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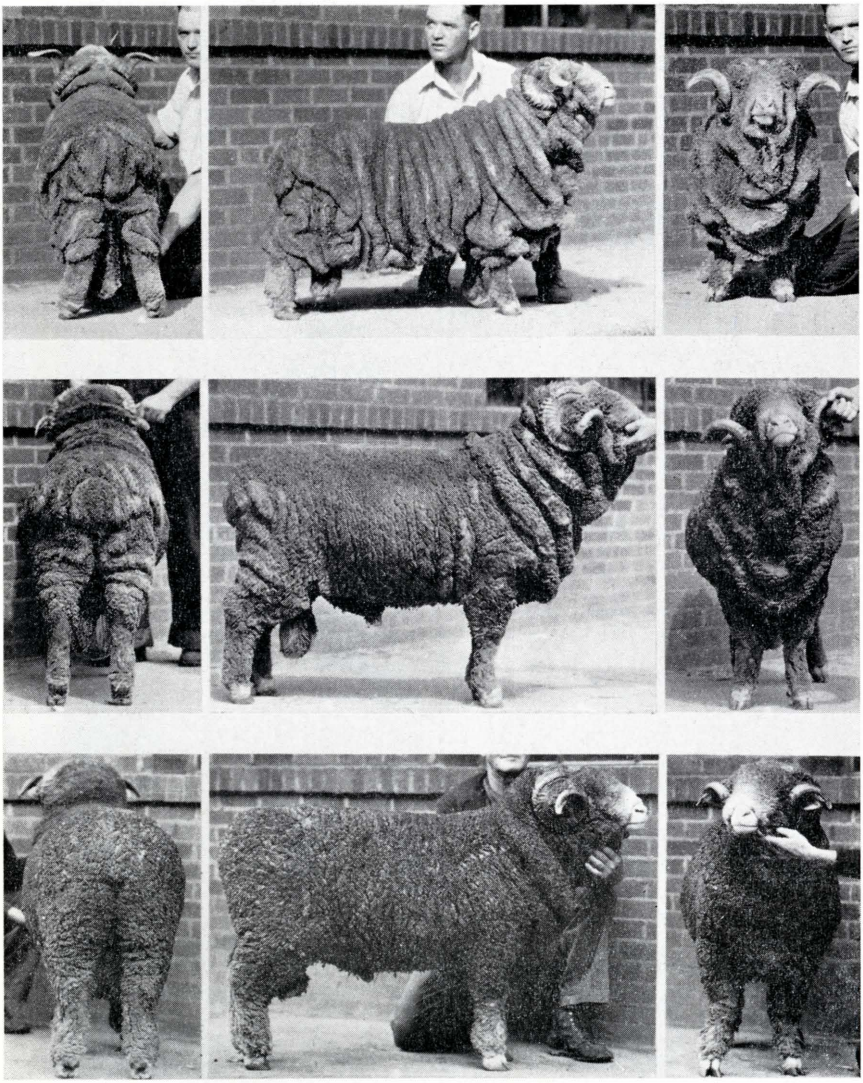

Figure 1. *Top.* Three views of a Merino A type ram. Note the extremely heavy wrinkling over the entire body. *Middle.* Three views of a Rambouillet B type ram. *Bottom.* Three views of a Rambouillet C type ram. These photographs were furnished by the Bureau of Animal Industry, U. S. Department of Agriculture

