CORRELATIONS BETWEEN DAMS AND DAUGHTERS

IN CLEAN PRODUCTION OF WOOL

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BY

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Bachelor of Science

Oklahoma Agricultural and Mechanical College

1939

Submitted to the Department of Animal Husbandry

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

1939

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PREFACE

The data included in this thesis were secured as a part of the wool research program carried on by the Oklahoma Agricultural Experiment Station. This station cooperates with the United States Department of Agriculture in carrying on a long time program of improvement in animals and animal products.

Although considerable experimental breeding work has been done with wool, and many observations having some genetic significance have been made, progress has been slow. This is partly due to the fact that the factors affecting wool production, and the amount that they affect it, are not too clearly understood.

This article deals with factors that do have a definite economic bearing on wool production.

The terminology employed in this thesis is that of the sheep husbandman as well as the research worker. The methods employed are similar to those used by the leading wool research men and scientific workers in the field.

Okla. A. & M. College

June 3, 1939 Emmanuel L. Vieth

ACKNOWLEDGMENT

The author is deeply indebted to Dr. Hilton M. Briggs and Dr. Oliver S. Willham of the Animal Husbandry Department of Oklahoma Agricultural and Mechanical College for their aid and guidance in the planning, performance and interpretation of this experiment.

TABLE OF CONTENTS

INTRODUCTION

Since the Revolutionary War and the War of 1812, the woolen industry has increased in importance in the United States. Prior to this time we had depended largely upon England, our mother country, to furnish us with woolen goods. At the time of these wars England placed an embargo upon woolen goods which caused us to greatly expand our own woolen industry.

Before we really began to manufacture woolen goods in earnest, very little attention had been paid to sheep in the United States. True, they had been brought here by the earliest explorers, but they had never really been given a great deal of attention. The increase in the manufacturing of woolens led to a corresponding increase in both numbers and quality of sheep in the United States. The pioneers began to select and breed for both better wool and better mutton production. The increase in wool production can be seen from the fact that in colonial days the average sheep sheared 2 pounds of fleece whereas they now shear 7.9 pounds.

The value of wool lies in its ability to be spun into yarn which in turn can be turned into woolen goods. Many animals other than the sheep, have a protective covering of fibers, but because they lack this ability to be spun into yarn they are nearly valueless.

Regardless of whether wool is the main product or merely a by-product in sheep production, it is very important to the industry as a source of income.

It has long been known that there are a number of factors that influence wool production. The commonly accepted factors influencing wool production are environment, age, ration and heredity. It seems to be an accepted fact that the hereditary factor is not a single genetic factor but rather a multiple factor inheritance. The amount that each factor contributes to the production of wool has not been ascertained.

According to Bywater (3):

> "No estimate of the amount of genetic variance in a population can be made without considering in some form or other the comparative likeness between relatives. Yet the observed correlations between relatives, especially among farm animals, may be enhanced or diminished by the influence of environment, according to the importance of environmental variations in modifying the character and according to the correlations between the environments under which different kinds of relatives are raised. Moreover, some of the gene pairs may exhibit some degree of dominance and some genes may interract in non-additive ways, that is, the effects of some gene combinations may be more (or less) than the sum of the average effects of those genes considered separately. These complications prevent obtaining precise answers to the question of how important each kind of genetic variance is. Yet the correlations between various kinds of relatives may indicate roughly what answers are reasonable . . . . Frequently the most useful measure for determining the genetic portion of the variance in a character is a direct correlation of that character between parent and offspring."

The purpose of this work is to determine the amount of correlation between dams and daughters in clean production of wool and thus eventually attribute, if possible, the amount that heredity plays in wool production.

REVIEW OF LITERATURE

The literature fails to divulge any direct work in regard to correlation studies between dams and daughters in the production of wool. A rather limited amount of research has been completed on other factors that influence the production of wool.

Davenport and Ritzman (6) found that advancing age, state of health, level of subsistence and exposure to changing weather conditions may affect the growth of wool. They point out that these factors in an unfavorable combination may alter the fleece weights from the same sheep as much as fifty percent.

