GENETIC AND ENVIRONMENTAL
FACTORS AFFECTING CERTAIN
PRODUCTIVE CHARACTERS IN SHEEP

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INTRODUCTION

Any discussion of the productive characters in sheep must of necessity include some characters of a purely aesthetic nature. Among traits judged to be of aesthetic but not of productive importance, one might include all of the fancy points and trade marks of the breed or breeds concerned. These points may be of economic importance because some sheep breeders are willing to pay for these characteristics even though improvement for productive factors may suffer as a result. Among productive characters, the most important might include those characters in an animal or breed of animals which gives it an advantage in supplying to man the basic needs to maintain his own existence as food, clothing and shelter. No doubt, overlapping exists relative to these two classes, and it is not always easy to determine which characteristics are aesthetic and which are productive. However, this problem must be considered by every constructive breeder of sheep when setting up his goals or ideals. In any event, the only general basis for any real conflict in breeding for fancy points and trade marks versus productive characteristics is the fact that each additional trait considered must necessarily weaken the selection which might otherwise have been practiced.

The evidence that is available at the present time would indicate that those qualities in sheep which have the most important productive value are complex in their inheritance. In contrast most aesthetic characters are inherited in a simple Mendelian manner. That is, these characters can be divided into clear-cut phenotypic classes exhibiting discontinuous variation which reveals the underlying genetic composition. The productive characters, on the other hand, cannot be so simply classified and they display continuous variation which is represented by a normal frequency distribution.

Most productive characters are affected by many pairs of genes and by many sources of environmental variations. It is rarely possible to identify the pertinent genes in a Mendelian way or to map the chromosome position of any of them. If it were possible to make such a study it would likely require many, many years and thousands of sheep to complete a genetic analysis of productive factors in this species. Even if the gene pattern of every character were known, one would still be confronted with the task of combining the desirable genes into sheep that would be an improvement over those in existence, and this task might require fully as much time as the analysis. Concerning this dilema, Lush (26, p. 356) concludes that fortunately this inability to identify and describe the genes individually is almost no handicap to the constructive breeder of economic plants and animals. What the breeder would actually do if he knew the details about all the genes which affect a quantitative (productive) character in a population differs little from what he would do if he merely knew how heritable the trait was and whether much or little of the hereditary variance came from dominance or overdominance, and from epistatic interactions between the genes.

Since environmental effects are not transmitted from parent to offspring, each new generation is better than the unselected parental generation only to the extent that the breeding values of those chosen as parents could be recognized through the shroud resulting from environmental and gene-environmental interactions. It must be remembered that heredity decides the upper limit of the production of an individual, while the environment determines how far that animal will go toward reaching the limit imposed by the genetic constitution.

So far the author has tended to look upon the environment as a liability in confusing the breeder in selecting the best genotypic animals. It cannot be stressed too strongly that conditions of feeding and management, and other aspects of the environment are of utmost importance in sheep breeding. However, it is not the objective of this thesis to champion heredity over environment, rather the purpose is to measure or evaluate both environmental and genetic effects as they naturally occur among sheep in western Oregon. It should be emphasized that selection in a flock must be practiced under a similar environment to which the resultant offspring will be exposed. The necessity for keeping animals under an environment that will permit them to show their differences in productivity arises from the fact that conscious selection for such differences is possible only when and as far as such differences are permitted to develop to a recognizable degree.

Since the present thesis concerns genetic and environmental factors affecting certain productive characters in western sheep, it is felt that a recent statement by Nordby (35, p. 68) is indicative of a new trend or approach to constructive sheep improvement. Nordby contends that the assurance against obsolescence of any breed will be in proportion to the willingness that sponsors of that breed permit science free expression in naming the order of emphasis that must be placed on utility and breed type characteristics in an effort to bring about basic agreement between the economics of production and consumption.

SOURCE AND GENERAL DESCRIPTION OF DATA

The files of the Sheep Breeding Project of the Oregon Agricultural Experiment Station have provided the records upon which the present study is based. Among the objectives of this program is the evaluation of the strong and weak points of several breeds of sheep as sires and as breeding ewes which are best adapted to western Oregon. The present study is primarily concerned with estimating genetic and environmental factors affecting lamb production in the station flocks. Greater relative emphasis is being placed upon lamb production rather than wool, because approximately 75 percent of the returns from this dual purpose species is realized from the sale of lamb or mutton in the area concerned. Production records have been compiled beginning with the breeding season of 1942 and includes information on the 1951 lamb crop.

The experimental flocks during 1943 through 1946 consisted of approximately 100 F_1 (Lincoln x Rambouillet) breeding ewes to which purebred Romney, Hampshire and Southdown rams were mated. The period from 1947 to 1950 was used to develop four commercial flocks of about 30 ewes each sired by Romney, Hampshire, Border Leicester and Cheviot rams from the original F_1 ewes.

Weather records have been kept at Oregon State College since

1889, according to Powers (40, p.1). While the College Weather Station instruments are exposed on the turret of Agricultural Hall, located in the Willamette Valley some two miles from the sheep pastures, these data should represent very closely the general climatic conditions as experienced by the Oregon State flocks. The 500 acres of hill pasture over which the sheep graze is situated among the eastern foothills of the Coast Range at a variable elevation of about 200 to 400 feet above sea level and at approximately latitude 44° 25' N. and longitude 123° 15' W.

Concerning the Corvallis climate, Powers (40, p. 2) asserts that it is fairly representative of the Willamette Valley and may be designated as a mild subcoastal type with moist, open winters, a dry harvest period in late summer and a remarkably long growing season. Prevailing westerly winds bring the modifying effect of the ocean which lies some 50 miles westward. The coldest winter weather and warmest summer weather are associated with the advent of a continental air mass from the north or east. This condition brings the very cold air from the eastern Oregon and Washington plateau over the Cascade Mountain Range or down the Columbia River Gorge in winter. In summer, the air which prevails over the eastern Oregon and Washington plateau is extremely dry and warm. Its eastward component across the Cascades or down the Columbia Gorge brings the hottest weather to the Willamette Valley and surrounding foothills. These extreme conditions are terminated in both summer and winter by the change in air circulation to a westerly component and the modifying effect of the Pacific Ocean is realized.

Powers (40, p. 2) also points out that the average annual temperature at Corvallis is 52.4 degrees Fahrenheit and the monthly averages range from 66.2 for July and August to 39.3 for January. The average maximum temperature is 74.7 in September and 45.4 in January, while the average minimum temperature ranges from 32.9 for January to 51.3 for August. Even in the warmest summer weather the nights are cool. The average date of the last moderate spring frost is April 12, while that of the first such frost in Autumn is October 25. This gives an average season of crop growth of 195 days.

The normal precipitation for the 60 years of record at the College Station is 39.06 inches. During the three winter months, 17.76 inches or 45.5 percent of the year's total occurs. Only 1.85 inches or 4.7 percent of the annual precipitation falls in the summer months. With May and September rainfall added to the three summer months, the 5-month normal is 7.55 inches or 19 percent of the year's total. July is the driest month with a normal precipitation of only 0.28 inch. January is the wettest month with an average precipitation of 6.47 inches. The average annual snowfall is 5.99 inches, all of which usually falls during the months of December through March.

Leonard (22), in describing the 500 acres of pasture land devoted to the Oregon State College flocks, states that they include both unimproved and improved sites. The unimproved acreas occupy the bulk of the acreage. They are located in Oregon White oak (Quercus garyiana) and Douglas fir (Pseudotsuga taxifolia) foothills and have a low carrying capacity. The forage in these unimproved sites consists largely of browse, annual weeds and annual grasses. The most important annual grass species from the standpoint of abundance and feed supplied are Medusa wildrye (Elymus caput madusa), Bristly dogs tail (Cynosurus echinatus), Soft chess (Bromus mollus) and Ripgut brome (Bromus rigidus). These species produce fair spring and fall grazing but mature and dry up very early offering poor summer pasture. There is considerable Hop clover (Trifolium dubium)in the more moist sites around seeps and natural drains. This produces fair to good spring feed. The moist areas with poor drainage are dominated by rushes and sedges of low nutritive value.

Concerning the improved pastures, Leonard contends that they consist of Alta fescue (Festuca arundinacea), Orchard grass (Dactylis glomerata), Tualatin oatgrass (Arratherum elatius), Meadow foxtail (Alopecurus pratensis), Bent grasses (Agrostis spp.), and Subclover (Trifolium subterranean) in various mixtures with a fair amount of Tufted hairgrass (Deschampsia caespitosa) moving into some of the more poorly drained locations. The better improved pastures are dominated by Alta fescue, Tualatin oatgrass, Meadow foxtail and Subclover. They are vastly more productive than the unimproved pastures and have a much longer season of usefullness. These improved pastures show marked response to Nitrogen fertilizers. The soils of both the improved and unimproved pastures are highly acid and low in available phosphorus.

Because of a lack of uniformity and a large range in palatability of species, the pastures must be intensively grazed when at their peak and the animals moved frequently for maximum utilization. This necessitates ample subdivision into relatively small paddocks since the sheep are run under fence and not herded as is done in most range areas of large scale sheep production. However, it should be pointed out that only in the last few years have these principles been employed to any degree. Hence, from the standpoint of sheep environment, conditions have been greatly improved over the last half of the period from 1943 to 1951.

In general, the breeding season in the experimental flock commences September 10 and the rams have been left with the breeding ewes for a variable length of time in the past but normally for a period of 6 to 10 weeks. Currently the breeding season is being limited to 6 weeks starting September 10. The lambs are dropped during February and March and weaned by late June or early July. The ewe flock remains on pasture throughout the entire year with supplemental feeding of alfalfa hay and grain just prior to and during lambing. While western Oregon's mild, moist and open winters are almost ideal for the existence and multiplication of internal parasites of sheep, a mixture of 1 part phenathiozine to 9 parts salt appears to be adequately controlling these pests in the flock concerned.

Each sheep in the flock carries a numbered ear tag for identification and periodic weights and other observations are made during the individual's stay in the experimental flock. The frequent use of a set of portable scales is deemed basic in carrying out the objectives of the Sheep Improvement Program upon which the present thesis is founded.

EFFECT OF RAM BREED IN FAT LAMB PRODUCTION

At the onset, it should be pointed out that in testing for breed effects, the taking of a representative sample of a particular breed is almost a technical impossibility. Therefore, conflicting results produced by rams of the same breed or different breeds may represent little more than individual sire differences. Hence, only minor differences should be expected when comparing similar breeds. Sampling difficulties become even more pronounced when representatives are taken by different researchers and while drawing from components of a breed existing under widely different environmental circumstances. A further reflection of the complexity of estimating real breed differences is manifested by an apparent refusal or inability of scientists to apply tests of significance to their reported results.

Review of Literature

Restricting the review to breeds of sheep normally encountered in the United States and emphasizing fat lamb production, the following findings are worthy of comment. Miller (30, p. 30) working in California, found that crossbred lambs from Rambouillet ewes and sired by Suffolk, Hampshire and Shropshire rams grew faster and had a higher appraised value at about 110 days of age than lambs sired by Rambouillet rams. Lambs sired by Romney and Southdown rams were lighter, but the Southdown lambs had a higher appraised value than the Rambouillet-sired lambs. Shropshire and Southdown rams sired lambs of highly desirable carcass quality, but the Suffolk and Hampshire rams sired the fastest growing lambs that had the highest appraised value.

