	5	7	10	12	14	15
RAMS:						
R 1	56	4.1	58	15.1	49.3	30.6
R 2	58	4.6	58	16.6	58.5	28.4
R 3	56	4.3	58	16.5	52.2	31.6
R 4	56	4.0	58	15.9	52.1	30.5
R 5	56	4.8	56	16.1	52.9	30.5
R 6	56	4.4	58	15.8	48.4	32.7
R 7	58	4.9	58	15.7	51.6	30.5
R 8	56	4.0	58	17.8	55.0	32.3
R 9	56	4.1	56	18.2	60.8	30.0
R 10	56	4.0	56	17.5	58.2	30.0
R 11	56	4.7	58	18.1	62.4	29.0
R 12	56	4.7	58	15.4	44.2	34.9
R 13	54	3.7	56	13.4	55.7	24.0
R 14	58	4.7	56	16.6	53.3	31.2
R 15	60	4.5	60	9.5	49.4	19.2
R 16	56	4.5	58	15.4	55.4	27.8
R 17	60	4.3	60	10.0	57.8	17.3
R 18	58	5.2	58	21.4	55.6	38.4
R 19	56	4.1	58	10.7	42.5	25.2
R 20	56	4.5	58	12.0	55.1	21.8
R 21	58	4.7	58	17.1	56.0	30.5
R 22	58	4.1	58	10.5	61.6	17.0
R101	58	3.7	58	13.0	42.7	30.5
R102	58	3.7	58	12.8	51.1	25.1
R103	58	4.7	58	13.9	52.9	26.2
R104	58	5.1	60	13.2	44.6	29.5
R105	56	4.0	58	18.1	53.0	34.2

Appendix III (continued)

Nº.	CHARACTERISTIC					
	5	7	10	12	14	15
R106	58	4.5	58	12.6	54.8	23.0
R107	60	3.4	60	11.7	51.0	23.0
R108	60	4.0	60	10.1	52.6	19.2
R109	64	3.7	64	17.1	53.8	13.2
R110	58	4.6	58	12.4	54.3	22.8
R111	60	3.8	60	7.5	56.9	13.2
R112	58	4.0	58	11.2	51.9	21.6
R113	64	5.5	58	10.6	62.2	17.0
R114	60	4.7	58	13.1	54.5	24.0
R115	58	4.9	58	16.9	53.5	31.6
R116	58	4.4	58	8.0	57.2	14.0
R201	58	3.5	60	13.4	55.8	24.0
R202	58	3.4	64	7.9	48.2	16.3
R203	60	4.7	64	9.8	56.6	17.3
R204	58	4.0	66	11.5	58.7	19.6
EWES:						
O 1	60	3.6	60	13.8	62.7	22.0
O 2	60	4.1	58	12.7	67.0	19.0
O 3	60	4.1	60	10.7	67.1	16.0
O 4	58	4.0	56	12.6	66.1	19.0
O 5	58	4.1	60	10.6	59.0	18.0
O 6	64	4.2	58	10.9	60.5	18.0
O 7	58	4.6	58	11.0	60.9	18.0
O 8	58	4.5	58	14.1	61.2	23.0
O 9	58	3.9	56	11.4	63.1	18.0
O 10	58	4.2	58	11.8	61.9	19.0
O 11	60	4.0	58	11.8	62.0	19.0
O 12	58	4.2	58	9.4	58.9	16.0
O 13	58	4.3	58	11.4	49.4	23.0
O 14	58	3.7	58	11.7	50.9	23.0

Appendix III (continued)

	CHARACTERISTIC					
N°.	5	7	10	12	14	15
0 15	60	4.4	58	13.0	57.1	22.8
0 16	56	4.0	60	11.0	53.0	20.7
0 17	60	3.6	58	10.7	52.3	20.4
0 18	60	3.7	58	8.9	54.3	16.4
0 19	58	4.5	60	7.6	58.4	13.0
0 20	58	3.5	58	7.3	54.3	13.4
0 21	60	4.2	60	8.3	57.5	14.4
0 22	66	3.6	60	7.4	55.4	13.4
0 23	64	4.0	60	9.2	61.6	15.0
0 24	66	4.6	60	9.7	64.4	15.0
0 25	60	3.9	60	7.3	60.6	12.0
0 26	58	4.8	58	15.5	64.5	20.4
0 27	60	4.1	58	10.1	64.6	15.6
0 28	58	4.8	58	11.5	58.8	19.6
0 29	60	5.1	58	9.9	60.5	16.4
0 30	64	4.4	58	10.3	58.9	17.5
0 31	64	4.6	58	10.0	61.1	16.4
0 32	58	4.1	58	7.8	59.4	13.2
0 33	58	4.3	56	11.8	51.5	23.0
0 34	60	4.3	58	11.9	54.3	22.0
0101	60	3.9	60	11.8	62.1	19.0
0102	58	4.2	60	15.9	66.3	24.0
0103	58	3.9	60	11.7	61.8	19.0
0104	66	4.7	64	9.7	60.4	16.0
0105	64	3.6	60	8.4	52.5	16.0
0106	60	4.6	60	9.2	61.6	15.0
0107	70	3.7	60	9.0	59.9	15.0
0108	60	3.9	64	9.9	52.2	19.0

