A study on some aspects of lifetime production in targhee and columbia sheep
by Arun Kumar Basuthakur

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Animal Science
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Abstract:
The relative lifetime lamb and wool production data for Targhee and Columbia sheep maintained by the Agricultural Experiment Station at Montana State University was analyzed for ewes born from 1950 to 1962. The productive traits concerned were analyzed by least square analysis of variance with interaction, phenotypic correlation and heritability was estimated. The total number of animals studied was 732 Targhees and 411 Columbias.

In Targhees, it was observed that type of birth of the ewes sire affects the number of lambs born, whereas in Columbias the type of birth of ewe affects the trait. The interaction of type of birth was observed to be significant for number of lambs weaned in Targhees.

The fleece production showed a significant effect of type of birth of ewe and her sire in Targhees but not in Columbias.

Multiple births showed a positive significant correlation in Targhees with type of birth of the ewes sire whereas in Columbias type of birth of ewe was significant. Lamb and wool production showed variable significant correlations with yearling and weaning weights in both the breeds but were of low magnitude.

The heritability for weaning and yearling weight were observed to be quite high in both the breeds in comparison tp other traits studied. The heritability of multiple births in Targhees was observed to be quite high compared to other breeds of sheep.

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Date 28th Jan 1970

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by 1651B

ARUN KUMAR BASUTHAKUR

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

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Approved:

R Z Blackwell
Head, Major Department

J. L. Van Horn
Chairman, Examining Committee

K Goering
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

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ABSTRACT

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INTRODUCTION

Sheep are perhaps one of the first ruminants domesticated by man. Sheep may be considered as man's first helpmates to supply him with wool, meat, milk and pelt. Today, there is no history of any religion or race where somewhere there is no mention of sheep.

The history of sheep in this country starts somewhere between 1493 to 1520, through import from Spain and England. During that time, wool was more important than lambs for slaughter. As early as in 1662, the first woolen mill was established and all possible encouragement and legislation for growing sheep was started in 1670.

Modern development to increase lamb and wool production in the United States started about 1912, when long wool breeds were crossed with high quality Rambouillet ewes to produce large ewes with greater production of wool and lamb. These early crosses resulted in the Columbia sheep. Under a similar demand, another high quality sheep breed was developed basically by crossing Columbia ewes with Rambouillet rams. These foundation sheep established the Targhee breed in 1926.

However, the increasing population and its many fold demands of today requires more production from domestic animals to keep it progressive under the present mechanism of economy. Research in other livestock has efficiency of production. Sheep not only produce fiber with many special characteristics but also it is one of the few mammals where incidence of multiple follicular growth and twinning is frequent.

Though the domestic sheep is said to have originated from two wild ancestors (Moufflon and Urial) the hundreds of completely dissimilar breeds with its tremendous diversity of production potentiality under the present bioclimatic conditions of the world entails an enormous store of genetic variability. Genetics study of sheep over the last half century revealed the presence of an impressive array of genetic phenomena.

Terrill (1958) reviewed the past 50 years of sheep breeding research but still some of the results show inconclusive understanding for practical emphasis under genetic law due to variablity between samples and breeds.

The Columbia and Targhee sheep which form one of the major sheep populations of this country have already gone through different mechanisms of selection and are at present improved and adopted breeds. To further increase the production ability of wool and lambs, it is essential to further investigate and know accurately the genetic potentiality and present production ability.

With the above in view, the present work was undertaken with the Columbia and Targhee sheep, stationed at the Red Bluff Sheep Research Ranch of the Montana State University, to study the phenotypic relations of different productive traits at different ages, including heritability and mechanism of inheritance of lifetime production of wool and lamb.

REVIEW OF LITERATURE

I. Fertility and Multiple Births

There seems to be very little evidence where selection in sheep has been used to increase the number of lambs born per ewe lambing. However, studies indicate that the fertility is extremely variable between breeds and between flocks within breeds.