Hultz, Gorman and Wheeler (17, p. 7) in Wyoming, used rams of six different breeds on range ewes. The lambs sired by Suffolk rams made the most rapid gains, followed by Hampshire, Lincoln, Rambouillet, Corriedale and Southdown sired lambs, in that order. Lambs from Rambouillet ewes that were sired by Columbia rams were heavier than those sired by Corriedale, Lincoln, or Romney rams at 140 days of age, according to Gorman, et al. (14, p. 42), also under Wyoming conditions. The ewes bred to Lincoln rams had the highest productivity and they were followed by ewes bred to Corriedale, Romney and Columbia rams, in the order given. This difference in productivity was due largely to differences in survival of the lambs. Burns and Johnston (5,p. 28), working in Wyoming, have recently reported a well-designed study to compare the effect of Hampshire and Suffolk sires when mated to Western Range ewes. Unfortunately, their data were not thoroughly analyzed. However, they indicated that Suffolk rams were superior to Hampshires. Since, fat lamb production in most of the western range states involves the use of black-faced rams (usually Hampshire or Suffolk) on crossbred ewes (predominately a cross of a long-wooled ram on a fine-wooled ewe), the literature reveals a copious number of reports concerning the results of such matings. The fact that both Hampshire and Suffolk rams are used would indicate that any real differences existing between these breeds must be relatively small and it is probably personal preference that dictates the breed of ram most producers employ in fat lamb production in this general area. Neale (33, p. 23), in New Mexico, reports that straight Rambouillet-bred lambs were heaviest at weaning and best adapted to the range conditions of that area. The weight of Hampshire-cross lambs varied directly with feed conditions but in no case were they better than straight Rambouillet lambs. The Romney crossbreds were somewhat smaller and slower maturing and their long wool made them appear heavier than their actual weights. The feed conditions were such that few, if any, of the lambs were sufficiently finished for sale as grass-fat. Neale concludes that in order to obtain an adequate advantage in feeder-lamb weight by crossbreeding, it is necessary to use rams which are larger than the ewes.

Miller and Dailey (31, p. 466), under Wisconsin conditions, reported that performance was highest when Rambouillet ewes were mated to Border Leicester rams. Lambs produced by Rambouillet ewes when mated to Columbia, Oxford and Hampshire rams were 20 percent heavier than purebred Shropshire lambs, but did not equal those sired by Border Leicester rams. Cheviot sired lambs lacked weight at 140 days, but they were well finished, had excellent livability, and were easy to raise. Of the six different breeds of rams tried on Rambouillet ewes, the Shropshire ranked sixth. While Winters, et. al. (58, p. 12), were working under more favorable conditions than Neale, as previously reported, they concur with his general conclusion by stating that the productivity of ewes is increased when they are crossed with rams of other breeds, particularly the larger breeds.

Confessing that the foregoing review is of limited interest with reference to the testing of breed adaptability to Willamette Valley conditions, it does serve, however, to emphasize that there are ample variations both between and within breeds to furnish a best genotype for the particular environment encountered.

Materials and Methods

Since the use of Western (crossbred) ewes mated to rams of the mutton breeds appears to be the most popular program for fat lamb production in Western Oregon, medium wooled F_1 (Lincoln x Rambouillet) ewes were chosen as a foundation or basic ewe for testing the relative merits of Hampshire, Southdown and Romney sires under hill pasture conditions thought to be representative of this area. Figure 1 portrays the type of F_1 Ewe employed. The first matings were made in the fall of 1942 at which time 60 yearling F_1 ewes were equally allotted to purebred rams of the three breeds concerned. In the following years (1943-1945) the ewe flock was enlarged by the addition of more F_1 ewes, thus, bringing the total number of test ewes to about 100 for the period through 1946. Ewes were mated to a different breed of ram each year to remove the chance of good or poor performing ewes being mated consistently to the same breed of ram.

Nelson, et al. (34,p. 4), have published a very general summary of the Oregon State College experimental flock during 1943-1946. They reported that the survival of lambs in each of the sire groups was first, Southdown; second, Hampshire; and third, Romney. The total drop was the same for each sire group. The immediate portion of the thesis is an attempt to apply a test of significance to the weaning results as previously summarized by the above authors.

Certain ewes have been excluded from the present analysis because they failed to satisfy the basic assumptions underlying analysis of variance technique (i.e., some of the ewes were not 1st cross Lincoln x Rambouillet).

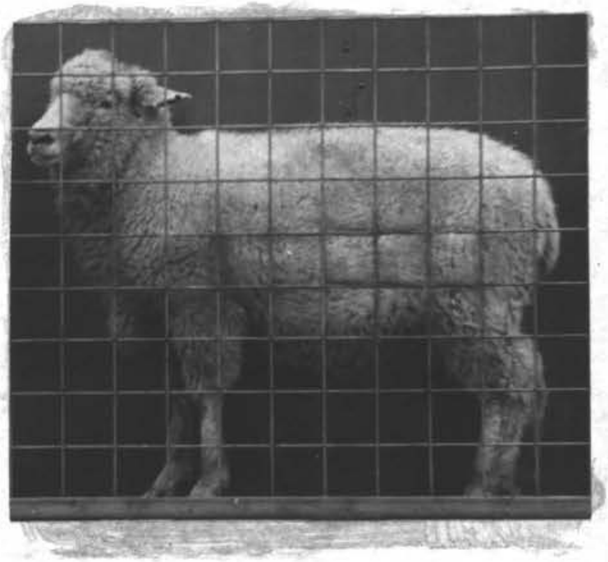


FIGURE 1. F_1 (LINCOLN x RAMBOUILLET) EWE

Ewe chosen to represent the base from which Hampshire, Southdown and Romney rams were compared with respect to their ability to sire fat weanling lambs.

A total of 101 F_1 ewes weaning 378 lambs form the basis of the test and are summarized in Table 1. Since a preliminary analysis indicated that differences due to sex and rearing were important in the lamb weaning weights, these differences were removed by a method suggested by Patterson (36, pp. 334-346). While twin lambs raised as singles are usually different from lambs raised as twins and lambs raised as singles, in the data at hand, the date of death was usually known so it was possible to classify a twin raised as a single as either a twin raised as a twin or just as a single lamb depending upon the age at death of its mate.

Since the age of the lamb is an important source of variation in lamb weaning weights, a regression of weight on age facilitated a linear correction for this phenomenon. The equation employed in putting all lambs on a constant age basis, as well as all other adjustment factors employed, is given in Table 1. The age of the ewe normally has a significant effect on lamb weaning weight but it was ignored in the present study because ewe age was confounded with year and, also, the different aged ewes were equally allotted to the various breed-of-sire groups each year.

The real value of a lamb at weaning is determined by many factors. However, the weight and degree of fatness are important elements normally considered in evaluating the relative producing ability of different sires and dams. Therefore, it is desirable to have combined into one figure the weight and finish of individual lambs after correcting for environmental or chance effects as sex, rearing and age.

An attempt was made to determine from market quotations the

TABLE 1

EFFECT OF BREED OF SIRE ON LAMB PRODUCTION
OF F_1 (LINCOLN x RAMBOUILLET) EWES

	Breed of Sire							
	Hampshire		Southdown		Romney		Total & Means	
Year	No. of Lambs	Mean Wt.	No. of Lambs	Mean Wt.	No. of Lambs	Mean Wt.	No. of Lambs	Mean Wt.
1943	16	76 (69)*	17	67 (61)*	21	66 (55)*	54	69 (61)*
1944	27	81 (79)	37	74 (72)	33	79 (74)	97	78 (75)
1945	46	81 (80)	38	73 (74)	38	72 (76)	122	75 (77)
1946	36	87 (86)	37	89 (86)	32	92 (90)	105	89 (87)
Total & Means	125	82 (80)	129	77 (75)	124	77 (75)	378	79 (77)

*Values in parenthesis represent corrected weaning weights and evaluation on the basis of condition: (Feeder lambs multiplied by .85 representing relative value of feeder lambs as compared to fat lambs).

	Male	Female
Single	-6.32	-2.62
Twin	+8.12	+11.82 = Correction for Sex and Rearing.

Correction by Regression of weight on age = Actual weaning weight + .25 (138 - actual weaning age).

average value of pounds of lamb in the various market grades. Swenson (46) of the USDA Production and Marketing Administration summarized and/or described the pitfalls encountered in properly evaluating the relative value of market lambs in western Oregon by stating that the feeder lamb market is rather an "in and out" business, depending considerably on packer demand, seasons, etc., and that no detailed quotations on feeder lambs is available. The report by the above author serves to exemplify a major handicap faced by commercial lamb producers. That is, market price is such a nebulous character that it is impossible to carry on a constructive breeding program while heeding the antics of price fluctuations.

Guided by the above considerations and realizing that commercial weanling lambs must be sold as grass fat, feeders or fed to a marketable finish, the following Table represents gleanings from weekly market quotations and reports from the Portland Union Stock Yards Company.

TABLE 2

AVERAGE PRICE PER HUNDRED DURING MAY, JUNE, JULY AND AUGUST OF 1947-1950 FOR WEST COAST LAMBS BY THE DIFFERENT MARKET GRADES

Fat Lambs		Feeder Lambs	
Choice	Good	Medium	Common
24	22	21	20
23.0		20.5	

20.5/23.0 = .85 value of a feeder lamb relative to a fat lamb.

After making the foregoing adjustments on weaning weight of the lambs in the different sire groups, all lamb weights were put on a fat lamb basis by multiplying the adjusted weaning weight of feeder lambs by .85. These adjusted values appear in parenthesis in the various classifications in Table 1.

In agreement with most other data on reproduction in sheep, the present results were characterized by disproportionate sub-class numbers throughout. Hence, after making the above adjustments, a non-orthogonal, two-way classification analysis of variance was performed. The method of analysis is that as given by Wilks (54, pp. 3-16), (55, pp. 174-175), Mann (27, pp. 130-138) and as assembled by Gysbers (15, pp. 15-20).

The present author readily acknowledges that numerous criticisms can be justly directed toward the foregoing methodology employed in testing for differences in the ability of the various rams to sire marketable lambs. However, the propensity of the method should not preclude its use since it is felt that its efficacy greatly outweights its recognized debility.

Results and Discussion

Unfortunately, these data do not permit an estimate of sire differences within a breed. Hence, it is not possible to estimate the extent to which individual sire effects may have influenced the overall results. Also, it would have been desirable to have included in the experimental design a control group or groups consisting of purebred individuals of like breeding of the rams employed.

Concerning the analysis of variance employed in testing for differences among the adjusted means in Table 1 for the different breeds of sires concerned, besides the usual assumptions underlying analysis of variance (i.e., randomness, normality, independence and equal variances) there is, in addition, the assumption of no interaction between year and breed of sire.

The desired F value in the present test is:

$$\frac{(n-r-s+1)}{(s-1)} \frac{(\Delta'/\Delta'_{00} - \Delta/\Delta_{00})}{(\Delta/\Delta_{00})}$$

with n-r-s+1 and s-1 degrees of freedom, wherein:

n = Total number of lambs = 378
r = number of years in the experiment = 4
s = number of breeds of sire groups = 3

The deltas in the above ratio represent the matrices resulting from the nonorthogonal analysis of variance, wherein:

Δ' = 424, 521, 073, 701, 960
Δ'_{00} = 1,073, 580, 475
Δ = 2,171, 394, 446, 671, 287, 157
Δ_{00} = 5,720, 677, 246, 885

The method used to obtain the value of the determinant of each of the above matrices is that given by Milne (32, pp. 17-22, 26-27).

The calculated F value in the above ratio equals 7.8 with 2 and 372 degrees of freedom and is significant at the 5 percent level. Hence, there is a real difference among the adjusted weaning values presented in Table 1 for the Hampshire, Southdown and Romney sire groups.

The nonorthogonality of these data do not permit a complete ranking of the different breed groups even though there is a significant difference among them. Hence, a detailed inspection of Table 1 and information on weaning percentages becomes of interest in appraising the relative performance of the Hampshire, Southdown and Romney sires.