Joseph (13) reported that the wool clip from two year old ewes was the heaviest and that age up to eight years had no detrimental effect on wool production. However, Spencer, Hardy and Brandom (24) report that the fleeces from three year olds are the heaviest. Jones, Homeyer, Davis, Dameron and Warwick (14) concur with Spencer, et. al. (24), for their studies on the fleeces from B and C type Rambouillets, found that the maximum production of wool on a clean, twelve month basis, was reached at three years of age for both B and C type Rambouillets.

Jones and Lush (15) studied the effect of age and individuality of sheep on fleece weights. They studied Texas Rambouillet ewes and wethers and found that sheep could be most satisfactorily culled for fleece production between $1\frac{1}{2}$ and $2\frac{1}{2}$ years of age, or at the second or third shearing.

These workers supported the findings of Joseph (13), Spencer et. al. (24), and Jones et. al. (14), that second year fleeces are consistently heavier than first year fleeces. Jones and Lush (15) also showed that the two year old clip of ewes is the heaviest and with wethers, the three year old clip is the heaviest. They also stated that fleece weights do not decrease much due to advancing age of the ewes before they reach seven or eight years of age. These conclusions substantiated the earlier reports of Hill (10) that the increase of age up to five or six years caused no reduction in wool production with purebred Rambouillet wethers.

Hill (11) showed that fleece weights of fine wool sheep are highly positively correlated with fiber length. These findings were corroborated by Wells (26), who found that the fleeces from two year old ewes were consistently longer than those from one year olds. This bears out the correlation between fiber length and weight since the weight of fleeces from two year old ewes was also consistently greater than the weight of fleeces from ewes one year old. Since fiber lengths do not ordinarily vary more than 1 to $1\frac{1}{2}$ centimeters throughout the life of the ewe, Wells (26) thought it reasonable to assume that advancing age does not greatly alter fleece weights. He pointed out that advancing age is often accompanied with failing health due to bad teeth, a weakened constitution and a loss of ability, on the part of the animal to utilize its feed to the best advantage. He concluded that these factors no doubt account for shorter staple and lighter fleeces of sheep past five or six years of age.

Various investigators have reported that the ration has a bearing on wool production. Wilson (27) fed three Romney wethers for six months on a fattening ration, followed for six months by a maintenance ration and then another six months on a sub-maintenance ration. The fleeces grown on the fattening ration during the first six months when compared with those grown during the third six month period on a sub-maintenance ration were:

(A) About 343 percent heavier in grease weight.

(B) About 319 percent heavier in scoured weight.

In experimenting with Shropshires at the Nebraska station, Weber (25) found that when sheep on full feed were subjected to a low plane of nutrition they produced less scoured wool. However, normal growth was again attained upon resumption of full feeding. When the method of feeding was reversed, those changed from a low to a high plane of nutrition produced 100 percent more scoured wool than during the previous period. This bears out previous work by Roberts and Wing (18), who fed a ration with a nutritive ratio of 1:4.2 to two lambs for 160 days with a resultant production of 7.31 pounds of raw wool as compared to 4.25 pounds of raw wool produced by two lambs, of similar breeding, fed a ration with a nutritive ratio of 1:10.9 for the same period.

Skinner and Smith (20) reported a yield of .8 pound more wool produced by ewes fed a dry ration than by those fed a succulent ration (corn silage). This increase, however, was not credited to the change in rations. Hill (11) also found that an absence of succulent feed had no detrimental effect on wool production. He took thirty Rambouillet wethers, of two and three year ages, from the range with a full year's fleece and sheared them. They were fed on native hay and oil cake. The average fleece weight (clean wool) for the one year on the range was $4.09 \pm .07$ pounds as compared to a mean fleece weight of $5.19 \pm .08$ pounds the three subsequent years in dry lot.

Cooke (4) found that the growth of wool was but slightly reduced when a ration insufficient for maintenance was fed. That the rate of wool growth was associated with the general thriftiness of the sheep was reported by Hardy and Tennyson (9). Joseph (12), in working with fine wool sheep, reported that if the sheep remains in normal health, the organs which are concerned with the secretion of the wool fibers are not easily affected by changes in the level of feeding, especially when the feeding level is continued for a period of less than five or six months. He concluded that quality of fiber is not affected at all and that quantity of fiber may be modified only slightly.

