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INHERITANCE
of
CHARACTERS IN SHEEP

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Inheritance of Characters In Sheep

This experiment was planned and the cooperation of the Federal Department at Washington secured by John A. Craig, then director of this experiment station.

It was started in 1909, the object being to produce a new breed of sheep especially suited to Oklahoma conditions.

A report of the progress of this experiment is to be found in Oklahoma Station Bulletin No. 126, by Professor S. F. Russell. The following description of type and proposed system of mating are taken from Oklahoma Bulletin No. 126.

Object

The object of this experiment is really two-fold; first, to develop a type of sheep that will be particularly suited to the climatic conditions of Oklahoma by cross-breeding Shropshires, Dorsets and Merinos; second, to study the inheritance of such characters as conformation, size, weight, growth, horns, color markings, folding of skin, fleece, time of breeding, time of lambing and prolificacy.

Description of Type

The essential characteristics to be sought in the new breeds are:

1. A desirable mutton conformation.
2. Ewes to breed freely in May and June.
3. Desirable size similar to that of Shropshire.
4. A dense, fine fleece, with excellent quality and good length.
5. Prolificacy maintained to a high degree of excellence.
6. Hornless character to be established as soon as desirable; individuals without horns occur in large numbers to make selection on that basis possible.
7. Color, while a good trade mark for types and breeds of farm animals, is at the same time of secondary importance, and selection for color should not be at the expense of form, fleece, size, early breeding and the hornless character.
8. It seems that to have a sheep without excessive folding of the skin is of much greater importance than color of face, ears, horns, legs and hoofs.

TABLE 1

Proposed System of Mating

Section 1

Shropshire
Dorset
Rambouillet

Section 2

Shropshire-Dorset
Shropshire-Rambouillet
Shropshire (Dorset-Rambouillet)
Dorset-Shropshire
Dorset-Rambouillet
Dorset (Shropshire-Rambouillet)
Rambouillet-Shropshire
Rambouillet-Dorset
Rambouillet (Shropshire-Dorset)

Section 3

Symbols:
S—Shropshire
M—Merino
D—Dorset
R—Rambouillet

(S (D-R))-(D (S-R)) = S3 D3 R2 = a
(S (D-R))-(R (S-D)) = S3 R3 D2 = b
(D (S-R))-(R (S-D)) = D3 S3 R2 = a
(D (S-R))-(R (S-D)) = D3 R3 S2 = c

Section 4

a + b = (S (D-R)-D (S-R))—(S (D-R)-R (S-D)) = S6 D5 R5 = a1
a + c = (S (D-R)-D (S-R))—(D (S-R)-R (S-D)) = D6 S5 R5 = b1
b + c = (S (D-R)-R (S-D))—(D (S-R)-R (S-D)) = R6 S5 D5 = c1

Section 5

a1 + b1 = S11 D11 R10 = X
a1 + c1 = S11 R11 D10 = Y
b1 + c1 = D11 R11 S10 = z

Section 6

x + y = S22 D21 R21 = A
x + z = D22 R21 S21 = B
y + z = R22 D21 S21 = C

In taking up this work after the bulletin was published by Professor Russell we carried on the work in much the same manner that it had been carried on in the past, using the proposed systems of mating found in Station Bulletin 126.

The conclusions drawn in this last publication are drawn from a study of the entire number of sheep used in this experiment, rechecking the figures used by Mr. Russell in his publication. We believe that it is necessary to publish this experiment entire at this time because the conclusions reached by Mr. Russell were all subject to change on further study. So our general conclusions at the end of this bulletin are reached without regard to the con-

clusions issued in the former publication and after a study of all the sheep used in this experiment since its beginning.

Any sheep showing folds to any marked extent does to a certain degree lack the compact mutton conformation because of the predominance of the fine wool characters. According to our data and observation of the flock, it is difficult to obtain the desired fineness of fleece without at the same time getting the undesirable feature of folds.

It has been noticed in the D-M or M-D cross of 42 animals only 8 were smooth, 24 had folds at neck, 10 showed looseness and 8 were wrinkled all over the body. The M-S or S-M cross showed but two smooth sheep out of 24, 15 had folds at neck and 5 were wrinkled all over.

The M (S-D) cross had 2 smooth animals out of 24. Twelve had folds at neck and 7 had folds all over.

S (M-D) 44 animals showed 21 animals smooth and 14 had folds at neck.