As a preamble to discussing Table 1, certain general points are of interest. It will be observed that all corrected means are below the corresponding unadjusted values with the exception of certain classifications in 1945. This is explained by the fact that there was an excessive number of late lambs in 1945 and evaluation on the basis of condition score (Feeder weight x .85) was overbalanced by plus corrections (Y + .25 (138-X)) for age at weaning. Otherwise, it would be expected that multiplication of feeder lamb weights by .85 would appreciably lower the resulting means.

The respective adjusted mean weaning weights in Table 1 are 80, 75 and 75 for the Hampshire, Southdown and Romney sires. Concurrently, the corresponding weaning percents are 110, 110 and 92 for these rams. Since the foregoing F test indicated a significant difference among the three breed-of-sire groups, it is rather apparent that the Hampshire rams were superior as sires of market lambs. While the Southdown and Romney sire groups were equal and below the general mean with respect to adjusted weaning weight, the higher lambing percent in the case of the Southdown rams would favor them over the Romney sires. The non-orthogonality of these data do not permit complete ranking of the different sire groups but it seems safe to conclude that the Hampshire rams gave the best results and exceeded the performance of the Romney and Southdown sires. These latter sires may or may not be equal in their ability to sire marketable lambs.

A general description of the lambs sired by the various rams emphasize that the Hampshire lambs were relatively high in weight with appreciable finish, the Southdown lambs were generally small but with above average condition, while the Romney lambs exhibited adequate weight but were lacking in condition or finish at weaning.

While no test of significance was applied to the year means shown in Table 1, it is rather obvious that year effects were significant with

1943 being an extremely poor year and 1946 an unusually good one with respect to sheep performance. Since this study concerns four years, it is felt that the experiment was executed under average environmental conditions and as such represents the general ability of Hampshire, Southdown and Romney rams to sire market lambs when mated to F_1 (Lincoln x Rambouillet) ewes under the economic and climatic conditions of the geographical area concerned.

SUPPLEMENTAL VERSUS NON-SUPPLEMENTAL FEEDING OF PREGNANT EWES

The volume of literature concerning the increased production possible when ewes are wintered on a high level of nutrition and care is indeed phenomenal. Numerous workers have demonstrated that increased feed consumption is rewarded by increased wool yields. Others point out the higher incidence of twinning and also greater lamb weights that go hand in hand with optimum care of the pregnant ewe. However, in most cases emphasis has been placed on obtaining maximum production or yield and not necessarily getting the highest return per animal unit at the most profitable level for the operator.

Review of Literature

Among workers who have stressed the handling of ewes in a manner to reap maximum profits under range or grazing conditions, Briggs, et al, (4, pp. 27-28), have shown that flushing of ewes just previous to breeding does not necessarily yield more pounds of lambs weaned. These researchers based their conclusions on eight years of work under Oklahoma range conditions. Forsling (12, p. 19), under Idaho conditions, recommends the feeding of range ewes only when adverse weather threatens the flock. While the latter author suggests that ewes should be wintered as cheaply as possible, at the same time, he recommends that a reserve of supplemental feed be maintained to meet any reasonably expected emergency. Robinson (43, p. 350), working with sheep in England, found that it took longer for a decrease in weight to occur than it did for an increase of the same magnitude which would indicate to the present author that sheep could conceivably undergo short periods of rather adverse conditions and not be too greatly affected. Cooper (8, p. 12), maintains that one of the largest expenses in a range sheep program is the wintering of the ewe band and with this in mind suggests that ewes should be made to utilize range to the fullest extent. Jordon, Klosterman and Wilson (18, p. 625), fed rations varying from 3.5% to 10.5% digestible protein to ewes during gestation and found no significant difference in production. This was true even though the weights of the ewes varied widely during the period of pregnancy. Similarly, Klosterman, et al. (21,p. 264), found no difference in production in ewes differing in their rations by 6.8 to 11% total protein.

Included in the Bibliography are other authors who have been concerned with the winter care of ewes but it is not felt that a review of their findings is necessary to establish the fact that ewes will produce well under a wide range of conditions. Also, it is noteworthy that pregnant ewes on pasture in western Oregon probably have at their disposal adequate Vitamin A and proteins throughout the winter months. This is due to the relatively mild climate permitting at least limited growth or persistence of green pastures during the winter months. Carbohydrates in the form of grain probably meets the needs of the pregnant ewe, on winter pasture in the Willamette Valley, better than does a protein supplement.

Materials and Methods

Animals employed in the present study of winter care of pregnant ewes were drawn from the experimental flock as described earlier in the thesis. To briefly summarize this experiment, 36 F_1 (Lincoln x Rambouillet) ewes of similar age and weight were divided into two groups of 18 ewes each. One group of ewes was given average feed allowances (i.e., two pounds of alfalfa hay and $\frac{1}{2}$ pound of grain per day per ewe plus pasture) and shelter while the other group received pasture only and were forced to employ only natural shelter as afforded by the pastures on which they were placed. Each main group of 18 ewes had been previously subdivided into 3 lots of 6 ewes each and mated to representative rams of purebred Hampshire, Southdown and Romney breeding.

The first matings were made on September 10, 1944 and the ewes remained in their respective care groups for two lambing seasons. However, death loss of ewes in both management groups necessitated the placing of three additional ewes in each of the two groups for the 1945 breeding season.

During lambing, birth weights were recorded and all lambs eartagged for identification. Lambs in both care groups were weaned, weighed and scored on July 10 regardless of age during the two years.

Scoring was accomplished by a committee of three competent judges and consisted of observations of both conformation or type and condition or degree of fatness.

The analysis of these data was simplified by using the total production of a ewe for any one year as the unit of observation. Sex of the lambs was ignored since they were approximately equally represented in the main classifications. No adjustment was made for type of birth and rearing because it was thought that the two levels of nutrition and care might have affected the relative proportion of twins and singles and thus represent, in part, treatment effect. The orthogonality imposed upon these data readily permits the testing of main effects and possible interactions. All lamb weights were put on a common age basis by the use of a regression of weaning weight on weaning age before testing for the various treatment effects.

Results and Discussion

Tables 3 and 4 summarize the general treatment effects of average winter care versus pasture only for pregnant ewes during 1945 and 1946.

When inspecting the average pounds of lamb produced per ewe (Table 3), it must be remembered that these averages are high because they include several twin lambs averaged into the production of the ewes. Further, in comparing the ewes in the various classifications it must be kept in mind that any comparison based on pounds of lamb weaned per ewe bred tells only a part of the story. However, considering pounds only, it is readily apparent that the levels of nutrition to which the ewes were subjected had a marked effect on production.

TABLE 3

AVERAGE POUNDS OF LAMB PRODUCED PER EWE BRED
(CORRECTED FOR AGE OF LAMB AT WEANING) *

	Average Care				Marginal Care				
	Breed of Sire			Year	Breed of Sire			Year	General
Year	Hamp.	S. D.	Rom.	Mean	Hamp.	S. D.	Rom.	Mean	Mean
1945	103	89	115	102	82	68	73	75	88
1946	95	114	114	107	99	92	109	100	104
Breed And Care Means	99	101	114	105	90	80	91	87	

*Age correction of lambs = actual weaning weight + .40 (140 - actual weaning age)

TABLE 4

AVERAGE POUNDS OF LAMB PLUS CONDITION SCORE
OF LAMBS PER EWE BRED

	Average Care				Marginal Care				
	Breed of Sire			Year	Breed of Sire			Year	General
Year	Hamp.	S. D.	Rom.	Mean	Hamp.	S. D.	Rom.	Mean	Mean
1945	214	199	218	210	170	156	150	159	185
1946	203	239	231	224	191	185	217	198	211
Breed And Care Means	208	219	224	217	181	171	183	178	

The ewes under average care produced 17.8 pounds more lamb per ewe bred than did ewes under marginal care. Considering year differences, 1945 averages are decidedly below those in 1946. The Hampshire sired lambs were very consistent from year to year as well as between levels of management in that they made fair showings in every classification. The Southdown sired lambs equaled the Romneys in 1946 under good care but were adversely affected by poor care in both years. A final consideration of Table 3 indicates that the lambs with the higher average weights under all conditions were sired by Romney rams.

To make more meaningful the comparison of treatment effects in this experiment, Table 4 has been compiled on an average per ewe basis of pounds of lamb produced plus condition score of the lambs concerned. Condition score as here used represents the degree of finish or fatness with 100 being ideal. In general, Table 4 demonstrates about the same pertinent facts as were portrayed in Table 3. However, it becomes noteworthy that under average care in 1946 the Southdown sired lambs were superior to all others. Further, the Romney sired lambs under marginal care in 1945 were decidedly inferior to those in all other categories.

Realizing that the averages presented in Tables 3 and 4 were merely indications, these data were subjected to an analysis of variance to determine if the various means differed significantly from one another. Table 5 shows the test of significance for the various means in Table 3. Similar results were found for the means based on pounds of lamb plus condition score. The findings of this further analysis shows that there is no significant difference in the

TABLE 5

ANALYSIS OF VARIANCE FOR
AVERAGE CARE VERSUS MARGINAL CARE OF
PREGNANT EWES (BASED ON CORRECTED
WEANING WEIGHT OF LAMBS)

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Total	71	68919.5		
Groups Treated Alike	11	16640.4	1512.8	
Breeds	2	1784.2	892.1	0.97
Years	1	4262.7	4262.7	4.62 *
Level of Nutrition	1	5165.9	5165.9	5.59 *
Pooled error for Main Effects	67	61873.8	923.5	
Year-Nutrition	1	1645.7	1645.7	1.89
Year-Breed	2	2217.3	1108.7	1.27
Breed-Nutrition	2	304.1	152.1	0.17
Year-Breed-Nutrition	2	5427.6	2718.8	3.12
Remainder	60	52279.1	871.3	

* Significant at the 5 percent level

performance of the different breeds of rams. This is true for both pounds of lamb per ewe bred and also for pounds of lamb plus condition score of the lambs. However, the ewes under average care weaned lambs that were superior to the marginal-care group. Also, there was found to be a significant difference between years and 1946 proved to be the better of the two. Lastly, none of the various interactions of levels of nutrition, breed of ram or years were found to be important.

Because the analysis of variance showed a significant difference not only between the two levels of care but also between years, it is of interest to speculate on the various possible factors entering into the environment of years and causing this great diversity.

While all weaning weights were corrected for age before any analysis was attempted, it is still important to see if the lambs were born at about the same time each year as a partial explanation of the difference in performance of ewes in 1945 and 1946. With this in mind, Table 6 was compiled and gives the relative frequency of ewes lambing in the various ranges of dates shown.

TABLE 6

LAMBING FREQUENCY OF EWES BY
YEARS AND LEVELS OF MANAGEMENT

	1945		1946	
Lambing Dates	Average	Marginal	Average	Marginal
February 1 to 10	2	7	1	6
February 11 to 20	7	3	14	9
February 21 to March 2	3	3	3	3
March 3 to 12	0	0	0	0
March 13 to 22	2	2	0	0
March 23 to April 2	2	2	0	0
April 3 to 12	2	1	0	0
Totals	18	18	18	18

Table 6 is striking because the length of lambing seasons were greatly different in the two years, yet there is no particular difference due to management within years. Remembering that the rams were with the same ewes (with the exception of six replacements) for the same length of time and between the same dates both years, we must conclude that other unknown factors were responsible for this great difference in length of lambing season in 1945 and 1946. In any case, it is believed that the conditions causing the late lambs in 1945 were probably felt throughout the entire period of growth to weaning.

A review of the research on fertility in sheep reveals that McKenzie and Berliner (29, p. 122), and Briggs, et. al (4, pp. 121-122) have indicated that high temperatures at time of breeding may often cause reduced fertility in rams. With this in mind the following Table of meteorological phenomena for specific months of 1944-45-46 has been incorporated into this study in the hopes of further explaining the great difference between the average weaning weights and length of lambing season for the two respective years.