Felton (7) secured results which indicated that the organs which are concerned with the secretion of the wool fibers are not easily subject to such influences as changes in the level of feeding for a short period, but are easily disturbed when the sheep becomes abnormal in health. The amount of wool fiber produced does not seem to be affected to the same extent as body weight, but the growth of wool is reduced when the ration is insufficient for maintenance.

The matter of repeatability, seasonal variations and environment are very closely associated. J. A. Hill (11) in trying to check whether a sheep that produces a large amount of wool one year will also produce a large amount of wool the next year (repeatability) ran tests on the repeatability of 30 wethers for three years and obtained a correlation coefficient of $0.70 \pm .07$. This was on a clean wool basis.

Malan, Van Wyk and Botha (16) reported that fleece and fiber attributes of a shoulder sample of Merino wethers sent from Grootfontein to Onderstepoort were analyzed for three successive years. They reported that the effect of the environmental changes were evident. Approximately 60% of the variation in the values of any of the fleece and fiber characteristics of one year can be expressed in terms of that for the previous year. Bosman (1) reported that a study of wool growth for the first three years in three Merino wethers failed to reveal any differences between the consecutive seasons or years as regards dry weight or fiber fineness. Jones and Lush (15) found a very high correlation (average about +.7) between fleece yields of the same group of ewes in consecutive years. They conclude that season has very little affect upon grease wool yields.

Hill (10) reported that results of an experiment in which 20 wethers were exchanged in order to check the part environment played in wool production, 10 native wethers of Ohio were sent to Wyoming and 10 native wethers of Wyoming were sent to Ohio. He stated that the results showed that a given sheep is likely to produce at least as much wool per year in Wyoming as in Ohio.

Investigators have found that the greasy fleece weight is not an accurate guage of wool production. Bosman (1) found that the greasy fleece weight is no indication of the clean-scoured fleece weight. Two rams, both producing 11 pounds of clean wool had greasy fleece weights of 31 and 20 pounds, respectively. In another case, Bosman and Mare (2) found that the fleece of a stud ram weighed 32.4 pounds when shorn but yielded only 10.7 pounds of scoured wool. Still another fleece weighed 25.3 pounds and yielded 12.3 pounds scoured wool.

Some dam-offspring correlations have been worked out by investigators relative to weaning weights of pigs and milk production in dairy cattle. Bywater (3) reported a correlation of 0.05 between dams at time of weaning and weaning weights of offspring in Poland-China swine. However, he obtained a correlation coefficient of 0.45 for litter-mates. Plum (17) reported a correlation of 0.31 for milk production between dams and daughters in dairy cattle. This correlation was based on their first year production records.

Various experimenters have used varying methods in the scouring of fleeces. Spencer, Hardy and Brandon (23) use the following method for scouring wool:

> "The samples as they are received are stored in a dry room until ready for testing. The method consists in placing a sample of approximately 250 grams in a weighed wire mesh basket, after which it is heated for three hours at 50°C to a constant moisture content and weighed in the oven. It is then scrubbed three times with deodorized gasoline

for 45 minutes each time and filtered after each washing. The sample is then air dryed, after which it is dried in the 50° oven for three hours and weighed, including the dirt collected on the filter paper. The difference between this and the original weight is due to the grease which was washed out by the gasoline. The sample is next washed with soap and water at 40 and 45° for 45 minutes, then with clear water for 30 minutes at the same temperature. In case the wool is very dirty a third washing may be necessary. The difference in weight after drying in the oven for 3 hours and the previous, after washing with gasoline, is due to the dirt removed."

Davenport and Ritzman (6) used 25 gram shoulder samples and removed grease with gasoline and dirt and other extraneous material with soap and water. They report that while it is recognized that the quality of wool on an average sheep is not uniform over the entire body, it was assumed that the shoulder sample would represent the general character of the greater part of the fleece in this respect.

Russell (19) used the following scouring solution for scouring wool:

2 liters cistern water
25 grams soda ash (Na_2CO_3)
15 grams soap (Ivory)

His scouring method was:

Washings	Temperature	Time
1. (scouring solution)	55°	15 minutes
2. (cistern water)	50°	5 minutes
3. (cistern water)	40°	5 minutes

This same solution and method was used by Darlow (5). The samples were dried in an electric oven before scouring to determine the moisture content. After the washings, the wool was again dried in the electric oven and then in a dessicator. The difference between the initial weight and final weight was designated as shrink.

