4-1-1921

Bulletin No. 127 - Studies in the Variation and Correlation of Fleeces from Range Sheep

University of Wyoming Agricultural Experiment Station

Follow this and additional works at: http://repository.uwyo.edu/ag_exp_stabulletins

Part of the Agriculture Commons

Publication Information

University of Wyoming Agricultural Experiment Station (1921). "Bulletin No. 127 - Studies in the Variation and Correlation of Fleeces from Range Sheep." University of Wyoming Agricultural Experiment Station Bulletin 127, 37-52.

This Full Issue is brought to you for free and open access by the Agricultural Experiment Station at Wyoming Scholars Repository. It has been accepted for inclusion in Wyoming Agricultural Experiment Station Bulletins by an authorized administrator of Wyoming Scholars Repository. For more information, please contact scholcom@uwyo.edu.
WORK IN THE CULLING CHUTE

STUDIES IN THE VARIATION AND CORRELATION OF FLEECE FROM RANGE SHEEP

Bulletins will be sent free upon request
Address: Director of Experiment Station, Laramie, Wyoming
UNIVERSITY OF WYOMING
Agricultural Experiment Station
LARAMIE, WYOMING

BOARD OF TRUSTEES

Officers
ALEXANDER B. HAMILTON........................................... President
W. C. DEMING................................................................. Vice President
FRED W. GEDDES............................................................. Treasurer
E. P. JOHNSON................................................................. Acting Secretary

Executive Committee
A. B. HAMILTON............................................................. FRED W. GEDDES
DEAN PROSSER

Members

Term
Appointed
Expires

1911 ALEXANDER B. HAMILTON, M. D. 1923
1911 LYMAN H. BROOKS 1923
1913 CHARLES S. BEACH, B. S. 1923
1914 MARY N. BROOKS 1923
1919 E. W. CROFT, M. D. 1925
1919 W. C. DEMING, M. A. 1925
1921 FRED W. GEDDES 1927
1921 DEAN PROSSER, B. A. 1927
1921 J. A. ELLIOTT, B. S. 1927
KATHARINE A. MORTON, State Superintendent of Public Instruction
Ex Officio
A. NELSON, Ph. D. Ex Officio

STATION STAFF

A. NELSON, Ph. D. ............................................ President
A. D. FAVILLE, M. S. ............................................ Director
E. P. JOHNSON .......................................................... Secretary
H. P. K. AGERSBORG, M. A. .................................. Assistant Parasitologist
O. A. BEATH, M. A. ............................................ Station Chemist
D. E. CABLE, M. S. ............................................ Assistant Chemist
A. T. CUNDY, A. R. C. Sc .................................. Assistant Chemist
C. ELDER, D. V. M. ............................................ Assistant Veterinarian
F. A. HAYS, Ph. D. ............................................. Associate Animal Husbandman
F. E. HEPNER, M. S. ............................................ Assistant Chemist
J. A. HILL, B. S. ............................................. Wool Specialist
E. H. LEHNERT, D. V. S ...................................... Veterinarian
P. T. MILLER, M. A. ............................................ Associate Station Chemist
J. C. OVERPECK, M. A. ........................................ Assistant Agronomist
*J. P. POOLE, A. M. ............................................ Botanist and Horticulturist
J. W. SCOTT, Ph. D.................................................. Parasitologist
A. F. VASS, M. S.................................................. Associate Agronomist
MARION V. HIGGINS ............................................ Librarian
VICTORIA BUTTERY ............................................... Clerk

*On leave.
Studies in the Variation and Correlation of Fleeces from Range Sheep*

J. A. HILL

INTRODUCTION

In those branches of animal husbandry concerned with the production of milk and eggs it has been found both by practical managers and scientific investigators, that a great many herds and flocks contain individuals which are losing money for their owner every day he keeps them. It has also been a matter of common observation that in the large bands of ewes that are ordinarily run on the range many individuals are far below the average in wool production. However, no investigations have been published dealing with the following problems which must be answered before it can be known whether or not culling methods, similar to those used in dealing with poultry and dairy cattle, may be applied with profit to range sheep. The problems are: (1) How much is the variation in wool production of the individuals within the flock? (2) What is the correlation between the fleece produced by a sheep one year and those produced by the same sheep in the years following? (3) How accurately is it possible to judge the value of a fleece while it is still on the sheep?