Kennedy et al. (1950), observed that in Merino sheep multiple births were associated with age of dam. Wright et al. (1953) studying Romney and Corriedales reported an average of 0.4 more lambs per ewe for dams born as twins compared to dams born as singles. Belic (1954) studying eight years of production in Tsigai sheep from Belgrade also observed higher incidence of more multiple births in animals born as twins compared to singles. He also reported in the same breed that the incidence of twinning increases with age and reaches a peak at four years of age. Later, Belic (1958) presented data showing that 8.1% have markedly low fertility, 2.1% have extraordinary fertility and regularly gave birth to twins or triplets and 0.1% produced two lambs more on the average than their lifetime number of lambings. In a similar study, Madsen et al. (1952) found no significant results in number of lambs produced from crossbred range ewes sired by Columbia, Targhee and Rambouillet.

In a flock of Wurttenberg ewes, Polach (1960) observed the maximum rate of twinning at five and one-half years of age. Teodoreanu

et al. (1959) reported maximum number of multiple births in Palas Merino at four to eight years of age. Desai et al. (1951) also reported that ewes born twins gave birth to 0.12 more lambs than ewes born as singles. The frequency of triplet production was also higher in the twin born group and there was consistently higher lifetime reproductive performance.

II. Wool Production

Wool production is another important trait in sheep. Total production however, varies from breed to breed and is affected by such things as density, fineness, staple length, lamb production age and nutrition.

Nagal (1947) in a Germanland Merino flock observed that with age the wool production slowly dropped. The average of the flock at two years of age was 4.1 kg and the average for the same flock at eight to ten years of age dropped to 3.5 kg. A similar observation was also reported by Sanchez (1950) that the production of Spanish Merino increases up to four years of age and then decreases with age.

Wright et al. (1953) studied the lifetime production and breeding performance of Romney and Corriedale ewes. They also observed that fleece weight and fertility changes with age. These data indicate that lambs born as singles produced more wool (0.27 ± 0.12 lb.) than lambs born as twins. Ali (1952) reported the average fleece weight

in Shorpshires as 9.1 lbs. with a standard deviation (S.D.) of 1.3 lbs. and considers that variability of body weight is negligible to improve wool production as compared to other qualitative traits of the fleece.

Hulet et al. (1969) reported wool production in Rambouillet, Targhee and Columbia sheep from two to six years of age. They have shown the average production in two groups according to the appearance of estrus during the first winter after birth. (Table I).

TABLE I. ANNUAL WOOL PRODUCTION IN RAMBOUILLET, TARGHEE AND COLUMBIA (Hulet et al. 1969)

Age	Estrus	Rambouillet (kg)	Targhee (kg)	Columbia (kg)
2	No	4.2 ± 0.01	4.6 ± 0.03	5.0 ± 0.02
	Yes	4.2 ± 0.08	4.5 ± 0.05	4.9 ± 0.07
3	No	4.4 ± 0.01	4.8 ± 0.02	5.3 ± 0.03
	Yes	4.4 ± 0.09	4.7 ± 0.05	5.3 ± 0.09
4	No	4.4 ± 0.02	4.8 ± 0.03	5.3 ± 0.03
	Yes	4.3 ± 0.06	4.6 ± 0.08	5.1 ± 0.13
5	No	4.3 ± 0.03	4.8 ± 0.03	5.2 ± 0.05
	Yes	4.3 ± 0.09	4.7 ± 0.09	5.0 ± 0.22
6	No	4.4 ± 0.10	4.7 ± 0.13	5.1 ± 0.18

As expected, the Columbia shows the highest production and Rambouillets the lowest among the three with Targhees intermediate. Their data does not show much variability due to age between two and

six years of age within each breed. In Rambouillets, Shelton (1968) reported the fleece weight from two to ten years of age. (Table II). The fleece weights according to his work show a decrease with increasing age after the age of three years.

TABLE II. AVERAGE WOOL PRODUCTION IN RANGE FINE WOOL EWES (Shelton 1968)

Age	No.	Av. Ewe Body Weight (kg)	Av. Fleece Weight (kg)
2	1330	44.0	4.36
3	1111	46.0	4.50
4	924	51.0	4.49
5	747	53.2	4.39
6	568	53.9	4.27
7	364	53.6	4.03
8	200	53.4	3.96
9	84	51.1	3.64

III. Weaning Weight

The weight at weaning is one of the most crucial measurements in sheep production. The variability of this particular trait is influenced by the level of nutrition of the dam, age of dam, birth weight and age of lamb at weaning, type of birth and rearing, climatic conditions and breed of sheep.