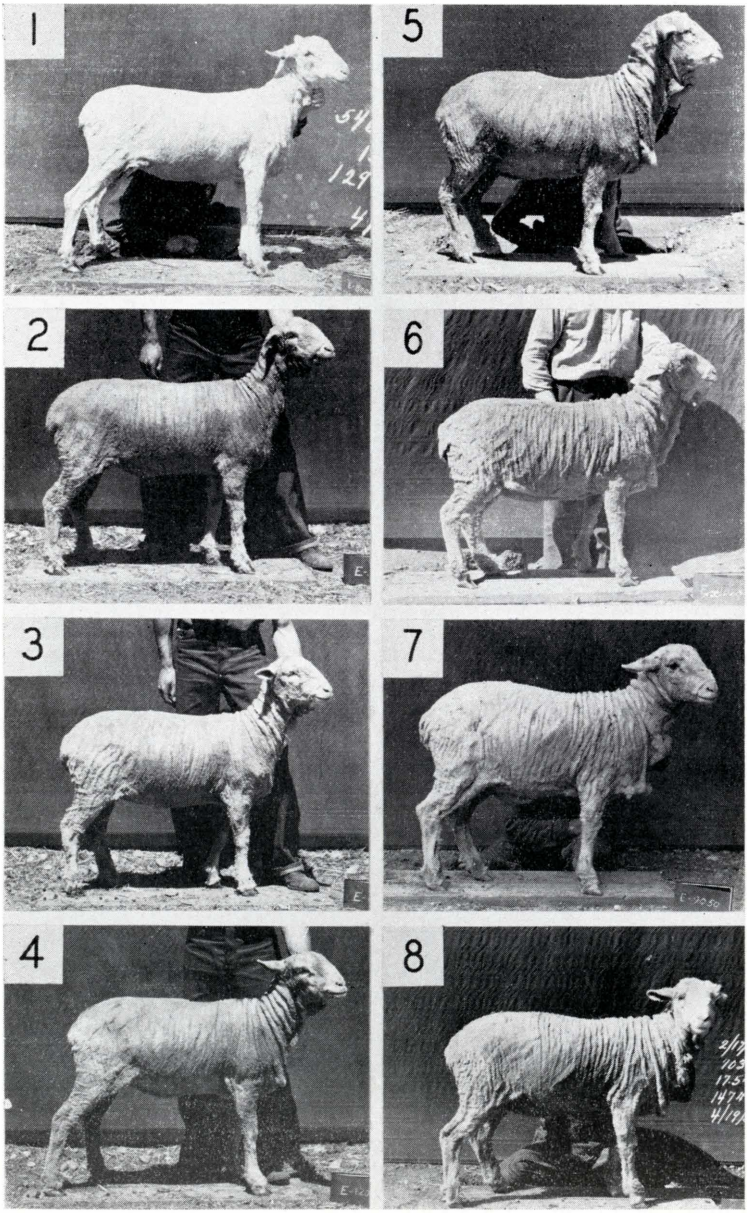

Figure 2. Standards used in classifying photographs of sheep according to amount of skin folds. These photograpic standards were selected from the photographs of sheep actually used in this study, and were taken just after shearing

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THE tendency towards smoother-bodied Rambouillet and Merino sheep has been evident for some time. Experimental work is necessary to determine the relative merits of the two types, especially from the economic standpoint.

The smooth-bodied type produces approximately the same amount of clean wool. The wrinkled type sometimes produces more grease wool, but it generally has a higher shrinkage. The smooth type has longer staple length and there is little or no difference in the fiber thickness. The number of fibers a sheep has on its skin area and the length of the fibers are the two most important characters which combine to make a large amount of clean wool.

The Utah Agricultural Experiment Station reports that a highly significant correlation was found between scores taken at different ages on lambs, indicating that selection at weaning, for example, should be fairly effective in segregating the smooth and wrinkled types.

The exact mode of inheritance of wrinkles is not known, but it, perhaps, is not too complicated. The plane of nutrition is reported to have some effect on the size and number of wrinkles. This would, no doubt, have a close tie-up with the inheritance of wrinkles within these breeds.

(By J. Leroy Van Horn, research assistant professor of Animal Husbandry, Utah Agricultural Experiment Station.)

SKIN FOLDS IN SHEEP

Milton A. Madsen, Alma C. Esplin, and Ralph W. Phillips[1]

INTRODUCTION

SHEEP vary greatly, even within breeds, in the number and size of folds in the skin. At one time producers were emphasizing the importance of having a large number of skin folds in fine wool sheep such as the Merino and Rambouillet. This was based on the belief that skin folds were associated with high yields of grease wool and fineness of wool fibers In recent years the trend has been toward a smoother bodied sheep with longer staple and less grease in the fleece.