THE VARIABILITY IN THE WEIGHT OF FLEECES PRODUCED BY RANGE SHEEP

As already suggested, this investigation was undertaken for the purpose of determining how the fleeces of range flocks vary in weight. To this end, a study of the fleece weights was made in six

*Papers from the Wool Laboratory of the University of Wyoming Experiment Station—No. 7. During the absence of the Wool Specialist, the following papers from the wool laboratory were published without a serial number:


There are still copies of all these papers of the series available for distribution to libraries and investigators.
bands of range sheep during the shearing season of 1920. The following is a description of the sheep:

*Flock “A”.* Cross-bred yearlings ranged in Natrona and Fremont Counties. Nearly all their wool would go into the half-blood or three-eighths blood grades.

*Flock “B.”* Cross-bred dry ewes owned by same man as Flock “A” and ranged in the same district. The wool graded about 65 per cent half-blood and the remainder three-eights with a sprinkling of quarter-blood. Being “drys” they were in better flesh than ewes with lambs, but otherwise, they were similar in age and breeding to the ewe flocks from which they had been separated on account of having no lambs.

*Flock “C”.* A mixture of cross-bred ewes and high-grade Rambouillets all with lambs by their side. They were ranged in northeastern Natrona County. The greater part of their wool was half and three-eighths blood, but there were also comparatively large amounts of fine and fine medium staple and clothing wool in the clip.

*Flock “D”.* Cross-bred ewes that had lambs. They were ranged in southern Natrona County. The wool was mostly half and three-eighths blood.

*Flock “E”.* Although owned by a different man, this flock was bred about the same as Flock “D” and was ranged in the same section of Natrona County.

*Flock “F”.* Rambouillet ewes that had lambs. These sheep were for all practical purposes pure-bred Rambouillets. Many of them were eligible for registry. They were ranged in Albany County. The wool was fine and fine medium combing and clothing, with an occasional fleece of half blood.

All the Natrona County sheep contained more or less blood of the English Down breeds as was shown by the sprinkling of black faces in the first five flocks. Yet, by far the greatest proportion of the blood was Cotswold and Rambouillet crossed back and forth to keep the sheep resembling half-breeds in the character of their fleeces.

The study of the weight of fleeces in these flocks was made at the time of shearing which was in June. The Natrona County
sheep were sheared with hand shears and those in Albany County by machine clippers.

The scales used for weighing the fleeces were ordinary cheap spring balances such as are sold for household use. One hundred fleeces were weighed from each flock. Weighing was not begun in a flock until the shearers had been at work on it an hour or more, because the fleeces that are first sheared after the pens are newly filled are generally lighter than the average of the flock, and those sheared when all the pens are being finished, are generally heavier than the average. After the weighings started, all the fleeces were weighed in the order in which they came to the sackers or graders, as the case might be. No effort was made to get the tyers to take particular pains to get all the wool into the fleece to which it belonged. They were just ordinary everyday fleeces such as are being sacked day after day during the shearing season at pens throughout the range country.

The weights were recorded to the nearest half pound, but it was found that this made unwieldy tables and for this reason, the weights were regrouped so as to tabulate them in groups with centers on the nearest pound. This was accomplished by dividing the half-pound groups equally between the pound groups on either side. If the half-pound group had an odd number of fleeces in it, the extra fleece was placed in the group that was on the side nearest the mean. Thus, if there were 3 fleeces recorded as weighing 4½ pounds, in regrouping them, one would be called a 4-pound fleece and two of them 5-pound fleeces. This process did not change the average weight of fleece in any flock by one-tenth of a pound.