Appendix III (Continued)

N^o.	CHARACTERISTIC					
	5	7	10	12	14	15
0109	66	4.4	58	10.3	58.9	17.5
0110	64	4.1	60	9.9	60.6	16.7
0111	66	4.6	58	9.7	63.4	15.3
0112	70	3.6	66	5.2	65.6	8.0
0113	70	4.3	66	4.3	57.1	7.6
0114	64	4.8	64	7.0	52.6	13.4
0115	64	3.9	60	8.4	60.2	14.0
0116	66	3.8	60	8.9	63.9	14.0
0117	60	4.4	64	4.4	49.3	15.6
0118	64	4.5	66	5.0	56.1	9.0
0119	58	4.3	60	10.1	57.5	17.5
0120	64	3.4	64	8.8	62.9	14.0
0201	66	3.4	64	8.4	60.1	14.0
0202	60	3.5	66	6.4	53.3	12.0
0203	66	3.3	64	6.8	61.4	11.0
0204	66	3.5	64	6.0	50.0	12.0
0205	66	4.2	64	7.7	53.5	14.4
0206	70	3.9	66	3.5	46.1	7.6
0251	80	3.2	80	4.0	56.5	7.0
0252	80	3.2	70	4.5	49.8	9.0
0253	80	3.0	66	4.5	56.3	8.0
0254	80	3.9	66	7.5	63.0	9.0
0255	66	3.4	66	3.7	58.8	7.0

APPENDIX IV Chemical analyses for alkali solubility, total disulphides & thiols, disulphides and thiols.

N°.	CHARACTERISTIC			
	1	2	3	4
RAMS:				
R 1	11.28	500	476	24
R 2	16.20	480	467	13
R 3	15.51	525	514	11
R 4	13.35	493	473	20
R 5	8.25	507	481	26
R 6	11.74	506	488	18
R 7	18.83	497	473	24
R 8	10.02	519	501	18
R 9	13.74	508	488	20
R 10	18.46	478	461	17
R 11	12.09	492	472	20
R 12	20.06	517	500	17
R 13	10.60	472	446	26
R 14	13.99	525	501	24
R 15	11.07	504	481	23
R 16	11.89	535	510	25
R 17	11.47	499	475	24
R 18	14.34	491	465	26
R 19	18.58	464	445	19
R 20	12.18	494	469	25
R 21	12.03	503	481	22
R 22	20.79	504	474	30
R101	12.54	525	502	23
R102	14.87	487	463	24
R103	15.57	478	456	22
R104	11.16	531	505	26
R105	9.78	518	492	26

Appendix IV (continued)

No.	CHARACTERISTIC			
	1	2	3	4
R106	14.70	489	466	23
R107	14.94	536	506	30
R108	20.28	498	471	27
R109	21.05	512	493	19
R110	22.11	488	466	22
R111	18.03	486	467	19
R112	10.74	483	463	20
R113	10.34	503	477	26
R114	8.41	487	464	23
R115	7.39	532	510	22
R116	6.96	528	506	22
R201	10.33	517	495	22
R202	7.50	515	495	20
R203	9.51	491	468	23
R204	12.33	504	487	17
<u>EWES</u>:				
O 1	9.13	476	456	20
O 2	13.24	490	466	24
O 3	17.02	492	472	20
O 4	16.89	505	482	23
O 5	12.95	499	472	27
O 6	8.84	503	483	20
O 7	13.32	488	468	20
O 8	8.97	523	496	27
O 9	10.10	516	473	43
O 10	14.55	469	438	31
O 11	11.55	490	470	20
O 12	13.98	511	482	29
O 13	6.82	517	489	28
O 14	6.83	539	508	31

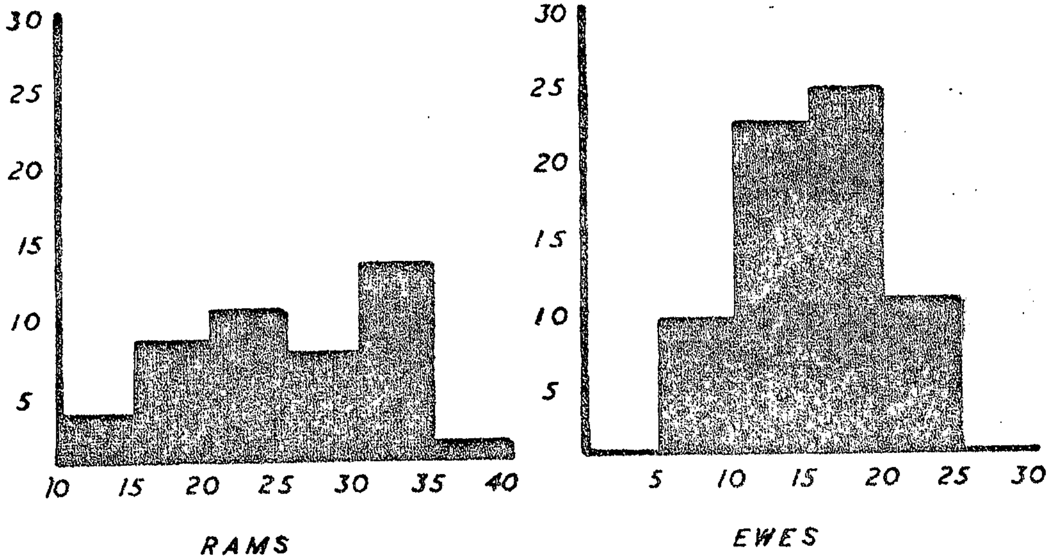
Appendix IV (continued)