The objects of this bulletin are to present a review of the available information concerning the relative merits of sheep differing in the amount of skin folds, and to present information on the inheritance of this character and the value of early estimates of the amount of skin folds for predicting this character in yearlings. The applications of the findings in sheep breeding are discussed.

Merino sheep have generally been classified into three types, A, B, and C, while only two types, B and C, have been used in classifying Rambouillets. There is much variation within these types, and there is no clear line of distinction between them, since one type blends into another. The types of animals falling in the three classes are illustrated in figure 1.[2]

REVIEW OF LITERATURE

THE literature dealing with the relation of skin folds to wool production is reviewed with regard to grease weight, clean weight, shrinkage, length and fineness. This is followed by a discussion of inheritance of skin folds, and the effect of nutrition upon their development.

GREASE WEIGHT, SHRINKAGE AND CLEAN WEIGHT

A number of reports by Jones and his co-workers in Texas *(3, 4, 6, 7, 10)* indicate that Rambouillet sheep of the B type produce larger amounts of grease wool than the smoother bodied sheep of the C type. The average yields of grease wool reported by Jones, *et al. (3)* for the two types were 9.8 and 8.9 pounds, respectively. Shrinkage of fleeces for the two types

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[1]Milton A. Madsen, research assistant professor in animal husbandry (on military leave), Alma C. Esplin, research professor of animal husbandry, Utah Agricultural Experiment Station, and Ralph W. Phillips, formerly research professor and head of the Department of Animal Husbandry, Utah Agricultural Experiment Station, now senior animal husbandman, in charge of genetics investigations, Bureau of Animal Industry, U. S. Department of Agriculture.

[2]These animals were considered of sufficient merit to be awarded first places in their respective classes and championships in their sex and type groups in one of this country's larger exhibitions of fine wool sheep, the Ohio State Fair, in 1936.

was 63 and 60 percent, so the average yields of clean wool were essentially the same for both types. Fleeces from C type animals weighed 9 percent less than those from B type on a grease weight basis, while on a clean basis the difference was less than 1 percent. A total of 2,280 fleeces were used in this study. Results presented in other reports by the Texas workers are in close agreement with those summarized above.

Spencer, Hardy and Brandon *(11)* found, in a study of 1,692 fleeces, that the grease weight increased as the number and size of skin folds on the neck increased. Of these fleeces, 1,353 were used in studies of shrinkage, and it was found that there was also a tendency for clean weight of fleece to increase slightly as the amount of folds increased. Amounts of moisture, grease and dirt also increased as the skin folds increased, so there was a greater shrinkage in the fleeces from the more wrinkled sheep.

LENGTH OF STAPLE

Rambouillet sheep of the smoother type produce wool of greater length than the more wrinkled sheep.

Spencer, Hardy and Brandon *(11)* found that the length of staple increaded as the amount of skin folds decreased. Their results were based on a study of 1,389 fleeces produced at the U. S. Sheep Experiment Station, Dubois, Idaho.

Jones and co-workers *(3, 4, 5, 6, 7, 10)* obtained similar results in studies of B and C type Rambouillets in Texas. In all cases reported, the average length of staple has been greater in C than in B type animals. Jones, *et al. (3)* found the average length of staple in C type animals to be 2.4 inches as compared to 2.1 inches in B type animals. Included in this study were 1,878 records on C type and 372 records on B type individuals.

FINENESS OF FIBERS

Spencer, Hardy and Brandon *(11)* found that fineness was not appreciably influenced by skin folds, but that there was a slight tendency for the smoother sheep to have more fine fibers.

Similar results are reported by Jones, *et al. (3)*, who found slightly but significantly finer fibers in fleeces from animals of the C type, as compared to those from the B type. Other reports by Jones and co-workers *(4, 5, 6, 7, 10)* indicate no important differences in fineness between B and C type Rambouillets.