Table I shows the frequency distribution of the weights of one hundred fleeces from each of these flocks after the original weights had been regrouped. From this table was calculated the mean, the standard deviation and the coefficient of variation for each of these flocks. These frequency constants are shown in Table II. It is worth noting that the average weight of six hundred fleeces is 8.4 pounds, while the average weight of fleeces for this state was estimated by the U. S. Department of Agriculture as being 8.3 pounds for 1920.
TABLE I

Frequency distributions of the annual fleece weight of range sheep, as found in samples of 100 from each flock.

<table>
<thead>
<tr>
<th>Weight to nearest pound</th>
<th>Flock “A”</th>
<th>Flock “B”</th>
<th>Flock “C”</th>
<th>Flock “D”</th>
<th>Flock “E”</th>
<th>Flock “F”</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>1</td>
<td>2</td>
<td>23</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>12</td>
<td>7</td>
<td>35</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>14</td>
<td>17</td>
<td>9</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>21</td>
<td>17</td>
<td>2</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>22</td>
<td>17</td>
<td>1</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>6</td>
<td>17</td>
<td>2</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>13</td>
<td>17</td>
<td>1</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>2</td>
</tr>
</tbody>
</table>

Some idea of how the variability in wool production compares with the variability in the production of milk and eggs may be obtained by comparing the coefficients of variation as shown in the last column of Table II with the coefficients of variation found by investigators of the Maine Experiment Station* for milk production by pure-bred Jersey cows and egg production by pure-bred Plymouth Rock hens. The correlation coefficients may be set out as follows:

- Egg production, pure-bred Plymouth Rocks........... 34.21 ± .37
- Milk production, pure-bred Jersey cows............. 25.56 ± .31

Wool Production:

- Highest Variation—Flock “C” (badly mixed)........... 21.96 ± 1.10
- Lowest Variation—Flock “F” (pure-bred Ram-bouillets)................................................. 15.15 ± .74
- Average of Table II.................................................. 17.92 ± .89

The probable errors of the coefficients for wool are rather high, with an average value of ± .89 but still not so high as seriously to impair their value as a measure of the variability of wool production. Flock “C” with the highest variation as indicated by a coefficient of variation of 21.96 ± 1.10 is the flock made up of

April, 1921  Studies of Fleeces from Range Sheep

TABLE II
Statistical constants of the annual fleece weight of range ewes calculated from Table I.

<table>
<thead>
<tr>
<th>FLOCK</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>6.30±.08</td>
<td>1.23±.06</td>
<td>19.53±.97</td>
</tr>
<tr>
<td>&quot;B&quot;</td>
<td>7.86±.09</td>
<td>1.39±.06</td>
<td>16.54±.81</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>8.79±.13</td>
<td>1.93±.09</td>
<td>21.96±.10</td>
</tr>
<tr>
<td>&quot;D&quot;</td>
<td>7.07±.08</td>
<td>1.15±.05</td>
<td>16.27±.80</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>7.79±.10</td>
<td>1.41±.07</td>
<td>18.10±.89</td>
</tr>
<tr>
<td>&quot;F&quot;</td>
<td>12.61±.13</td>
<td>1.91±.09</td>
<td>15.15±.74</td>
</tr>
</tbody>
</table>

two distinct types of sheep. Flock "F" with the lowest coefficient of variation, 15.15±.74 was the one that was nearly all purebred Rambouillets. Yet, in spite of the good breeding, there is still a wide variation in the amount of wool produced by the individuals of this flock as is shown by the difference between 8 pounds, the weight of the lightest, and 18 pounds, the weight of the heaviest fleeces in the hundred.

What will be the effect of culling on these and similar flocks? Suppose it is decided to discard all ewes that do not come up to a certain standard of production, as measured by weight of fleece; how many will be culled, and what will be the shearing average of those that remain?