N°.	CHARACTERISTIC			
	1	2	3	4
0 15	14.95	503	473	30
0 16	13.66	536	503	33
0 17	11.63	538	502	36
0 18	15.46	547	516	31
0 19	11.63	511	476	35
0 20	12.03	505	470	35
0 21	16.04	477	443	34
0 22	12.64	503	476	27
0 23	16.63	484	452	32
0 24	17.10	464	436	28
0 25	13.36	497	478	19
0 26	15.20	483	458	25
0 27	19.70	473	444	29
0 28	11.90	522	506	16
0 29	14.52	501	460	41
0 30	12.03	509	469	40
0 31	13.51	491	448	43
0 32	19.44	486	444	42
0 33	15.10	500	460	40
0 34	15.52	478	449	29
0101	14.12	546	509	37
0102	13.17	499	463	36
0103	13.05	501	469	32
0104	15.42	515	484	31
0105	17.58	486	470	16
0106	15.97	504	482	22
0107	14.33	530	503	27
0108	15.39	515	497	18
0109	15.46	511	494	17

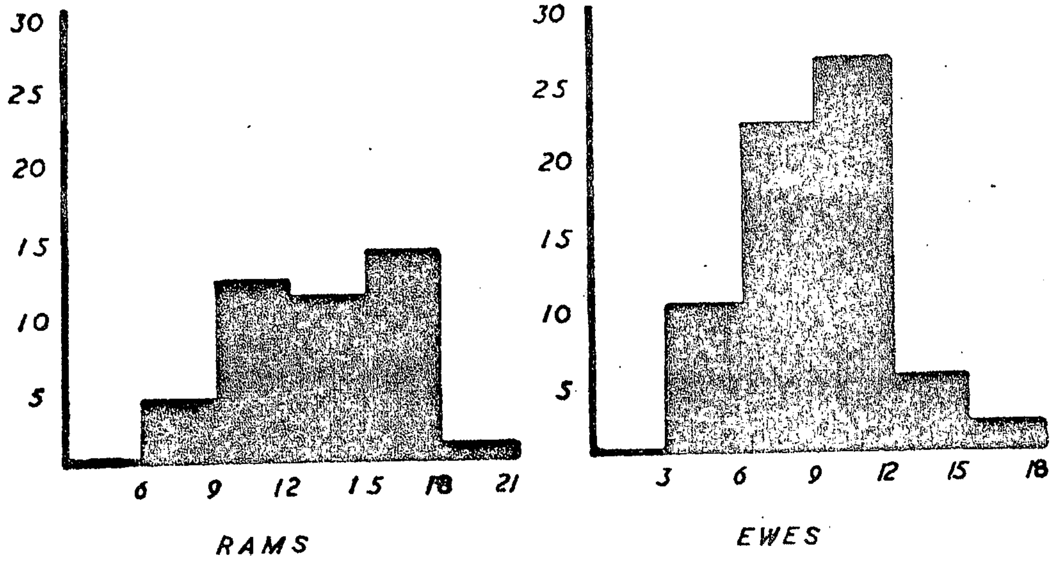
Appendix IV (continued)

N°.	CHARACTERISTIC			
	1	2	3	4
0110	15.46	482	458	24
0111	11.17	509	488	21
0112	16.63	492	473	19
0113	12.88	496	475	21
0114	9.56	512	492	20
0115	12.49	513	488	25
0116	14.55	524	490	34
0117	18.92	495	482	13
0118	13.56	536	518	18
0119	11.11	514	495	19
0120	13.38	520	489	31
0201	12.52	515	486	29
0202	11.70	513	488	25
0203	14.84	470	447	23
0204	12.72	514	492	22
0205	10.94	518	493	25
0206	13.81	491	467	24
0251	13.08	512	488	24
0252	9.05	537	515	22
0253	14.06	535	512	23
0254	17.71	528	504	24
0255	18.62	513	489	24

