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STUDIES ON INBREEDING IN SHEEP

I.—The Effects of Inbreeding on Birth and Weaning Weights of No-Tail Lambs

By

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SUMMARY

Birth and weaning weight records of a closed no-tail flock of sheep belonging to the South Dakota Agriculture Experiment Station, covering a period of 13 years and five generations were analyzed. This study was carried out to investigate the effects of inbreeding of lambs, dams and sires on birth and weaning weights of lambs.

It was found that an increase of 10 per cent in the degree of inbreeding of dams caused a decrease of 0.30 and 2.36 pounds in birth weight and weaning weight of their lambs, respectively. The inbreeding of the lambs resulted in an average decrease of about 2.55 pounds in weaning weight for each ten per cent increase in inbreeding. All the preceding values border on statistical significant. The inbreeding of the sire nad no effect on the lamb weights.

The average increase in inbreeding of the no-tail flock was 1% per year, and 4% per generation. It was found that about one-fourth of the genes that were heterozygous in the foundation stock were fixed in the fifth generation.

INTRODUCTION

In recent years inbreeding projects have been initiated by many experiment stations to obtain a more conclusive answer on how to derive greater benefit from this system of mating.

With few exceptions, the experiments of inbreeding with large animals, as well as those with laboratory animals, have resulted in reduced vigor as characterized by slower growth, smaller size, greater mortality and lower production and fertility. The present paper reports the effects of inbreeding of lamb, inbreeding of dam and inbreeding of sire on birth weight and weaning weight of no-tail lambs.

MATERIAL AND METHODS

Data used in the present study were taken from the breeding records for the no tail sheep flock raised by the South Dakota Agriculture Experiment Station, U.S.A. Birth and weaning records covering a period of 13 years (from 1947 to 1960) were used in this study. There were 750 and 613 records for birth and weaning weights, respectively.

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The flock has been closed to outside blood since 1948 Lambs were weighed within 24 hours after birth to the nearest 0.1 pound and then every month until they reached weaning age. As the lambs were not weaned at the same age, actual weaning weights were adjusted to 120 days to eliminate the effect of age on weaning weight.

The method used in this work to obtain the relationship coefficients is somewhat different from the method reported by Wright (1922 &1923) in tracing pedigrees and calculating the individual paths and summing them. All the animals in the flock were used in the claculations.

Relationship figures were calculated for each year, starting from the foundation stock in 1913; i.e. one year at a time until the final year was reached, using the method and formula reported by Emik and Terrill (1949) :

$$RXY = 0.5 \ (RSY + RDY)$$

where RXY = average relationship between X and Y individuals

RSY = average relationship between sire of X and Y individual

RDY = average relationship between dam of X and Y individual

The inbreeding coefficient of this flock ranged from 0.00 to 48 per cent with an average of 18.5 per cent.

For analysing the data, the individuals were arranged into generations by considering the lambs born in 1947 and 1948 as the first generation. Five successive generations were obtained from such arrangement.

The animals included in the study were sired by 36 different rams. An analysis of variance indicated that sire differences accounted for significant portion of the variation in both birth and weaning weights. To eliminate sire differences and to keep all coefficients comparable, the correlations and regressions were calculated on an intra-sire basis. The methods suggested by Snedecor (1959) for statistical analysis were followed.

RESULTS AND DISCUSSION

The inbreeding coefficient increased gradually from 11.6% in generation I to 24.6% in generation 5 (Table 1). The average increase in inbreeding per year was about one per cent. As the generation interval in this flock was nearly four years, it was concluded that the average increase in the inbreeding coefficient per generation was 4 per cent.

Dickson and Lush (1932) stated that the inbreeding increased from 2.2% in 1896 to 5.5% in 1926 in the Rambouillet breed of sheep in the United States or 0.69% per generation. Carter (1940) studying the genetic history of the Hampshire breed of sheep in U.S.A., reported that the inbreeding rose from 1.4% in 1925 to 2.9% in 1935.