EXPERIMENTAL PROCEDURE

The data used in this experiment were gathered from the Oklahoma Agricultural and Mechanical College flocks. The animals studied were purebred Shropshire, Hampshire, Southdown, Rambouillet and Dorset ewes. There is no inbreeding in the flock. The results were obtained for the years of 1939 and 1938. In some cases this involved the same pairs of daughters and dams in both years, but no attempt was made to check repeatability. All the dam-daughter pairs that were available were used in the experiment.

The effects of age, environment and feed were held as nearly equal as is normally possible. Both dams and daughters were given the same care and feed and no fleeces were taken from ewes under one year of age.

Davenport and Ritzman (6) reported that although no one portion of a ewe's fleece is entirely representative of the entire fleece, it was considered that a shoulder sample would be fairly accurate as a means of comparison. The samples in this experiment were taken from the left side of the ewe, immediately behind the shoulder. As a means of checking technique, some check samples were taken from the same location on the right side from some of the ewes. The samples were two inches square and were taken by cutting a strip two inches long with a two inch electric clipper.

After the samples had been taken they were placed in fruit jars and stored in a room until scoured. In order to remove any influence of humidity the samples were dried in a dessicator for 24 hours before weighing. The weights were taken on a Welch gram balance, the accuracy of which was guaged to .1 gram. All weights were made to the nearest .1 gram.

The scouring method employed is similar to those that have been employed at this station in all previous investigations involving the scouring of wool. The scouring solution consisted of the following formula:

1	quart water
12.5	grams soda ash (Na_2CO_3)
7.5	grams soap (Ivory)

All scouring was done in quart jars and the solution strained off through a cloth to prevent the escape of any fibers. Four washings were given to each sample. They were as follows:

Washings	Material Used	Time	Initial Temp.
1	Scouring solution	15	120°F
2	Scouring solution	15	120°F
3	Water plus 12.5 grams Na_2CO_3	5	120°F
4	Water plus 12.5 grams Na_2CO_3	5	120°F

After the samples had been scoured they were dryed for several days at room temperature and then placed in the dessicator for 24 hours after which they were weighed. The difference between the original weight after being placed in the dessicator and the final weight after drying in the dessicator was the amount of shrinkage. Since these compilations were based on the amount of clean wool produced the clean wool weight was divided by the greasy wool weight and multiplied by 100 to make it on a percentage basis. This percentage figure was then multiplied times the greasy weight of the entire fleece to obtain the total amount of clean wool produced.

The data obtained in this experiment were first analyzed on a yearly basis. All breeds were grouped together in this analysis. This resulted in two correlations, one for 1938 and one for 1939.

A third correlation was made to check the possibility that the correlation coefficient was influenced by one ewe having more than one daughter in the study. In case a ewe had two or more daughters, the production of all the daughters was averaged and used as one item. An average was taken of each ewe that had samples taken for both years and this average was used in the calculation of the third correlation coefficient.

The Rambouillet breed was the only breed that had enough pairs to form a separate breed analysis. In this correlation the data for Rambouillets for both 1938 and 1939 were combined. An analysis of variance was run on a check of technique. The resulting variance was very insignificant.

EXPERIMENTAL RESULTS

The results of this experiment are shown in Tables I to IV. Table I is a correlation evolved from an analysis of all breeds for the year of 1938. Table II is a correlation of all breeds for 1939. Table III is a combination of the two years, 1938 and 1939, using averages wherever more than one daughter appeared, or whenever one ewe had data for both years. Table IV is a correlation for Rambouillets based on both the years of 1938 and 1939.