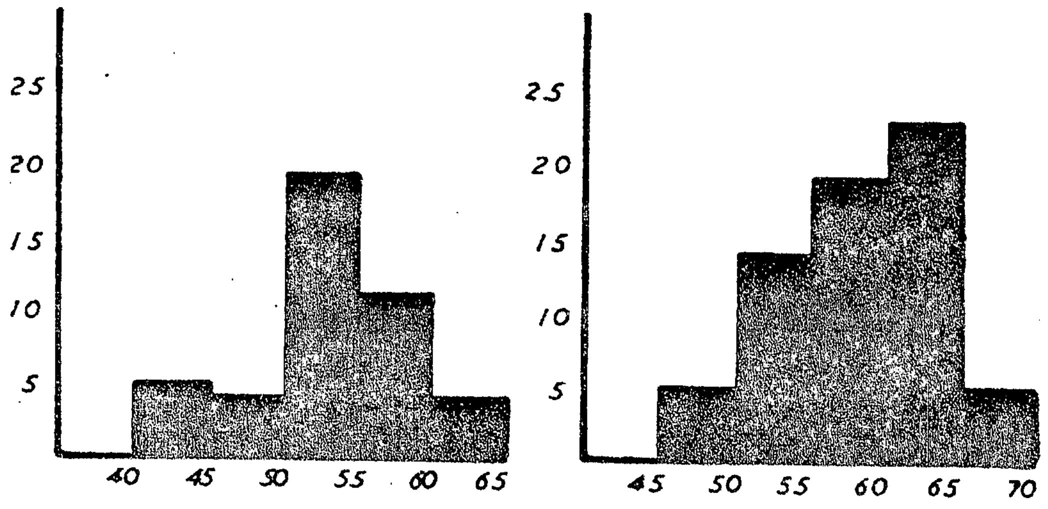
APPENDIX. V. FREQUENCY DISTRIBUTION OF OBJECTIVELY DETERMINED CHARACTERISTICS AND ESTIMATED SPINNING COUNT.



GREASY FLEECE WEIGHT (lb)



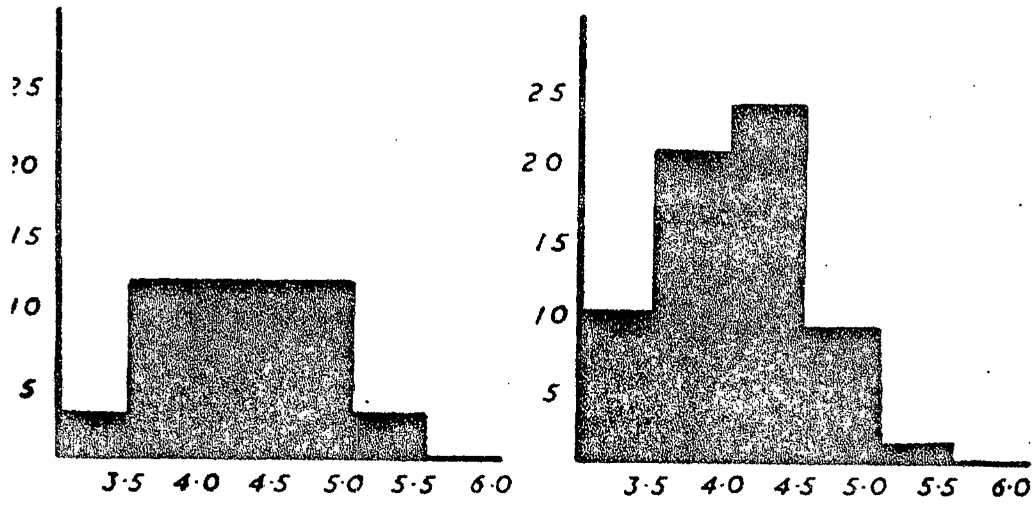
AMOUNT OF SCOURED WOOL (lb)



