THE ASSOCIATION BETWEEN AGE OF DAM AND VARIOUS PRODUCTION TRAITS IN SHEEP

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Submitted to the
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fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1968

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ACKNOWLEDGMENTS

The author acknowledges with profound gratitude the immeasurable guidance afforded him by Dr. Joe V. Whiteman, Professor of Animal Science, not only during the course of this study but also during the entire period of the author's stay in this institution.

The indebtedness of the author to Dr. Robert D. Morrison, Professor of Mathematics and Statistics, and to Henry F. Magalit, Graduate Assistant in Mathematics and Statistics on leave from the University of the Philippines, for their valuable assistance in the analyses of data, is also sincerely recognized.

A special appreciation is extended to the author's wife, Norma, for her inspiring encouragement and unceasing assistance in this undertaking.

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INTRODUCTION

Scientists are often confronted by the presence of many extraneous variations which may distort genetic or treatment effect. These environmental variations which are not pertinent to the responses being measured may lead to imprecise analyses of data and consequently, to faulty or no conclusions.

Selection of breeding animals are done on the basis of phenotypes which if masked by environmental forces may tend to conceal genetic merit. Thus, environmental forces tend to operate toward obstructing the breeder's effort to select individuals having the greatest breeding value. A knowledge of the influence of uncontrollable environmental factors on the phenotypic measures of economically important traits is necessary for effective selection practices.

Age is one of the environmental forces that contributes to the variability of some measures of an animal's genetic worth. A ewe, for instance, may produce more lambs than another during a certain lambing season, but this does not necessarily mean that the ewe that produced more lambs has a better genetic reproductive potential than the other. Part of the difference in their performance may be due to the difference in their ages; the former may be a five-year-old ewe whereas the latter is a yearling ewe. Similarly, a lamb

may be heavier at weaning than another but again, the difference may be due in part to the fact that the lighter lamb is out of a two-year-old ewe while the heavier lamb is out of an older ewe. Variation such as these should be recognized by a breeder and adjustment should be made in order for him to measure the genetic difference between individuals with a higher degree of accuracy and/or precision.

It is the purpose of this study to evaluate the influence of age of ewe upon various performance traits in sheep, and to devise correction factors for adjusting these traits for the effect of age of ewe utilizing the data collected from the experimental sheep flock maintained at the Fort Reno Livestock Research Station, El Reno, Oklahoma.

REVIEW OF LITERATURE

This literature review will deal primarily with the influence of age of ewe on various measures of performance. These performance traits will be divided into three general classes: (a) reproductive performance of the ewes, (b) wool production of the ewes, and (c) performance of the lambs.

Influence of Age of Ewe on Her Reproductive Performance

The reproductive performance of a ewe is determined by her fertility, prolificacy and ability to produce live lambs and to rear them during the critical period of life, i.e., the first two weeks after birth, and through weaning. The measures of performance are influenced to a considerable extent by age of ewe.

Influence of Age of Ewe on Fertility

The term fertility has been used to mean different things by different authors. For instance, Young et al. (1962) defined fertility as the number of lambs born and the number of lambs weaned per ewe. Similarly, Kelly (1939), Polach (1960) and Yalcin and Bichard (1964) used fertility as a measure of the number of lambs born per ewe or a group of ewes. Sidwell et al. (1962) defined fertility as the number of ewes lambing of ewes bred. This means that if 90

ewes lambed out of 100 ewes bred, then the fertility of the flock is said to be 90 percent. In this discussion, fertility will be used as that defined by Sidwell et al. (1962).

Several workers have indicated that fertility tends to be lower for young and old ewes than for those of the middle ages. In a study of over 6,500 mating records of Rambouillet, Corriedale, Columbia and Targhee ewes, Terrill and Stoehr (1939) demonstrated that changes in fertility of ewes with age were very definite. Table I shows a partial result of this study. There was a steady increase in the percent-

TABLE I

INFLUENCE OF AGE OF EWE ON FERTILITY
(TERRILL AND STOEHR, 1939)

Age at lambing, yr.	Number of matings	Percentage of ewes lambing
2	1,768	78
3	1,485	86
4	1,498	88
5	945	91
6	682	87
7	325	90
8	87	87
9	18	100

age of ewes lambing until five years of age followed by a slight decline in the sixth year with a further increase in

the seventh and ninth year. The decrease in the sixth year was probably due to old age. The authors pointed out that practically no culling for age took place until after lambing in the sixth year. Further decrease in fertility with advancing age was probably offset by the culling of all ewes showing indication of decline in vigor with age. Hence, the authors believed that fertility was likely to decrease after six years of age if no culling was done. Based on the evaluation of the production records of 1,287 Palas Merino ewes in Roumania, Teodoreanu and Russu (1959) stated that the incidence of infertility was higher in younger and older ewes than in ewes four to eight years of age. The average fertility of the flock was 92.9 percent.

Using production records of the Rambouillet flock maintained at Texas (Sonora) Experiment Station, Campbell (1962) studied the performance of ewes of various ages in terms of lamb and wool production. His data included about 3,300 observations taken over a 20-year period. He claimed that fertility of ewes increase with age. This was verified by the results given in Table II. The percentage of dry ewes dropped from 30.0 percent for two-year-old ewes to 9.8 percent for ewes six years of age. Then it increased, varying from 17.4 percent to 21.4 percent for ewes eight to ten years of age. Campbell remarked that continuous culling of low producers in the flock had been practiced so that the data did not represent the true picture of fertility change with age. However, since most breeders normally cull to some extent, the results presented should approximate those

of an average flock.

Sidwell et al. (1962) studied the fertility, prolificacy and lamb livability of some purebred and crossbred ewes. The study involved a total of 3,621 lambs born, 2,046 lambs weaned from 2,962 ewes bred to lamb in February to April during the years 1952 to 1959 inclusive. Using methods of least squares, constants were fitted for years, age of dam, type of birth and for breeds and crosses, and least squares means were computed for each trait under study. Relative to age, young and old ewes were found to be less

TABLE II

FERTILITY OF EWES OF VARIOUS AGES (CAMPBELL, 1962)

Age of ewes, yr.	No. of observations	Percentage of dry ewes
2	871	30.0
3	679	11.8
4	525	11.4
5	427	11.5
6	339	9.8
7	241	12.9
8	126	21.4
9	69	17.4
10	21	19.0

fertile than ewes of the middle ages. Fertility increased from 86.9 percent for two-year-old ewes to 94.2 percent for

seven-year-old ewes followed by a decrease to 82.2 percent for nine-year-old and older ewes.

In a more recent study, Turner and Dolling (1965) investigated the influence of age on reproductive performance of an experimental flock of Peppin Merino ewes in Australia. They found that lambing percentage was highest for ewes five to six years of age. The trend was a rise from 81.9 percent for two-year-old ewes to 91.7 percent for five- to six-year-old ewes and a gradual fall to 86.5 percent for ten-year-old ewes.

Vesely and Peters (1965) working with Rambouillet, Romnelet, Corriedale and Romeldale ewes in Canada reported that age of ewe had no significant effect on fertility. In their study, no definite trend of fertility changes with age was found although the six-year-old ewes had the highest fertility with 95.3 percent. The seven-year-old ewes were the least fertile (89.5 percent). In a later study, Vesely et al. (1966) working this time with Romnelet, Rambouillet, Columbia, Targhee and Suffolk ewes, found almost similar result except that the highest fertility was obtained in five-year-old and seven-year-old ewes.

Age of ewe has a definite effect on fertility. Young and old ewes are, in the majority of cases, less fertile than ewes that are of the intermediate ages.

Influence of Age of Ewe on Prolificacy

Generally, prolificacy which is measured as the number of lambs born per birth, increases with age until a peak

production is reached around five to six years and then, like fertility, declines with advancing age. This trend is shown in Figure 1, adopted from the work of Johansson and Hansson as cited by Reeve and Robertson (1953). This study

Figure 1. Association Between Age of Ewe and Prolificacy. (Johansson and Hansson as Cited by Reeve and Robertson, 1953)

involved 58,381 birth records of four breeds of sheep in Sweden. The figure clearly illustrates a steady rise in the number of lambs born per birth until five to six years of age followed by a gradual fall. Although both the young and aged ewes were less prolific than those of the middle ages, it was evident that aged ewes produced more lambs per birth than the very young ones.

In an earlier study, Marshall and Potts (1921) investigated means of increasing lamb yield and found that age of ewes was one of the important factors affecting lamb production. Their data, collected from a flock of Southdown ewes in Beltsville, Maryland over a nine-year period, included eight age groups (two through nine years). They reported that the proportion of twins increased until the ewes were five and six years old. Lambing rate, the number of lambs born as a percentage of ewes lambing, increased from 111.4 percent for two-year-old ewes to 161.2 percent for six-year-old ewes. Then it dropped to 142.8 percent and 113.6 percent for seven and eight-year-old ewes, respectively, and rose again to 162.5 percent for ewes nine years of age. This relatively high lambing rate of the nine-year-old ewes may be due in part, to the fact that only a few observations was included in this age group. Also, the authors suspected that the figure may have been, to a slight extent, affected by selection because some ewes have been kept to advanced age that might have been disposed of one or two seasons earlier had it not been for their marked prolificacy.

The results of the study by Terrill and Stoehr (1939) on the changes of prolificacy of ewes with age was practically the same as they reported on fertility. Lambing rate was found to increase steadily with age, from 109 percent for two-year-old ewes to 150 percent for nine-year-old ewes. However, age effect after the sixth year may have been confounded with selection since ewes showing indication of decline in vigor with age were culled.

Rendel (1965) studied the birth records of four breeds of sheep in Sweden. He reported that lambing rate consistently increase with increasing age. However, his data included only ewes up to five years of age, so, no statement relative to lambing rate of older ewes was made. The incidence of multiple birth in Rhamani sheep in Egypt was investigated by Karam (1957). He found that the number of lambs per birth increased at a decreasing rate from one breeding to the next until the maximum was reached at five to seven years of age. The average litter size for two-year-old ewes was 1.12 and for seven-year-old ewes, 1.46. No data for ewes older than seven years were available.

Records of a flock of about 1,600 breeding Scottish Blackface ewes in Great Britain were evaluated by Purser and Roberts (1959). Prolificacy of this flock was not particularly good with a mean lambing rate of about 92 percent (number of lambs born as a percentage of the number of ewes alive. The two-year-old ewes had the lowest lambing rate with 77.4 percent. This increased steadily to 104.7 percent for ewes six years of age.

A part of the work by Sidwell et al. (1962) discussed in the previous section involved a study of the prolificacy of ewes of different ages. They observed that age of ewe showed an important effect on prolificacy (Table III). The percentage of lambs born of ewes lambing increased steadily with age. There was an increase from 126.2 lambs born per 100 ewes lambing for two-year-old ewes to 153.4 lambs for nine-year-old and older ewes.

TABLE III

INFLUENCE OF AGE OF EWE ON PROLIFICACY
(SIDWELL ET AL., 1962)

Age of ewe, yr.	No. of ewes bred	No. of ewes lambing	Percentage of lambs born of ewes lambing
2	732	636	126.2
3	647	587	130.9
4	515	476	136.8
5	427	391	143.2
6	288	259	144.9
7	190	179	140.7
8	109	98	145.4
9+	54	44	153.4

Campbell (1962) in his evaluation of the Rambouillet flock records in Texas found that twinning rate increased from 7.3 percent in two-year-old ewes to 27.4 percent in four-year-old ewes. It varied between 19.8 percent to 38.9 percent in ewes five to ten years of age.