TABLE I

The Scoured Wool Production of Dams and Daughters, 1938

	Dams			Daughters			
Breed	Ear Tag No.	X Yield	X^2	Ear Tag No.	Y Yield	Y^2	XY
Ramb.	936	5.23	27.3529	707	5.59	31.2481	29.2357
"	967	4.67	21.8089	729	4.72	22.2784	22.0424
"	863	5.17	26.7289	760	5.98	35.7604	30.9166
"	918	6.21	38.5641	715	6.62	43.8244	41.1102
"	827	5.10	26.0100	784	5.77	33.2929	29.4270
"	918	6.21	38.5641	772	7.35	54.0225	45.6435
"	863	5.17	26.7289	898	4.97	24.7009	25.6949
"	967	4.67	21.8089	788	4.08	16.6464	19.0536
"	853	5.17	26.7289	973	6.03	36.3609	31.1751
South.	1078	2.48	6.1504	1123	1.75	3.0625	4.3400
"	1051	2.53	6.4009	1080	2.16	4.6656	5.4648
"	1081	2.18	4.7524	1113	2.42	5.8564	5.2756
Dorset	18	1.96	3.8416	83	5.19	26.8361	10.1724
"	8	3.62	13.1044	79	3.58	12.8164	12.9586
Hamp.	T195	3.92	15.3664	A2371	4.15	17.2225	16.2680
"	T105	3.71	13.7641	A18372	2.45	6.0055	9.0893
"	T168	3.68	13.5424	A3371	3.51	12.3201	12.9168
"	T111	5.41	29.2681	A1371	4.59	21.0681	24.8319
Shrop.	672	2.77	7.6729	541	2.82	7.9524	7.8114
"	519	6.40	40.9600	578	4.55	20.7025	29.1200
		86.26	409.1192		88.28	436.7400	412.5488

$$r = \frac{412.55 - \dfrac{86.26 \times 88.28}{20}}{\sqrt{409.12 - \dfrac{(86.26)^2}{20}} \sqrt{436.74 - \dfrac{(88.28)^2}{20}}} = 0.761$$

TABLE II

The Scoured Wool Production of Dams and Daughters, 1939

Dams				Daughters			
Breed	Ear Tag No.	X Yield	X^2	Ear Tag No.	Y Yield	Y^2	XY
Ramb.	708	5.62	31.5844	786	7.29	53.1441	40.9698
"	936	4.85	23.5225	791	3.87	14.9769	18.7685
"	750	7.33	53.7289	821	6.78	45.9684	49.6874
"	956	5.05	25.5025	803	7.65	58.5225	38.6325
"	918	5.65	31.9225	786	5.40	29.1600	30.5100
"	963	3.53	12.4609	806	4.69	21.9961	16.5557
"	847	4.84	23.4256	770	7.45	55.5025	36.0580
"	936	4.85	23.5225	708	5.62	31.5844	27.2570
"	918	5.65	31.9225	772	5.72	32.7184	32.3180
"	847	4.84	23.4256	751	6.74	45.4276	32.6216
"	863	3.11	9.6721	898	3.95	15.6025	12.2845
South.	1051	2.33	5.4289	1165	2.67	7.1289	6.2211
"	1073	2.20	4.8400	1080	2.26	2.8900	3.7400
"	1051	2.22	5.4289	1080	2.26	5.1076	5.2658
"	1078	2.77	7.6729	1123	1.69	2.8561	4.6813
"	1081	1.96	3.8416	1113	1.24	1.7956	2.6264
Dorset	405	1.69	2.8561	100	3.64	13.2496	6.1516
"	18	1.71	2.9241	83	3.33	11.0889	5.6943
"	50	2.58	6.6564	91	3.46	11.9716	8.9268
"	70	3.45	11.9025	115	2.48	6.1504	8.5560
"	50	2.58	6.6564	105	2.57	6.6049	6.6306
Hamp.	228571	3.85	14.8225	2097	4.53	20.5209	17.4405
		82.77	363.7203		94.83	493.9679	411.6084

$$r = \frac{411.61 - \dfrac{82.77 \times 94.83}{20}}{\sqrt{363.72 - \dfrac{(82.77)^2}{22}}\ \sqrt{493.97 - \dfrac{(94.83)^2}{22}}} = 0.8211$$