RAMS

EWES

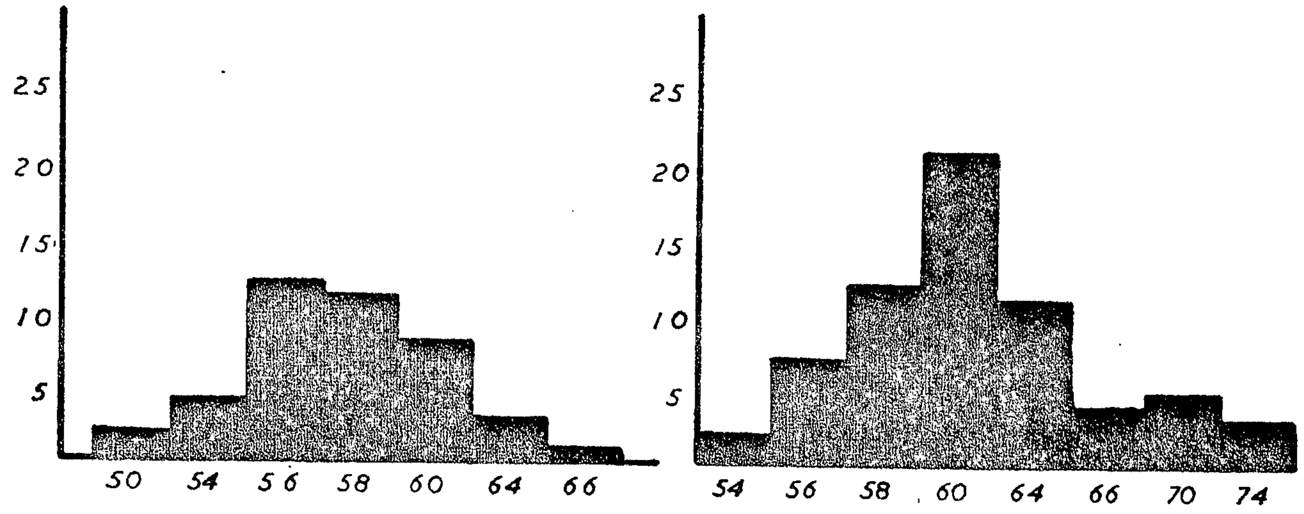
YIELD %



RAMS

EWES

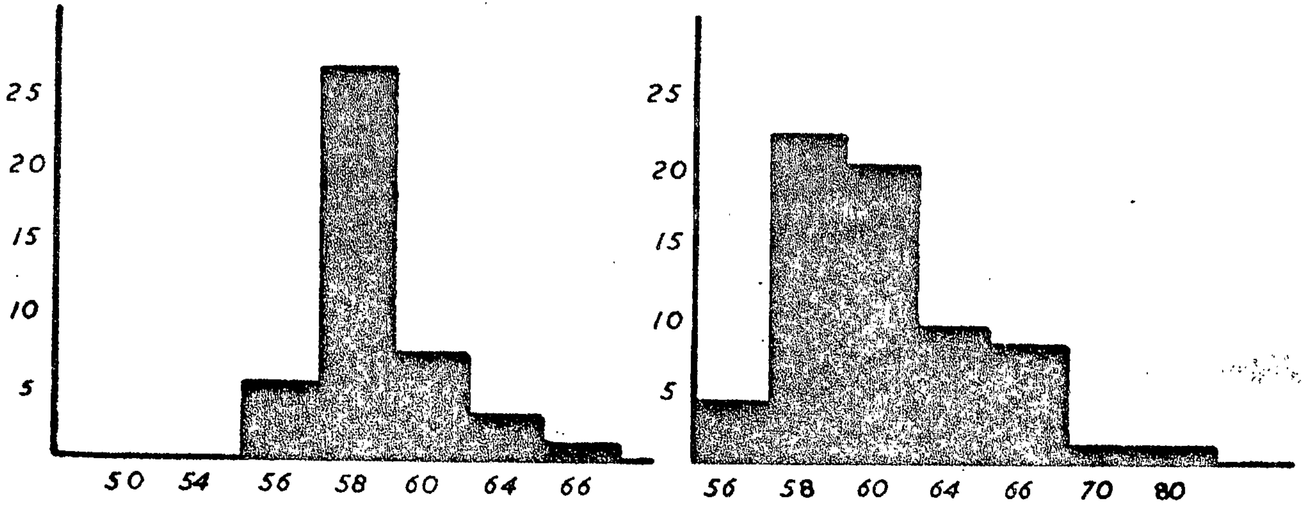
STAPLE LENGTH (inches)



RAMS

EWES

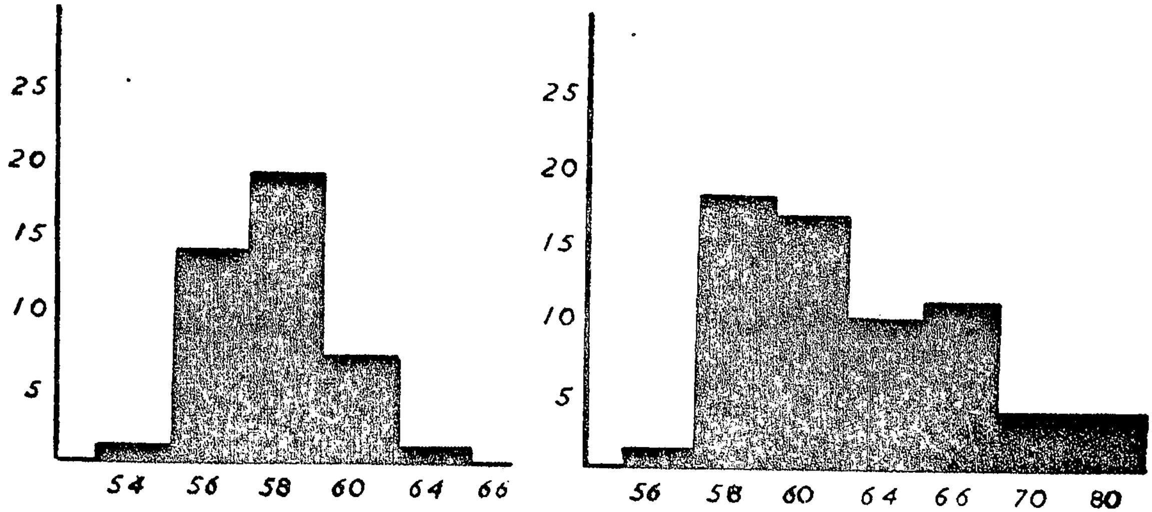
SPINNING COUNT (estimated)