The C cross had 5 smooth out of 12 animals, B had 7 and A had 10 out of 12 animals.

The A cross had less of the fine wool blood than either of the other crosses while C had the most concentration of this blood.

The horned character will be hard to overcome and breed out because as a rule this character is dominant except when crossed with the Shropshire. The Dorsets have horns in both sexes and the Merino in the ram.

There were 43 sheep of the D-S or S-D cross and 36 were without horns. Seven had horns. The hornless character of the Shropshire is incompletely dominant over the horns of the Dorset. The (S-D) or (D-S) had 2 sheep and both have horns. This is a small number but there is a greater concen-- tration of Shropshire blood than in the former cross.

The D (D(S-D)) cross showed that out of three animals all three had horns. Seventeen of the D (S-M) cross show 10 with horns and 7 without. Of 25 M (S-D) or M (D-S) 20 had horns and 5 did not. The latter is significant because it is a higher percentage than in the D (S-M) cross.

Of the A, B and C cross each had eight animals with horns and four without. The concentration of Dorset blood is different in each of these crosses, but the horns are the same in each.

The value of this is questionable because the data on rams and ewes is combined, and we do not know which sex was horned.

It can be seen from the foregoing table that the horned character appears recessive at times at least.* When the Dorset blood is present to any considerable concentration the horns are present in at least a percentage of the offspring.

It will be remembered that the object for having the Dorsets in this experiment is on account of their early breeding qualities.

Our data shows that the percentage of fall lambs in the Dorset breed was 30.7, and the Merino 56.25.

The S-D cross had 39.2% fall lambs. The D (D-S) had 25% fall. The S-D cross had a higher percentage of fall lambs than the Dorset purebreds. The D (D-S) had a smaller percentage than either the Dorset or S-D. Thirty-

*Evolution, Variation and Heredity, R. H. Locke.

nine lambs were born from M-D or D-M cross and 60% of them were fall lambs. This is in line with what might be expected but 27 S-M or M-S had a percentage of 63 for fall lambs. The Shropshire is a late breeding sheep, therefore this result is hardly what would be expected.

The poor showing of the Dorset may be attributed in part to the lack of proper feeding, that is green feed or flushing during the early breeding season. It will also be seen later that the Dorset breeds early but the percentage of lambs is small in this breed as compared to the others.

The early breeding of the Dorsets at this station have not come up to expectations or as high as some of the others. This early breeding of the Dorsets is more of an individual matter than a breed characteristic. As is shown elsewhere, a very high percentage of the ewes that are born in the fall will produce fall lambs.

Data on Time of Breeding

This has nothing to do with lambing as many of the services noted below failed to impregnate the ewe. It will be noticed in studying this data in connection with the one on lambing that the figures do not necessarily correspond. There were about 57% of the Dorsets recorded here that took the ram early enough to produce fall lambs while only 30.7% of them actually produced fall lambs. This is in line with what has been published concerning this before. The Dorsets show a large percentage of ewes breeding early but a low percentage of them producing fall lambs. This can be explained only by the fact that the ewes do not get with lamb on the first service and oftentimes not until the third or fourth.

In this discussion we have divided the time of breeding for fall and spring lambs at the period ending August 7. All matings before this are in time for fall lambs, all after are for spring lambs. According to this division there were about 60% of the Rambouillet ewes taking the ram during the early months or for fall lambs. Referring to data on time of lambing it will be seen that 54% produced fall lambs, a good deal better showing than the Dorset.

Sixty-two percent of the Merino ewes bred before August 7th. Of these 56.2% brought fall lambs. This is about the same results as shown by the Rambouillet, and is a very good percentage of lambs as compared to ewes bred.

Of the cross breds, the S-M or M-S cross showed 74% of the ewes breeding before August 7. This is a larger percentage than the purebred Merino. The Shropshire is notably a late breeding sheep, therefore we would naturally expect the S-M cross to show a smaller percent of early breeding ewes. This high percentage includes 25 ewes and is unexplainable from our records. This same cross showed 65% of fall lambs.

Both the D-S and S-D cross showed 56.4% of the ewes breeding before August 7th. This is about what would be expected as it is somewhat less than the purebred Dorsets. The percentage of fall lambs in this cross is something around 32, slightly more than the purebred Dorset.

The A cross showed 50% breeding before and 50% breeding after August 7th, but only 14.3% of them produced fall lambs.