TABLE III
Effect of dividing Flock "B" into any two groups possible on the basis of fleece weight to the nearest pound.

<table>
<thead>
<tr>
<th>Highest weight of cull group</th>
<th>Percentage in cull group</th>
<th>Percentage in select group</th>
<th>Average fleece wt. in cull group—lbs.</th>
<th>Average fleece wt. in selected group—lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>99</td>
<td>4.0</td>
<td>7.9</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>98</td>
<td>4.5</td>
<td>7.9</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>86</td>
<td>5.8</td>
<td>8.2</td>
</tr>
<tr>
<td>7</td>
<td>37</td>
<td>63</td>
<td>5.8</td>
<td>8.2</td>
</tr>
<tr>
<td>8</td>
<td>70</td>
<td>39</td>
<td>6.5</td>
<td>8.6</td>
</tr>
<tr>
<td>9</td>
<td>92</td>
<td>8</td>
<td>7.2</td>
<td>9.3</td>
</tr>
<tr>
<td>10</td>
<td>98</td>
<td>2</td>
<td>7.5</td>
<td>10.3</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>—</td>
<td>7.9</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Table III shows how such a system of culling would have worked in Flock "B" which, of the flocks studied, is probably most representative of the sheep ordinarily grazed in Wyoming. The table is so constructed as to show the average production per head in each of two groups, one of which may be called the cull group.
and the other, the select group. Each line across the table shows what the average production would be in two groups divided on the basis of the fleece weight stated in the first column. For example, if all the sheep from Flock "B" with fleeces that were recorded as weighing not more than 6 pounds had been placed in the cull group, then this group would have contained 14 per cent of the sheep in the flock, and their average weight of fleece would have been 5.8 pounds. The select group made up of those sheep with fleeces that were recorded as weighing more than 6 pounds would have contained the remaining 86 per cent of the flock, with an average fleece weight 8.2 pounds. As a further example of the use of the table, it is interesting to note that if the 37 per cent that are shown in the table as shearing 7 pounds or less, had been placed in the cull group, then the average fleece weight of the select group remaining would have been 8.6 pounds, which is almost three-quarters of a pound more than the average fleece weight of the original flock. This and similar tables, which can be constructed for the other flocks in Table I and for any other flock for which the variability of the fleece weight is known, are very suggestive of the effect which systematic culling would have on the wool production of the range states. An additional point of interest to the practical flockmaster who studies records of wool production such as are shown in Table I is the question of the lightest fleece a ewe can produce and still return a profit to her owner. If a sheep that produces only a 5-pound fleece fails to pay her expenses in an average year, the sheep that shears 5 pounds and less will not be kept after the owner knows the facts in the case.

THE CORRELATION BETWEEN THE WEIGHT OF FLEECE PRODUCED ONE YEAR WITH WEIGHT OF THE FLEECE PRODUCED BY THE SAME ANIMAL IN SUBSEQUENT YEARS.

No matter how wide the range of variation in fleece weight may be, culling as it has to be carried out in sheep husbandry will be of no effect if mature sheep that are high producers one year do not continue to be relatively high producers the remainder of their lives. For, if culling is done on the basis of actual production, as it will doubtless have to be, for some time at least, the profit or
loss of producing the fleeces on which the culling is based is already a fact before the culling is done. Now if the next year, the ewe that was saved because she was a heavy producer this year, is just as likely as not to be a low producer, and if the low producer this year has an even chance of being the high producer next, it follows that culling will get the flockmaster nowhere. For this reason, a study was undertaken to determine the correlation between the amount of wool which a sheep produces one year and the amount produced during the subsequent years of its life.