Joustra (1964) summarized the records of 162 Merino, 231 Precoce and 172 Suffolk ewes two to seven years of age. He reported that the incidence of multiple births, i.e., twins and triplets, increased with age of ewe.

The lifetime record of 260 Border Leicester x Cheviot ewes which included 1,891 lambs born and 1,674 lambs weaned was analyzed by Yalcin and Bichard (1964) in Great Britain. It was found that the number of lambs born increased with

increasing age; maximum production was reached at five to six years of age with mean litter size of 1.87.

The result obtained by Turner and Dolling (1965) in their study of the Australian Merino flock indicated that the proportion of ewes mated which had multiple birth rose from a minimum of two percent for two-year olds to a maximum of 20 percent for seven and eight-year-olds with only a slight decline thereafter. Looking at the lamb production as a percentage of the ewes mated, it increased from a minimum of 84 percent for two-year-old ewes to 111 percent for seven-year-old ewes, and then falls to 104 percent for ewes ten years of age.

Vesely et al. (1966) studied the production records of Romnelet, Rambouillet, Columbia, Targhee and Suffolk ewes in Canada and found that prolificacy increased with age up to five years and then declined. The increase was from 141.3 percent for two-year-old ewes to 169.5 percent for five-year-old ewes. The lambing rate of the seven-year-old ewes was 154.1 percent. In an earlier study where Rambouillet, Romnelet, Corriedale and Romeldale ewes were involved, Vesely and Peters (1965) observed that prolificacy increased from 118.6 percent for two-year-old ewes to about 150 percent for ewes four to seven years of age.

Forest and Bichard (1967) analyzed the lambing records of 1,200 Clun Forest ewes to investigate the scope of selection for increased litter size. Average litter size was found to increase with age to a maximum at three to four years. The average production was 1.15 at one year, 1.54 at

two years and 1.76 at three years and older. In a study involving 1,987 Hampshire, Corriedale and Western crossbred ewes in Virginia, Inskeep et al. (1967) demonstrated that the number of lambs born per ewe increased with age until about the sixth year and it decreased as the ewe grew older. The average litter sizes were 1.23, 1.64 and 1.40 for ewes two, six and eleven years of age, respectively.

The influence of age on prolificacy of ewes can be summed up by stating that prolificacy increases with increasing age, reaching the maximum around five to six years and then declines.

Influence of Age of Ewe on Lamb Mortality

Perhaps the best measure of the ewe's reproductive performance is her ability to produce live young and rear them through weaning. This is so because income is a function of the total pounds of lamb raised to weaning, and this in turn is dependent upon the number of lambs raised to this stage more than any other factor.

It has been demonstrated that lamb mortality at birth is related to the age of ewe. Terrill and Stoehr (1939) reported an increase in the number of lambs born alive as a percentage of ewes bred from 73 percent for two-year-old ewes to 113 percent for five-year-old ewes; the percentage for older ewes ranged from 101 percent to 144 percent. In a later paper, Terrill (1952) indicated that lamb mortality at birth decreased with increasing age of dam up to six years.

Karam (1959) studied some factors affecting lamb mortality at birth in the Rhamani sheep in Egypt. His data inc-

luded 1,109 lambs from 895 lambings. He found that there was a decrease in lamb mortality at birth with advancing age of ewe up to five years of age after which it started to increase. However, the differences between adjacent ages were not statistically significant.

A study of lamb mortality from birth to weaning including stillbirths in two hill flocks in Great Britain was conducted by Purser and Young (1950). They found that mortality rate in lambs of young ewes was higher than that in lambs of older ewes. Their data which included 5,381 Blackface and 2,426 Welsh single lambs indicated that mortality decreased with age of dam to 14.3 percent for lambs of four- to six-year-old Blackface ewes and to 9.4 percent for lambs of three- to four-year-old Welsh ewes. Ewes having their first lambs had mortality rates twice as great as that for the mature ones.

Sidwell et al. (1962) reported that the percentage of lambs born alive of total lambs born and percentage of lambs weaned of lambs born alive were generally greater for ewes four to six years old than for younger or older ewes. Table IV shows their findings. The increase in lamb livability with age of dam was definite. The number of lambs born alive as a percentage of the total number of lambs born was highest in ewes four to six years of age with about 97 percent. The number of lambs weaned as a percentage live lambs born was highest for five-year-old ewes (93.7 percent).

Working with Australian Merino ewes, Turner and Dolling (1965) found that the number of single lambs weaned as a

TABLE IV

INFLUENCE OF AGE OF DAM ON LAMB LIVABILITY
(SIDWELL ET AL., 1962)

Age of dam, yr.	Percentage of lambs born alive of total lambs born	Percentage of lambs weaned of live lambs born
2	92.8	79.6
3	96.1	84.0
4	96.9	90.1
5	97.0	93.7
6	96.6	87.6
7	94.4	84.8
8	95.5	77.2
9+	92.1	90.2

percentage of single lambs born increased from 75 percent for two-year-old ewes to 87 percent for six-year-old ewes. The corresponding figure for twin lambs were 58 percent and 70 percent. In a similar study, Lax and Turner (1965) concluded that ewes four to six years old had the highest lamb survival rate (lambs weaned as a percentage of lambs born). These studies and that of Sidwell et al. (1962) showed similar trend of the change in lamb survival rate with age of dam, but the figures in the former were considerably lower.

In a study involving 1,014 lambs born and 830 lambs weaned from 769 Rambouillet, Romnelet, Corriedale and Romel-

dale ewes in Canada, Vesely and Peters (1965) found that lamb survival from birth to weaning was highest in lambs of four- to five-year-old ewes (86 to 88 lambs weaned per 100 lambs born). In a later study (Vesely et al. 1966), similar results were found except that survival rate was higher (about 90.5 percent) and the maximum was in lambs of three- to five-year-old ewes

Generally, the pattern of survival rate to weaning of lambs is one of rise with increasing age followed by a decline. The lambs with the highest survival rate are those from ewes four to six years of age.

Influence of Age of Ewe on Wool Production

The productivity of a ewe is measured not only in terms of lambs she produces but also the wool she yields during shearing time. Wool production, like any other trait, is influenced by many factors. Undoubtedly, age is one of the important factors that affects the amount of wool a ewe will produce. It is a matter of common knowledge among sheepmen that the average wool production changes with age. The object of this review is to establish the pattern of wool production changes with age of ewe.

Perhaps the very first report on the influence of age of ewe on wool production was the one published by Williams and Cunningham in the Arizona Agricultural Experiment Station 27 Annual Report in 1916. The breeds of sheep involved in this study were Hampshire, Shropshire, Tunis, Native and crosses among them. The first clip was the lighthest of all

(5.3 pounds). Fleece weight increased until the third shearing (6.89 pounds), while the fourth and fifth shearing were slightly lower. The sixth clip (6.93 pounds) showed a marked increase over the others. It should be pointed out, however, that before the sixth clip was taken most of the inferior sheep in terms of wool, mutton and other qualities were eliminated from the flock so that only the better ones remained. This accounted for the relatively high wool yield in the sixth shearing.

Lush and Jones (1923) investigated the influence of age on the fleece weights of range Rambouillet and Corriedale ewes in Sonora (Texas) Station. They concluded that the fleeces of two-year-old ewes were heavier than those of the yearling ewes, usually 10 to 20 percent heavier in normal years. The heaviest fleece was produced by the two-year-old ewes. Later fleeces were somewhat lighter than those produced by the two-year-old ewes but were heavier than the yearling fleece. Fleece weight of ewes did not decrease very much on account of old age before they reached the age of at least seven or eight years.

Wool production records of range Rambouillet ewes one to seven years old raised in Dubois, Idaho were studied by Spencer et al. (1928). Their findings are shown in Table V. Fleeces were clipped from the yearlings when they averaged slightly more than a year old hence they represented a growth of about 407 days from the date of birth. The fleeces from ewes two years old or older were almost exactly one year's growth. The average fleece weight increased with

TABLE V

WOOL PRODUCTION OF EWES OF DIFFERENT AGES
(SPENCER ET AL., 1928)

Age, yr.	Grease Wool		Clean Wool	
	No.	Ave. Wt., lb.	No.	Ave. Wt., lb.
1	252	9.12	247	3.62
2	359	10.43	296	4.11
3	333	11.59	251	4.48
4	274	11.14	204	3.98
5	251	11.20	191	3.76
6	221	11.12	178	3.95
7	160	10.22	119	3.34

age of ewe up to three years of age and then there was a decline in fleece weight after that age. Similarly, the clean or scoured fleece weight, which was determined by scouring a sample from each ewe in the laboratory and converting the result into the actual yield, was heaviest for the three-year-old ewes. There was a general decline after that age except that the fleeces of the six-year-old ewes yielded an average of 0.19 pound of clean wool more than the five-year-old ewes.

Johansson and Berg (1940) analyzed the wool production records of 413 Oxford Down, 948 Shropshire, 530 Cheviot and 112 Swedish Landrace ewes in Sweden. All ewes had at least 5 years record. The highest production was reached at three to four years in ewes sheared once a year. In ewes sheared

twice a year the heaviest fleeces were obtained at two years of age.

The fleece weights of registered Rambouillet ewes in Texas totalling 2,650 were evaluated by Jones et al. (1944). Eleven age groups (one to eleven years) were represented. The heaviest production of grease wool attained at three to four years with an average of about 9.40 pounds. Wool production decreased steadily at subsequent ages. Old ewes, namely those nine to eleven years old, actually clipped less wool than the yearling and/or the two-year-olds. Clean fleece weights showed a similar pattern and, likewise, peak production was reached at three years. Clean fleece weight of the three-year-old ewes averaged 0.03 pounds heavier than that of the four-year-old ewes but the difference was not significant.

Slen and Banky (1959) analyzed 1,475 fleece weights of Rambouillet, Romnelet and Corriedale ewes representing seven years of production. They reported that maximum clean fleece production was reached in the second year. From the second to the fourth year, production remained essentially the same. Then significant decline occurred in the fifth year and continued on through the sixth and seventh years.

Purser and Roberts (1959) working with a flock of about 1,600 breeding Scottish Blackface ewes reported a steady decline of fleece weight with age. Ewes that were 1.5 years old produced on the average 3.99 pounds of fleece. Wool production decreased with age to 3.50 pounds for ewes 6.5 years of age.

Bennet et al. (1963) collected 3,967 fleece records

from ewes of Columbia, Rambouillet and Targhee breeding in Utah. They observed that the two-year old ewes produced the heaviest clip of wool and production decreased with each additional year. Relative to clean wool, they reported that the difference between the two- and three-year-olds was slight but the seven-year-old and older ewes produced about 0.5 pound less clean wool than did the two-year-old ewes.

Studying the lifetime record of 260 Border Leicester x Cheviot ewes in Great Britain, Yalcin and Bichard (1964) found a very marked decline in wool production with age of ewe. They estimated a decrease from 0.4 to 0.7 pounds of fleece per year from the first clip.