Sidwell et al. (1949) studied the size of Navajo lambs at weaning from the lifetime production of 414 Navajo ewes in New Mexico. The adjusted average weaning weight at approximately 139 days of age was 59.4 lbs. with a standard deviation of 9.8 lbs. Six measureable environmental factors found to have an important effect upon the weaning weights of the lambs were year of birth, age of dam, type of birth, type of rearing, sex, and age of lamb at weaning. Weaning weights were observed to be 5.2 lbs. below average for 1939 to 1946; whereas, those in 1941 were 6.9 lbs. above average. Two-year-old ewes weaned the smallest lambs; 4-to 7-year-old ewes weaned intermediate weight lambs. Columbia rams sired the heaviest lambs at weaning followed by Corriedale crossbreds, Navajo and Romney rams, respectively. Single lambs were 11.2 lbs. heavier than twins and 2.9 lbs. heavier than twins raised as singles. Ewe lambs averaged 4.4 lbs. less than ram lambs.

The effect of crossbreeding Navajo ewes to Columbia and Romney rams and Navajo crossbred ewes to Lincoln and Cotswold rams on weaning weight was reported by Price et al. (1951). The average weaning weight of Cotswold cross lambs was 65.1 lbs. and was significantly higher than that of the other three crosses. The average weaning weights of Columbia (64.0 lbs.) and Lincoln (63.29 lbs.) cross lambs were significantly greater than that of the Romney cross lambs (61.38 lbs.). The average weaning weights of the Columbia and Romney sired lambs differed

by 2 lbs. and although the number of observations was small, the difference was significant.

Similar work on the effect of age of dam and type of birth on weaning weights of lambs in Rambouillets was reported by Shelton et al. (1968) as follows:

TABLE III. AGE OF DAM AND EFFECT OF TYPE OF BIRTH ON WEANING WEIGHTS IN RAMBOUILLET SHEEP

Age	No.	Average Weaning Weights (kg) Singles (S)	Twins (T)	(S-T)
2	1330	28.1	25.5	2.6
3	1111	31.8	27.7	4.1
4	924	32.0	27.3	4.7
5	747	32.0	27.8	4.2
6	568	32.2	26.6	5.6
7	364	28.5	26.5	2.0
8	200	29.4	25.6	3.8
9	84	27.6	25.1	2.5
10	23	24.0	25.7	-1.7

In this case, the maximum average weaning weight of lambs was for the dams from three to six years of age. The maximum difference (5.6 kg) between singles and twins was at six years of age. Sex difference was not studied. In general, the difference in weight between the whole group of dams for singles and twins was 2 to 5 kg.

IV. Yearling Weight

Yearling weight is another measure with which many other characteristics of future production have been correlated. Yearling weight is thought to be of greater importance in predicting the future production than weaning weight.

Hulet et al. (1969) reported average yearling weight in Rambouillet, Targhee and Columbia sheep based on the appearance of estrus or no estrus during their first winter after birth.

TABLE IV. MEAN AND STANDARD ERROR FOR YEARLING WEIGHT IN RAMBOUILLET, TARGHEE AND COLUMBIA SHEEP

	Rambouillet		Targhee		Columbia	
	No. Lambs	Mean-S.E.	No. Lambs	Mean-S.E.	No. Lambs	Mean-S.E.
No estrus	2110	52.6 ± 0.10	1663	57.7 ± 0.26	1153	56.1 ± 0.16
Estrus	254	54.2 ± 0.67	267	56.4 ± 0.45	119	57.7 ± 0.50

They reported no important interactions between estrous status and years or estrous status and type of birth and rearing for any of the weaning or yearling traits.

V. Phenotypic Correlation

It is important to know the degree of relationship among traits and the sign of the correlation. Shelton and Menzies (1968) studied the simple correlation coefficients (Table V) in a Rambouillet flock stationed at Sonora, Texas. The data collected were for the years 1930 to 1966.