The material used in making this study was the annual production of wool by a small flock of sheep that were on a feeding experiment at the Wyoming Experiment Station. The sheep in question were 30 pure-bred Rambouillet wethers, aged two and three, that were selected from a range band with the idea of making a flock as even as possible with respect to size as well as weight and general character of their fleeces. At the time of their selection, they carried a full year's fleece which had been grown while they were grazed on the range. This was immediately sheared; thus it is known how much wool they produced in a year on the range. The sheep were taken to the Experiment Farm and put in a small feed lot for six months and sheared again. The wool grown during this preliminary six months' period, does not enter into the calculations that follow. As soon as the short fleece had been removed, the sheep were divided into three lots and put on a feeding experiment, the details of which are not of importance in connection with the present study except as they represent a difference of environment as compared with the range, or a difference from year to year. During the whole time of the experiment, which lasted three years, they were kept in small dry lots with a small stall for shelter. At no time during the experiment did the sheep receive any green grass or roots or other succulent forage. The rations consisted entirely of native hay and oil cake. One ration was native hay alone, on which each of the lots in turn subsisted for a year. During the other two years, the ration was native hay with a light feed of cake for one year and native hay with a heavy feed of cake the other. It will be seen from this brief outline of the experiment that the change from the range to the feed lot was a greater change of environment than occurs be-
tween the production of any two fleeces by an ordinary sheep during its life on the range. Furthermore, the changes of feed, after the experiment started, were greater than the changes from one year to another on the range.

The shearing was all done with hand shears. The amount of wool left on after shearing was not more uniform than is the case with hand shearing on the range. After being sheared, the fleeces were all scoured separately; so it is known how much clean wool each sheep produced each year during the time included in this study. One sheep died during the last year of the experiment, and so only the records of the other twenty-nine are used as a basis of the calculations that follow.

**TABLE IV**

*Correlation table for the production of clean wool: one year on the range compared with the average of three subsequent years in the feed lot.*

<table>
<thead>
<tr>
<th>Year on the range</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>6.5</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals**

<table>
<thead>
<tr>
<th>Average of three years in feed lot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Mean weight of scoured wool in fleece:
1 year on range = 4.09 ± .07 lbs.
3 years in feed lot = 5.19 ± .08 lbs.
Coefficient of correlation = +0.51 ± .09.
Coefficient of regression = 0.45.

Table IV shows the correlation between the weight of scoured wool in the fleece which each of the sheep produced on the range with the average weight of scoured wool in the three fleeces produced while on the feeding experiment. From this table was calculated a correlation coefficient of +0.51 ± .09. It is worth noting in this connection that the average weight of scoured wool in the fleeces produced on the range was 4.09 pounds while the average of the three years in the feed lot was 5.19. This seems to indicate that range sheep do not ordinarily get enough feed to bring out fully their inherent capacity for wool production.
TABLE V

Correlation table for the production of clean wool: the first year in the feed lot compared with the average of two subsequent years in the same feed lot.

<table>
<thead>
<tr>
<th>First year in feed lot</th>
<th>Average of second and third years in feed lot.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>4.0</td>
<td>1</td>
</tr>
<tr>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>1</td>
</tr>
</tbody>
</table>

Mean weight of scoured wool in fleece:
1st year in feed lot=5.12±.09 lbs.
2nd and 3rd years in feed lot=5.22±.06 lbs.
Coefficient of correlation=±0.70±.07.
Coefficient of regression=0.76.

Table V shows the correlation between the weight of scoured wool in the fleeces produced the first year in the feed lot and the average of the two subsequent fleeces produced by the same individuals. This table gives a correlation coefficient of ±0.70±.07. The mean weight of scoured wool from the last two years in the feed lot was slightly greater than that produced the first year, showing that the increased age of the sheep had, up to this point, caused no falling off in the production of wool. Nor did the continued absence of succulent food appear to have any cumulative effect detrimental to wool production.

It is not surprising in view of the marked change of environment from range to feed lot, that the coefficient of correlation between the fleeces representing this change should be much higher than the one between periods of less violent change. It is well to remember, in this connection, the fact that an interval of six months intervened between the last of the growth of the fleece produced on the range and the first of the growth of the first fleece in the feed lot. The correlation between two fleeces the second of which starts growing where the first leaves off, will tend to be greater than in the case where a comparatively long interval intervenes between the growth of the two. For, in the former case, the
same conditions of health and nutrition that made for high or low production at the end of the period of the growth of the first fleece will most likely continue into the first part of the period of the growth of the second. In the case of an interval between fleeces, this continuity is broken.