After analyzing the wool production record of Rambouillet, Romnelet, Corriedale and Romeldale ewes, Vesely et al. (1965) indicated that age had a significant effect on fleece weight. The highest grease fleece production was obtained from three-year-old ewes with 10.1 pounds. This was 0.6 pounds heavier than that of the two-year-old ewes. Grease fleece weights decreased with age to 9.2 pounds for the seven-year-old ewes. The clean fleece weight showed similar pattern of change with age. The three-year-old ewes yielded the heaviest clean fleeces with 5.5 pounds which was 0.3 pounds and 0.9 pounds heavier than those of the two-year-old and seven-year-old ewes, respectively. In the 1966 study with Rambouillet, Columbia, Targhee and Suffolk ewes, Vesely et al. found that both grease and clean fleeces were heaviest for ewes that were two years old and that wool production declined with increasing age.

In Australia, Brown et al. (1966) estimated the effect of age of ewe in fleece characteristics using records of breeding Merino ewes that were 1.5 to 10.5 years old. They reported that both grease and clean wool production showed a sharp peak at 3.5 years. The average production at this age was 9.3 pounds and 5.9 pounds for grease and clean wool, respectively. The 1.5-year-old ewes produced 8.7 pounds grease wool and 5.4 pounds of clean wool on the average. For the 10.5-year-old ewes, production was 7.1 pounds and 4.2 pounds of grease and clean wool, respectively.

This review indicates that wool production, both grease and clean, is generally heavier for two- to three-year-old ewes. Henceforth, there is a decrease in wool production with advancing age and the decrease is usually gradual.

Influence of Age of Ewe on Lamb Characteristics

The important production characteristics of lambs, such as birth weight, weaning weight and rate of gain, depend considerably upon the ewe. During the period from birth to weaning especially the first few weeks after birth, the ewe is almost entirely the source of the lamb's nourishment. Thus the physiological changes which accompany the increase in age of ewes are reflected in the performance of the lambs.

Influence of Age of Dam on the Birth Weight of Lambs

Lambs born to mature ewes are generally heavier at birth than those born to relatively younger ones. Yalcin and Bichard (1964) suggested that this phenomenon might be

due to the increasing weight of ewes with age, having in mind that bigger ewes in terms of weight and/or body measurements usually give birth to heavier lambs.

Kincaid (1943), working with a commercial flock of native ewes of variable breeding in Virginia, reported that lambs from the same ewe were on the average 1.5 pounds heavier at birth at the third lambing than they were at first. Where the ewes were older at first lambing, the difference in weight of lambs between the first and third lambing decreased. He further observed an average annual increase of 0.63 pounds in birth weight of lambs as the ewes increased in age from two to six years.

Weight of lambs from five breeds of ewes were studied by Nelson and Venkatachalam (1949) in Michigan. Lambs from mature dams were found to weigh ten percent more than those from two-year-old ewes. No mention was made as to what age of dam the maximum birth weight was attained. Hunter (1956) working with Border Leicester and Mountain Welsh sheep in Great Britain, also found that lambs born to mature ewes were heavier than those born to two-year-old ewes.

Blackwell and Henderson (1955) estimated the effect of some environmental factors on the birth weight of lambs by analyzing 2,158 weight records of lambs from 560 ewes of Corriedale, Hampshire, Shropshire and Dorset breeds. They obtained a curvilinear relationship between age of ewe and birth weight of lambs. The linear component of the regression equation was 0.71 and the quadratic, -.06. Based on this equation, maximum birth weight was attained when age

of dam was six years.

Sanchez Belda and Munoz (1960) studied the factors that influence birth weight of lambs from Mancha ewes in Spain. They reported that lambs from three- to seven-year-old ewes averaged 0.84 pounds more than those from two-year-old and eight- to nine-year-old ewes.

Using the data from animals born during the course of the development of the Romnelet breed of sheep in Canada, Peters et al. (1961) determined the birth weight changes in lambs relative to age changes in ewes. Lambs born to four-year-old and older ewes were significantly heavier at birth than those from three-year-old ewes. Lambs from two-year-old ewes were lighter than those from older ewes. Similar results were obtained by Sidwell et al. (1964) in a study involving four groups of purebred ewes and several cross-breds. The results of these two studies are presented in Table VI.

In a study involving data on 8,740 lambs, Bennet et al. (1963) found that five-year-old ewes produced the heaviest lambs at birth. Lambs from five-year-old ewes were on the average heavier by 1.82 pounds, 0.75 pounds, 0.20 pounds and 0.02 pounds than lambs from ewes two, three, four and six years old, respectively.

Smith and Lidvall (1964) reported that the effect of age of dam on birth weights of Hampshire lambs was significant. Birth weight of lambs increased with age of dam up to about five years and then remained relatively constant to ten years.

TABLE VI

INFLUENCE OF AGE OF DAM ON BIRTH WEIGHTS OF LAMBS

Age of dam, yr.	Peters et al. (1961) No.	Peters et al. (1961) Ave. Wt., lb.	Sidwell et al. (1964) No.	Sidwell et al. (1964) Ave. Wt., lb.
2	1606	8.2	701	7.31
2	1507	8.8	706	7.84
4 - 6	2764	9.3	1578	8.35
7+	240	9.2	438	8.41

Yalcin and Bichard (1964) looked at the lifetime records of two group ewes: those that lambed first at one year of age (lambed-bred or LB) and those that lambed first at two years of age (shearling-bred or SB). They reported that the maximum birth weight was reached at the third pregnancy when the dams were about three to four years old. In relation to age, they also observed an additional effect of parity. Lambs from the SB ewes of two and three years old were considerably lighter (1.18 pounds and 0.40 pounds, respectively) than those from LB ewes of the same ages, although the SB ewes produced slightly heavier lambs at birth as far as the average lifetime production was concerned.

Vesely and Peters (1964) analyzed birth weight records of lambs from Rambouillet, Romnelet, Corriedale and Romeldale ewes. They reported that two-year-old ewes bore lighter lambs than older ewes. The birth weights showed a

slight increase for each year of increase in age up to six years of age. The deviations from the overall birth weight mean (9.71 pounds) were -0.84, +0.48 and +0.31 for lambs from ewes two, six and seven years old, respectively.

In a later study, Vesely et al. (1966) reported that lambs from Romnelet, Rambouillet, Columbia, Targhee and Suffolk ewes attained maximum birth weight when the dams were four to six years old. Lambs from ewes of these ages weighed about 10.2 pounds compared to 9.3 pounds for two-year-old ewes and 9.7 pounds for seven-year-old ewes.

Juma and Faraj (1966) investigated the factors affecting birth weights of Awassi lambs in Iran. Their data consisted of 923 single born lambs from five lambing seasons. They reported that lighter lambs were obtained from the first lambing when the ewes were two years old. Significantly heavier lambs were produced from the second to the fifth lambings.

Generally, lambs born to young and old ewes are lighter at birth than those born to ewes of the middle ages. The heaviest lambs are produced by ewes about four to six years of age.

Influence of Age of Dam on Weaning Weight and Rate of Gain of Lambs

The influence of age of dam on weaning weight of lambs is virtually the same as that on birth weight. Hazel and Terrill (1945) collected weanling data on 2,183 Rambouillet lambs born out of 892 ewes during the period 1941-1942. They found that lambs from mature ewes (three years old and

older) weighed 6.1 pounds more than lambs from two-year-old ewes at weaning. Similar study (Hazel and Terrill, 1946) with range Columbia, Corriedale and Targhee lambs showed that lambs from two-year-old dams were 8.7 pounds lighter than those from mature ewes. Working with five breeds of sheep, Nelson and Venkatachalam (1949) found that lambs from mature dams were 10 percent heavier than those from two-year old ewes. Similar findings were reported by Karam et al. (1959) and Young et al. (1965).

In these studies what had been done relative to weaning weight of lambs as influenced by age of dam was essentially a comparison of the weight of lambs from two-year-old ewes and older. This type of study does not show the pattern of change of the weaning weight of lambs with the change in age of dam. Several studies have been conducted in such a way that the pattern of change in weaning weight of lamb with age of dam could be shown.

Sidwell and Grandstaff (1949) measured the effect of several environmental factors upon the weaning weight of lambs. Their data consisted of the lifetime production records of 424 ewes, the ages of which were categorized into two-year, three-year, four- to seven-year and eight- to eleven-year groups. The maximum weaning weight was exhibited by lambs from ewes that were four to seven years of age. These lambs were 3.5 pounds and 3.1 pounds heavier than lambs from ewes two years old and eight to eleven years old, respectively.

After analyzing 1,295 weaning records of lambs from

463 Corriedale, Hampshire, Shropshire and Dorset ewes, Blackwell and Henderson (1955) reported a curvilinear relationship between weaning weight of lambs and age of dam. The regression coefficients were 3.09 (linear) and -.32 (quadratic). Maximum weaning weight was reached at about five years of age.

Brown et al. (1961) studied the influence of age of dam by comparing the weight of lambs from young ewes (two and three years old) with those from mature ewes (four, five and six years old). The weight of lambs from mature ewes was also compared with the weight of lambs from aged ewes (seven years old and older). They concluded that, in general, as ewes approached maturity, their lambs grew faster and were heavier.

Peters et al. (1961) found that lambs from three- to six-year-old ewes were heavier at weaning than those from two-year-old or seven-year-old ewes.

Shelton and Campbell (1962) observed that, at weaning, Rambouillet lambs out of two-year-old dams weighed about five pounds less than those out of mature ewes (three to seven years old). Old ewes (eight to ten years old) weaned lambs weighing about eight pounds lighter than ewes in the years of peak production.

Bennet et al. (1963) reported that ewes five years of age weaned the heaviest lambs. However, the difference between the lambs from ewes of this age and those from three, four and six years of age was not significant. The lightest lambs (about seven pounds lighter) were produced by the two-

year old ewes.

Weaning records of 3,423 lambs were analyzed by Sidwell et al. (1964). Their findings are presented in Table VII.

TABLE VII

INFLUENCE OF AGE OF DAM ON LAMB'S WEANING WEIGHT AND GAIN TO WEANING (SIDWELL ET AL., 1964)

Age of dam, yr.	No. involved	Weaning weight, lb.	Gain to weaning, lb.
2	701	55.0	48.0
3	706	58.3	50.7
4 - 6	1578	59.0	51.0
7+	438	56.4	48.3

Lambs from dams three to six years of age were significantly heavier and gained better than those from dams two years old and seven years old and older.

Vesely and Peters (1964) found that lambs from mature ewes (three years and older) were 1.8 to 3.0 pounds heavier than lambs from two-year-old ewes. There was no significant difference in weaning weight of lambs from different age classes of mature ewes. There was, however, a slight decline in weaning weight after the ewes reached six years of age. Vesely et al. (1966) reported similar findings.

Like birth weight, weaning weight is generally greater for lambs from mature dams than for those from young and very old ewes. The highest weaning weight is usually exhibi-

ted by lambs from four- to six-year-old ewes.

Summary of the Literature Review

It is well documented that age of ewe has a considerable influence on the economically important traits in sheep. Generally, young ewes are less productive than mature ewes. Fertility of ewes increase with increasing age up to about four to seven years of age and then declines with advancing age. Similar trends exists for prolificacy. Mortality is higher for lambs from young and old ewes than for those from ewes at intermediate ages. Wool production shows an inverse relationship with age of ewe, that is, ewes shear less wool as they grow older.

Young ewes usually produce lambs that are inferior in performance compared to lambs from relatively mature ewes. Lambs born to young ewes are generally lighter at birth and at weaning than lambs born to mature ewes. The heaviest lambs at birth and at weaning are usually produced by ewes which are four to six years of age. Lambs from these ewes also gain better than lambs from younger and older ewes.