TABLE V. SIMPLE CORRELATIONS AMONG TRAITS MEASURED IN RAMBOUILLET (Shelton et al. (1968)

	Yearling breeding weight	Mature weight	Years in breeding flock	Number lambs born	Number lambs raised	Number dry seasons	Number multiple births	Average fleece weight	Total wool production	Total lamb production	Lambs born Times bred	Lambs born Times bred
Weaning weight	.660**	.418**	.039	.101**	.088**	-.049	.126**	.059	.063	.102**	.130**	.125**
Yearling weight		.621**	.069*	.131**	.124**	-.039	.151**	.147**	.105**	.148**	.166**	.154**
Mature weight			.269**	.203**	.159**	.228**	.221**	.295**	.349**	.207**	.012	-.017
Years in flock				.853**	.826**	.409**	.477**	.017	.949**	.821**	.220**	.222**
Number lambs born					.954**	-.011	.757**	-.059	.793**	.936**	.604**	.542**
Number lambs raised						-.016	.696**	-.083**	.764**	.980**	.565**	.634**
Number dry seasons							.022	.209**	.438**	-.020	-.480**	-.417**
Number multiple births								.021	.456**	.651**	.597**	.498**
Average fleece weight									.295**	-.101**	-.135**	-.169**
Total wool production										.576**	.188**	.190**
Total lamb production											.532**	.600**
Lambs born Times bred												.856**

*(P<.05)
**(P<.01)

There was a low but significant negative correlation between the average wool yield and the various reproductive efficiency traits in the flock. The number of multiple birth was nonsignificantly correlated with average fleece weight. Most of the traits show a positive relationship with both weaning and yearling weight. However, of the two, yearling weight would be of more value in predicting future performance due to its higher correlation. Total lamb production and multiple births were significantly positively correlated with yearling and mature weight. Mature weight and years in breeding flock show a low positive correlation with the number of dry seasons. Years in flock was highly correlated with total wool and lamb production.

Kennedy (1966) studied the phenotypic correlation between fertility and wool production in Merino sheep in Australia. He observed that the correlation between number of lambs born or weaned was negatively correlated with grease wool weight. He reported correlations of -0.09 and -0.12 between grease wool weight, number of lambs born and number of lambs weaned, respectively. Young, et al. (1960) while estimated phenotypic correlations between fertility and grease or clean weight at different ages in Merino sheep in Australia and reported no consistant trend.

Belic (1954) studied the effect of fertility on wool production

in Tsigai sheep. Wool production for ewes producing singles and twins was reported separately. His observations show the greater the fertility in Tsigai ewes the lower the wool production.

Slen et al. (1954) obtained a correlation of 0.40 between the yearling weight and clean fleece weight. In a similar study with Corriedale sheep, Wright et al. (1953) found a significant correlation between yearling weight and grease fleece weight. Sanchez (1950) shows positive significant correlation of 0.49 between grease fleece weight and yearling weight in Spanish Merino.

Terrill and Kyle (1953) in a study of the Columbia, Targhee and Rambouillet breeds found a positive significant correlation between the yearling and weaning weight with clean fleece weight. Spencer et al. (1928) obtained a phenotypic correlation between yearling weight and grease fleece weight of 0.16, in Rambouillet sheep.

Bassett (1965) studied the data collected at the Montana Agricultural Experiment Station, Bozeman, over the period of 1955 to 1963 and reported the following correlations between yearling weight and grease fleece weight for Rambouillet 0.49, Targhee 0.67 and Columbia 0.56.

VI. Heritability

Wright et al. (1953) studied the lifetime wool production and breeding performances of Romney and Corriedale ewes. The heritability of fleece weight was 0.52 for both breeds.

Ali (1952) in his study with Shorpshire, Columbia and Hampsire sheep obtained heritability estimates of 0.52 by the regression method and 0.32 by the correlation method for fleece weight. The analysis was composed of animals with mixed genetic materials including cross-breds and inbreds and the above figures were calculated without controlling the variation due to body weight. Further estimates of heritability for fleece weight in the same sample based on the intra-year regression of offspring on dam within breed of sire was 0.43, which differred only slightly from the corresponding within sire estimate of 0.51.