The coefficients of correlation by being positive and fairly large indicate that the sheep which produces a large amount of scoured wool one year is pretty sure to continue to produce relatively large amounts of wool the remainder of its life. This fact can be more definitely related to the problem of culling by means of regression coefficients, calculated from correlation coefficients. The regression coefficient for Table 1 is 0.45 which means that for similar sheep undergoing changes of environment as radical as between the range and the feed lot that has been described, a group of them that produces 1 pound more scoured wool to the fleece the first year will, during the 3 subsequent years, produce fleeces that will give 0.45 pounds more clean wool than the average. Greater or smaller differences above or below the mean of the first year will be followed by proportional differences above or below the mean the subsequent year. The regression coefficient of 0.76 from Table V shows that under changes of environment and nutrition, no more violent than took place during the time the sheep were in the feed lot, a group with a production 1 pound above the average the first year, will have an annual production 0.7 pounds above the average the 2 years immediately following. Suppose, for example, that Flock "B" were divided into 2 groups, as shown in Table III, one of which contained the 37 per cent that sheared 7 pounds or less, with an average fleece weight of 6.5 pounds; the remaining 86 per cent having an average of 8.6 pounds per fleece. If these 2 groups were kept 2 years longer and sheared separately each year, it would be expected that the cull group which was 1.4 pounds below the average fleece weight the first year, would have an average fleece weight of 0.7 times 1.4, or 0.98 pounds practically, an even pound—below the average of the next two years; likewise, the select group, with a fleece weight 0.7 pounds above the average the first year, will be expected to have fleeces 0.7 times 0.7 or nearly $\frac{1}{2}$ pound above the average the second year. That is, the select group which out-sheared the cull
group by 2.1 pounds the first year, can be expected to continue during the next two years to out-shear it by a little less than 1.5 pounds on each fleece. Hence, so far as the results obtained from one small flock can be depended upon, the correlation is high enough to indicate that the effect of culling will not all be lost after the first year.

It is interesting to compare the correlation coefficients for wool production with those obtained at the Maine Experiment Station* for milk production in Jersey cows. The milk produced during one lactation period was compared with the total production of five lactation periods, and was found to give correlation coefficients ranging from $+0.74 \pm 0.03$ to $+0.86 \pm 0.02$. These correlation coefficients for milk production are considered by the investigator who did the work as being high and as indicating that culling will be very beneficial in keeping out the low producers. While both the values are higher than the high value for sheep, it should be noted that the one lactation period is included in the total of the five and this makes a higher correlation than would otherwise be the case. The correlation coefficient for wool production is not greatly below that of milk production, a branch of animal husbandry in which culling has been used with great benefit for a number of years.

THE CORRELATION BETWEEN THE LENGTH OF STAPLE AND THE WEIGHT OF THE FLEECE.

Culling, to be practical under the conditions that now exist and are likely to continue in the management of range sheep, must be done on the basis of the estimated value of the wool while it is still on the sheep's back rather than by the weight of the fleece after it is removed. There is always a hurry and rush at the shearing pens so that it would be impossible to keep within reasonable bounds, the expense of weighing a fleece the instant it is taken off and marking for the purpose of culling the ewe that produced it. If there were only a small force to do the weighing and recording, the identity of the ewe would in most cases, be lost before her fleece could be weighed. Therefore, from the standpoint of culling, it is important to study those variables that most affect

*Gowen, op. cit.
the value of the fleece and that, at the same time, are most easily judged on the sheep's back.