Reports by Bell, Spencer and Hardy *(1)* and by Jones, *et al (6, 7)* indicate that there is greater uniformity of fineness of fibers in the smoother types of sheep. It has been commonly observed that wool fibers on the crests of skin folds tend to be coarser than the fibers between the folds.

OTHER FACTORS RELATED TO SKIN FOLDS

Jones, *et al. (7)* state that smoother type of Rambouillet seems less susceptible to blow fly "strikes" than the more wrinkly type. This is an important factor in areas where the blow fly is prevalent.

The smoother sheep are easier to shear,, less second cuts are necessary, and there is less likelihood of cutting the skin.

Spencer, Hardy and Brandon *(11)* report that character of the fleece was a trifle higher in fleeces from smoother sheep. Character of the fleece, as judged, consisted of regularity of crimp, brightness, and evenness of distribution of yolk.

The relation of skin folds to density was studied by Spencer Hardy and Brandon *(11)* and they found that density tended to increase as the amount of skin folds increased. Density was judged by touch of the hands; that is, the judge grasped a handful of wool and estimated its density. It seems probable that greater length of staple in the smoother sheep caused the fleeces to feel less dense than they actually were.

Bell, Spencer and Hardy *(1)* found that wrinkly, excessively greasy-fleeced American Merino sheep may produce fewer wool fibers per square inch of skin area than smooth bodied sheep of the same breed, and concluded that wrinkling did not contribute to density of wool fiber.

Jones and co-workers *(3)* did not find significant weight differences between B and C type animals.

Smooth lambs have, in general, been regarded with more favor for use in the feed lot.

INHERITANCE OF SKIN FOLDS

Studies of the inheritance of skin folds have been under way at the Texas Agricultural Experiment Station for several years, and annual progress reports by Jones, *et al. (6, 7, 8, 9, 10)* indicate that there may be some dominance of the genes for freedom from skin folds and that the number of genes involved may be relatively small. The study is not yet complete, so any conclusions must be considered as tentative. However, the results seem to indicate the possibility of producing true breeding smooth animals in the Rambouillet breed.

In connection with the inheritance of skin folds, Spencer, Hardy and Brandon *(11)* found that there was a close relationship between folds on the neck and folds on the body. Rambouillet sheep in the group studied that had any appreciable number of body skin folds were almost sure to show folds on the neck. Some sheep that were smooth on the body had neck folds, but those smooth on the neck were almost sure to be smooth on the body.

LEVEL OF NUTRITION AND SKIN FOLDS

A recent preliminary report by Carter *(2)* indicates that level of nutrition may be an important factor in determining the number and size of skin folds. Two groups of 15 animals (Australian Merino) each were fed, one on a high and one on a low plane of nutrition, beginning at 6 to 8 weeks of age and continuing to one year of age. A tattooed area of skin on either side of each animal was observed, at intervals, after clipping. At 12 months of age skin wrinkles had become approximately twice as numerous and nearly five times larger in the animals maintained on a high plane of nutrition as compared to those on a low plane. These differences were also reflected clearly in the general development of folds elsewhere on the body surface, such as the neck and breech. Important variations occurred within each group.

DISCUSSION OF LITERATURE

A review of the literature indicates that the smoother type Rambouillet sheep yields approximately the same amount of clean wool as the more wrinkled type, and that this wool is as fine or finer and is longer in staple. The more wrinkled animals yield more grease wool, but this would not be an advantage if wool is sold on the basis of its real value as determined by actual shrinkage tests.

Available information also indicates that the presence or absence of skin folds is partially controlled by inheritance, and that the expression of this characteristic may be partially dependent upon plane of nutrition. The mode of inheritance has not yet been determined.

On the basis of available information, there appears to be no reason why production of high-quality fleeces cannot be obtained from smooth-bodied sheep. However, Jones and co-workers *(7)* point out that selection for lack of wrinkles by ranchmen has sometimes been followed by a reduction in wool production. Selection for one thing, to the almost complete exclusion of other points, is probably the most important reason for this result. For this reason it is important that we know more about the inheritance of skin folds and when this character can best be evaluated.