Morley (1954) estimated heritability of grease fleece weight and yield in Merino sheep. One set of estimates was obtained by parent-offspring regressions for the data obtained between 1943 to 1952, and another set of half-sib analyses from data from sheep with first adult shearing in 1953. The estimates were 0.40 and 0.39 for grease fleece weight and yield, respectively, by parent offspring, regression and 0.44 and 0.75 by the paternal half-sib method.

Young et al. (1960) studied heritability of grease fleece weight and nine other wool characteristics in Merino sheep. Their study included three groups of sheep namely (1) half-sib selection group (2) mass selection group (3) control group. The heritabilities of grease fleece weight by groups were: 0.499, 0.360 and 0.449, respectively. The data were analyzed by dam-daughter correlation. Within

the major groups, the data have been classed as to mating groups which again have been sub-classed as per to type of birth of progeny and their dam. The characteristics were measured when animals were 15 to 16 months of age.

Rendel (1956) analyzed the routine records of a sheep farm in Sweden from 1925 to 1942, comprising 30,989 births of Cheviots, Oxford Down, Shorpshire and Swedish Landrace sheep. There were 5093 dams and 425 sires. The average number of births per ewe was 6.09, and the overall frequency of multiple births was 51.1%, the Landrace being highest with 69.1%, and the Oxford Down next with 51.0%. Estimates of heritability of multiple births obtained by two methods were in fairly good agreement but differed somewhat between breeds. When the results of the two methods were averaged, the heritability for multiple birth in the four sheep breeds was estimated to be 0.113. (Table VI).

Robertson and Lerner's method (used by Rendel 1956) for estimate of the heritability includes the ratio between the average genotypic change and the selection differential with the argument that even if no artificial selection is applied there exists a natural selection for such traits as viability or incidence of multiple birth, since individuals with high viability or high fertility will get more offspring in the next generation than those having low viability or fertility.

TABLE VI. ESTIMATES OF HERITABILITY AND REPEATABILITY OF MULTIPLE BIRTH WITHIN HERDS IN DIFFERENT BREEDS (Rendel 1956)

Breeds	Heritability	Heritability[1/]
Cheviot	0.224	0.185 ± 0.023
Shorpshire	0.042	0.037 ± 0.011
Landrace	0.088	0.062 ± 0.023
Oxford Down	0.084	0.080 ± 0.020
Average	0.126	0.099 ± 0.010

1/ By Robertson and Lerner's Method

The heritability mentioned here of 0.113 was somewhat lower than that of Johansson and Hansson (1943) for multiple birth in sheep (0.214) calculated by dam-daughter correlation when estimated from the half-sib correlation (0.196) based on the average of two lambings.

Karam, et al. (1958) while studying multiple birth in Texal sheep in Egypt calculated the heritability for the number of lambs born. They used both daughter-dam and half-sib correlation. The average number of lambs per lambing for each ewe was used. A heritability estimate of 0.255 was calculated by doubling the overall daughter-dam regression using 343 pairs. The available daughter-dam pairs within sire group were only 2.81 per sire. Another estimate of 0.298 was obtained by multiplying the intra-class correlation by four for the half-sib correlation.

Karam (1959) reported heritability for weaning weight in Rahmani sheep as 0.18 and yearling weight as 0.19. Mac Naughton (1957) reported the heritability estimates of 0.33 and 0.52 for weaning and yearling weight in Corriedale sheep. Bosman (1958) reported heritability estimates for two groups of Merinos as 0.09 and 0.47 for grease fleece weight, 0.23 and 0.44 for clean fleece weight, 0.48 and 0.22 for wool production.

Vesely et al. (1961) reported heritability of Rambouillet sheep from Canada for weaning weight 0.28 ± 0.09, yearling weight 0.37 ± 0.11, and clean fleece weight 0.48 ± 0.08.

The heritability was calculated by intra-sire regression of daughter on dam adjusting the data for year, age of dam, type of birth and rearing and age of lamb or yearling ewe. The data were collected for over a 12 year period.