Winters *et al* (1947) indicated that the coefficient of inbreeding rose to 4 for the ewes and 7% for the lambs of Shropshire sheep during the period 1936 to 1941 in the Minnesota Experiment Station flock. Issawi (1950) studied the development of three inbred lines of Shropshire sheep in Minnesota, during the period 1926 to 1949. The average amount of inbreeding increased 3-.3% 2.5% and 3.8% per generation for the three lines studied.

Ragab *et al* (1952) stated that the inbreeding coefficient increased from 0.4% in 1941 to 22.9% in 1950 for Ossimi sheep, and from 0.6% in 1944 to 11.3% in 1950 for the Rahmani breed of sheep in Egypt. They reported that the average increase in inbreeding was 5.3% and 4.03% per generation for the Ossimi and Rahmani flocks, respectively. The average increase in inbreeding was 1.3% and 1.03% for the same breeds.

During the period under study, the inbreeding coefficient of the no-tail lambs reached 24.9%in 1960. This is greater than two generations of half brother and sister mating, and less than the inbreeding for three generations of half brother and sister mating. It was observed from these data that the introduction of a few Rambouillet ewes and one ram, and a Columbia ram during 1948 did not cause a sudden drop in the inbreeding coefficient of the flock as a whole. After 1948 the no-tail flock was closed and the inbreeding rose gradually.

Because inbreeding tends to reduce heterozygosity, it should result in greater uniformity among offspring than can be achieved by any other mating system. Inbreeding in the no-tail flock fixed about one-tenth of the genes in generation 1, that were heterozygous in the foundation stock. In the fifth generation it was found that about one-fourth of the initial heterozygosity had been removed. If the system of mating responsible for such rate of inbreeding in the no-tail flock is continued in the future, it will be possible to fix about one-half of the genes in the flock during another period of 40 years. Such a scheme could be carried on only if the rate of growth, viability of animals and other desirable characters are not affected adversely.

The Effect of inbreeding of Lamb, Dam and Sire on The Birth Weight of the Lamb

Inbreeding of lamb effect :

The average inbreeding of lambs, birth weight in pounds, correlation and regression of birth weight on inbreeding for different generations are included in Table 1. The results show that although there were gradual increases in both birth weight and inbreeding of the lambs from the first to the fifth generations, yet negative correlations and regressions were found between birth weight and inbreeding of lamb at the first and second generations. Positive relationships were found for the other three generations, and this might be due to selectioon which was practiced toward higher birth weight. The estimates for correlation and regression for birth weight on inbreeding were non significant, except in the case of the fifth generation and this might be due to the few numbers of lambs used in this generation.

TABLE 1.—Effect of Inbreeding of Lamb on its Birth Weight

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	90	8	8.77	11.6	—.002	—.004
2	213	23	9.32	16.3	—.067	—.019
3	268	19	9.75	19.3	—.019	—.008
4	152	13	10.15	23.2	—.019	—.008
5	27	7	10.65	24.6	—.159	—.053*

* P <0.05.

The pooled regression coefficient for all five generations was found to be —.001 and was non-significant. This means that inbreeding of lamb did not affect its birth weight significantly. Ragab and Asker (1954) stated that inbreeding was respondible for decreasing birth weight of Ossimi lambs.

Inbreeding of dam effect

The average inbreeding of dams decreased from 14.9 per cent to 9.1% in the first and second generations and this probably might be due to the limited introductions of Rambouillet and Columbia sheep in 1948. Inbreeding of dams gradually increased from the second to the fifth generation (Table 2).

Nagative correlations and regressions of birth weight on inbreeding of dams were found at all generations studied. Also, at the third generation the correlation estimate was significant and the regression coefficient was highly significant.