We are comparatively safe according to the preceding data in concluding that this character of early breeding does not follow Mendel's law of Variation,* also that there is nothing definite about its inheritance at all.

The S-M cross had a higher percentage than any of the other crosses or purebreds.

The A cross which is nearest the proposed goal in this cross-breeding showed only 50% of ewes breeding early and 14.3% produced fall lambs.

No attempt is made to explain the failure of the ewes bred in the fall to conceive.

The following is inserted as a matter of interest mainly because there is no mention of a study of the inheritance of this particular character in the experiment proper. It is interesting, however, to study inheritance of prolificacy in connection with early breeding and also from the standpoint of transmission of said character.

The number of Dorset ewes recorded in this work is 75. These ewes produced 107 lambs or a prolificacy of 142.7%. This includes a large number of ewes and is carried over a number of years. Considering the length of time covered this is a very good percentage.

The Merino show a prolificacy of 123.5% for 17 ewes.

The D-M or M-D cross shows a percentage of 166⅔ for 30 ewes. This is larger than either of the purebred. This is very desirable of course, but we cannot say this character is following a certain line of inheritance laws. Whether this increase is directly traceable to this cross or just happened is not known.

The D (D-M) or D (M-D) shows 150% prolificacy and 122% including all Shropshires ever used in this experiment.

The S-M or M-S shows only 103% with 27 ewes. If this would follow the same laws or course as the D-M or M-D cross we might expect a larger percentage than either of the purebreds. At least we would expect as much as either of the purebreds. This low figure cannot be attributed to the Shropshire because in crossing Shropshire with Dorsets we get a prolificacy of 153.3%.

We cannot make a general statement that the cross-breds are more prolific than the purebred. This is not true of M-S or S-M cross nor the S (M-D) or S (D-M). This cross had a percentage of 120 while the M (S-D) or M (D-S) showed only 111%.

The A cross which is the farthest we have gone in our proposed matings with ewes old enough to breed, showed a percentage of 112.5. This was on 8 ewes only and might increase if the number were larger. At present, however, it is a little discouraging.

From the figures recorded we are unable to see where this character follows the Mendelian ratio and we are unable to figure out any ratio that certain crosses will follow.

*Variation, Heredity and Evolution, by R. H. Locke, Chapter VII.

The variation is large and no direct connection can be found between this variation and the method of crossing.

Average Weight of Lamb at Birth

Our data shows that the R (S-D) cross breed is the largest when born. This is, however, on such a small number averaged that it is not at all conclusive.

The Merino purebred gives a surprising result when we see that the average weight at birth is 10.15 pounds.

The average weight of 39 Shropshire lambs was 8.86 while 28 S-M or M-S showed an average weight of 9.22 pounds at birth. This seems to show that the Merino raises the average weight of the Shropshire at birth when crossed with them.

The average weigh of 110 Dorsets was 8.37 pounds, a very good average for such a large number of lambs. 50 lambs of the D-M cross averaged 7.51 pounds at birth, which is considerably less than either of the original purebreds.

The D-S or S-D cross had an average for 23 lambs of 8.54 pounds which is a moderate size for lambs and mid-way between weights of Shropshire and Dorset. When the three breeds were combined the size seemed to decrease with the exception of the S (M-D). Thirty-one lambs of this cross had an average weight of 9.06. The M (S-D) 10 lambs averaged 7.625, 16 D (S-M) averaged 7.31. In this case the Shropshire on top seemed to add size that was not present in the other crosses.

In comparing the A, B and C crosses we find 9 of the A cross averaged 8.32, 7 of the C cross averaged 9.3 and 8 of the B cross averaged 8.625.

The size of the ewe may to a certain extent determine the size of the lambs at birth. However, the weights of the various combination of breeds are hardly what we might expect. The size of lambs at birth as shown later will not necessarily determine the size of the mature sheep.

Weight of Lambs at 6 Months of Age

The weights given below are more in accordance with the mature size than the weights at birth.

Of the purebreds, the Dorsets were largest. Thirty-eight Dorsets had an average weight of 97.8 pounds. Eleven Shropshires averaged 94.3 pounds. All of the breeds and cross breds, excepting the A, B and C crosses were about the relative size that would be expected. The A cross averaged 78 for 12 animals, the B cross averaged 54.4 for 12 animals, and the C cross averaged 60 for 12 animals. This is not at all satisfactory when we remember that these last crosses are nearing our goal of proposed matings.