Pioneer sheepmen in Utah used sheep that were fairly smooth and which produced light fleeces. Later on, the tendency was to use wrinkly rams with heavy fleeces. Now that emphasis is being placed on a smoother type, it is important that proper breeding and selection methods be used, so that the level of wool production will be maintained.

In order to obtain additional information that could be used as a guide in selecting for smoother type sheep, the Utah Agricultural Experiment Station has been conducting a study on the college flock of Rambouillets.

MATERIAL AND METHODS

THE material used in this study was obtained from data collected in a study of the flock of Rambouillet ewes maintained at the Utah State Agricultural College. In this study photographs[3] were obtained of the sheep at four different intervals: (1) a short time after birth, (2) approximately 6 months of age, (3) just before shearing, and (4) after shearing. These photographs were collected to be used as a means of permanent identification of the individuals and to study the change in type of Rambouillet sheep at different ages. In some instances the mature ewes were photographed at older ages, depending upon their age at the time the study was initiated.

Photographs of ewes were selected to show the representative types, from smooth bodied ewes without wrinkles to the extreme type with numerous wrinkles on the body and large folds on the neck. The eight photographs shown in figure 2 were used to represent these different types of wrinkling for body folds of sheep. The scores ranged from 1 to 8 with the larger numbers indicating increased numbers of body folds. All the other photographs used in this study were then compared with the standard set and scored.

DATA AND DISCUSSION

RELATION BETWEEN DAMS AND DAUGHTERS

THE scores for skin folds of all daughters and dams used in this study are shown in table 1. The average body score of all dams is 3.8 and the average of their daughters after shearing is 4.4. This shows that in the final selection of breeding stock, ewes that were smoother than the average of the population had been retained. A positive coefficient of correlation of + .22 was found between the score for skin folds of the dams and daughters after shearing. The coefficient is not sufficiently high to be significant at the 5 percent level. The number of comparisons available was relatively small. Additional comparisons of the dams' score with the score of the daughters at birth, six months, and before shearing were also made and are shown in table 2. The relation between yearling scores and the dam and the daughter's scores at birth was found to be statistically significant, but in the other cases the coefficients only approached significance at the 5 percent level.

The coefficient of correlation of dams and daughters, based on yearling scores after shearing, with the sire held constant, is + .17. Although this is a positive correlation, it is considerably below the 5 percent level of

[3]The photographs were taken with an Eastman 5 x 7 inch view camera. The lens was approximately 11½ feet from the sheep and was 34 inches from the ground. Most of the pictures were exposed 1/50 of a second at F. 22.

Table 1. *Body scores of skin folds of Rambouillet sheep, taken from photographs*

Sheep no.	After birth	Six months	Before shearing	After shearing	Dam no.	After shearing
7034	1	2	1	2	5383	3
7048	2	2	2	3	C2823	3
7052	4	3	3	4	C1974	3
7062	4	4	4	6	8067	3
8004	1	1	1	1	5461	2
8009	2	2	1	3	3024	5
8010	2	2	1	3	7893	3
8022	4	4	3	3	7941	3
8029	2	4	4	3	8301	5
8035	3	5	5	4	5008	5
8036	3	4	4	4	5008	5
8045	4	7	5	6	8067	3
8054	6	5	5	5	5005	6
8055	–	3	1	3	7893	3
8061	3	4	4	3	2018	7
8063	2	3	1	2	5019	5
9009	1	2	1	3	C2402	4
9010	2	2	1	6	C2402	4
9015	3	2	1	5	8052	3
9023	3	4	2	6	8067	3
9028	1	3	3	5	7059	1
9036	2	4	3	6	8301	5
9043	2	3	3	5	3024	5
9050	6	6	7	7	2018	7
9051	2	3	1	3	C2823	3
9052	2	3	1	5	C2823	3
9053	5	6	4	8	5004	4
9057	3	6	5	6	7003	6
9058	1	4	5	7	C1974	3
9060	6	4	4	8	7037	6
11013	2	3	4	5	8301	5
11016	1	1	1	4	8061	3
11019	3	4	3	5	5017	7
11020	2	4	6	6	5017	7
11034	2	4	5	6	5461	2
11035	3	6	4	5	5461	2
11036	2	4	6	6	5461	2
11048	4	6	3	6	8055	3
11069	2	3	4	4	7014	5
11071	3	2	1	4	8009	3
11087	2	4	4	4	C1974	3
11099	2	4	3	5	3020	7
12002	–	2	1	4	8010	3
12017	2	–	1	3	9058	7
12023	2	–	4	4	8061	3
12024	3	–	5	5	8061	3
12027	1	–	1	2	8004	1
12030	2	–	4	4	8004	1
12031	2	–	3	3	8004	1
12045	2	–	1	3	8063	2
12054	1	–	1	4	8301	5
12084	3	–	3	4	5383	3