TABLE III

The Average Scoured Wool Production of Dams and Daughters, 1938 and 1939

	Dams			Daughters			
Breed	Ear Tag No.	X Yield	X^2	Ear Tag No.	Y Yield	Y^2	XY
Ramb.	708	5.62	31.5844	786 791	7.29	53.1441	40.9698
"	936	5.04	25.4016	708 707	5.03	25.3009	25.3512
"	750	7.33	53.7289	821	6.78	45.9684	49.6974
"	956	5.05	25.5025	803 796	7.65	58.5225	38.6352
"	918	5.93	35.1640	772 715	6.27	39.3129	37.1811
"	963	3.53	12.4609	806 770	4.69	21.9861	16.5557
"	847	4.84	23.4256	751 888	7.05	49.7025	34.1220
"	863	4.14	17.1396	760 973	5.23	27.3529	21.6522
"	967	4.67	21.8089	729	4.72	22.2784	22.0424
"	827	5.10	21.0100	784	5.77	33.2929	29.4270
"	967	4.67	21.8089	788	4.08	16.6464	19.0536
South.	1051	2.43	5 .9049	1165 1080	2.36	5.5696	5.7348
"	1073	2.20	4.8400	1173	1.70	2.8900	3.7400
"	1078	2.63	6.9169	1123	1.72	2.9584	4.5236
"	1081	2.07	4.2849	1113	1.88	3.5344	3.8916
Dorset	405	1.69	2.8561	100	3.64	132496	6.1516
"	18	1.84	3.3856	83	4.26	18.1476	7.8384
"	50	2.58	6.6564	91 105	3.02	9.1204	7.7916
"	70	3.45	11.9025	115	2.48	6.1504	8.5560
"	8	3.62	13.1044	79	3.58	12.8164	12.9596
Hamp.	228571	3.85	14.8225	2097	4.53	20.5209	17.4405
"	T195	3.92	15.3664	A2371	4.15	17.2225	16.2680
"	T105	3.71	13.7641	A18372	2.45	6.0025	9.0893
"	T168	3.68	13.5424	A3371	3.51	12.3201	12.9168
"	T111	5.41	29.2681	A1371	4.59	21.0681	24.8319
Shrop.	672	2.77	7.6729	541	2.82	7.9524	7.8114
"	519	6.40	40.9600	578	4.55	20.7025	29.1200
		108.17	489.2843		115.80	573.7438	513.3500

$$r = \frac{513.35 - \dfrac{108.17 \times 115.80}{27}}{\sqrt{489.28 - \dfrac{(108.17)^2}{27}}\ \sqrt{573.74 - \dfrac{(115.80)^2}{27}}} = 0.753$$

TABLE IV

The Scoured Wool Production of Dams and Daughters of the Rambouillet Breed, 1938 and 1939

Dams			Daughters			
Ear Tag No.	X Yield	X^2	Ear Tag No.	Y Yield	Y^2	XY
708	5.62	31.5844	786	7.29	53.1441	40.9698
936	4.85	23.5225	791	3.87	14.9769	18.7695
750	7.33	53.7289	821	6.78	45.9684	49.6974
956	5.05	25.5025	803	7.65	58.5225	38.6325
918	5.65	31.9225	796	5.40	29.1600	30.5100
963	3.53	12.4609	806	4.69	21.9961	16.5557
847	4.84	23.4256	770	7.45	55.5025	36.0580
936	4.85	23.5225	708	5.62	31.5844	27.2570
918	5.65	31.9225	772	5.72	32.7184	32.3180
847	4.84	23.4256	751	6.74	45.4276	32.6216
863	3.11	9.6721	898	3.95	15.6025	12.2845
936	5.23	27.3529	707	5.59	31.2481	29.2357
967	4.67	21.8089	729	4.72	22.2784	22.0424
863	5.17	26.7289	760	5.98	35.7604	30.9166
918	6.21	38.5641	715	662	43.8244	41.1102
827	5.10	26.0100	784	5.77	33.2929	29.4270
918	6.21	38.5641	772	7.35	54.0225	45.6435
863	5.17	26.7289	898	4.97	24.7009	25.6949
967	4.67	21.8089	788	4.08	16.6464	19.0536
863	5.17	26.7289	973	6.03	36.3609	31.1751
	102.92	544.9856		116.27	702.7383	609.8730

$$r = \frac{609.87 - \frac{10292 \times 116.27}{20}}{\sqrt{544.98 - \frac{(102.92)^2}{20}}\ \sqrt{702.74 - \frac{(116.27)^2}{20}}} = 0.575$$

DISCUSSION

In discussing the results of this experiment, the meaning of the correlation coefficient must be kept clearly in mind. Fisher (8) stated that the aim of measuring the amount of heredity by this method is based on the supposition that the whole class of factors which tend to make relatives alike, in contrast to the unlikeness of unrelated animals, may be grouped together as heredity. The correlation does not prove this fact, but merely tells us the degree of resemblance (in this case) between clean yield of wool of dams and daughters. The correlation coefficient tells us the relative importance of the factors which act alike upon the clean yields of wool of dams and daughters, as compared to the total factors at work. The correlation between dams and daughters measures the importance of factors which act alike on both dams and daughters, as against the remaining factors which affect dams and daughters independently.