There is an idea prevalent in some sections at least, that the first cross in any kind of livestock, providing the breeds are of the same type, will result in an animal superior to either of its parents. This does not hold true in all crosses according to our data. The S-D or D-S was smaller than either of the purebreds at 6 months of age. This should not be taken as absolute

proof as there were a comparatively small number of animals included but it is representative of the results obtained at this station.

Color

The color markings of sheep are not of the material value that some of the other characters studied in this test are; however, a dark faced sheep meets a stronger demand on the market than a white faced sheep. It is desirable to have black faces on our crosses but this is not as important as form, horns, etc., therefore, it has not received the attention of the other characters. It was deemed more important to produce mutton type and develop the black face later.

The S-D or D-S cross followed what has been said of this cross before. The Shropshire is a dark brown at the extremities and the Dorset is white. None of the F1 generation had a white face. Sixteen were brown and eleven mottled. The D (S-D) or (D-S) showed about the same color as the F1 generation with a slightly larger percentage of grays. The S (S-D) or S (D-S) had only two animals and had gray brown faces.

The A cross showed one white face and the others were all a combination of black and white. The C crossbreds were half white and one fourth white-brown. All of these advanced crosses were well removed from the desirable dark color.

The color of legs corresponded fairly closely to the color of face.

The color of face and legs showed no dominance of any color but rather an intermediate condition.

Wool

The data taken on wool each year was practically complete. This is necessary because the inheritance can be studied from the standpoint of weight of fleece, fineness of fiber, amount of yolk, etc. There were a few fleeces missed occasionally because of lost ear tags and marks of identification, but with these few exceptions every year at shearing time the fleece from each was weighed and the weight carefully recorded. At shearing time the density of the entire fleece was also estimated and recorded. The terms used in this estimate are: Excellent, good, medium, fair, and open.

When we tried to get an average of the density of the breeds and crossbreds it was impossible because of the terms used. Accordingly we changed this system and are now using numbers instead of words. Number 1 is used instead of excellent, 2 for good, 3 medium, 4 fair and 5 open. By this system we can easily get an average of the numbers and will thus have the relative density of the fleece within any given breed or crossbred.

In addition to this we recorded the covering of fleece on the face, ears, fore legs, hind legs and belly. The terms used here were complete, good, fair, scant and bare. Here again we substituted the numbers, 1, 2, 3, 4, and 5 for the words.

Weight, Density and Covering of Fleece

In our work of the pure breds the Dorset is the lowest in every respect. The Dorset is known and often criticized for its poor wool covering. The computed weight for 365 days was 6.613 pounds. This was a little below what could be expected in the Dorset as a rule.

The Rambouillet and Merino are both wool breeds and are very similar in fleece covering. The Rambouillet averaged 18.5 pounds and the Merino 17.23 for 365 days growth. The heavier weight of the Rambouillet fleece is due primarily to the size of the sheep rather than density of fleece.

The average on covering was 1.554 for the Rambouillet and 2.2 for the Merino. This is hardly what would be expected as the Merino is very well covered as a rule. The density of the fleece, however, was greater in the Merino, being 1.36 while it was only 1.47 in the Rambouillet.

The Shropshire is a medium wool breed, having fair density but is very completely covered. The average weight for the Shropshire was 9.08 for a period of 365 days, only a fair average for Shropshire. The density is shown as 2.9 or just fair while the average of the covering is 2.31, just a little less than the Merino.

The S-M or M-S cross had 24 sheep cutting the first fleece with an average computed weight for 365 days of 12.52 pounds. This is a decided increase in weight of fleece over the purebred Shropshire. The average density of this cross was 2.16. Almost an average of the Shropshire and Merino density. The average covering is 2.256. The Merino is 2.2 and Shropshire is 2.31. It will be seen that in every respect the S-M or M-S crossbred is middle way between the purebreds in fleece covering.

The D-S or S-D crossbreds have an average fleece weight of 8.47 pounds for 365 days. This is a material increase over the average of the pure bred Dorset. The density of this cross was 2.9, the same as that of the purebred Shropshire.

The D-M or M-D cross averaged 9.53 pounds for 365 days, an increase of 3 pounds over the purebred Dorsets. The average density was 2.33. This is nearer the density of the Merino than of the Dorset. The average fleece covering was 3.1 or half way between the purebreds.