Table 2. *Correlation and regression coefficients between scores of dams after shearing and daughters at different periods*

Dam	Daughter											
	After shearing			Before shearing			Six months			At birth		
	r	*a*	b_{yx} with standard error	*r*	*a*	b_{yx} with standard error	*r*	*a*	b_{yx} with standard error	*r*	*a*	b_{yx} with standard error
After shearing	.223	3.68	.20±.12	.25	2.01	.25±0.14	.27	2.61	.24±.13	.32*	2.75	.44±.19

*Approaches significance. (P.=∠.05)

significance. Assuming that this figure is representative of the true relationship, then approximately 125 pairs of animals would be required for the coefficient to be highly significant, statistically. These figures indicate that there is a relationship between the number of folds on the dams and on their offspring. However, the relationship is not high and there are probably other factors which could not be measured in this study that influence the body score for wrinkles.

DIFFERENCES BETWEEN PROGENY OF RAMS

The 52 daughters used in this study were sired by 7 different rams. Two sires had only one offspring each and were left out of the comparison of rams. Five sires had four or more progeny available for study. The body score of the ram and the average of the dams and daughters are shown in table 3. Scores on the rams were obtained from photographs taken after shearing, but since several of the rams were purchased these pictures could not be taken at comparable ages. Hence sire scores, which are given for completeness, are not comparable to those of dams and daughters, either from the standpoint of age or of possible differences resulting from sex.

Table 3. *Average body scores of skin folds between progeny of rams*

Sire number	U.E.S. 459	U.E.S. 517	W.S.H. 5413	U.S.A.C. 6033	U.S.A.C. 11015
Number of daughters	9	25	6	6	4
Sire scores*	6	4	8	7	2
Average dam score	3.55	4.7	3.0	2.3	2.5
Average daughter score	3.8	4.8	4.3	5.16	3.0

*Scores on sires were taken at different ages and are not entirely comparable with each other or with the yearling scores on dams and daughters.

An analysis of variance shows no significant difference in the average body scores of daughters from the different rams used. This is accounted for, in part, by the small number of offspring from each sire.

VALUES OF SCORES AT DIFFERENT AGES

The average skin fold score of ewes at different ages is shown in table 4. With the exception of the period just before shearing, the figures indicate that there is an increase in skin folds, as indicated by the score, from birth to after shearing. The lower score just before shearing reflects the increased difficulty of determining accurately the degree of skin wrinkling at this time because of the full fleece. This condition is accentuated by any trimming of the wool as commonly practiced by most shepherds, particularly in show flocks and with sheep being prepared for sale. Ob-

Table 4. *Average skin fold score of ewes at different ages*

Item compared	Period			
	After birth	Approx. 6 months	Before shearing	After shearing
No. of sheep	50	41	52	52
Average score	2.56	3.69	2.96	4.44

viously, the best time to evaluate animals on this characteristic is just after shearing. These findings cannot be interpreted to indicate that there is a real increase in the amount of skin folds as the sheep develops, since this could only be determined by careful study of shorn animals at each stage. However, there was probably some increase in the amount of wrinkling with age, since Carter *(2)* observed increases with age in the number and size of wrinkles in marked areas on the sides of Merino sheep.