RAMS

EWES

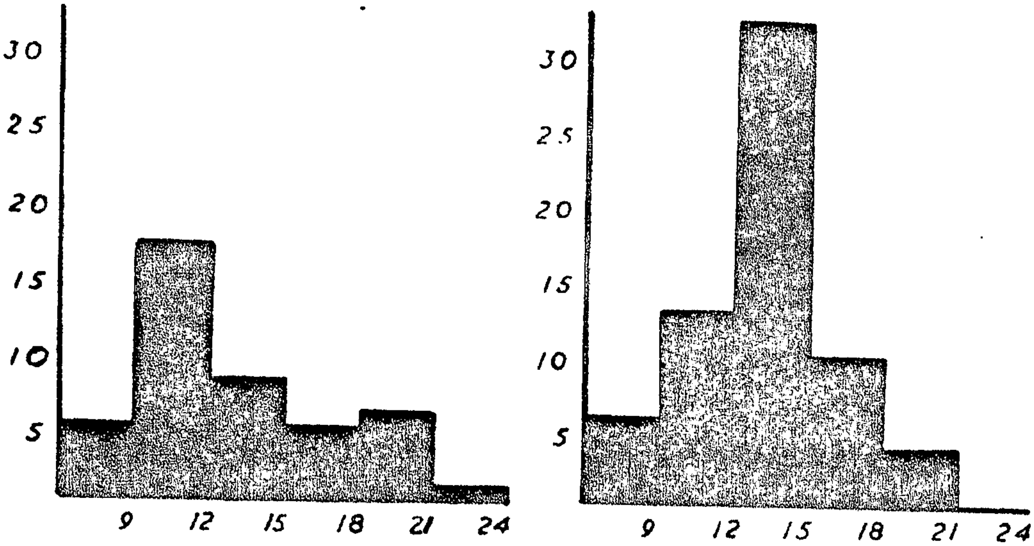
SPINNING COUNT (c.p.i.)



RAMS

EWES

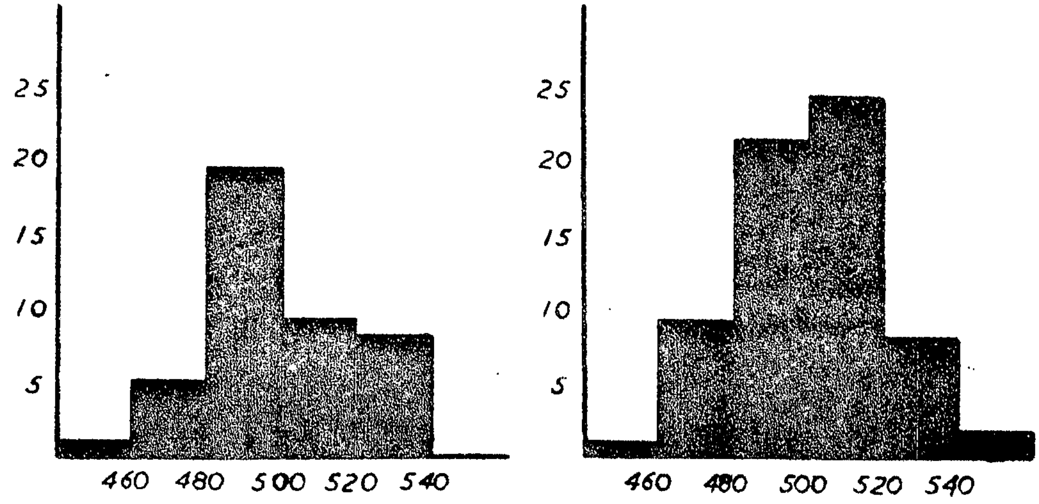
SPINNING COUNT (measured)



RAMS

EWES

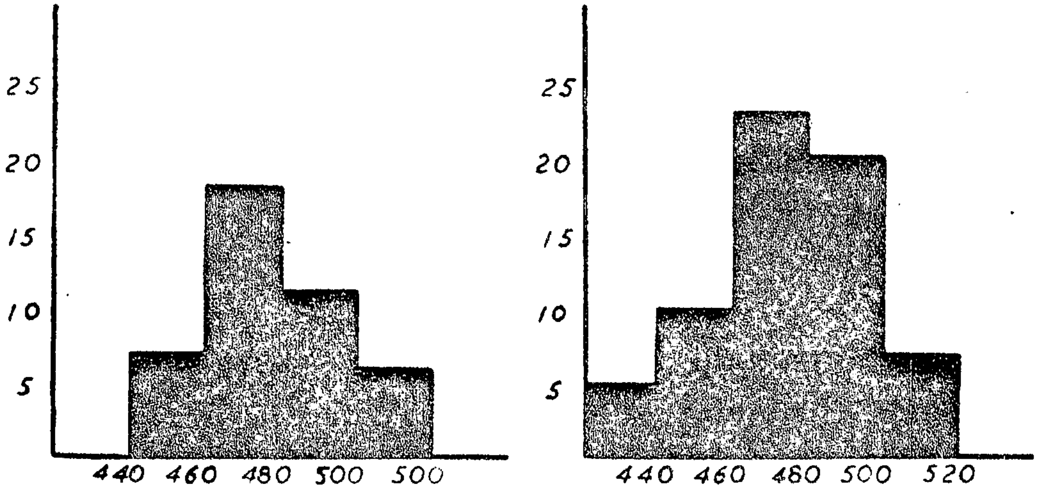
ALKALI SOLUBILITY (%)