The M (M-S) or M (S-M) had an average weight of 7.3 pounds for 365 days with an average density of 3 and a covering of 2.6. This was not as good as the fleece shown by the S-M or M-S cross. There were 25 sheep representing the D (S-D) or D (D-S) cross and showing an average weight for 365 days of 8.6, a little increase over the D-S or S-D cross. The S (S-D) or S (D-S) showed 11.2 pounds for 365 days with a density of 2 and fleece covering of 3. This is a greater weight and density than the purebred Shropshire.

The C cross had an average fleece weight of 7.32 pounds for 365 days, an average density of 3 and an average covering of 2.6. The B cross averaged 8.2 pounds fleece weight for 365 days, showed an average density of 4 and an average fleece covering of 3. The A cross had an average weight of

8.91 pounds for 365 days, an average density of 2.75 and a fleece covering of 2.75.

The lack of weight of fleece in these various crosses can be attributed in part to the lack of size of the sheep. It will be noticed that the C cross has a density of 3, or less than the Shropshire, and the B cross has a density of only 4. The A cross had a density and fleece covering of 2.75, or a little in advance of the Shropshire.

The density and fleece covering appeared to be dominant over lack of covering and open fleece in the first cross. This can be seen by studying the S-M, D-S and D-M crosses. After the first cross the density was not as certain but appeared in some crosses at least to break into a 3-1 ratio. Three sheep showed density and 1 showed a loose fleece. On the whole the latter crosses are not as satisfactory as we might expect from results obtained in the first cross. There has been no improvement in our A, B and C crosses as to weight, density or covering. In the B and C crosses especially there is a deterioration in this respect as compared to the purebred Shropshire.

The density of fleece on our crossbreds as mentioned in the object of this experiment are far from realization at present.

At shearing time in addition to taking the samples to be used in measuring the fineness, amount of crimp and stretch there is a sample taken from the rib. This is divided into two equal parts and placed in small envelopes bearing the ear tag number of the sheep, shearing date and labeled sample A and Sample B. The samples are used in determining the moisture content and amount of yolk and foreign material in the fleece.

Method of Calculation

Percentage moisture $= W^1\ W^2 \times 100 \div W$.
Percentage shrink (excluding moisture) $= W^2\text{-}W^3 \times 100 \div W$.
Percentage shrink (including moisture) $= W^1\text{-}W^3 \times 100 \div W$.
$W^1 - W^2$ = weight of moisture lost
$W^2 - W^3$ = weight of yolk and foreign matter lost
$W^1 - W^3$ = weight of total loss in moisture, yolk and foreign matter

Method of Procedure

A convenient sized sample of wool is taken and carefully weighed to the third decimal or chemical balances and placed in an electric vacuum oven for at least two hours and oftentimes longer.

The weight of the normal sample of wool is that referred to as W^1 and the weight after the first heating or drying as W^2. The difference between these two weights is the moisture content.

Formula	Scouring Method		
Solution formula	Washings	Temperature	Time
Cistern water	No. 1 Scouring solution	55°	15 min.
2 liters			
Soda Ash (NA2 CO_3) 25 gms	No. 2 Water (cistern)	50°	5 min.
Soap (Ivory laundry) 15 gms	No. 3 Water (cistern)	40°	5 min.

The samples used in determining moisture content are securely fastened on an endless cloth belt and are so marked that the fleece number is kept straight. This endless belt is then slowly moved through the above mentioned solutions for the stated time. There is some wool lost in this process but not enough to unbalance the results, especially considering that the error is almost equal in every sample.

When the scouring is finished the samples are removed and placed in the oven until completely dry which takes several hours and are then taken out, placed in a desicator and allowed to cool. When they have become cool they are weighed. This weighing is that referred to as W^3. From these weights it is possible to calculate all we need to know concerning the scouring qualities of the fleece.

It is a well known fact that the finer the texture of wool the more yolk there is present and as a rule more foreign matter because dust in particular clings to the wool grease.

The scouring percentage or percentage of shrink in this work may not compare favorably with that given for the various breeds. It is practically impossible where such a small sample of wool is scoured to get the definite results we might expect when thousands of fleeces are scoured. The loss of a very small particle of wool would in this case effect the results materially. The loss of any wool in the scouring was prevented as nearly as possible and theoretically at least the possible error is the same in all the samples. Therefore, even though the percentage for the breeds may not be just what it should be the same process was used on them all and we can draw a direct comparison between the various breeds and crossbreds which will be fairly accurate. This is our main purpose as we wish to determine the inheritance of the various characters.