MATERIALS AND METHODS

The Sheep Flock

The data used in this study were obtained from the experimental sheep flock (Project S-908) at the Fort Reno Livestock Research Station near El Reno, Oklahoma. This project was initiated in 1955 and continued through 1966.

The initial flock was composed of 100 grade Rambouillet and 100 1/4 Panama - 3/4 Rambouillet (RPR) yearling ewes purchased during April and May, 1965 in the Del Rio, Texas area. The experimental flock was increased in number by saving ewe lambs from the original ewes and buying yearling ewes from Texas, New Mexico and Oklahoma City Market. The raised replacements were selected from the first ewe lambs to reach 90 pounds during the respective years.

Table VIII shows the kinds and sources of ewes that made up the ewe flock included in this study. The exact birth dates of the purchased ewes were not known. However, the best information indicated that the ewes that made up the original flock were born approximately in February of 1964. The purchased replacements were born approximately in March of the year previous to the year when they were bought making them about seven months older than their raised contemporaries. The Rambouillet-Merino ewes purchased in New Mexico in 1957 were probably about 80 percent

TABLE VIII

BREEDING, SOURCE, YEAR OF BIRTH AND YEAR OF ACQUISITION OF EWES THAT MADE UP THE EXPERIMENTAL FLOCK

Initial Number	Breeding	Source	Year of Birth	Year Acquired
100	1/4 Panama-3/4 Ramb.	Texas	1954	1955
100	Grade Ramb.	Texas	1954	1955
20	Dorset x RPR	Raised	1956	1956
20	Panama	Texas	1956	1957
20	Ramb.-Merino	New Mexico	1956	1957
20	Dorset x RPR	Raised	1957	1957
20	Dorset x Ramb.	Raised	1957	1957
20	Rambouillet	Texas	1957	1958
20	Market White Face	Oklahoma	1957	1958
20	Dorset x RPR	Raised	1958	1958
20	Dorset x Ramb.	Raised	1958	1958
20	3/4 Ramb.-1/4 Col.	New Mexico	1958	1959
20	Rambouillet	New Mexico	1958	1959
30	Dorset x RPR	Raised	1959	1959
30	Dorset x Ramb.	Raised	1959	1959
20	Dorset x RPR	Raised	1960	1960
20	Dorset x Ramb.	Raised	1960	1960
15	3/4 Dorset	Raised	1960	1960
5	3/4 Ramb.	Raised	1960	1960
8	Dorset x RPR	Raised	1961	1961
8	Dorset x Ramb.	Raised	1961	1961
8	Dorset x Western	Raised	1961	1961
20	3/4 Dorset	Raised	1961	1961
12	3/4 Ramb.	Raised	1961	1961
20	Rambouillet	Texas	1961	1962
3	Dorset x RPR	Raised	1962	1962
10	Dorset x Ramb.	Raised	1962	1962
7	Dorset x Western	Raised	1962	1962
11	3/4 Dorset	Raised	1962	1962
11	3/4 Ramb.	Raised	1962	1962
25	Rambouillet	Texas	1962	1963
25	Rambouillet	Texas	1962	1963

Rambouillet and 20 percent Delaine Merino. The market Whiteface ewes bought from the Oklahoma City Market in 1958 were fine-wool ewes and were mostly Rambouillet but probably contained some Panama, Columbia or Corriedale breeding.

The ewe flock was managed according to the usual practices of sheep producers in Oklahoma. The ewes were grazed on wheat pasture with their lambs during the fall and winter and on native bermuda grass pasture during the remainder of the year. They were fed about one-half pound of grain each day for six weeks prior to the start of the lambing season. The amount of grain was increased to one pound after lambing and was maintained at this level for six to nine weeks while the ewes were on wheat pasture. In addition, the ewes also received one pound each of grass hay daily.

The ewes were sheared from five to ten days before the beginning of the spring breeding season. The grease fleece weights were recorded and a determination of the clean wool production was made using the method and equipment described by Neale et al. (1958).

After shearing, the ewes were weighed and scored. Their weights were recorded to the nearest pound. The scoring system used consisted of numerical values from 1 to 9; 1 representing a very thin, emaciated ewe, and 9 a very fat ewe, with the intermediate scores representing ewes of various relative intermediate conditions.

The ewes were mated to Dorset rams during the early part of the study. During the later years, Dorset, Hampshire,

Suffolk and Rambouillet rams were used. The rams were purchased from private farms in Oklahoma.

During 1955 and 1956, a 48-day breeding season commencing on May 20th was used. In 1957, breeding started on June 3rd and was limited to 32 days;a20-day clean-up breeding period was done starting August 1st. In 1958 and thereafter, the breeding season has been of a 40-day duration. The clean-up period in 1958 was for 20 days starting August 11th. Since 1959, clean-up breeding period has been lengthened to 30 days, from August 21st to September 20th. There was no clean-up period in 1966 since the project was terminated in that year. Figure 2 shows the breeding and lambing calendar for years other than those indicated earlier. The data inc-

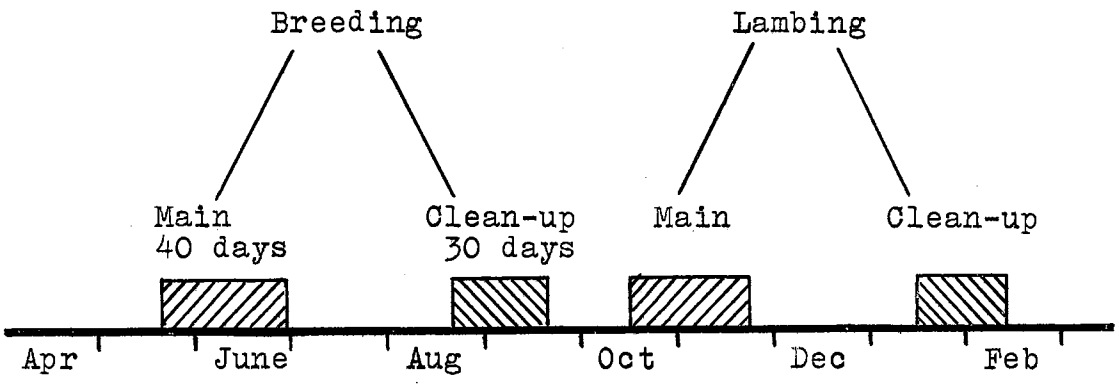

Figure 2. Breeding and Lambing Schedule of the Experimental Ewe Flock.

luded in this study were those from the main breeding and lambing periods.

The fall-born replacement ewe lambs were first exposed

to fertile rams during the late summer (clean-up) breeding season. At this time the raised replacement were about 10 months old while the purchased replacements were about 17 months old. The first lambing records of these ewes were not included in this study.

During the breeding season, the ewes were divided into several small groups each with 20 to 70 ewes. In making up the breeding groups, a like number of each kind of ewe relative to age, breed, weight and previous year's performance was placed into each group. The rams were placed with the ewes each afternoon and removed the following morning allowing them to rest during the day. The rams were fitted with marking harnesses so that the mating date and the ram concerned for each ewe mated could be recorded. Mating records obtained in this manner were not perfect: a few ewes were mated but not marked and others were marked but not mated. When a ewe lambed but did not have a mating record, the probable mating date was estimated by subtracting an average gestation period of 147 days from the lambing date.

The ewes were tagged (crutched) and had their faces sheared about two weeks before fall lambing began. About this time, the ewes were also weighed and scored. At lambing, birth date, birth weight, birth type and sex of each lamb were recorded a few hours after the lamb was born. Birth weights were recorded to the nearest one-tenth of a pound. Each lamb was identified by a number similar to that of its dam. In case of twins, both received their dam's number, but one of the pair had its number preceded by a bar

(-). In case of triplets, identification of the lambs were made by the use of bar (-) and plus (+) with the number. All the lambs were docked during the first week after birth. The ram lambs were castrated between one and four weeks of age.

While the lambs were on wheat pasture with their dams, they had access to a creep containing a mixture of about 63 percent ground grain milo, 32 percent ground alfalfa hay and 5 percent molasses. When the older lambs were about 45 days old, biweekly weighing of lambs was started. The lambs were weaned when they were about 70 days old and weighed about 50 pounds. Regular biweekly weighing was continued until all lambs were marketed. Lambs were marketed when they reached a minimum weight of about 95 pounds.

Traits Studied

The production traits included in this study were divided into two general classes: (a) those that were measured on the ewes, and (b) those that were measured on the lambs.

The traits measured on the ewes included the following:

a. Fertility - measured as the number of ewes lambing per one hundred ewes bred.

b. Prolificacy - measured as the number of lambs born per ewe lambing.

c. Rearing ability - measured as the number of lambs reared to about two weeks of age per ewe lambing.

d. Weight of ewe at breeding - average of the weights taken before and after the breeding

season.

e. Condition score of ewe at breeding - average of the scores taken before and after the breeding season.

f. Grease wool production - fresh wool weight right after clipping.

g. Clean wool production - determined using the "squeeze" machine.

The traits measured on the lambs included the following:

a. Birth weight of lambs.

b. Adjusted 70-day weight or adjusted weaning weight of lambs - determined using the formula

$$\frac{(\text{Weaning weight} - \text{Birth weight})\ 70}{\text{Weaning age}} + \text{Birth weight.}$$

c. Pre-weaning rate of gain or rate of gain from birth to 70 days of age.

d. Post-weaning rate of gain or rate of gain from 70 days to market.

Each observation for each trait measured on the ewes was classified according to origin, breed, year and age of ewe. Origin referred to whether the ewes were raised or purchased. The third column of Table VIII shows the source or origin of the ewes. Three breed groups were represented in the raised ewes: Dorset crossbreds, 3/4 Dorset and 3/4 Rambouillet. The purchased group was classified into two breed groups namely, Rambouillet and 3/4 Rambouillet. The data collected over the years 1958 to 1966, inclusive, were included. Nine age groups of ewes were represented; the

grouping is presented in Table IX.

TABLE IX

CODE FOR AGES OF THE RAISED AND PURCHASED EWES

Code	Age, months	
	Raised Ewes	Purchased Ewes
1	24	31
2	36	43
3	48	55
4	60	67
5	72	79
6	84	91
7	96	103
8	108	115
9	120	127

For the traits measured on the lambs, each observations was classified according to sex of lamb, type of birth and type of rearing, plus the other categories included in the traits measured on the ewes. Type of birth referred to whether the lambs were born as singles or as twins. The lambs that were born as triplets were included in the twin group since only a few were born as such. Concerning weaning weight and pre-weaning rate of gain, type of birth and type of rearing were combined into a single classification and was referred to as type of birth and rearing. The grouping in this class was as follows: SS - born as single,

reared as single; TS - born as twin, reared as single; TT - born as twin, reared as twin.

Analysis of Data

The data were analyzed by methods of least squares as outlined by Harvey (1960). Analysis was done within origin of ewes. Each trait was assumed to be the sum of the effects of several variables in addition to the overall mean.

For fertility, prolificacy, rearing ability, average breeding weight, average breeding score, grease wool production and clean wool production, the model was

$$Y_{kmnp} = u + B_k + W_m + A_n + e_{kmnp}$$

where

Y_{kmnp} is an observation on one of the traits above.

u is an effect common to all observation, the overall mean.

B_k is the effect due to kth breed.

k = 1, 2, 3 for raised ewes

k = 1, 2 for purchased ewes

W_m is the effect due to mth year.

m = 1, 2, ..., 9 (1958, 1959,..., 1966)

A_n is the effect due to nth age of ewe

n = 1, 2, ..., 9 (according to code in Table IX)

e_{kmnp} is a random error unique for each observation.