One character that is easy to judge before the wool is sheared is its length, and length is one of the important factors that control the amount of wool. Furthermore, up to a certain point, the value of a fleece per pound increases with its length. On the other hand, it has been the opinion of some that increase in length is offset by a decrease in density, that is to say, the closeness with which the fibers of the fleece are packed together. It is important, then, to get some measure of the correlation between the length and the weight of the fleece, and it was for this purpose that the investigation now being reported was made.

The material was obtained at a shearing shed in which the range sheep being shorn were nearly all pure-bred Rambouilletts. The wool from these sheep was divided into two grades according to length, namely, combing wool, fleeces in which the average length was more than \(2\frac{3}{4}\) inches, and clothing wool, fleeces too short for the combing grade. The length was not measured but was determined by the judgment of the grader aided to some extent by comparison with the length of a part of one of his fingers. Length was the only character considered in dividing the wool into the two grades. The fleeces weighed were not graded especially for the experiment and the grader did not know that any experiment was to be tried. All that was done was to weigh the fleeces from two bins just before they were packed. The weights were taken on the spring balances mentioned in the first section of this bulletin and were recorded to the nearest half pound. All together 69 fleeces were weighed, 30 from the clothing bin and 39 from the combing bin.

Since the lengths were only made into two graduations, long and short, in making a correlation table, the weights have been considered as being divided into only two classes, heavy and light, the heavy being those fleeces weighing 11.5 pounds or more. The point selected at which to make the division was the point on the scale of weights as recorded, that was nearest the average of the total weight, came the nearest to dividing the fleeces into two equal portions, and was near the middle of the range, that is about half-way between the heaviest and the lightest fleeces. With the
fleeces thus made into two classes according to weight, the fourfold correlation table shown in Table VI was constructed, and from it, the approximate correlation was calculated by Yule's formula, \[ \frac{AD - BC}{AD + BC} \]. This gave a correlation coefficient of \[ +0.56 \pm 0.06 \], showing that the length of fiber has a most important effect on the weight of the fleece.

**TABLE VI**

*Correlation table for length of staple and weight of fleece.*

<table>
<thead>
<tr>
<th>Length</th>
<th>Weight</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light (Below 11.5 lbs.)</td>
<td>Heavy (11.5 lbs. and above)</td>
<td>Totals</td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td>22</td>
<td>8</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>(less than 2½ inches)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combing</td>
<td>17</td>
<td>22</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>(greater than 2½ inches)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>39</td>
<td>30</td>
<td>69</td>
<td></td>
</tr>
</tbody>
</table>

Approximate correlation coefficient (Method of Yule) = \( +0.56 \pm 0.06 \).

The relation which the length had to weight may perhaps be made more clear by comparing the average weight of the clothing fleeces which was 10 pounds, with the average length of the combing fleeces which was 11.7 pounds. Thus, the grader classifying the fleeces on the basis of length alone, divided them into two groups, the longer of which was almost one and three-quarters pounds heavier than the shorter. It is just as easy to judge the length of a fleece while it is still on the sheep as it is after it has been sheared.

On the basis of prices as quoted in Boston during the spring of this year of 1921, it was estimated that the shorter fleeces had an average ranch value of $1.60 and the longer ones a ranch value of $2.98. This higher value of combing wool was due both to its lighter shrinkage and higher value per pound after scouring.

This investigation clearly points to the conclusion that for fine-wooled sheep, length of staple is a most important factor in determining the weight and value of the fleece.
SUMMARY AND CONCLUSIONS

While the conclusions to be drawn from the foregoing investigations are not as trustworthy as they would be if they were based on larger numbers and more flocks covering a wider area, yet it is safe to say that:

(1) The variation in the amount of wool produced by typical range flocks is great enough to make it certain that culling is a good means of increasing the average weight of the fleece without a radical change in the type of sheep.

(2) There is a high enough correlation between a fleece produced after maturity and the weight of the subsequent fleeces produced by the same sheep to make culling effective.

(3) In fine-wooled sheep studied, there was a high correlation between the length of a fleece and its weight and value.