RAMS

EWES

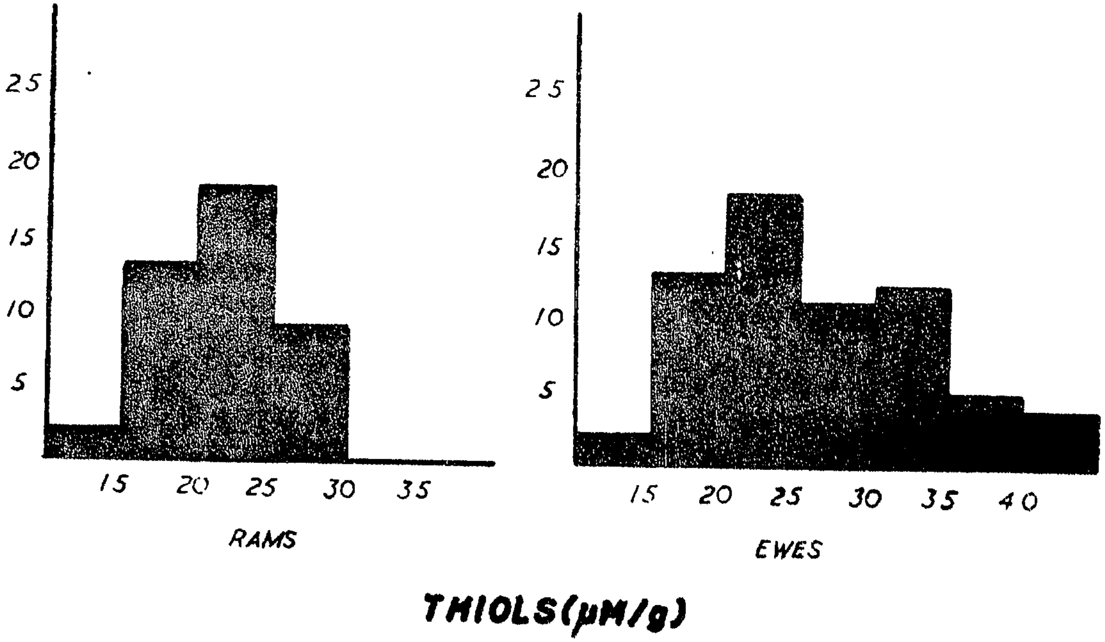
TOTAL DISULPHIDES + THIOLS(μM/g)



RAMS

EWES

DISULPHIDES (μM/g)


25
20
15
10
5
15
20
25
30
35
RAMS
25
20
15
10
5
15
20
25
30
35
40
EWES
THIOLS(µM/g)

APPENDIX VI Fibre thickness, spinning count relationship according to 1) Duerden and 2) American Society for Testing Materials. (A.S.T.M.)

	Fibre thickness (μ)	
Spinning count	Duerden	A.S.T.M.
150^{s}	14.0 - 14.7	
120^{s}	14.7 - 15.4	
100^{s}	15.4 - 16.2	
90^{s}	16.2 - 17.0	
80^{s}	17.0 - 17.9	17.7 - 19.1
70^{s}	17.9 - 18.9	19.2 - 20.5
66^{s}	18.9 - 20.0	
64^{s}	20.0 - 21.3	20.6 - 22.0
62^{s}		22.1 - 23.4
60^{s}	21.3 - 23.0	23.5 - 24.9
58^{s}	23.0 - 25.5	25.0 - 26.4
56^{s}	25.5 - 29.0	26.5^{+}

APPENDIX VII Analyses of variance for polynomial regression of the first and second degree.

Abbreviations:

source of variation	source
degrees of freedom	df
sum of squares	ss
mean squares	ms
due to regression	tR
deviation about regression	daR
F-value	F
highly significant	**
significant	*
non significant	N.S.

Test between 1st. and 2nd. degree polynomial regression:

$$\frac{\text{improvement in terms of sum of squares}}{\text{mean square (deviation about regression}} \text{ from 2nd. degree polynomial regression} = \text{F-value}$$

1. Analyses of variance for the regression of quality on spinning count (M) (6 on 5)

RAMS:

Analysis of variance 1st. degree polynomial

Source	df	ss	ms	F	
tR	1	2.97684	2.97684	0.63798	N.S.
daR	40	186.64178	4.66604		
Total	41	189.61865			

Improvement in terms of sum of squares: 2.97684

Analysis of variance 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	34.86626	17.43313	4.39342*
daR	39	145.75238	3.96800	
Total	41	189.61865		

Improvement in terms of sum of squares: 31.88941

test between 1 and 2, F = 8.03665 N.S.

EWES:

Analysis of variance for 1st degree polynomial

Source	df	ss	ms	F	
tR	1	3.21761	3.21761	0.70134	N.S.
daR	63	289.02807	4.58774		
Total	64	292.24572			

Improvement in terms of sum of squares: 16.73833

Analysis of variance of 2nd. degree polynomial

Source	df	ss	ms	F	
tR	2	19.95595	9.97797	2.27197	N.S.
daR	62	272.28973	4.39176		
Total	64	292.24572			

Improvement in terms of sum of squares: 16.73833

test between 1 and 2, F = 3.81130 N.S.