In this case, it was impossible to eliminate the influence of age, ration and environment from the correlation. Therefore, the correlation is not a true representation of the hereditary influence on clean wool production. For as Fisher (8) explains:

> "We may note that if environmental effects are increased in magnitude the correlations would be reduced; thus the same population, genetically speaking, would show higher correlations if reared under relatively uniform nutritional conditions, than they would if the nutritional conditions had been very diverse; although the genetical processes in the two cases were identical."

However, one need not become alarmed over the possibility that the correlation coefficient obtained in this work, by the use of the formula of Snedecor (21), would have no meaning. The conditions under which this experiment was run will probably correspond very closely to the conditions on most farms where sheep are raised. Therefore, the correlations obtained in this experiment should correspond rather closely to the correlations one would expect to get on the average farm.

According to Snedecor's "Table of Significance for Correlations" (22), all correlations obtained in this experiment were highly significant. Table I shows that in 1938, using all breeds, a correlation of 0.761 was obtained. The results for 1939, using all breeds with the exception of the Shropshire, are shown in Table II. The correlation for 1939 was 0.821. When both years were taken together, using an average yield where the same ewe was used more than once, the resulting correlation as shown in Table III was 0.753.

Taking this combined correlation of 0.753 as perhaps the more reliable average when using all breeds, we find upon applying Snedecor's test (22) $(1-r^2)$, that only 43.3% of the factors affecting the clean production of wool are unaccounted for in our correlation.

This correlation may seem to be a bit high, but the elements of age, ration and environment have had a chance to play a part in the correlation. Another factor that probably tends to raise the correlation coefficient in these cases is the variation in the clean yields of wool of the various breeds. The fact that one breed has a fairly large average yield as compared to a low yield for another breed tends to exaggerate the correlation coefficient. In this problem the mean Rambouillet yield was 5.57 ± .17 pounds as compared to 2.17 ± .09 pounds for the Southdowns. The fact that the combined yearly correlation is lower than an average of the two yearly correlations is not necessarily due to the fact that some of the dams had appeared in the problem more than once, thus decreasing the variance. The slight difference in the annual wool clip that would result from the ration, environment, and the slight difference that could exist in length of time between shearing dates would probably tend to lower the correlation when average yields are used.

Table IV shows that the correlation between Rambouillet dams and daughters, combining the years of 1938 and 1939, was 0.575. In this correlation by combining the years of 1938 and 1939 a greater variation in ration and environment was probably present than in the yearly correlations. The use of only one breed in the analysis would also eradicate the tendency of widely varying breed yields to increase the correlation coefficient. These factors probably explain at least a part of the lowered correlation as compared to the yearly correlations of all breeds combined.

Since the factors of age, environment and ration were affecting the correlation coefficients obtained, one might be prone to surmise that they played the major role in the correlations. The fact that these factors probably did not play too great a part in the correlation is suggested by Jones and Lush (14) who stated that fleece weights do not decrease much due to advancing age of the ewes before they reach seven or eight years of age. Of the sixty-one ewes considered in this study, twelve were one year old at the time of shearing, four were more than eight years old and the other forty-five ranged from two to eight years of age. The conclusions of Jones and Lush (14), substantiated the earlier reports of Hill (10) that the increase of age up to five or six years caused no reduction in wool production with purebred Rambouillet wethers. Wells (26) suggested that it was reasonable to assume that advancing age does not greatly alter fleece weights.

Furthermore, the effect of ration upon the growth of wool has been shown to not be of very great importance as long as normal health is maintained. Cooke (4) found that the growth of wool was but slightly reduced when a ration insufficient for maintenance was fed. Joseph (12), in working with fine wool sheep, reported that if the sheep remains in normal health, the organs which are concerned with the secretion of the wool fibers are not easily affected by changes in the level of feeding, especially when the feeding level is continued for a period of less than five or six months. He concluded that quality of fiber is not affected at all and that quantity of fiber may be modified only slightly. Felton (7) secured results which indicated that the organs which are concerned with the secretion of the wool fibers are not easily subject to such influences as changes in the level of feeding for a short period, but are easily disturbed when the sheep becomes abnormal in health. The amount of wool fiber produced does not seem to be affected to the same extent as body weight, but the growth of wool is reduced when the ration is insufficient for maintenance.