Coefficients of correlation of scores at different ages are shown in table 5. In all cases the correlations were highly significant according to Fisher's *t* test. These results indicate there is a definite relationship of body wrinkles during the interval shortly after birth until after the sheep have been sheared. This fact should be of value as an aid in selecting young sheep for breeding purposes, since the correlations are sufficiently high to indicate that progress can be made by selecting the smoother individuals at birth or at weaning time.

Table 5. *Correlation and regression coefficient of body scores at different ages*

Age / Age	Six months			Before shearing			After shearing		
	r	*a*	b_{yx} with standard error	*r*	*a*	b_{yx} with standard error	*r*	*a*	b_{yx} with standard error
After birth	.62*	0.63	.56—.12	.47*	1.48	.36—.10	.52*	0.64	.43—0.10
Six months				.75*	1.67	.63—.08	.59*	1.12	.53—.11
Before shearing							.59*	0.23	.61—.13

*Highly significant (P = .01)

Regression coefficients of scores at birth, 6 months, and before shearing on scores after shearing are also presented in table 5. These coefficients were all highly significant according to Fisher's *t* test. Using the regression formula, $Y = a + b_{yx}X$, it is possible to estimate scores

after shearing as yearlings from scores obtained at earlier periods. To obtain the yearling value, X, from an earlier value, Y, the formula is rearranged as follows:

$$X = \frac{Y - a}{b_{yx}}$$

Thus, if the score at six months is 3, one takes the necessary values for a (1.12) and b_{yx} (.53) from table 5, and the calculations are as follows:

$$X = \frac{3 - 1.12}{.53}$$

or, $X = 3.54$.

SUMMARY

A review of the available literature dealing with skin folds indicates:

1. That smoother bodied Rambouillet sheep may produce as much clean wool as do the more wrinkled types. Wrinkled sheep tend to produce more grease wool, but their wool has a higher shrinkage.

2. Wool from the smoother bodied type is equally fine, and the fineness tends to be more uniform. Wool on folds tends to be coarser than that in adjacent areas.

3. Length of staple tends to be greater on the smooth bodied type.

4. There is an indication that skin folds are inherited and that the mode of inheritance may be fairly simple. Therefore, careful selection for smoother types should be effective, and particularly so when selection of rams is based on progeny tests.

5. A high plane of nutrition appears to stimulate development of skin folds.

Analysis of data collected at the Utah Agricultural Experiment Station shows:

1. Correlation between the scores of dams after shearing with the scores of daughters after birth, at six months, before shearing, and after shearing were 0.32, 0.27, 0.25, and 0.22, respectively. Only the first of these was large enough to be statistically significant with the numbers available. When adjusted for sire differences, the correlation between dams and daughters after shearing was + 0.17.

2. There is an increase in skin folds as the sheep mature. After birth the average score was 2.6, compared with 4.4 after shearing.

3. The progenies of five rams were compared, after adjusting the scores for differences caused by dams. The differences were not large enough to be statistically significant with the numbers available for study.

4. Scores just before shearing averaged 2.96, compared to 4.44 just after shearing. Obviously, the fleece covers up folds to some extent, making the sheep appear smoother than they actually are.

5. Highly significant correlations were found between scores taken at various ages, indicating that selections at weaning, for example, should be fairly effective in segregating the smooth and wrinkled types. The score for skin folds at later ages can be estimated from scores obtained at earlier ages, using the regression formula that is presented.

The available information indicates that it is desirable to select for the smoother bodied types. While doing this careful attention should be given to fleece yields and other important characters, of course. There is evidence that skin folds are inherited, but not highly so; therefore, the rate of progress from the wrinkled to the smooth type will not be extremely rapid, even with careful selection.

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