Since the extremely warm September of 1944 was the period in which the rams were first turned with the ewe flock for the 1945 lamb crop, it is felt that this, no doubt, was a major factor in causing the lateness of the resulting lambs. This and other points are of interest in Table 7.

It was observed that March of 1945 was subject to a prolonged rainy period with temperatures at or near freezing contrasted to a much milder March in 1946. This period of adverse weather came at a

TABLE 7

METEOROLOGICAL PHENOMENA FOR THE PERIOD
AUGUST 1944 TO JULY 1946

Month	Average Temp. Of.	Deviation from Mean	Total Rainfall in Inches	Deviation from Mean
August	67.0	0.8	Trace	- 0.43
September	65.6	4.6	2.18	0.61
October	58.5	4.9	1.36	- 1.52
November	44.4	- 1.0	4.63	- 1.80
December	38.6	- 2.2	2.74	- 3.40
January	42.2	2.9	4.34	- 2.13
February	45.2	2.9	5.04	- 0.11
March	45.0	- 1.2	5.06	1.47
April	49.8	- 1.1	2.33	- 0.23
May	58.0	2.2	3.10	1.22
June	62.3	1.3	0.22	- 0.92
July	68.2	2.1	0.14	- 0.14
August	68.8	0.6	0.08	- 0.35
September	61.2	0.2	0.94	- 0.63
October	54.7	1.1	0.89	- 1.99
November	45.8	0.4	10.08	3.65
December	41.7	0.9	5.03	- 1.11
January	40.6	1.3	4.79	- 1.68
February	42.9	0.6	4.28	- 0.87
March	46.6	0.4	4.59	0.46
April	51.2	0.3	0.68	- 1.88
May	59.0	3.2	0.59	- 1.29
June	59.2	- 1.8	0.98	- 0.16
July	63.2	- 2.8	0.57	0.28

Last Killing Frost in the Spring

1945 March 5
1946 February 11
Average April 12

time when the late lambs of 1945 were very susceptible to any form of inclement weather. Another factor contributing to the lighter lambs of 1945 is the fact that in this year there was a decided deficiency of rainfall during June and July resulting in pastures of lower quality at a time when the lambs were in the main getting most of their nourishment from grass. One last consideration in the discussion of year effect is the most pertinent observation that the last killing frost in the Spring of 1945 occurred on March 5th. Remembering that the average last killing frost in the Corvallis area is April 12, it would not appear that 1945's last killing frost caused a reduction in performance of the animals of this study. However, when a comparison is made between the last killing frost of 1945 and that of 1946 which came on February 11, it becomes rather apparent that the lambs in 1946 were at a decided advantage as far as early spring pastures were concerned. Hence, a relative improvement in the 1946 lamb crop would present the 1945 lambs at a great disadvantage on a comparative basis.

In concluding the discussion of factors that most logically seem to account for the significant differences observed in this study, it is rather obvious that there should have been differences in the two levels of management, but the environmental effects of year arise as one of the vagaries so often hounding the experimenter as well as the practical sheepman. Hence, it is certain that to draw definite conclusions on the factors considered in this report, additional years would need to be investigated, especially so when one considers that in years like the winter of 1950 no group of ewes could be expected to forage for themselves and still deliver a good lamb crop, even on the best of hill pastures.

WINTER CARE OF REPLACEMENT EWE LAMBS

Since it is the general practice in sheep production to breed lambs at about 18 months of age for lambing for the first time at two years of age, the cost of maintaining such lambs during their first winter has been investigated with a view to reducing such costs to a minimum.

Review of Literature

Esplin, Madsen and Phillips (10, p. 12), reports an experiment undertaken to determine the effects of feeding ewe lambs during the first winter of their lives, rather than keeping them on the usual sparse winter ranges of Utah normally alloted to replacement ewe lambs. Greater gains were made by the lambs that were given special feed during their first winter. However, most of this advantage in weight was lost when these lambs were put on range the following summer, since they gained only slightly more than the range lambs from the beginning of the feeding period until breeding time. Death losses were less in the group receiving special feed during their first winter. The percentage of ewes lambing at two years of age, of those alive at breeding, was 64.7 in the group that was fed and 45.5 in the range group.

Roberts, Davies and Williams (42, p. 32), working under severe economic and climatic conditions in Wales, have measured the feasibility of wintering ewe lambs on pasture areas differing greatly in productivity. While lambs at some centers made practically no winter gain, those at other centers gained as much as 15 pounds per individual.

There was a distinct tendency, however, for the badly wintered lambs to catch up with the others in the course of the following summer grazing period. However, poorly wintered lambs tended, when lambing a year later, to give lambs of rather smaller birth weight and also exhibited reduced fertility. Thompson (49, p. 300) in Tasmania, concludes that ewe lambs should be carried through to their second spring without check-in weight gains. Phillips, et al. (39, p. 345) in a study of the effect of winter care on sexual development of range ewe lambs, reported that feeding gave more fully developed reproductive traits but declined to say just how far a rancher should go in furnishing extra feed for replacement ewe lambs.

Materials and Methods

During the period from 1947 to 1950 the sheep program of the Oregon Agricultural Experiment Station was directed toward the development of four commercial flocks of ewes sired by Romney, Hampshire, Border Leicester and Cheviot rams from the previously mentioned F_1 (Lincoln x Rambouillet) ewes. Replacement ewe lambs during this period were equally divided into supplemental-fed and pasture-only groups during their first winter. The number of replacement ewe lambs consisted of 40 to 50 animals each year.

The reproductive performance of the fed and not fed ewe lambs was studied during their respective first lambing season. No test of significance is being applied to the weanling results as presented in Table 8 and Table 9, as these data represent only a progress report. Also, the 1950 replacement ewe lambs have not reached their first lambing season at this date.

TABLE 8

THE EFFECT OF WINTER CARE OF
REPLACEMENT EWE LAMBS ON THEIR
FIRST LAMBING AND WEANING PERCENTAGES

	Supplemental Feed			No Supplemental Feed		
Year	No. Bred	Lambing %	Weaning %	No. Bred	Lambing %	Weaning %
1947	21	129	114	24	133	92
1948	26	123	96	29	100	90
1949	22	96	77	21	119	81
Mean	69	116	96	74	116	88

TABLE 9

THE EFFECT OF WINTER CARE OF
REPLACEMENT EWE LAMBS ON BIRTH AND
WEANING WEIGHTS OF THEIR FIRST LAMBS

	Supplemental Feed			No Supplemental Feed		
Year	No. Bred	Birth Wt.	Weaning Wt.	No. Bred	Birth Wt.	Weaning Wt.
1947	21	8.7	69	24	8.2	66
1948	26	9.0	75	29	9.6	73
1949	22	9.7	77	21	8.7	72
Mean	69	9.1	73	74	8.8	70

Results and Discussion

Figure 2 depicts very clearly the general effect of supplemental versus no supplemental feed on the weights of replacement ewe lambs. While growth curves are presented for the replacement ewe lambs of 1950 only, similar effects were manifested in the lambs of 1947, 1948 and 1949. The feeding period usually extended from early December to about mid-March of the following year (i.e., about 90 to 120 days depending on pasture and weather conditions).

While invariably, the supplemental-fed lambs attained considerable weight advantage during the feeding period, such differences tended to disappear within two months after termination of supplemental feeding. Hence, on the basis of weight alone, there appears to be no particular advantage in providing supplemental feed to replacement ewe lambs during their first winter.

However, Tables 8 and 9, which summarize the later performance of the lambs in this study, indicate that the reproductive efficiency of the poorly fed lambs is drastically reduced. It is surprising that the lambing percents of the two groups are identical, yet the weaning percents are markedly different. This would indicate that ovulation and/or fertility are affected by somewhat different physiological processes as compared to size of lamb at birth and future milking ability of the ewe. It might be pointed out that a partial explanation of the observed larger average birth weights in the case of the 1948 non-fed replacement ewe lambs is probably a result of a higher percentage of single lambs being born to these ewes.

While the differences observed between the reproductive

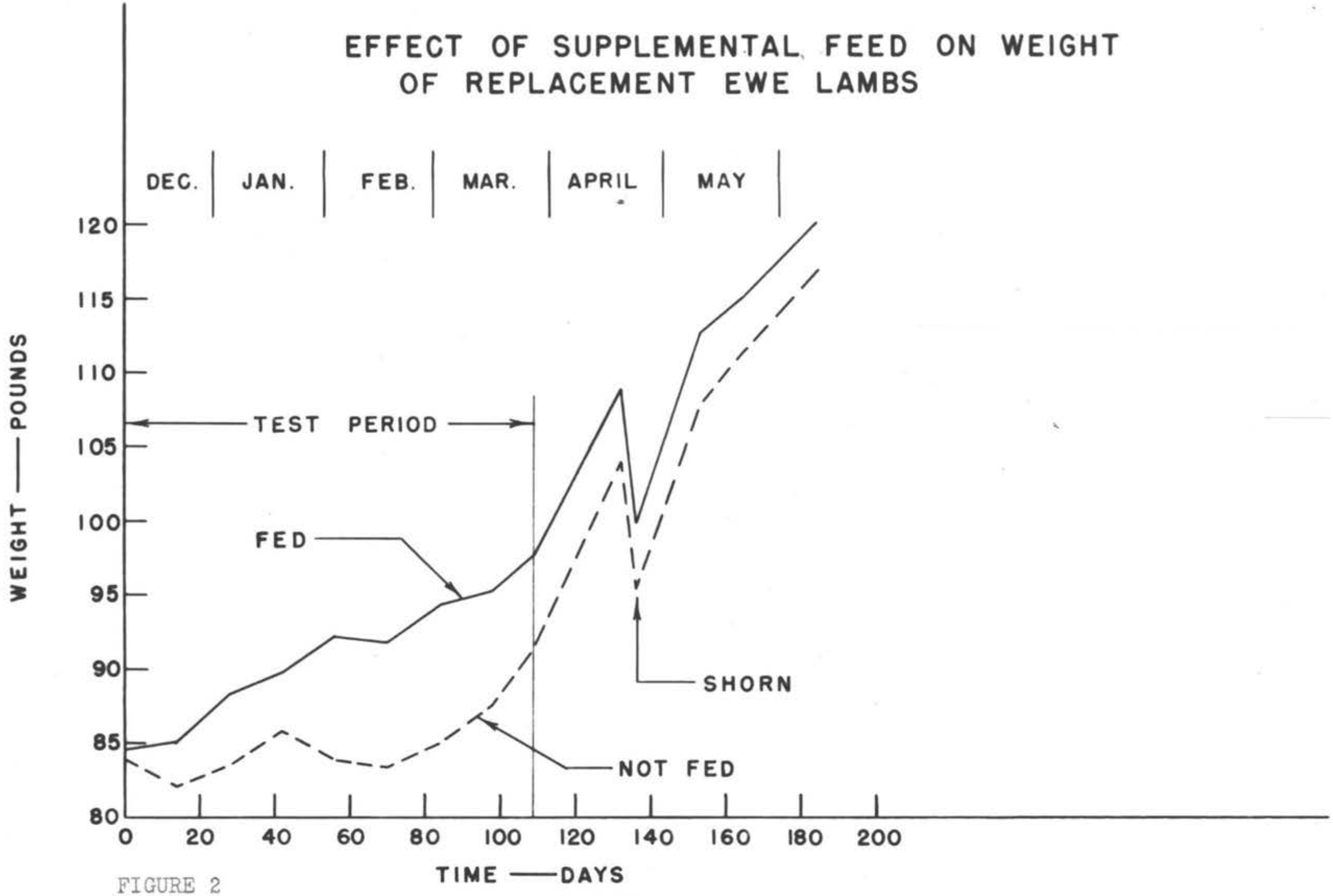

EFFECT OF SUPPLEMENTAL FEED ON WEIGHT
OF REPLACEMENT EWE LAMBS
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
120
115
110
105
100
95
90
85
80
WEIGHT —— POUNDS
TEST PERIOD
FED
SHORN
NOT FED
0
20
40
60
80
100
120
140
160
180
200
TIME —— DAYS

FIGURE 2

performance of the two groups of replacement ewe lambs is very thought provoking, additional studies on sexual maturity, milking ability and other physiological traits would be necessary to clarify the nature of the observed variations.