For birth weight of lamb, the model was

$$Y_{ijkmnp} = u + S_i + T_j + B_k + W_m + A_n + e_{ijkmnp}$$

where

Y_{ijkmnp} is the birth weight of each lamb.

u is an effect common to each observation, the overall mean.

S_i is the effect due to ith sex.

$i = 1, 2$

T_j is the effect due to jth type of birth.

$j = 1, 2$

The remaining variables are defined as in the previous model.

For adjusted 70-day weight and pre-weaning rate of gain the model was

$$Y_{ijkmnp} = u^* + S_i + R_j + bX_{ijkmnp} + B_k + W_m + A_n + e_{ijkmnp}$$

where

Y_{ijkmnp} is an observation on one of the above traits.

u^* is the theoretical overall mean when birth weight, X, is equal to the absurd value of zero. The overall mean u, when birth weight is equal to the average is $u = u^* + b\bar{x}$.[1]

R_j is the effect due to type of birth and rearing.

$j = 1, 2, 3$ (SS, TS, TT)

b is the coefficient of the linear regression of the dependent variable (Y) on the independent variable (X).

X_{ijkmnp} is the birth weight corresponding to a given observation.

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[1]The overall mean presented in Appendix Tables XLIV and XLV is u and not u*. Correspondingly, the standard error is for u.

The remaining terms are defined as in the previous model.

For post-weaning rate of gain the model was

$$Y_{ikmnp} = u^* + S_i + bX_{ikmnp} + B_k + W_m + A_n + e_{ikmnp}$$

where

Y_{ikmnp} is the post-weaning rate of gain of each lamb.

u* is the theoretical overall mean when weaning weight, X, is equal to the absurd value of zero. The overall mean u, when weaning weight is equal to the average is $u = u^* + b\bar{x}$.[1]

b is the coefficient of the regression of the dependent variable (Y) on the independent variable (X).

X_{ikmnp} is the weaning weight for the corresponding post-weaning rate of gain.

The remaining terms are defined as in the previous models.

All these models were constructed with the assumption that no interaction existed among the effects and that the random errors were normally distributed with mean zero and variance σ^2.

The least squares or normal equations used in the analysis were given by

$$(X'X)\beta = X'Y$$

were β was the vector of least squares constants, $X'X$ was the coefficient matrix and $X'Y$ was the right hand member. The normal equations were not independent hence a restriction was imposed to obtain a solution. The restriction im-

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[1] The overall mean presented in Appendix Table XLVI is u and not u*. Correspondingly, the standard error is for u.

posed was that the sum of the estimates of the constants within a given class in each model is equal to zero. Thus the least squares constants for each class were expressed as deviations from a mean zero.

From the normal equations, estimates of the least squares constants were solved algebraically by

$$\hat{\beta} = (X'X)^{*-1} (X'Y)^{*}$$

where $\hat{\beta}$ was the vector of the estimated least squares constants, $(X'X)^{*-1}$ was the inverse of the coefficient matrix and $(X'Y)^{*}$ was the right hand member, under the restrictions imposed. The construction of the observation matrix X under the restriction imposed was discussed by Cunningham (1967).

The standard errors of the least squares estimate of the constants were obtained by

$$s_{\hat{\beta}_i} = \sqrt{C_{ii}\,\hat{\sigma}^2}$$

where C_{ii} was the corresponding diagonal inverse element for a particular constant and $\hat{\sigma}^2$ was the error mean square obtained in the analysis of variance.

The standard error of the sum of two estimated constants was obtained by

$$s_{(\hat{\beta}_i + \hat{\beta}_j)} = \sqrt{(C_{ii} + C_{jj} + 2C_{ij})\,\hat{\sigma}^2}$$

where C_{ii} and C_{jj} were the corresponding diagonal inverse elements for the two constants, C_{ij} was the off-diagonal element corresponding to the two constants and $\hat{\sigma}^2$ was the error mean square.

Pairwise comparisons among the least squares estimates for effects of age of ewe on each of the trait were done using Duncan's multiple range test modified by Kramer (1957).

Significant difference between any two age effects was said to exist if

$$(a_i - a_j) > \sqrt{\hat{\sigma}^2(C_{ii} + C_{jj} - 2C_{ij})/2}\ z_{p,df}$$

where $(a_i - a_j)$ was the difference between two age effects, C_{ii} was the diagonal inverse element corresponding to a_i, C_{jj} was the diagonal inverse element corresponding to a_j, C_{ij} was the off diagonal inverse element corresponding to a_i and a_j, $\hat{\sigma}^2$ was the error mean square, $z_{p,df}$ was the standardized range value in Duncan's table, p was the number of means in the range chosen and df was the number of degrees of freedom corresponding to $\hat{\sigma}^2$.

The sums of squares for the analyses of variance were computed using the formula

$$\text{Sum of Squares} = A'Z^{-1}A$$

where A' is the row vector of a particular set of estimated constants, Z^{-1} is the inverse of the segment of the $X'X$ inverse matrix corresponding by row and by column to this set of constants, and A is the column vector of the set of estimated constants. The sum of squares obtained in this manner is equal to the reduction in sum of squares due to fitting all constants in the model minus the reduction in sum of squares due to fitting all constants in the model except the set being considered. As an example, the analysis of variance for weaning weight is shown in Table X.

Because of the large number of observations involved in this study, it was expected that the tests of the hypothesis that each of the effects in the models was zero

TABLE X

ANALYSIS OF VARIANCE FOR WEANING WEIGHT

Source of variation	Degrees of freedom	Sum of squares	Mean square	Expected mean square[2]
Total	N - 1	SS		
Direct effects				
Sex	1 - 1	SS_s	MS_s	$\sigma^2 + K_s\sigma_s^2$
Type of birth and rearing	j - 1	SS_r	MS_r	$\sigma^2 + K_r\sigma_r^2$
Regression on birth weight	1	SS_b	MS_b	$\sigma^2 + K_b\sigma_b^2$
Breed of dam	K - 1	SS_d	MS_d	$\sigma^2 + K_d\sigma_d^2$
Year	m - 1	SS_w	MS_w	$\sigma^2 + K_w\sigma_w^2$
Age of dam	n - 1	SS_a	MS_a	$\sigma^2 + K_a\sigma_a^2$
Error (residual)	(N-1)-(i-1+ ...+ n-1)	SS-(SS_s+ ...+SS_a)	MS	σ^2

[1]N is the total number of observations; i is the number of sex groups; j is the number of type of birth and rearing groups; K is the number of breed of dam groups; m is the number of year groups; n is the number of age of dam groups.

[2]K_s, K_r, K_b, K_d, K_w, K_a represent the average number of observations per subgroup computed by

$$K_i = (1/df)(N - \sum_i n_i^2/N)$$

where N is the total number of observations, n_i is the number of observations in each subgroup, and df is the respective degrees of freedom.

would indicate that the effects were significant sources of variation. In view of this, estimates of the variance components were obtained and their importance assessed by expressing each as a percentage of the total variance.

Additive and multiplicative correction factors for the effect of age of ewe (raised ewes only) were devised for the following traits: prolificacy, rearing ability, breeding weight, grease and clean wool production, 70-day weight of lambs and pre-weaning rate of gain of lambs. The usefulness of the two types of correction factors were assessed by determining how effective each was in equalizing the variances within each age group.

RESULTS AND DISCUSSION

Influence of Age on Ewe Characteristics

Fertility

In this study, fertility rate was computed for each breed-year-age subgroup by determining the number of ewes lambing in each subgroup and expressing the number as a proportion of the number of ewes mated in the particular subgroup. In the analyses, each proportion was treated as an observation. This explains the relatively low number of observations involved in the analyses of this trait as compared to that of the others.

The analyses of variance for the fertility of the raised and purchased ewes are presented in Table XI. In the raised ewes, breed of ewes, year of lambing and age of ewe were important sources of variation. Together, they accounted for over 50 percent of the total variation. Age of ewe alone accounted for 26 percent of the total variation. In the purchased ewes, not any of these three sources of variation was significant. Age of ewe contributed practically zero to the total variation. Similar findings were reported by Vesely and Peters (1965) in which they studied four breeds of sheep in Canada and observed that age of ewe had no significant influence on fertility.

The least squares estimates of the constants for the

TABLE XI

ANALYSES OF VARIANCE FOR FERTILITY
OF THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Breed	2	.0199*	.0010	1	.0232	.0004
Year	8	.0103*	.0010	8	.0185	.0010
Age	8	.0158*	.0019	8	.0107	.0000
Error	44	.0034	.0034	47	.0116	.1016

*P < .005

effects of breed, year and age groups on the fertility of the two groups of ewes are shown in Appendix Tables XXXV and XXXVI. These estimates represent the average deviation of each subgroup from the overall mean. In the raised ewes, the 1/2 Dorsets exhibited higher fertility rate than the 3/4 Dorsets or 3/4 Rambouillets. In the purchased ewes, the straight Rambouillets were more fertile on the average than the 3/4 Rambouillets. Fertility of the ewes fluctuated from year to year with no definite pattern.

The least squares means and standard deviations for fertility of ewes in each age group are presented in Table XII. The least squares means, expressed as percentages, represent the average fertility of the various age groups adjusted for breed of ewe and year of lambing. These least squares means were obtained by adding the estimated least squares constants for each age subgroup to the overall mean u. The standard error for each mean was computed according to the formula (standard error of the sum of two estimated constants) given on page 41. The standard deviations given in the table were obtained by extracting the square root of the variances which were estimated by arranging the data into breed by year by age of dam subclasses, pooling the appropriate corrected sums of squares and dividing by the appropriate degrees of freedom. Figure 3 shows the graphical representation of the least squares means. It was evident that fertility increased with age up to a certain point and then decreased with advancing age. In the raised ewes, fertility rate increased from 87.0 percent for the

TABLE XII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR THE FERTILITY OF THE EWES BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2,3]	Standard deviation	Least square mean[2,3]	Standard deviation
1	87.00±1.75	6.31	83.49±4.67	12.35
2	92.13±1.92	6.92	86.43±3.88	11.64
3	94.43±2.09	7.54	88.34±3.94	11.82
4	94.49±2.50	7.50	86.20±4.19	11.85
5	90.18±3.01	7.37	87.09±4.16	11.77
6	90.25±4.02	6.96	87.60±4.19	11.85
7	84.48±4.17	7.22	83.01±4.32	12.22
8	82.70±4.94	6.99	74.32±5.16	12.64
9	65.65±6.61	6.61	90.14±9.66	13.66

[1]Coded as in Table IX.

[2]±Standard error.

[3]Percentage of ewes lambing of ewes bred.