TALBE 2.—Effect of Inbreeding of Dam on Birth Weight of Lamb

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	90	8	8.77	14.9	—.129	—.032
2	213	23	9.32	9.1	—.065	—.014
3	268	19	9.75	14.7	—.162*	—.048**
4	152	13	10.15	20.1	—.027	—.016
5	27	7	10.65	25.0	—.294	—.102

* P<0.05 ** P<0.01.

The pooled regression coefficient for all five generations was found to be —.03 and was highly significant. On the basis of this pooled regression coefficient, it was found that there was a decrease fo 0.3 pound in lambs birth weight for every increase of 10 per cent in the degree of inbreeding of their dams

The present results are not in accordance with those reported by Ragab and Asker (1954) who stated that the coefficient of inbreeding of the dam did not affect the birth weight of her offspring significantly in Ossimi sheep.

Inbreeding of sire effect :

The average inbreeding of sires increased from 11.8% in the first generation to 20.4% in the third generation (Table 3). Inbreeding averaged 18.5% and 18.6% for the fourth and fifth genrations, respectively.

In the third generation, the estimates for both correlation and regression for birth weight on inbreeding of sires were found to be highly significant. The pooled regression coefficient for all generations (being —.025) was not significant.

TABLE 3.—Effect of Inbreeding of Sire on Birth Weight of Lamb

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	90	8	8.77	11.8	—.074	—.018
2	213	23	9.32	20.1	—.051	—.017
3	368	19	9.75	20.4	—.233**	—.086**
4	152	13	10.15	18.5	—.077	—.062
5	27	7	10.65	18.6	—.215	—.135

** $P < 0.01$.

The Effect of Inbreeding of Lamb, Dam and Sire on Weaning Weight of the Lamb

Inbreeding of lamb effect :

Weaning weight of lambs is important because income from meat production largely comes from the sale of lambs soon after weaning and because it is correlated with mature body weight (Terrill, 1939).

Table 4 shows the average inbreeding of lambs, corrected weaning weights in pounds, correlation and regression of weaning weight on inbreeding of lamb for different generations studied. Weaning weight increased from 59.36 pounds in the first generation to 66.53 pounds in generation 2. It ranged between 62.64 and 65.08 pounds for the other three generations. Inbreeding of lambs increased gradually from 11.4% to 24.7% for generation 1 and 5.

Negative correlations and regressions of weaning weight on inbreeding of the lamb were found for all generations studied (Table 4). In generation 2 the estimates for both correlation and regression were highly significant.

TABLE 4.—EFFECT OF INBREEDING OF LAMB ON ITS WEANING WEIGHT

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	76	8	59.36	11.4	—.084	—.083
2	170	23	66.53	16.8	—.273**	—.602**
3	221	19	64.68	19.4	—.076	—.186
4	124	12	65.08	23.5	—.016	—.035
5	22	7	62.64	24.7	—.279	—.372

** $P<0.01$.

The pooled regression coefficient for all five generations was found to be —.255 and was highly significant. On the basis of this result, one should expect a decrease of 2.55 pounds in weaning weight of no-tail lambs for every increase of 10 per cent in their inbreeding. The present results are in agreement with those reported by other workers. Clambocki and Nahimison (1945) Hazel and Terrill (1945 & 1946), Terrill *et al* (1947 & 1943), White (1949), Ragab and Asker (1954) and Brown *et al* (1961) using different breeds of sheep reported that inbreeding of lambs was responsible for decreasing their weaning and yearling weights.

Inbreeding of dam effect :

The average inbreeding of the dams decreased from 14.8% to 9.4% in the first and second generations, while it gradually increased to 25.2% in the fifth generation (Table 5). Negative correlations and regressions for weaning weight of lambs on inbreeding of their dams were found for generations studied except the first generation where relationships were positive. The estimates of correlations and regressions were highly significant for the third and fifth generations.

The pooled regression coefficient for all genrations was found to be —.236 and was highly significant. This means that a decrease of 2.36 pounds in weaning weights of lambs is expected for every increase of 10 per cent in the degree of inbreeding of their dams.