Vachal (1962) reported heritability of grease fleece weight as 0.37 in Stravropol Merino sheep. His sample consisted of 536 dam-daughter pairs sired by 69 rams of about two years of age. While in another group with Mutton Merino blood, he obtained heritability of 0.299 calculated on 241 dam-daughter pairs.

EXPERIMENTAL PROCEDURE

The data under study were those records which were regularly recorded as part of the normal routine research activity of the Animal and Range Science Department, Montana Agricultural Experiment Station, Bozeman, Montana. These data include the female lambs of Targhee and Columbia breeding born from 1950 to 1962 and their subsequent production in the band.

In general, the ewes were bred from two years to eight years of age. The total production of wool was considered from their first year but for lamb production, it was from the second year when they were expected to produce the first lamb crop. The age of culling was the period the animal lived in the band from its year of birth and the production was calculated accordingly. The elimination of ewes from the band was due to death or as otherwise discussed under selection. The number of ewes available for study are tabulated in Tables VII and VIII.

Management Practices

All the animals were managed as a typical band of range ewes on the unfenced area of the Station and on National Forest allotments. The animals were collected and brought to the headquarters of the Station only during breeding, lambing and data collecting time.

In general, the breeding season for the period was mid-November to early December and consequently the lambing time was April and May.

The ewes were mated in small flocks of 40 to 60 with their respective breed of rams under a pen-mating system. During the breeding season, mixed hay and alfalfa hay were supplied in addition to the continuous flowing water. At the end of the breeding season, the ewes were herded together on the range until the start of the expected lambing season. Hay was fed whenever snow was too deep for grazing or if there was not sufficient feed. During the lambing season, the herd was brought to the shed and the ewes were managed under shed lambing conditions.

Just after parturition, the dam and the lamb were taken to a 4' x 4' pen or "jug" and kept for 24 hours or more depending upon the condition of the lamb and mothering ability of the dam. Then both the dam and the lamb were collected in a small pen where five to ten such animals can be kept at a time and maintained for five to six days prior to putting them in a larger group. The time for the passage of the dams and lambs from the jug to the corral depended on the number of jugs available and speed of parturition during the season. The same number paint brand was branded on the lamb and mother. The lamb numbers were checked from a breeding sheet previously prepared and accordingly the lamb was eartagged, weighed and a docking ring applied while in the jug. The lamb number and birth weight was entered in the lambing book according to breed and band including dam number and sire number. The number of the lamb, birth weight and day of birth

was also entered on the respective ewe card.

Ewes and lambs were then grazed during May and June on the Station and by July taken in a single flock to the forest allotment for summer grazing.

At the end of August, when the age of the lambs was approximately 18 weeks, the animals were collected and a weaning weight determined at the summer pasture. The animals were weighed on a platform balance and males and females were separated. The animals, after being collected in the drafting yard, were led through the squeeze into a chute provided with cutting gates. The ewes, and lambs were thus separated before weighing. The weights were entered on a work sheet. The female lambs joined their mother again whereas the male lambs were weaned and transferred to a separate pasture for grazing. All weaning weights thus recorded was also entered on their respective dam cards. During September, the flock was trailed from the summer range to the Station.

The same type of drafting yard as mentioned above was used. The animals were weighed individually, branded and the weight recorded on work sheets.

The shearing program at the Station occurs during the month of June or in later years in April. Each animal was machine shorn and the fleece was rolled down from the shearing cabin. The fleece was individually collected, weighed on a hanging-pan spring balance at the spot

and rolled in a cheese cloth or plastic bag including an identification tag bearing the number of the animal.

The number and weight of the fleece was also recorded on a work sheet. A number of fleeces were then packed together and transported to the Wool Laboratory of the University for further analysis. The fleece weight, in addition to other wool quality standards, were then entered on the ewe production record card.

Though the above was the general management practice as a whole, some of the animals from both the breeds have gone through different kinds of nutrition, flushing and other management experiments. No. separate management was done for the treated or untreated groups.

Selection

No particular type of selection was practiced during the early years of this study. Only ewes with some visible defects were eliminated from the flock. Ewes with continuous reproductive failure were also culled. However, no record of any particular type of selection in practice for the early years were available.