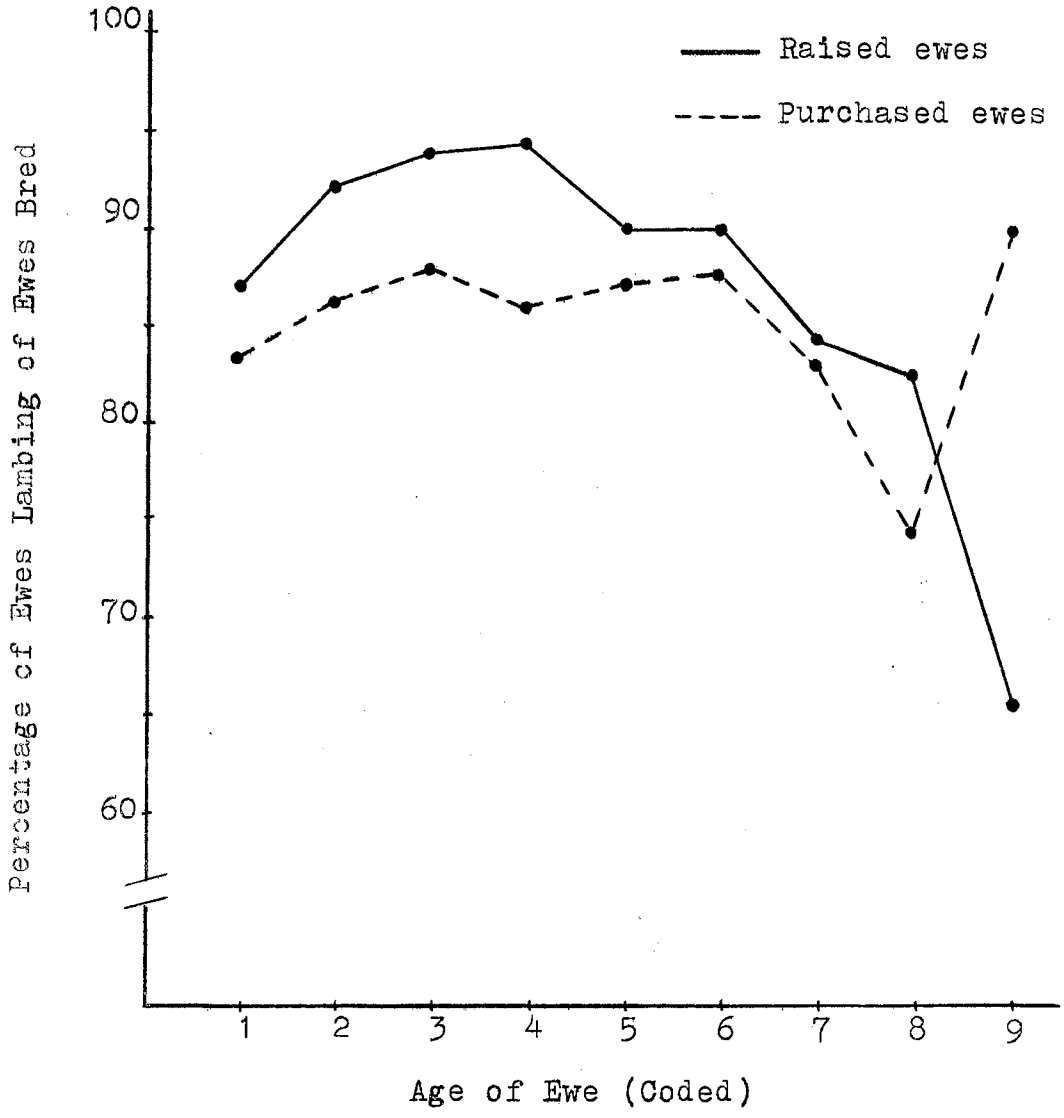

Figure 3. Influence of Age of Ewe on Fertility.

two-year-old ewes to 94.5 percent for the five-year-old ewes. Then there was a very definite decline in fertility as the ewes grew older. The lowest fertility rate was exhibited by the ten-year-old ewes with 65.5 percent. However, this figure was deemed not to be very reliable because of the very low number of observations involved which included only 19 ewes. The standard deviations indicate that fertility rate was more variable in ewes that were four, five and six years of age than in ewes in other age groups.

A similar trend in fertility change with age was observed by Turner and Dolling (1965) who reported that lambing percentage rose from 81.9 percent for two-year-old ewes to 91.7 percent for ewes five to six years of age and then fell gradually to 86.5 percent for ten-year-old ewes. In the present study, however, the decline in fertility after reaching the peak was such that the older ewes (seven to nine years old) exhibited lower fertility than the younger ewes (two and three years old).

In the ewe flock involved in this study, no culling was done except for a few cases where the ewes became so emaciated and/or exhibited extremely worn teeth such that recovery or maintenance was thought to be very unlikely. Hence, it was believed that the results presented herein portrayed a better picture of fertility change with age than some of those reported in the literature. Terrill and Stoehr (1939) reported that the decrease fertility with advancing age was offset by the culling of ewes showing decline in vigor with age so that the result of their study showed an increasing

trend in fertility up till the ewes were nine years old. However, they suggested that without culling, there would have been a decline in fertility after six years of age. Campbell (1962) held the same premise but added that such result approximated that of an average flock since most sheep raisers do cull to some extent.

In the purchased ewes, although age of ewe did not significantly influenced fertility, an apparent trend of change of fertility with age also existed. There was a tendency for ewes 4.5 to 7.5 years of age to have higher fertility rate than younger and older ewes. Vesely and Peters (1965) and Vesely et al. (1966) also reported that age of ewe had no significant effect on fertility but highest fertility was obtained in ewes five to seven years of age.

Prolificacy

Prolificacy as used in this study is defined as the number of lambs born per ewe lambing, or the lambing rate on a per-ewe-lambing basis. The analyses of variance for the prolificacy of the two groups of ewes are presented in Table XIII. Although the analyses showed that significant differences existed among years and among age classification, the variance components indicated that neither year nor age was a very important source of variation. In the raised ewes, year accounted for 3.6 percent of the total variation while age accounted for 5.9 percent. The corresponding figures in the purchased ewes were 2.5 percent and 3.5 percent. In spite of the large number involved, the analy-

TABLE XIII

ANALYSES OF VARIANCE FOR PROLIFICACY
OF THE TWO GROUPS OF EWES

Source of variance	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Breed	2	0.0438	0.0000	1	0.1032	0.0000
Year	8	1.5684*	0.0099	8	1.2283*	0.0061
Age	8	2.3552*	0.0164	8	1.5910*	0.0084
Error	1196	0.2503	0.2503	1494	0.2265	0.2265

*P < .005

ses showed that breed was not a significant source of variation. Nevertheless, in the raised ewes the 3/4 Rambouillet seem to be more prolific than either the 1/2 Dorset or the 3/4 Rambouillet as evidenced by the estimated least squares constants shown in Appendix Table XXXVII. In the purchased ewes, the 3/4 Rambouillet produced more lambs per ewe lambing than the straight Rambouillet.

Table XIV presents the least squares means and standard deviations for the prolificacy of the two groups of ewes classified into different age groups. The graphical representation of the means is shown in Figure 4. In the raised ewes, the number of lambs born per ewe lambing increased with age until the ewes were about seven years of age. The increase was from 1.28 lambs per birth for two-year-old ewes to 1.68 lambs per birth for seven-year-old ewes. From eight years of age on, there was a decrease in prolificacy with the ten-year-old ewes producing on the average 1.27 lambs per birth. The number of lambs born per ewe lambing was less variable in two- and ten-year-old ewes than in ewes in other age groups as shown by the standard deviations.

In the purchased ewes, a similar pattern of prolificacy-age association existed except for a decrease in the 6.5-year-old ewes. Also, the lambing rate of these ewes were a little lower compared to that of the raised ewes. The 2.5-year-old ewes produced on the average 1.09 lambs per birth. This increased to 1.46 in the ewes 5.5 years of age. There was a drop in the average number of lambs per birth to 1.37 in the 6.5-year-old ewes followed by an increase to 1.45 in

TABLE XIV

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR THE PROLIFICACY OF THE EWES BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2,3]	Standard deviation	Least square mean[2,3]	Standard deviation
1	1.28±.04	.46	1.09±.05	.38
2	1.49±.04	.50	1.27±.04	.48
3	1.56±.04	.52	1.26±.04	.44
4	1.63±.05	.54	1.46±.04	.50
5	1.67±.06	.52	1.37±.04	.53
6	1.68±.07	.54	1.45±.04	.50
7	1.46±.08	.50	1.39±.04	.45
8	1.36±.10	.52	1.31±.06	.44
9	1.27±.15	.51	1.28±.17	.31

[1]Coded as in Table IX.

[2]±Standard error.

[3]No. of lambs born per ewe lambing.

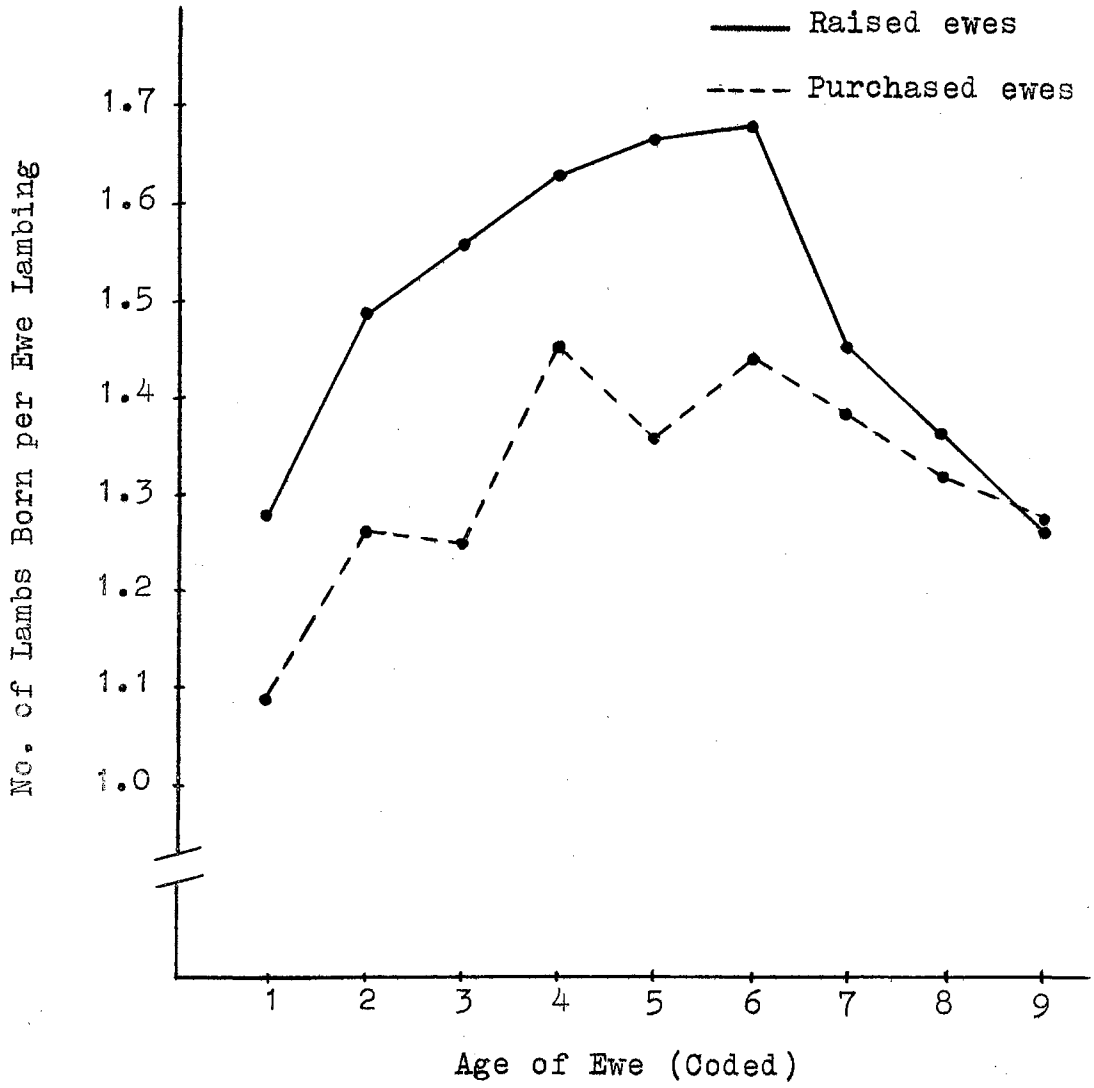

Figure 4. Influence of Age of Ewe on Prolificacy.

the 7.5-year-old ewes. Like in the raised ewes, the number of lambs per birth was less variable in the two extreme age groups.