The present resluts are not in accordance with those reproted by Ragab and Asker (1954) who stated that the coefficient of inbreeding of the dam did not affect the weaning weight of her offspring significantly in Ossimi sheep. However, Brown *et al* (1961) working on spring lambs reproted that inbreeding of dam was not a significant source of variation although the partial regression coefficient indicated a decline in growth associated with increased inbreeding of dam.

TABLE 5.—EFFECT OF INBREEDING OF DAM ON WEANING WEIGHT OF LAMB

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	76	8	59.36	14.8	—.013	—.018
2	170	23	66.53	9.4	—.110	—.169
3	221	19	64.68	14.4	—.198**	—.364**
4	124	12	65.08	20.1	—.099	—.348
5	22	7	62.64	25.2	—.629**	—.926**

** P<0.01

Inbreeding of sire effect :

Table 6 includes the average inbreeding of sires per generation, weaning weights of lambs and correlations and regressions for weaning weight on inbreeding. Negative correlations and regressions for weaning weight of lambs on inbreeding of their sires were found for the first, third, fourth and fifth generntions. In the second genration, the figures for both correlation and regression were found to be positive and significant. The pooled regression coefficient for all generations (—.069) for weaning weight of lambs on inbreeding of their sires was non-significant.

TABLE 6.—EFFECT OF INBREEDING OF SIRE ON WEANING WEIGHT OF LAMB

Generation	No. of lambs	No. of sires	Average weights pounds	Average inbreeding per cent	Correlation	Regression
1	76	8	59.36	11.5	—.144	—.177
2	170	23	66.53	19.9	.208*	.503**
3	221	19	64.68	20.3	—.008	—.018
4	124	12	65.08	18.6	—.094	—.383
5	22	7	62.64	18.3	—.318	—.839

* $P<0.05$ ** $P<0.01$.

The present analyses support the conclusion that there is a depressing effect on both birth and weaning weight of lambs with increasing levels of inbreeding of the lamb as well as of both parents. For lamb birth weights, only the regression of birth weight on inbreeding of the dam was significant. Lamb weaning weights were significantly affected by the inbreeding of both the lamb and its dam.

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دراسات عن تأثير تربية الأقارب فى الأغنام

١ ـ تأثير تربية الأقارب على الوزن عند الميلاد والوزن عند الفطام فى الأغنام عديمة الذيل

كمال غنيم ، ج . و . ماكرتى

الملخص

حللت سجلات قطيع من الأغنام عديمة الذيل بمحطة تجارب جامعة سوث داكوتا بالولايات المتحدة الأمريكية لدراسة تأثير تربية الأقارب للحملان والأمهات والآباء على وزن الحملان عند الميلاد وعند العظام . وشملت الدراسة السجلات التى تجمعت فى الفترة بين ١٩٤٧ ـ ١٩٦٠

واظهرت نتائج هذا البحث أن كل زيادة فى معامل تربية الأقارب للأمهات قدرها ١٠٪ كان مصحوبا بنقص قدره ٠٫٣ ، ٢٫٣٦ رطلا فى متوسط أوزان الحملان عند الميلاد وعند العظام على التوالى . واتضح أن زيادة معامل تربية الأقارب بمقدار ١٠٪ للفرد نفسه قد سبب نقصا فى الوزن عند العظام بنحو ٢٫٥٥ رطلا . أما معامل تربية الأقارب للآباء فانه لم يؤثر على الأوزان السابقة للحملان بطريقة معنوية ولم يتضح له اتجاه معين .

وقد وجد أن معامل تربية الأقارب فى القطيع يزداد بمقدار ١٪ كل عام، ٤٪ فى كل جيل ، وأن حوالى ¼ العوامل الوراثية التى كانت خليطة فى الأغنام التى استعملت لتأسيس القطيع تحولت الى عوامل أصيلة فى الجيل الخامس نتيجة استخدام تربية الأقارب فى القطيع جيلا بعد جيل .