This work was not all kept up to date and some of the samples were old before they were scoured. This would give different results from those when the wool was freshly clipped. Here again all the breeds represented had the same treatment and the relationship between them would be the same. The amount of yolk present in a fleece will to a certain extent depend on the care and feeding of the sheep and the amount of dirt and foreign material varies a great deal, depending to a large extent on the way the sheep are fed.

When the variability of foreign material is considered, it will be readily seen that the scouring percentage may vary from what is expected and this variance is not due to inheritance of fine wool but rather due to the carelessness of the feeder.

The percentage of moisture was also taken up and compared. This factor is not of as much importance as the yolk and foreign matter and will vary somewhat in this test due to the length of time the fleece has been kept before the scouring was done.

The Shropshire produced a wool that was a good deal more dense and carried more yolk than that of the Dorset. The Dorset is notably a loose dry fleeced sheep. The Shropshire in this work had an average shrink of 46.520 percent on twenty-two trials. The Dorset on sixty-eight trials averaged 45.427.

According to what has been said of the fineness of wool and its scouring qualities we might expect the Shropshire fleece to show more shrink than that of the Dorset. This might be explained by the fact that although the Dorset fleece is low in yolk content it is extremely high in dirt and foreign materials because of this looseness and dryness of fleece. It does not exclude dirt as it would if it were denser and carried more yolk.

The purebred Rambouillets showed a shrink in scouring of 54.996 percent on ten trials. This was about what might be expected considering that the Rambouillet is a fine wool sheep.

The S-D cross had 35 individuals and showed a shrinkage of 44.667 percent. This was less than either of the purebreds but was close enough, varying only one percent, that there was nothing of a marked degree showing the tendency of this character of fine compact fleece. The D-S cross having seven trials showed something that was a good deal more interesting, a shrinkage of 37.949. This was less than either of the purebreds. In the F^1 generation the ram seems to have a little more influence on wool than the ewe.

The S-M and M-S crosses both had a shrinkage of around 52 percent as did also the M-D cross. The D-M cross, however, showed a shrink of only 40.14 percent. This again appears as though the Dorset ram had considerable influence even when crossed with Merino ewes.

The D (S-D) cross had a shrinkage of 42.762 percent. The D (D-M) cross had a shrink of 42.454. It here appeard that the Merino when not present in more than 25 percent had very little influence on the scouring qualities of the wool. The D (M-D) had a little the advantage, scouring 44 percent loss. The D (S-M) cross and the D (M-S) cross shrank a little more than when there was a double cross of the Dorset.

The S (D-M) cross loses 48.484 percent in scouring and the M (S-D) cross loses only 43.13 percent. We might ordinarily expect about the same amount of shrink in this cross as was found in the S-M or M-D crosses. This, however, was not true.

The D (D (S-D)) cross carrying a very large percentage of Dorset blood (87.5%) had a shrinkage about the same as that of the Dorset—41.37. The D-S (S (M-D)) had a shrinkage of 44.338 percent.

It will be noted that when the fine wooled breeds were used in this crossing the F^1 generation showed that the fine wooled blood had a marked influence on the scouring qualities of the wool. There was such a variety of characters studied in this test that we could not follow the breeding for fine wool to the exclusion of all other characters. However, from the results obtained so far the fixing of this character would be fairly easy of accomplishment. The tendency to the fine wool characteristics was very noticeable when there was as much as one-third of the blood coming from the fine wool.

Mr. D. A. Spencer of the Sheep Division, Bureau of Animal Industry, Department of Agriculture, Washington, D. C., consented to select some samples of wool showing the Bradford count as used for designating the fineness of wool on the English market. The Bradford count is a system of figures designating the number of hanks (560 yards) a pound of combed

wool will spin when spun to capacity. The larger numbers designate the finest wools.

This was not substituted entirely for our measurement work but gave us an easy means of determining the comparative fineness of the fleece obtained from sheep used in this experiment.

A sample of the fleece was obtained at shearing time and closely compared to our samples showing the count, and the count was thus determined.