These results agree closely with those of Karam (1957) who found that the number of lambs per birth increased from one gestation to the next until the maximum was reached at five to seven years of age. Turner and Dolling reported the same trend of lamb production changes with age of ewe. Several workers (Marshall and Potts, 1921; Purser and Roberts, 1959; Yalcin and Bichard, 2964; Vesely et al., 1966; Inskeep et al., 1967) however, observed an increase in lambing rate until only the sixth year of age or earlier and then decreased thereafter. Further, some researchers (Terrill and Stoehr, 1939; Sidwell et al., 1962) reported an increase in lambing rate with age until nine years or older but attributed this steady increase to culling. If ewes showing decline in vigor and/or reproductive performance were culled at each age, then the succeeding age groups would contain a higher proportion of better performing ewes. Hence, lambing rate in a particular age group would be expected to be better than in the one previous.

Rearing Ability

The term rearing ability as used in this study refers to the ability of a ewe to produce live lambs and to keep them alive during the early stage of life. It is more or less a measure of the livability of lambs considered as a characteristic of the ewe. Quantitatively, rearing ability

was measured as the number of lambs that survive to about two weeks of age per ewe lambing. This trait should be measured ideally using the number of lambs reared to weaning. But in this study, some lambs were sold or transferred to other projects before weaning so that the actual number of lambs weaned could not be determined.

The analyses of variance for the rearing ability of the two groups of ewes are presented in Table XV. Like in the preceding analyses, year and age appeared to be significant sources of variation but they accounted for only a very low percentage of the total variation. Appendix Table XXXVIII gives the estimated least squares constants for the effects of breed, year and age groups on the rearing ability of the two groups of ewes.

The least squares means and standard deviations for the rearing ability of the different age groups of ewes are shown in Table XVI and the means are graphically depicted in Figure 5. In the raised ewes, there was an increase in the number of lambs reared per ewe lambing from 1.13 for the two-year-old ewes to 1.49 for the six-year-old ewes. Then a sharp decline followed ending up to a low 0.86 lambs reared per ewe lambing for the ten-year-old ewes. Nine- and ten-year-old ewes lost about 0.4 lambs per ewe lambing during the interval from birth to about two weeks. In the purchased ewes, the number of lambs reared to two weeks per ewe lambing was 1.03 in the 2.5-year-old ewes and increased to 1.34 in the 5.5-year-old ewes. Then it dropped off slightly to 1.26 in the 6.5-year-old ewes and rose again to

TABLE XV

ANALYSES OF VARIANCE FOR REARING ABILITY
OF THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Breed	2	0.6172	0.0015	1	0.4358	.0002
Year	8	1.8601*	0.0114	8	0.8466*	.0033
Age	8	2.4664*	0.0165	8	1.0741*	.0047
Error	1196	0.3510	0.3510	1494	0.3014	.3014

*P < .005

TABLE XVI

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR THE REARING ABILITY OF EWES BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2,3]	Standard deviation	Least square mean[2,3]	Standard deviation
1	1.13±.04	.41	1.03±.05	.34
2	1.34±.05	.50	1.21±.05	.45
3	1.38±.05	.51	1.21±.05	.43
4	1.42±.06	.53	1.34±.05	.49
5	1.49±.07	.53	1.26±.05	.51
6	1.32±.09	.53	1.33±.05	.49
7	1.20±.10	.49	1.17±.05	.41
8	1.00±.12	.45	1.22±.07	.44
9	.86±.17	.44	1.04±.20	.00

[1]Coded as in Table IX.

[2]±Standard error.

[3]No. of lambs reared per ewe lambing.

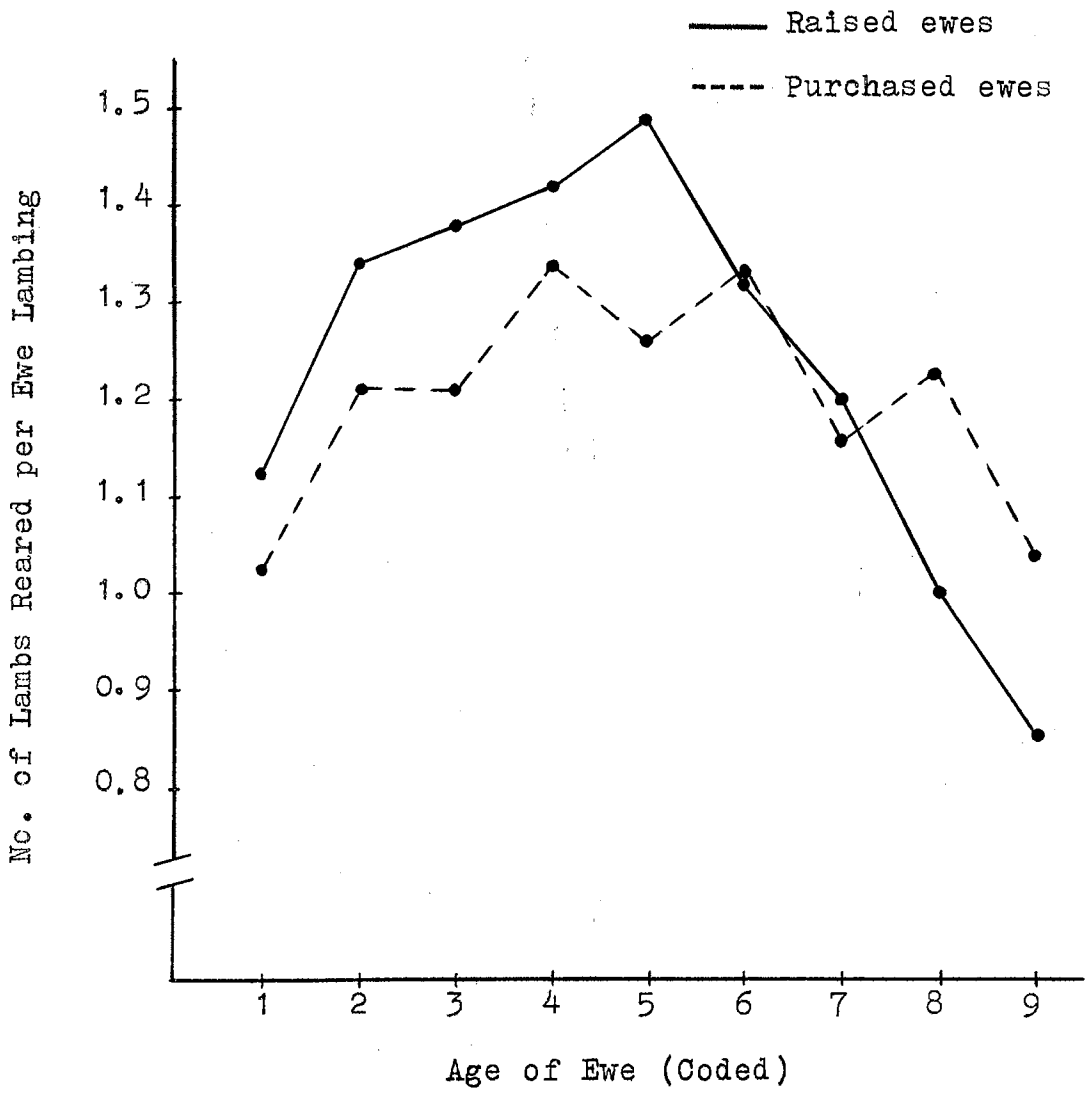

Figure 5. Influence of Age of Ewe on Rearing Ability.

1.33 in the ewes 7.5 year of age. There was a decrease thereafter to 1.04 in the 10.5-year-old ewes. The standard deviation showed that in both groups of ewes the number of lambs reared to two weeks is less variable in ewes at the extreme age classification.

Direct comparison of these results with others is limited since most of the published reports dealt primarily with the number of lambs that survive to weaning instead of that which were reared to about two weeks as was used in the present study. At any rate, the published reports, indicated that the percentage of lambs weaned of ewes bred were generally greater for ewes four to six years of age (Sidwell et al. 1962; Turner and Dolling, 1965) the trend being an increase from the two-year-olds to these ages, and then a decline in older ewes. The lamb survival from birth to weaning as a percentage of lambs born was highest in four to six-year-old ewes (Lax and Turner, 1965; Vesely and Peters, 1965). These findings, agree comparably with the present result insofar as the pattern of lamb's survival as related to age of ewe is concerned.

The rearing ability of the ewes can be considered to some extent as a reflection of their milking ability. A good milk producing ewe has a better chance of rearing her lambs than ewe that barely produces milk, considering other things being equal. Milk production of ewes has been demonstrated to increase with age (Bosma, 1939; Montanaro, 1940; Barnicoat et al., 1956) with the maximum yield occuring in ewes five to six years of age. This affords a part explana-

tion of the increasing trend in the rearing ability of ewes in relation to age as found in the present study with the peak exhibited by ewes six years of age. It should be kept in mind, however, that many other factors contribute to the variation in the rearing ability of ewes. For instance, the weight of lamb at birth and its type of birth may partly determine the likelihood of the lamb being reared to two weeks and/or through weaning. Weight of ewe most probably has a considerable contribution to its rearing ability considering that a large ewe in term of weight and body measurements usually bears larger lambs and has a greater capacity of producing more milk. They are mentioned merely to illustrate the complexity that exists and to emphasize that the explanation given relative to the rearing ability change with age is just a part of the complex governing mechanism.

Weight at Breeding

The analyses of variance for the breeding weight of the two groups of ewes are given in Table XVII. In both groups, the factors included in the model were all statistically significant sources of variation. However, in the raised ewes, breed accounted for only a very low percentage of the total variation. Year and age were definitely important sources of variation accounting for 9.4 percent and 21.4 percent of the toal variation, respectively. In the purchased ewes, the corresponding figures were 6.8 percent, 10.3 percent and 25.6 percent for breed, year and age, res-

TABLE XVII

ANALYSES OF VARIANCE FOR BREEDING WEIGHT
OF THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance components	Degrees of freedom	Mean square	Variance component
Breed	2	1,219.08**	4.72	1	1,912.34*	21.80
Year	8	5,565.71*	36.98	8	6,489.26*	32.92
Age	8	1,974.03*	84.72	8	15,631.56*	81.51
Error	1296	267.91	267.91	1732	182.04	182.04

*P < .005

**P < .025

pectively. Age contributed considerably to the variation in weight of ewes. The estimated least squares constants for the effects of breeds, years and age groups on the ewe weights are given in Appendix Table XXXIX.