During the later parts of the study, some regular and systematic type of selection was practiced. A ewe that did not produce a lamb for two consecutive years was taken out of the band. Face cover, weaning and yearling weights, type of birth and general wool production and grade was used in selection for the latter years of the study.

Selection was more intence for the Targhees than the Columbias for some years at the beginning as the Targhee flock was large and Columbia numbers were quite small. During that period to increase the number of Columbia sheep, no ewe excepting an extreme case of continuous reproductive failure or visible defects was eliminated from the flock.

For rams, also no particular type of selection method is available in the record for the early years. They were selected by visual appraisal giving some importance to verility and body weight. During later years however, consideration of characteristics as mentioned above was used for selecting stud rams including rate of growth.

Statistical Analyses

To avoid entanglement effect of age at culling, years of birth, type of birth of ewe and of her sire and interaction of type of birth in this case, from the disproportionate subclass frequencies, the least squares method of analysis was undertaken. The method as discussed and suggested by Harvey (1960) was followed.

Phenotypic Correlation

The estimate used for the correlation is the ratio of the covariance to the geometric mean of the two variances.

The conventional formula according to Fisher (1967) and Mather (1946) as used by other workers in the field has been used to calculate the correlation between two metric characters.

Heritability

Heritability estimates were calculated from the intra-class correlation of paternal half-sibs, which were computed within year subclasses using a nested analysis of variance.

The sire variance (6_s^2) contains one-fourth of the additive genetic variance while three-fourths of the additive genetic variance is included in the error variance (6_e^2) in addition to other sources of variation.

The general formula used is $h_i^2 = \frac{4b_s^2}{6_s^2 + 6_e^2}$

h_i^2 = Heritability of trait

h_s^2 = Between sire component of variance

6_e^2 = Within sire component

RESULTS AND DISCUSSION

Least Squares Analysis

Results

Lifetime production records of lamb and wool from 732 Targhee and 411 Columbia ewes including their weaning and yearling weight were analyzed by the least squares method. No adjustments for any data were made. The analysis of variance was undertaken for each trait to analyze the effect of age at culling, year of birth, type of birth of the ewe, type of birth of the ewe's sire and the interaction between type of birth of the ewe and her sire on the ewe's lifetime. The data for each breed were tabulated and analyzed separately. (Tables X and XI).

Number of Lambs Born Per Ewe

The effect of year of birth and type of birth of the ewe are significant ($P<.05$) in the Columbia. But neither the type of birth of her sire nor the pooled interaction between the type of birth of the ewe and her sire shows any significant effect on the number of lambs produced.

In the Targhees, the year of birth is significant ($P<.01$) but unlike the Columbias, the type of birth of the ewe is nonsignificant. The least squares means for the ewes born as singles sired by rams born as singles has the lowest mean (4.93) of the four types if interactions and ewes born as twins sired by rams born as twins is higher for both

the breeds, In Targhees, however, ewes born as singles sired by rams born as twins shows the highest average (5.34) whereas in Columbias where both were born as twins. (Tables VII, VIII and IX)

Number of Lambs Weaned

In the Columbias, the effect of age at culling of dam is significant, whereas all of the factors studied were nonsignificant. In the Targhees, the year of birth and the interaction between type of birth of dam and her sire, are highly significant ($P \leq .01$). However, the type of birth of the ewe and type of birth of her sire separately seems to have no significant effect on the number of lambs weaned. The effect of age at culling shows a considerable increase from two years to eight years for both the breeds in regard to mean. The highest number of lambs weaned was by the seventh and eighth year groups for both the breeds. The effect of type of birth on the means as usual was better where either the dam or the dam's sire was born as a twin. In the Columbias, as before, the mean was highest when both the ewe and her sire were born as twins.

Total Pounds of Lamb Weaned Per Ewe

In Columbias, the age at culling was significant and all other factors are nonsignificant. In Targhees, similarly the age at culling of dam, year of birth and the interaction between type of birth of the ewe and her sire were highly significant ($P \leq .01$) as it was for