Apparently the greater survival of lambs and higher weaning weights in the case of the replacements that were fed should dictate that serious consideration be given to furnishing at least limited supplemental feed to replacement ewe lambs in the area under consideration.

Two pounds of alfalfa hay and one-half pound of grain plus free access to pasture constituted the daily ration of the fed-group of replacement lambs during the test period. However, since the pastures in this area remain green during the winter months, it is postulated that a more economical ration in the form of good pasture and supplemental grain might suffice as an adequate level of nutrition for replacement ewe lambs in a commercial sheep operation.

RAM DAYS AS A PERMANENT CHARACTERISTIC OF F_1 (LINCOLN x RAMBOUILLET) EWES

Ram days may be defined as the number of days from the time the ram is turned in with the breeding ewes until a particular lamb is dropped. The term thus defined is a general measure of overall flock or mating fertility since both male and female obviously contribute to its magnitude.

Review of Literature

Cadmus (6, pp. 15-16), appears to have been the first worker to define ram days. He maintains that ewes preserve their relative order of lambing within a flock to a significantly high degree; that is, a ewe that lambs with the last quarter of her age group in the flock the first year will tend to lamb late in each succeeding year. On this basis, records for one lambing season might be used to cull late lambing individuals in the flock. The importance of a low number of ram days can best be appreciated when it is remembered that the lambing season is probably the most expensive, time consuming and trying of any operation facing a sheepman, and as such is measured directly by the number of ram days.

Numerous other workers have approached the study of flock fertility in a similar manner to Cadmus, although not using the term "Ram Days". Since ram days measures length of gestation plus number of days from time the ram is put with the ewes until successful mating, any study of the length of gestation or number of heat periods for ewes to settle constitutes a study of the components of ram days.

Kennedy and Bettenay (20, p. 91), observed 1278 Merino ewes through a breeding and lambing season and found an average gestation period of 150.27 days with a standard deviation of 1.97 days. During the first 17 days (average heat cycle in sheep) 82 percent of the ewes settled. Kelly and Shaw (19, p. 27), in a similar study concluded that selection within a breed or strain should yield a restricted lambing season. Chittenden and Walker (7, p. 232), found the average length of gestation in range ewes to be 149.6 days. Range ewes bred to Hampshire rams experienced a gestation of 148.61 days and it was concluded that the breed of ram influenced length of gestation.

Terrill and Hazel (47, p. 71), investigated 2499 gestations in range sheep and found a range of 141 to 159 days. They estimated the intra-class correlation of paternal half sibs to be .11 and that of maternal half sibs to be .18. Hence, they concluded that the length of gestation was inherited from both sire and dam.

Wallace (53, p. 20), in a study of fertility in a large flock in New Zealand, observed that some ewes are barren and never come into heat, others show regular heat cycles but never settle. Some ewes appeared to settle but later showed signs of heat-possibly due to early abortions. To the present author the work of Wallace emphasizes the complexity of fertility and indicates that there is a need for detailed experiments in this all-important problem in sheep breeding.

Goot (13, pp. 313-325), working with the Romney breed in New Zealand, found the average number of tuppings (average services to settle ewes) per ewe to be 1.3. He gives elaborate curves of the relative frequency or number of ewes coming into heat by days and concludes that this phenomenon is normally distributed.

In the light of more recent investigations, Q'Mary, Pope and Cassida (41, pp. 499-503), there are indications that by the use of hormones it may eventually be possible to completely synchronize the heat cycle of ewes to the point where ram days would measure primarily the length of gestation. Until this is accomplished the practical sheepman is interested in having his ewes lamb out in a minimum ram-day interval.

Lush and Molln (24, pp. 19-21), defined repeatability as the fraction of the difference between two animals in one season which would most likely be found between them in a later season. The term is now frequently used in the animal improvement field and serves to measure permanent differences between individuals. These permanent differences may be due to genetic and/or permanent environmental effects. How much of the difference in ram days between ewes is genetic and how much permanent environmental effects is immaterial when dealing with such questions as what will be the future ram days of a ewe selected on the basis of her past performance. However, it does become important when estimating how much the ram days of the next generation will be lowered by culling a certain portion of high ram-day ewes from the flock.

Materials and Methods

The estimate of repeatability in the present study of ram days concerns the records of 130 F_1 ewes during the years 1943 to 1949 inclusive. These ewes have been described elsewhere in the thesis with respect to management and breeding practices. The ewes concerned produced 502 individual ram-day observations during the 7 year period or an average of 3.9 lambings per ewe. The average length of ram days was 163.2

A preliminary analysis indicated that age of ewe and breed of ram to which the ewe was mated were not significant sources of variation in these data. A few ewes failed to lamb each year and as a means of penalizing such animals, they were given a minimum number of ram days. This operation was deemed advisable, since otherwise, it would have been necessary to discard the observation. The minimum value computed was based upon the maximum number of ram days possible considering the number of days the rams were actually with the ewe band. Hence, ewes with no record of lambing were assigned a ram-day value of 230 for that particular year. A total of 12 ewes were assigned such values. No ewe was barren more than one season.

Only year and ewe individuality could be demonstrated to exert important effects on ram days. No correction for the effect of year was made because it was obvious that any adjustment with a whole number would be an over-correction.

The method employed by Lush and Molln (24, pp. 1-40), coupled with Winsor and Clarke's (57, pp. 25-28) formula for computing variance components in a one-way classification, when applied to the unadjusted ram days of the above ewes, yielded the desired estimate of repeatability.

Results and Discussion

Table 10 demonstrates the methodology employed in the calculation of the coefficient of repeatability of ram days in the ewes concerned. The value of this coefficient is 0.1068. The figure has its greatest usefulness in selecting ewes for the ability to lamb in a minimum number of ram days. Since allowances must be made for the reduced variability of averages when comparing means based on differing numbers of records, the correlation between repeated records (repeatability) is needed for this. If repeatability of a particular trait in a given flock is known, the best estimate of the real producing ability of an individual in the flock with respect to that trait, when there are one or more records available on that individual, can

TABLE 10

ANALYSIS OF VARIANCE FOR RAM DAYS
OF F_1 (LINCOLN x RAMBOUILLET) EWES

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F	Components of Mean Square	Estimate of Component
Total	501	116227.19	231.990			
Between Ewes	129	39096.11	303.071	146*	$\sigma^2_W + 3.860\sigma^2_B$	24.800
Within Ewes	372	77131.08	207.342		σ^2_W	207.342

* Significant at 5% level

$$\text{Repeatability} = \frac{\sigma^2_B}{\sigma^2_W + \sigma^2_B} = \frac{24.800}{232.142} = .1068$$

be calculated. The equation given by Lush (25, p. 168) for comparing without bias individuals which have unequal numbers of records is as follows: Most probable producing ability of any ewe is the flock average plus $\frac{nr}{1 + (n-1)\,r}$ times the amount by which the average of the ewe's n records deviate from the flock average. In applying the above formula in the present case of ram days, n is the number of ram-day observations in a particular ewe's average, r = .1068 and is the coefficient of repeatability, and the flock average for ram days is 163.2. The letter r (i.e., repeatability) in the above formula is more easily understood if it is looked upon as the correlation between any two ram-day observations on the same ewe. It is also the fraction of the total intra-flock variance of single records which is due to the real differences among the producing abilities of flock mates with respect to ram days.

Table 11 presents the weight which should be applied to the amount by which the average of the records exceeds the flock average for several different combinations of numbers of records and levels of repeatability.

TABLE 11

FACTORS FOR WEIGHING THE AMOUNT WHICH AN INDIVIDUAL'S AVERAGE RECORDS EXCEEDS THE FLOCK AVERAGE (FROM THE FORMULA $\frac{nr}{1 + (n-1)\,r}$)

Number of Records	Repeatability									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
1	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
2	.18	.33	.46	.57	.67	.75	.82	.89	.95	1.00
3	.25	.43	.56	.67	.75	.82	.87	.92	.96	1.00
4	.31	.50	.63	.73	.80	.86	.90	.94	.97	1.00
5	.36	.56	.68	.77	.83	.88	.92	.95	.96	1.00
6	.40	.60	.72	.80	.86	.90	.93	.96	.98	1.00
7	.44	.64	.75	.82	.88	.91	.94	.97	.98	1.00
8	.47	.67	.77	.84	.89	.92	.95	.97	.99	1.00

To illustrate the use of Table 11 and the current coefficient of repeatability of ram days, a ewe will be chosen from the flock concerned. Since repeatability of ram days is 10 percent and the ewe chosen as an illustration has lambed six times with an average ram days of 160 in a flock with an average ram days of 163, Table 11 readily facilitates the desired estimate of the most probable producing ability of this ewe. Looking in the above Table under row six and column one, we find the entry .40. Consequently, the best estimate of the real producing ability of the ewe with respect to ram days is 163 + .40 (160-163) = 161.8.

Going one step further, it is of interest to see how accurate are these estimates and what progress can be made toward reducing the average number of ram days in a flock through culling on the basis of these estimates. In order to do this the correlation between the estimated producing ability of a ewe and her real producing ability is needed. The desired correlation is simply the square root of the weighing factor which is applied to the amount by which the average of a ewe's records deviate from the flock mean (i.e., see $\frac{nr}{1 + (n-1)\,r}$ in Table 11.)

Table 12 presents the size of the correlations for various combinations of numbers of records and levels of repeatability.

The use of Table 12 is easily demonstrated. In the present flock, culling on the first ram day observation of ewes would result in progress 32 percent as fast as culling based on perfect knowledge of the real producing ability of each of the ewes (see entry at junction of column one and row one).

The Table can also be used to show how much is gained through the use of repeated records (ignoring the factor of generation interval). It is readily apparent from an inspection of this Table that

TABLE 12

CORRELATION BETWEEN THE REAL PRODUCING ABILITY AND THE AVERAGE OF THE INDIVIDUALS RECORDS (CALCULATED FROM $\sqrt{\frac{nr}{1 + (n-1)\,r}}$)

Number of Records	Repeatability .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
1	.32	.45	.55	.63	.71	.77	.84	.89	.95	1.00
2	.43	.58	.68	.76	.82	.87	.91	.94	.97	1.00
3	.50	.65	.75	.82	.87	.90	.94	.96	.98	1.00
4	.55	.71	.79	.85	.89	.93	.95	.97	.99	1.00
5	.60	.75	.83	.88	.91	.94	.96	.98	.99	1.00
6	.63	.77	.85	.89	.93	.95	.97	.98	.99	1.00
7	.66	.80	.87	.91	.94	.96	.97	.98	.99	1.00
8	.69	.82	.88	.92	.94	.96	.97	.98	.99	1.00

the gain in accuracy of selection through the use of repeated records is greatest when repeatability is low. Likewise, when repeatability is one or perfect, nothing is to be gained by using a second record. Table 12 also illustrates that the gain from each successive record is less than the gain from the preceding one no matter what is the level of repeatability.