This work was not carried on before this year, therefore the results given in our work are for the 1921 fleece only. The figures given below are averages of all the fleeces, therefore the numbers will not correspond to the numbers used in the Bradford system.

It showed that the Dorset had the coarsest wool, grading only 43 which was rather low on the whole for Dorsets. The Shropshire graded 47.3. This again was a little below what we had a right to expect from the Shropshire. The Rambouillet, a fine wool sheep, graded 63.*

The S-D cross, the first cross made in this test, had a fleece average of 47 for 1921. This was a good deal more like the Shropshire than it was like the Dorset. The S-M cross graded 54. The D-R cross showed a grade of 58. The D (S-M) and D (M-S) both averaged a little better than the purebred Shropshire.

The S (D-M) averaged 47 and S (M-D) 49, being practically the same grade as when the Dorset was the top cross. The R (S-D) graded 56, a considerable improvement over Dorset and Shropshire purebreds.

The A cross graded 48, the B 50 and the C 52.

Our prediction that the sire has more influence than the dam in the F generation as far as wool is concerned seems to be disproved. Rather from the preceding we would be more justified in saying that the fine wool of the Rambouillet and Merino is partially dominant over the coarser wools of the Shropshire and Dorset. Here again we can say what was said following the table on scouring percentage; namely, the character of finer wool could be fixed with a fair degree of ease because where as much as one-third of the blood comes from a fine wooled breed the tendency is strongly in favor of fine wool. The A, B and C crosses showed an improvement over the Dorset and Shropshire in this respect for the first time in all of the characters so far discussed. The actual measurements of the fibers will serve as a check on this and will follow in this bulletin.

Length and Stretch of Fiber

At shearing time a sample of wool was taken from the shoulder, one from the rib, and one from the thigh. Three sample fibers were taken from each of the three main samples. These were measured in crimp then stretched and measured again. The average length of shoulder fiber in crimp and stretched was determined and also the average for rib and thigh samples.

These data were taken on every individual fleece and the number given here are average of all the individuals in that particular breed or cross.

*These figures are the average for all fleeces, therefore they will not necessarily correspond to "counts" ordinarily used.

The first thing to be noted is that the purebred Dorset fleece was shorter in crimp than the crossbred fleece M-D. This is unexpected as the Merino has a very short staple as compared to the medium wool breeds. This was probably due to the fact that many of the fleeces averaged with the Dorset are those coming from lambs. The cross D-M was shorter than the pure Dorsets and was more what might be expected in that respect than the M-D cross, but the percentage of stretch of both these crosses is less than the stretch of the pure Dorset.

The measurements of Shropshire showed some greater length in crimp than did the Dorset. Due in part perhaps that there were very few sheep clipped under one year of age. The percentage of stretch was very high in the Shropshire, averaging 73.64%. This was higher than the Rambouillet, a fine wool breed.

The crossbred S-D had a stretch of only 41.30%, a good deal less than either of the purebreds. There were 30 animals or fleeces averaged in this cross and the results should be fairly accurate. The crossbred D-S showed a stretch of 62.89 more what we might expect but there were only four (4) animals averaged in this result so it would be hardly as reliable as the first one mentioned.

The stretch of fiber to a certain extent corresponds closely to the amount or number or crimp. Our work would indicate that this particular character was not strongly transmitted by the fine wooled breeds. We might even say from the results shown that stretch does not behave at all in the manner of unit characters. The only explanation we could possibly offer if this is a definite transmissable character is that some crosses offer an especially favorable combination while other crosses are directly opposite. This explanation is necessary when we see that some crosses fall far below the lowest of the parents and again some crosses show much more stretch than the best of the parents. We might expect that the S-D cross is a very poor combination in this respect while the D-S cross is much more desirable.

Summary

1. The fineness and factors influencing weight of fleece appear to blend.
2. Smooth skin and folds blend with a slight tendency to folds in first cross.
3. The fineness of wool and folds seem to go together in inheritance.
4. A dark face in this system cannot be obtained without Shropshire blood predominating.
5. The early breeding character is not common to all Dorsets but appears partially dominant over late breeding when the Dorsets are selected for this character.
6. Mutton and wool conformation tend to blend with mutton predominating in first cross.
7. The polled character of Shropshire is incompletely dominant over horns of Dorset. Horns appear more often on rams than on ewes.
8. Fleece covering is dominant over bareness.
9. Color markings of sheep blend. A black and white produce a mottled face in F^1 generation.