Hill (10) has also pointed out that environment does not play an important part in the production of clean wool. He reported the results of an experiment in which 20 wethers were exchanged in order to check the part environment played in wool production. 10 native wethers of Ohio were sent to Wyoming and 10 native wethers of Wyoming were sent to Ohio. He stated that the results showed that a given sheep is likely to produce at least as much wool per year in Wyoming as in Ohio.

The findings of these investigators tend to cause one to believe that while environmental factors do play a part in wool production it is not a great influencing agent. In fact, Davenport and Ritzman (6) found that when advancing age, state of health, level of subsistence and exposure to changing weather conditions were in an unfavorable combination they did not affect the growth of wool from the same sheep more than fifty percent.

The results of this experiment lead one to believe that heredity plays a large part in the production of clean wool. Although, due to the other factors involved, the amount can not be definitely given, it is reasonable to assume that it is considerable. It will be recalled that dam-daughter correlations of 0.761 and 0.821 were secured when all breeds were taken together and 0.575 when the Rambouillets were studied separately.

The results of the Rambouillet correlation wherein just the one breed was studied would probably be more applicable to the average conditions than the yearly basis in that usually only one breed is kept. It would be hard to find a flock wherein the ratio of the various breeds would be similar to the one used in the yearly correlations. Even when analyzing the correlation between dams and daughters of the Rambouillet breed, it must be remembered that the same correlations may not hold true for the other breeds of sheep.

The dam-daughter correlations obtained in this study were considerably higher than those obtained by Bywater (3) between dam and offspring in weaning weights of swine, and by Plum (17) who worked out a correlation between dams and daughters in milk production of dairy cattle. Bywater (3) reported that the weaning weights of dams and offspring in swine would be greatly affected by environment, care and feed. In litter-mates where these factors were controlled reasonably well a correlation of 0.45 was obtained.

Plum (17) reported a correlation of 0.31 between dams and daughters in milk production of dairy cattle. It would seem reasonable to expect this figure to be lower than those obtained in this study since it seems quite evident that ration in particular plays a greater influence on milk production than on wool production. It is an accepted fact, that as long as ewes are obtaining a maintenance ration, wool production is affected very little. The study of Plum was based on quite a number of different herds while this study with sheep was based on but one flock. It would be natural to assume that the variance of environment, care and feed in Plum's problem would be greater than in this study of ewes. This would tend to decrease his correlation coefficient in comparison with the one obtained by this author on sheep.

The data used in this experiment were all from one flock, under one breeding system, and they were kept under a reasonably uniform system of feeding and management. The estimates obtained apply to the population studied and caution should be used in applying them to widely different populations, although there seems to be no reason for believing that they would not be typical of similar flocks under similar conditions.

SUMMARY

This experiment was conducted on all the available dam-daughter pairs of sheep, from which fleeces had been taken in 1938 and 1939, in the Oklahoma Agricultural and Mechanical College flock.

The only characteristic studied was the clean yield of wool. This clean wool was obtained by scouring a two inch shoulder sample and using that as the basis of determination. All correlation coefficients reported in this study were based on the dam-daughter relationship in production of scoured wool.

An analysis of variance was run on scouring technique and proved the experimental error in technique to be insignificant.

A correlation coefficient between dams and daughters was determined for 1938. All breeds were used in this analysis. This correlation coefficient was 0.761. Likewise, a correlation coefficient of 0.821 was determined for all breeds in 1939.

When the data for the years 1938 and 1939 were combined, a correlation coefficient of 0.753 was obtained. Averages were used in the latter as a single item wherever more than one daughter appeared, or whenever one ewe had data for both years.

The correlation coefficient was calculated for the dam-daughter pairs of the Rambouillet breed. Data for the two years were combined and yielded a coefficient of 0.575. A

statistical analysis of the results obtained shows this and other correlations made between scoured wool yield of dams and daughters to be highly significant.

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