In the light of the previously reported findings of Cadmus (4, pp. 15-16), it would appear that the present estimate of 10 percent is extremely low for this phenomenon. However, it must be remembered that the F_1 ewes were employed in testing for ram breed effects because of their extreme uniformity and similar genotypes. Obviously, the average ram day interval of 163.2 in these ewes would indicate relative high fertility. In any event, there is a need for additional estimates to be calculated on the basis of records from pure breeds and other breeding flocks in this species.

EFFECT OF BREED AND MANAGEMENT PRACTICES ON PRE-AND POST-WEANING WEIGHTS IN SHEEP

The maintenance cost of animals is one of the largest items in the growth cost. Hence, rapid growth and early maturity are factors to be desired in farm animals. In a commercial sheep operation devoted to the production of grass-fat lambs at weaning, early growth and fattening are even more important than in other livestock enterprises. Currently, there exists a great need for more detailed growth data in lambs and weight changes throughout the life of the mature ewe. Such information is essential in properly describing breed and individual differences.

Review of Literature

While most studies concerned with weanling lambs must of necessity constitute a consideration of the manifestations of the growth phenomenon, attention is especially directed to reports by Blunn (2, pp. 41-49 and 3, pp. 306-310), Foster (11, pp. 1-3), Hammond (16, pp. 97-105), Phillips (37, pp. 121-141) and Simmons (44, pp. 50-58) who have been concerned with growth and/or weight changes in sheep. Some of the problems encountered in obtaining frequent weights of range lambs are enumerated by Phillips, Stoehr and Brier (38, p. 180). Generally, such problems center around the roughness and inaccessibility of the ranges normally occupied by the ewes while suckling their lambs.

Materials and Methods

The design and development of a set of portable scales has facilitated the taking of very frequent weights throughout the life of animals in the experimental flock. Figures 3 and 4 portray the scales concerned. Figure 3 shows the weighing apparatus assembled for movement to the particular location for which it is desired to weigh sheep. Figure 4 depicts the scales set for weighing. While no pens or chutes are evident in these two figures, the weigh rig carries complete equipment for setting up holding pens, chutes and cutting gates which are necessary for handling sheep in the weighing operation.

The extreme smallness and ready accessibility of the Oregon State College Experimental flock coupled with the services of the above scale has permitted the making of many more individual weight observations than has been possible in few if any other experimental flocks known to the present author. Since close collaboration exists between the sheep project and the range management program at the experiment station, all sheep are weighed each time they are moved from one pasture to another. The above conditions of management and cooperation has resulted in the repeated weighing of all sheep in the flock at varying intervals but in general about every two or three weeks since these practices were instigated commencing with the 1950 lamb crop. Not only is it possible to weigh the flock with a minimum of confusion and labor, but it is felt that the operation is performed in

FIGURE 3. OREGON STATE COLLEGE PORTABLE SHEEP WEIGHING SCALE ASSEMBLED FOR MOVING.

FIGURE 4. OREGON STATE COLLEGE PORTABLE SHEEP WEIGHING SCALE SET FOR OPERATION.

such a manner that no deleterious effects are manifested in the growth and performance of the animals.

The foregoing management practices have improved pasture utilization and given resultant good lamb growth and at the same time yielded valuable information relative to the growth and fattening rate of the various breeds of sheep involved.

As mentioned earlier in the thesis, the experimental flock during 1947 through 1950 consisted of four commercial lines or breed groups. These four breed groups evolved as a result of the saving of replacement ewe lambs from the mating of Hampshire, Border Leicester, Cheviot and Romney rams to F_1 (Lincoln x Rambouillet) ewes. Figures 5 through 8 portray representative sires, sire groups and individual lambs from the above breed groups. The detailed growth curves presented in the following pages of the thesis are based upon weight changes as observed in these sheep.

Results and Discussion

The extreme linearity of weight from birth to weaning for the 1950 and 1951 lamb crops is exemplified by Figures 9 and 10. Figure 9, which is based upon the average weight of all lambs of a given age for each week specified, is made possible in the relatively small sized flock by taking frequent weights from birth to weaning (i.e., at any one weigh period the lamb ages vary among themselves from 35 to 40 days). In any event, when lamb weights were plotted by weeks of age, the growth curve was smoothed out as a result of the apparent removal of temporary changes in growth rate. It was hoped that this method would make the weights between different weeks of age more

FIGURE 5. HAMPSHIRE TOP LINE FROM
F_1 (LINCOLN x RAMBOUILLET) EWE

Representative Ram, Sire group
and individual lamb.

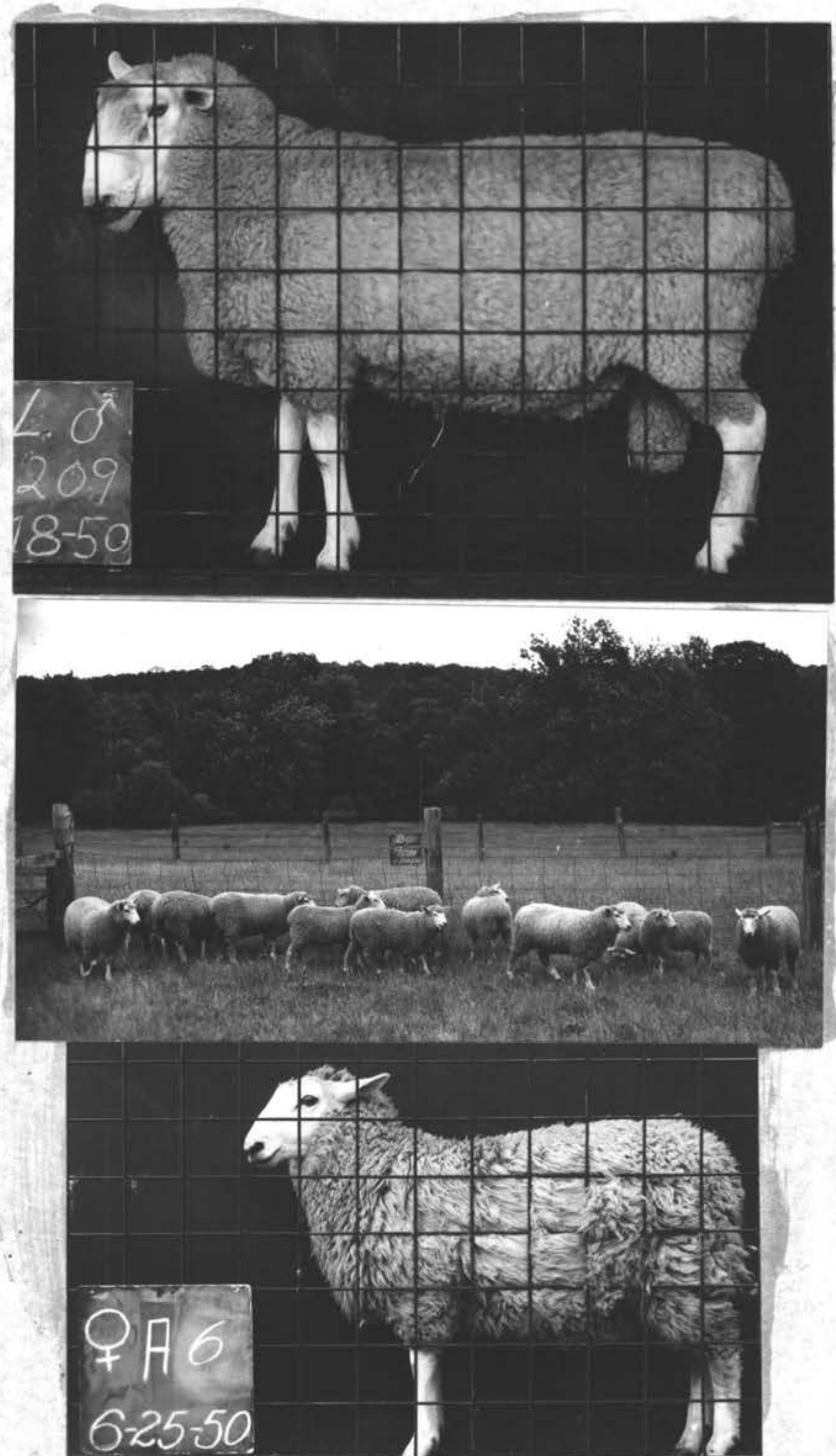


FIGURE 6. BORDER LEICESTER TOP LINE FROM F_1 (LINCOLN x RAMBOUILLET) EWE

Representative Ram, Sire group and individual lamb.

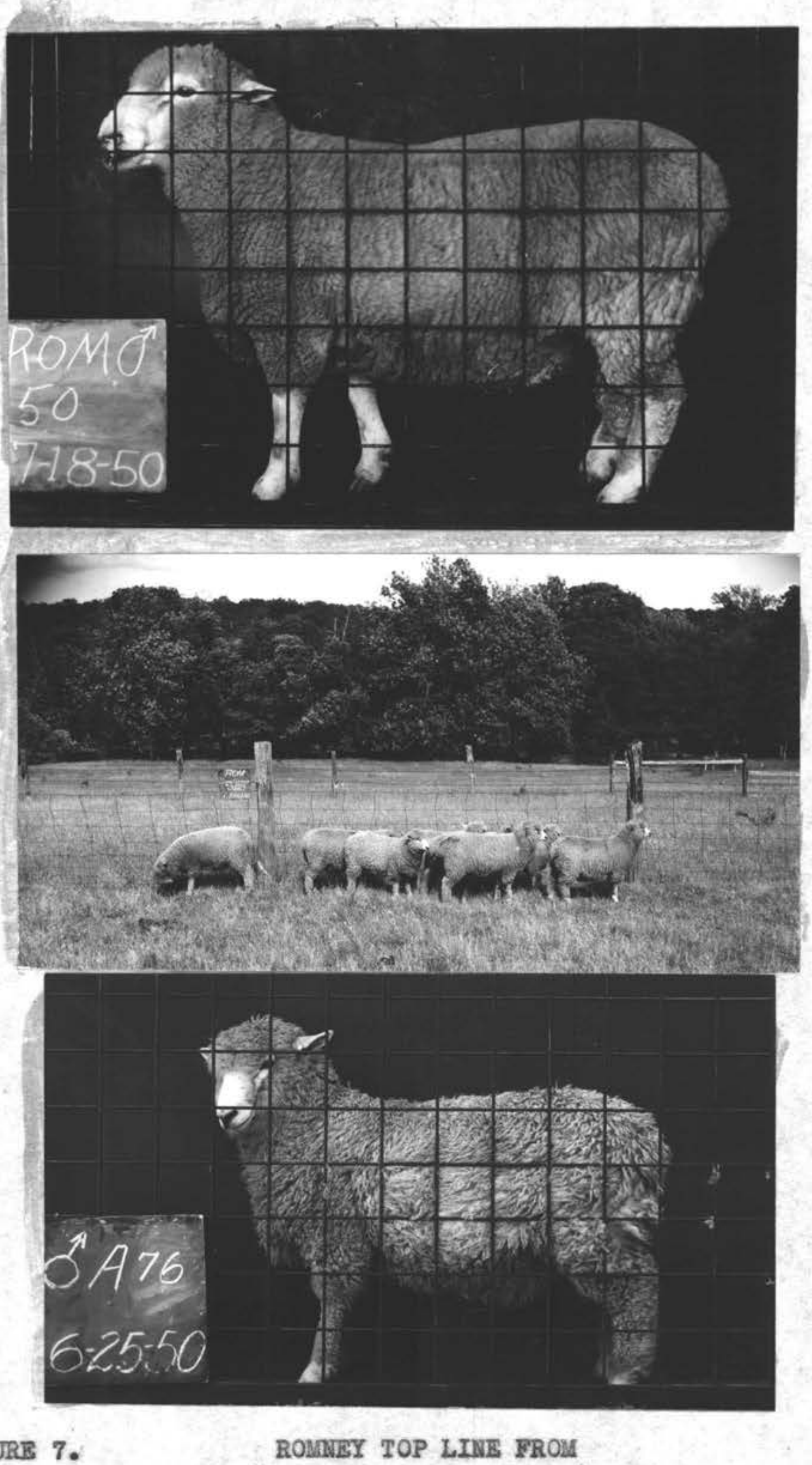


FIGURE 7. ROMNEY TOP LINE FROM
F_1 (LINCOLN x RAMBOUILLET) EWE

Representative Ram, Sire group
and Individual lamb.