2. Analyses of variance for the regression of Length (M) on spinning count (M) (7 on 5)

RAMS:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	0.12828	0.12828	0.51609 N.S.
daR	40	9.94312	0.24857	
Total	41	10.07141		

Improvement in terms of sum of squares: 0.12828

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	0.13165	0.06582	0.25827 N.S.
daR	39	9.93976	0.25486	
Total	41	10.07141		

Improvement in terms of sum of squares: 0.00336

Test between 1 and 2, F = 0.13184 N.S.

EWES:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	2.52242	2.52242	14.96486 **
daR	63	10.61855	0.16855	
Total	64	13.14150		

Improvement in terms of sum of squares: 2.52242

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	2.70888	1.35444	8.04932 **
daR	62	10.43261	0.16826	
Total	64	13.14150		

Improvement in terms of sum of squares: 0.18645

Test between 1 and 2, F = 1.10811 N.S.

3. Analyses of variance for the regression of of amount of scoured wool (M) on spinning count (M) (12 on 5)

RAMS:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	164.43817	164.43817	20.74261 **
daR	40	317.10211	7.92755	
Total	41	481.54028		

Improvement in terms of sum of squares: 164.43817

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	164.78073	82.39036	10.14495 **
daR	39	316.75958	8.12203	
Total	41	418.54028		

Improvement in terms of sum of squares: 0.34255

Test between 1 and 2, F = 0.04218 N.S.

EWES:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	221.62207	221.62207	50.38204**
daR	63	277.12634	4.39883	
Total	64	498.74841		

Improvement in terms of sum of squares: 221.62207

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	237.34112	118.67058	28.14603**
daR	62	261.40728	4.21624	
Total	64	498.74841		

Improvement in terms of sum of squares: 15.71905

Test between 1 and 2, F = 3.72822 N.S.

4. Analyses of variance for the regression of yield (M) on spinning count (M) (14 on 5)

RAMS:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	28.50263	28.50263	1.23968 N.S.
daR	40	919.67700	22.99192	
Total	41	948.17968		

Improvement in terms of sum of squares: 28.50263

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	46.16111	23.08055	0.99791 N.S.
daR	39	902.01855	23.12868	
Total	41	948.17968		

Improvement in terms of sum of squares: 17.65847

Test between 1 and 2 , F = 0.76348 N.S.

EWES:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	18.81185	18.81185	0.75606 N.S.
daR	63	1567.51269	24.88115	
Total	64	1586.32470		

Improvement in terms of sum of squares: 18.81185

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	24.75047	12.37523	0.419134 N.S.
daR	62	1561.57422	25.18667	
Total	64	1586.32470		

Improvement in terms of sum of squares: 5.93861

Test between 1 and 2, F = 0.23578 N.S.

5. Analyses of variance for the regression of greasy fleece weight on spinning count (M) (15 on 5) .

RAMS:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	667.25268	667.25368	24.93590 **
daR	40	1070.34863	26.75871	
Total	41	1737.60132		

Improvement in terms of sum of squares: 667.25268

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	667.57312	33.78656	12.16673 **
daR	39	1070.02832	27.43661	
Total	41	1737.60132		

Improvement in terms of sum of squares: 50.32043

Test between 1 and 2, F = 0.011679 N.S.

EWES:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	655.26355	655.26355	69.42243**
daR	63	594.43875	9.43875	
Total	64	1249.90722		

Improvement in terms of sum of squares: 655.26355

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	689.78161	344.89080	38.17578**
daR	62	560.12561	9.03428	
Total	64	1249.90722		

Improvement in terms of sum of squares: 34.51807

Test between 1 and 2, F = 3.82079 N.S.

6. Analyses of variance for the regression of greecy fleece weight on length (15 on 7)

RAMS:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	141.89172	141.89172	3.55683 N.S.
daR	40	1595.70947	39.89273	
Total	41	1737.60132		

Improvement in terms of sum of squares: 141.89172

Analysis of variance for 2nd. degree polynomial

Source	df	ss	ms	F
tR	2	171.67086	85.83543	2.13775 N.S.
daR	39	1565.93042	40.15206	
Total	41	1737.60132		

Improvement in terms of sum of squares: 29.77914

Test between 1 and 2, F = 0.74166

EWES:

Analysis of variance for 1st. degree polynomial

Source	df	ss	ms	F
tR	1	186.60714	186.60714	11.05368 **
daR	63	1063.30005	16.87777	
Total	64	1249.90722		

Improvement in terms of sum of squares: 186.60714

Analysis of variance for wnd. degree polynomial

Source	df	ss	ms	F
tR	2	300.42602	150.21301	9.80873 **
daR	62	949.48108	15.31421	
Total	64	1249.90722		

Improvement in terms of sum of squares: 113.81886

Test between 1 and 2, F = 7.43223 **