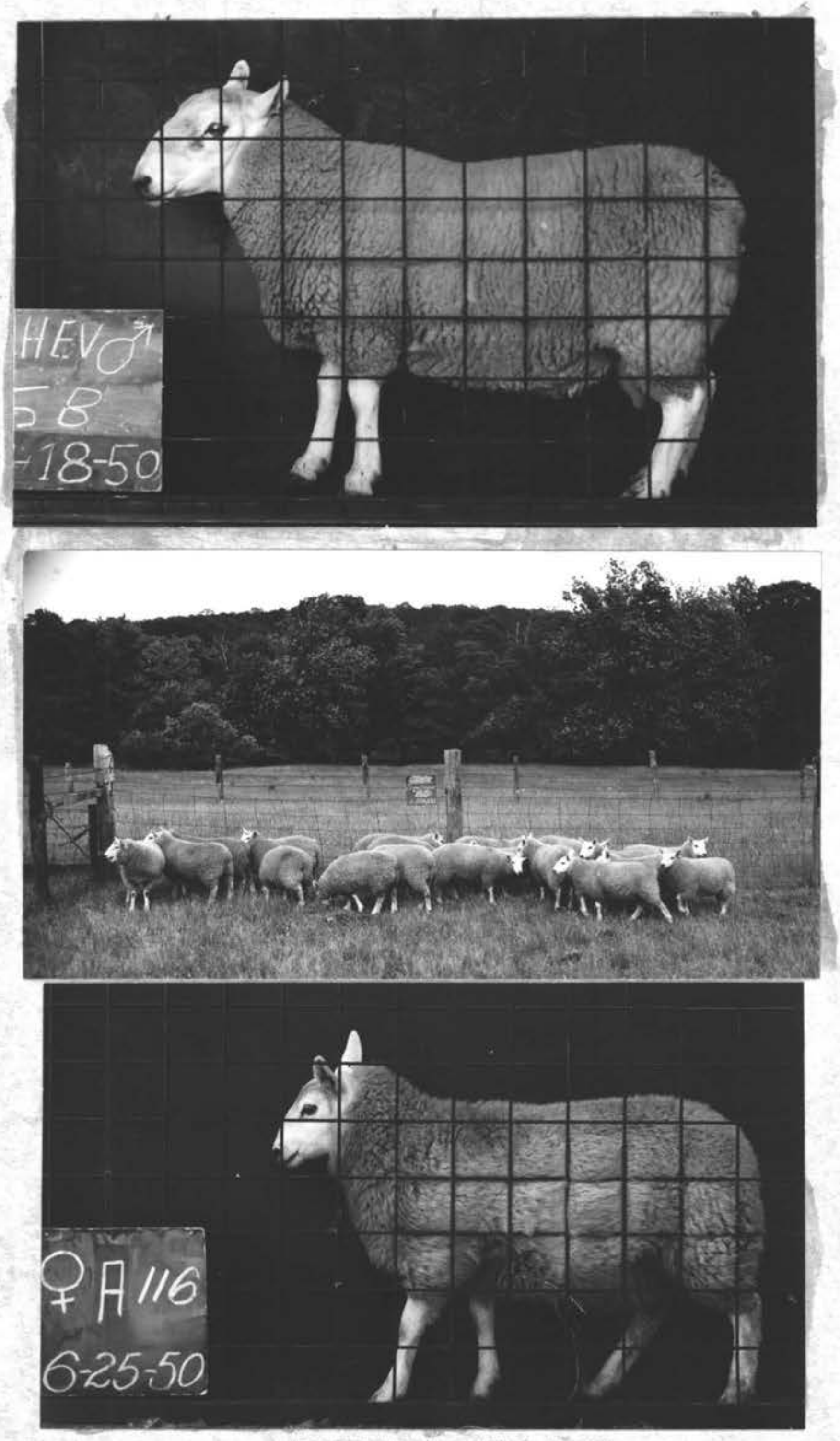


FIGURE 8. CHEVIOT TOP LINE FROM
F_1 (LINCOLN x RAMBOUILLET) EWE

Representative Ram, Sire group
and individual lamb.

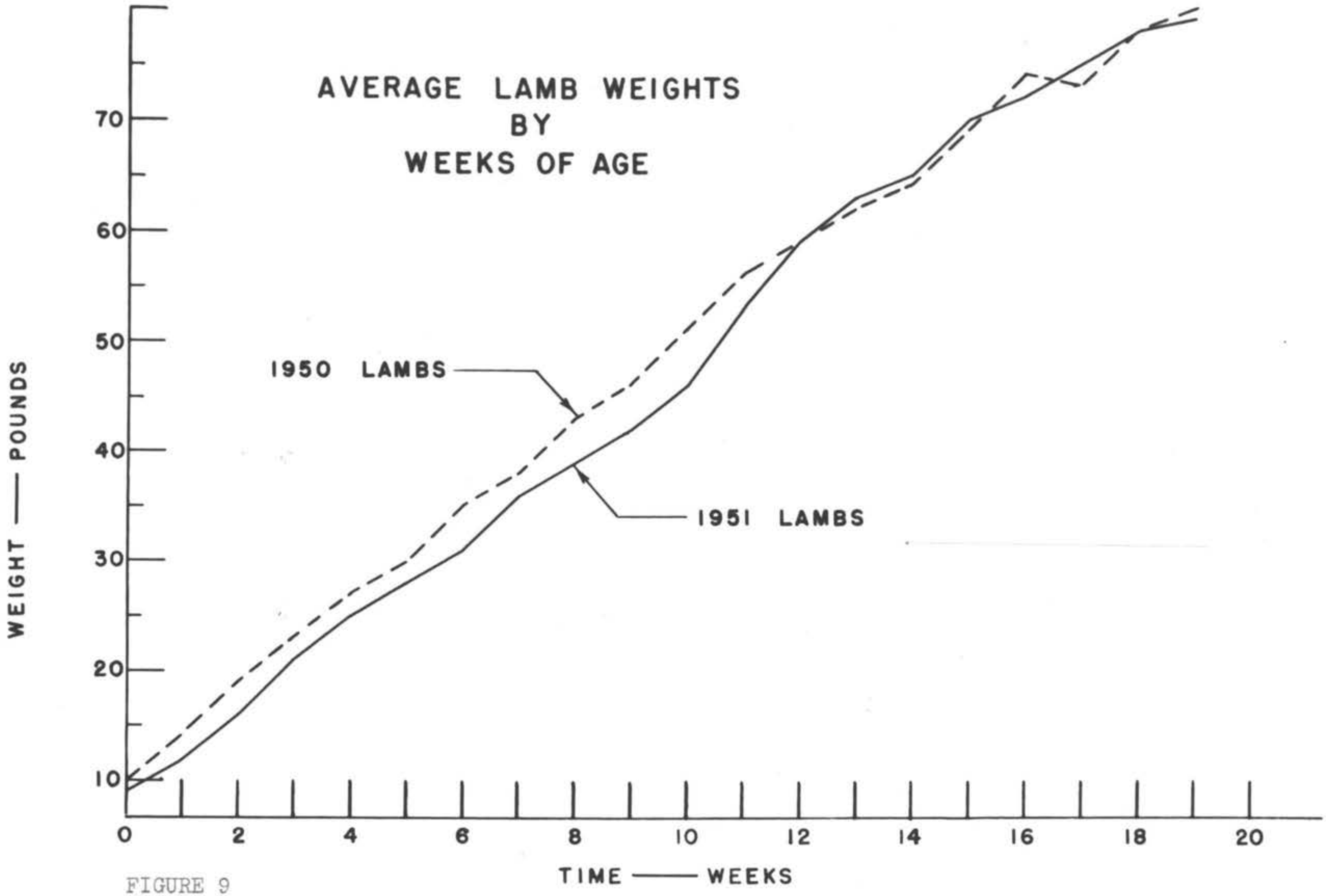
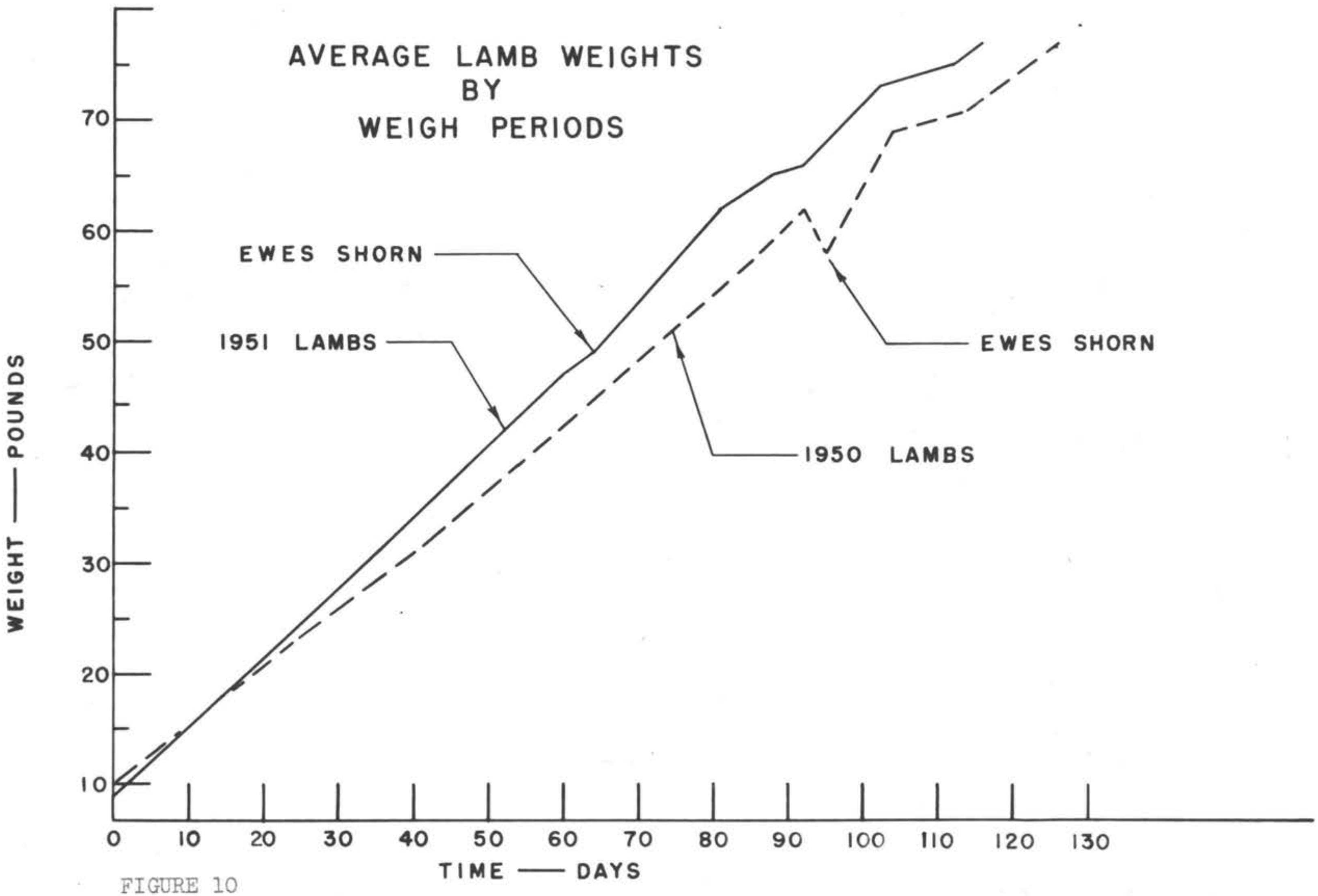

AVERAGE LAMB WEIGHTS
BY
WEEKS OF AGE
1950 LAMBS
1951 LAMBS
WEIGHT —— POUNDS
TIME —— WEEKS
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
16
18
20

FIGURE 9


AVERAGE LAMB WEIGHTS
BY
WEIGH PERIODS
EWES SHORN
1951 LAMBS
EWES SHORN
1950 LAMBS
WEIGHT —— POUNDS
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TIME —— DAYS
FIGURE 10

independent than usual since the lambs at any one age-week were not necessarily the same lambs found in the adjoining week. It was desired to calculate heritability of lamb weight at different weeks of age, but the animal numbers were too small. In the event of the calculation of such coefficients, it is advantageous that the lambs in the different age groups be different individuals if possible. Otherwise, comparisons among the different estimates of heritability will not be very meaningful.

Figure 10 represents the weights of the same lambs as shown in Figure 9. However, in Figure 10 the average weight of all lambs at any one weigh period was plotted against time in days spaced according to the number of days between weigh periods. Environmental effects such as shearing of the ewes is very apparent with respect to growth in the case of the 1950 lambs. Besides the general similarity of the growth curve of the 1950 and 1951 lamb crops, other points are of interest. The 1950 lamb crop was dropped with a one-pound advantage in weight, yet at weaning the 1951 lambs averaged 10 days younger and weighed the same as the 1950 lambs.

It is felt that the better performance in the case of the 1951 lambs resulted from the moving of the band very rapidly from pasture to pasture thus getting maximum utilization of the forage at a time when the lambs were the most sensitive to feed conditions. Other management practices thought to have affected the two lamb crops involve the date at which the ewes were shorn. In 1950 the ewes were shorn May 25 at a time when they were probably decreasing in milk yield, and the lambs changing over to pastures which were no longer as lush as formerly. The shearing operation was prolonged over a three-day period in 1950 which caused the lambs to decrease in weight 3 to 5 pounds at a crucial point where they should have gained at least half of this amount. In contrast, the ewes suckling the 1951-lamb crop were shorn a month earlier than the ewes in 1950. Shearing was done by a crew which required less than one day. No weight loss was discernible in the case of the 1951 lambs as a result of shearing the ewes. While Figure 10 indicates that the weaning weight of the 1951 lambs was 77 pounds (i.e., last weight shown), it is noteworthy that twenty top lambs had been removed for slaughter 10 days before the regular weaning date of June 16.

During 1950 and to a greater extent in 1951, condition scores were placed on the lambs at weigh periods approaching the expected weaning date. Since the flock consisted of four lines of commercial ewes of different breeding (Hampshire, Romney, Cheviot and Border Leicester), it was possible to make comparisons of how degree of finish changed with time in the case of the lambs in the four breed groups. Most of the lambs in the different breed groups appeared to reach a fair degree of finish at some point before weaning. However, in the case of the Romney and Border Leicester lambs, such condition or degree of fatness often persisted for only a limited time and some lambs previously judged to be fat were scored as feeders at the regular weaning date. This would indicate a need for very frequent topping out of finished lambs when producing and/or comparing lambs differing in growth and fattening potentialities. In short, management practices should be directed toward marketing lambs at a given degree of finish within a breed rather than setting a constant weaning date based on average age of the lambs. This latter point is extremely important in western Oregon where pastures begin to decline by mid-June and are usually dried up by early July. While it would be very difficult to have several weaning dates under range conditions, it is felt that the commercial farm flock operator cannot afford to pass up additional profits simply by neglecting to remove for sale lambs that exhibit a suitable size and degree of finish.

Figure 11 is concerned with the growth or size differentiation exhibited by the previously mentioned four commercial breed groups lambing in 1950. Growth curves are shown for these lambs from birth to weaning and extended to about 15 months of age for the replacement ewe lambs. The Cheviot lambs are observed to exhibit the lowest initial and subsequent weights. The Hampshire lambs were below the Romney and Border Leicester lambs at birth but at 15 months of age exceeded all others. In concluding the discussion of Figure 11, it is noteworthy that environmental influences appear to be felt equally by the 4 different breeds of sheep.

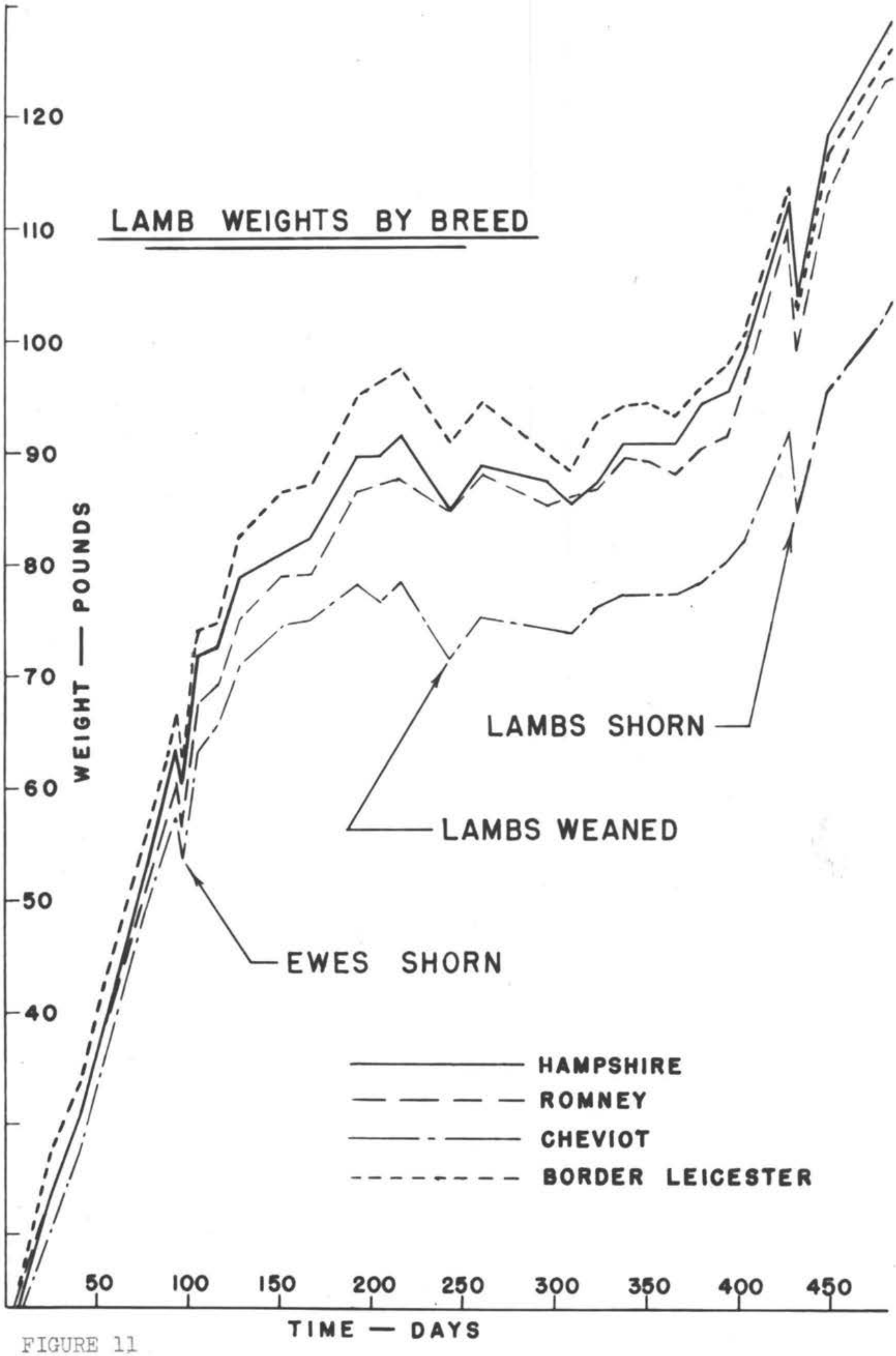

LAMB WEIGHTS BY BREED
120
110
100
90
80
70
60
50
40
WEIGHT — POUNDS
LAMBS SHORN
LAMBS WEANED
EWES SHORN
HAMPSHIRE
ROMNEY
CHEVIOT
BORDER LEICESTER
50
100
150
200
250
300
350
400
450
TIME — DAYS

FIGURE 11

SUMMARY AND CONCLUSIONS

The files of the sheep breeding project of the Oregon Agricultural Experiment Station have provided the records upon which the following conclusions and summary are based. The thesis is concerned, in part, with observations made on the 1943 to 1951 lamb crops. Since the sheep concerned in this study exist in an ecological niche greatly different from that normally thought to be ideal for the ovine species, the conclusions presented probably are not applicable to animals located under other environmental circumstances. In any event, there is little doubt that sheep have a place in the agriculture of the Willamette Valley. Especially, if the proper breed or breeds are employed and if efficient management practices are incorporated into the operation of the enterprise.

The adjusted weaning weight of Hampshire, Southdown and Romney sired lambs from F_1 (Lincoln x Rambouillet) ewes is 80, 75 and 75 respectively with corresponding weaning percents of 110, 110 and 92. Concerning their ability to sire pounds of fat lamb at weaning under the conditions of this experiment, Hampshire rams are superior to those of Southdown and Romney breeding. These data do not permit a further ranking of the Southdown and Romney rams.

The weather is highly variable in Western Oregon during the winter months with respect to different years; therefore, management practices should be geared to provide both feed and shelter to pregnant ewes when the need arises. However, there is reason to believe that if sound range management practices have been followed and if there is a mild open winter, commercial ewes should be able to go through the entire winter with no supplemental feed and only the crudest of shelter.

On the basis of weight alone there appears to be no particular advantage in furnishing supplemental feed to replacement ewe lambs under the climatic conditions concerned. However, while supplemental feeding does not appear to improve fertility, it does increase birth weight and survival to weaning of the first lamb crop from ewes receiving such treatment. It is suggested that fertility and lactation differ in the factors influencing their behavior.

The supplemental feed used in wintering the pregnant ewes and replacement ewe lambs in this study consisted of alfalfa hay and grain. It is postulated that a more economical supplement in the form of grain might suffice as an adequate level of nutrition for replacement ewe lambs and pregnant ewes in a commercial sheep operation.

The coefficient of repeatability for ram days based on 130 F_1 (Lincoln x Rambouillet) ewes is .1068. This estimate represents the degree to which ram days is a constant characteristic of these ewes. The figure has its greatest usefulness in selecting ewes for the ability to lamb in a minimum number of ram days. This low value of repeatability indicates that progress through selection for shorter "ram days" will be quite slow.

It is extremely important that management practices be directed toward marketing commercial weanling lambs at a given weight and degree of finish within a breed rather than setting a constant weaning date based on average lamb age, because the lambs reach a peak in finish and then lose condition at varying rates depending upon breed and other factors unless marketed at the proper degree of finish. Also, weather permitting, ewes should be shorn well in advance of the weaning of their lambs. The shearing operation should not be unduly prolonged.

The portable scales now employed in the Oregon State College sheep breeding project readily facilitates the weighing of sheep with a minimum of effort, time and confusion. Hence, there is being accumulated valuable data relative to growth and maturity in the different breeds within the ovine species which should be a useful contribution to the field of animal science.

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