The least squares means and standard deviations for the breeding weight of the two goups of ewes according to age group are presented in Table XVIII and graphically plotted in Figure 6. The variation in weight of ewe by age was very definite. There was an increasing trend at a diminishing increment up to about the sixth age group. At this age, the raised ewes weighed about 143 pounds. A general pattern of decrease in weight followed after the maximum was reached at this age. The greatest yearly increment in weight occurred between the first and second age groups. In the raised ewes, weight increased by 17 pounds from two to three years old. In the purchased ewes the increase from 2.5 years to 3.5 years was about 16 pounds. Comparable results were obtained by Coop and Hayman (1962) who reported that the annual increase from the yearling ewes were 16, 8, 6 and 4 pounds so that the total increase to the five-year-old ewes was 34 pounds. Coop and Clark (1966) on the other hand, reported that ewes failed to gain in weight after they entered the breeding flock, but this was because of the environment the ewes were in - the high country where terrain and pasture conditions were poor. The table also shows that the youngest ewes in both groups were the least variable in weight.

TABLE XVIII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR THE BREEDING WEIGHT OF EWES BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb.	Standard deviation	Least square mean[2], lb.	Standard deviation
1	120.42±1.14	10.97	111.20±1.21	10.94
2	137.06±1.24	12.86	126.81±1.12	11.84
3	144.52±1.39	13.75	136.16±1.09	13.24
4	147.21±1.64	13.08	141.55±1.08	13.30
5	147.66±1.95	12.77	142.36±1.06	12.01
6	148.43±1.34	12.40	142.61±1.09	13.81
7	146.07±2.58	12.89	140.53±1.16	12.88
8	138.35±3.13	15.35	142.81±1.52	12.65
9	132.96±4.44	14.84	135.90±4.09	18.79

[1]Coded as in Table IX.

[2]±Standard error.

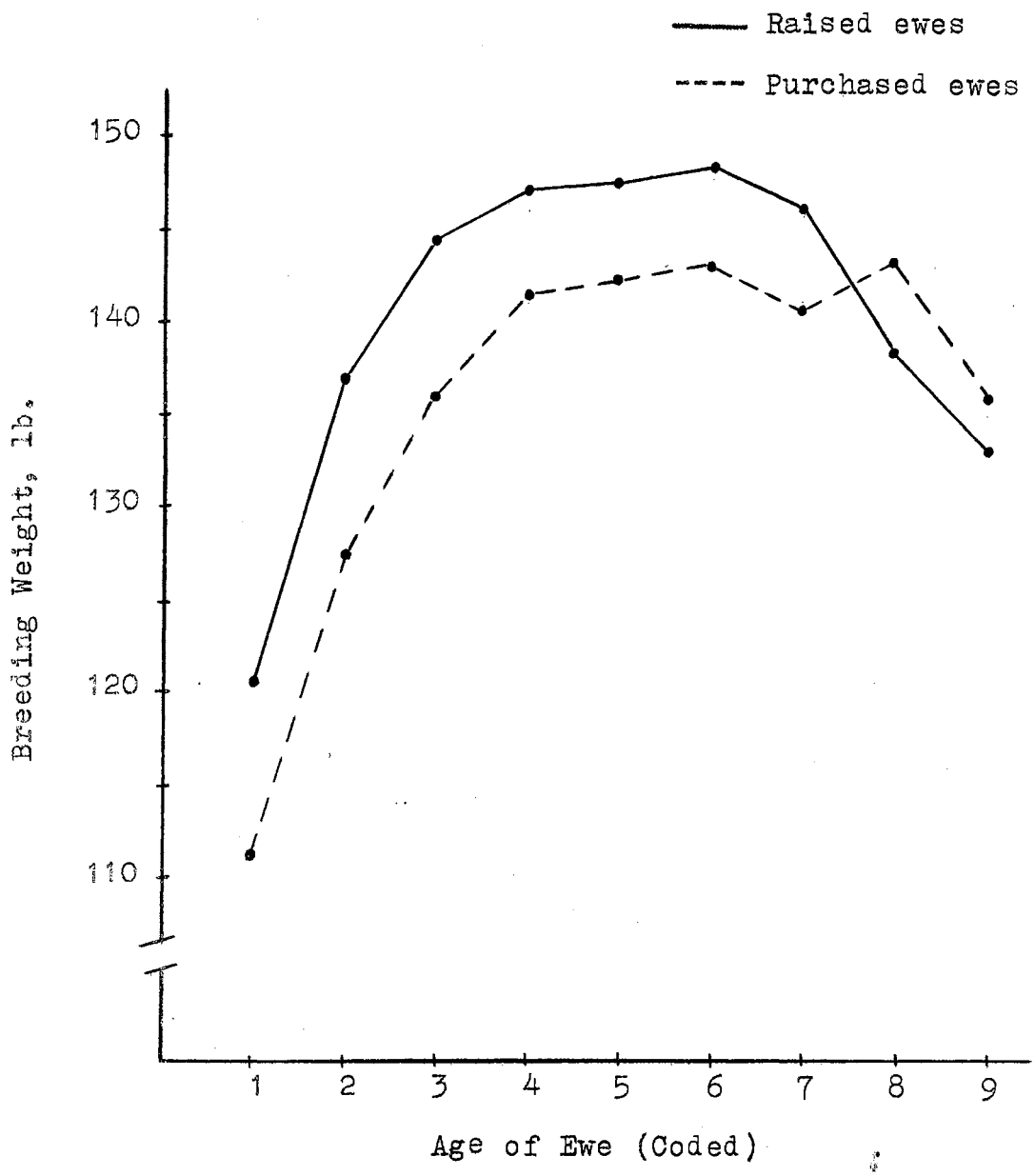

Figure 6. Influence of Age of Ewe on Breeding Weight.

Score at Breeding

The analyses of variance for the breeding score of the two groups of ewes are shown in Table XIX. In the raised ewes, breed differences in score were not statistically significant although the 1/2 Dorset and 3/4 Dorset ewes scored about 0.20 units higher than the 3/4 Rambouillet ewes (Appendix Table XL). Year and age accounted for 17.6 percent and 13.3 percent of the total variation, respectively. In the purchased ewes, breed, year and age were all significant sources of variation accounting for 8.1 percent, 12.8 and 7.6 percent of the toal variation, respectively. The 3/4 Rambouillet ewes scored about .34 units higher than the straight Rambouillets as shown by the least squares estimate of the constant in Appendix Table XL.

The least squares means and standard deviations for the breeding score of the different age groups of ewes are presented in Table XX and the means are graphically diagrammed in Figure 7. Although the differences in score between adjacent ages were small, the trend was apparent that score increased with age to about five years and then declined. In the raised group the highest score was obtained in the five-year-old ewes whereas in the purchased group, the ewes 5.5 years of age scored the highest. A difference of over one unit score existed between the highest and lowest scoring ewes.

Wool Production

The analyses of variance for the grease and clean wool

TABLE XIX

ANALYSES OF VARIANCE FOR BREEDING SCORE
OF THE TWO GROUP OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean squares	Variance components	Degrees of freedom	Mean squares	Variance component
Breed	2	1.57	0.005	1	3.12*	0.14
Year	8	22.85*	0.16	8	43.63*	0.22
Age	8	16.84*	0.12	8	26.17*	0.13
Error	1296	0.60	0.60	1732	1.24	1.24

*P < .005

TABLE XX

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR THE BREEDING SCORE OF EWES BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2]	Standard deviation	Least square mean[2]	Standard deviation
1	6.12±.05	.87	5.43±.10	.90
2	6.75±.06	.76	6.03±.09	.95
3	6.93±.07	.75	6.40±.09	.89
4	6.95±.08	.74	6.72±.09	.87
5	6.81±.09	.69	6.21±.09	1.05
6	6.73±.11	.78	6.09±.09	.98
7	6.54±.12	.69	5.70±.10	.96
8	5.00±.15	1.06	5.60±.13	.89
9	5.84±.24	.83	5.48±.34	1.00

[1]Coded as in Table IX.

[2]±Standard error.

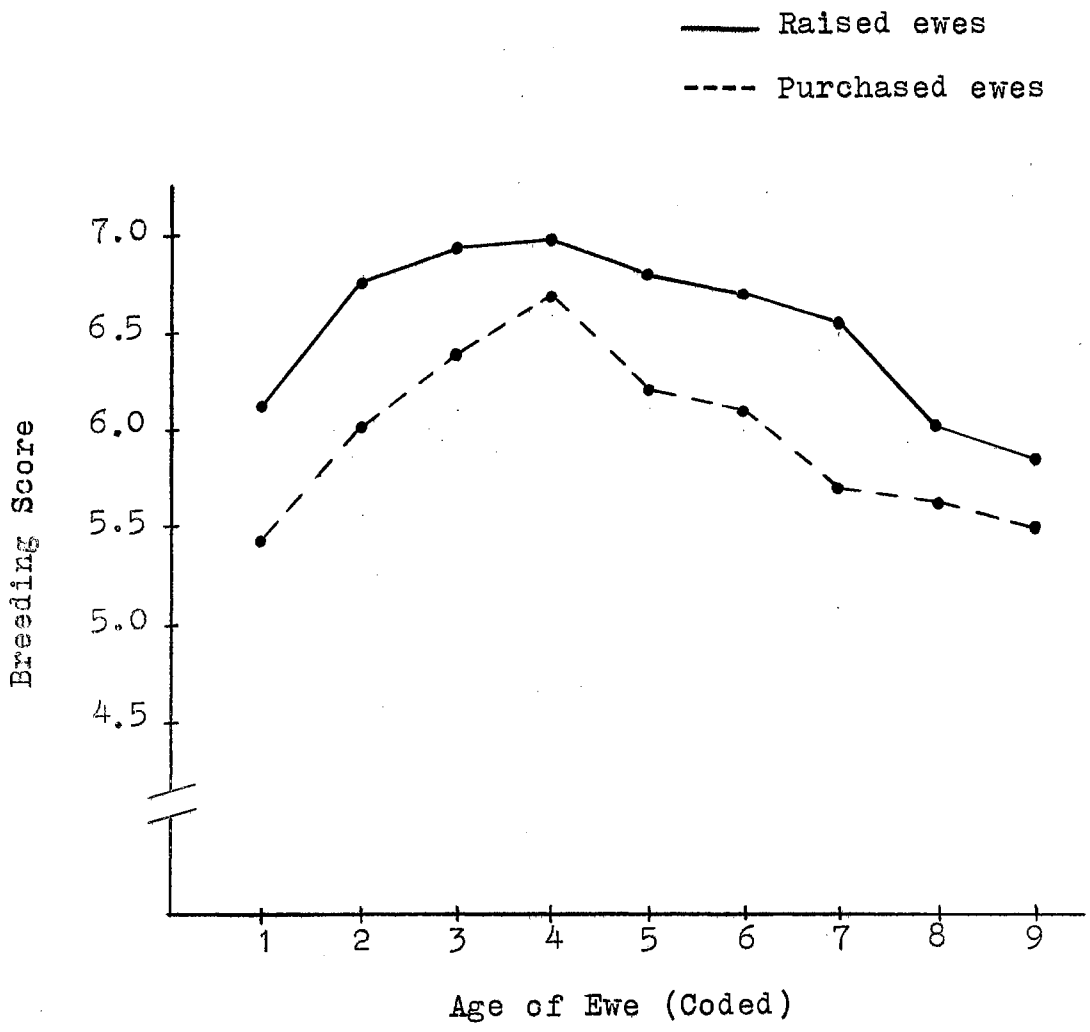

Figure 7. Influence of Age of Ewe on Breeding Score.

production of the raised and purchased ewes are presented in Tables XXI and XXII. In all analyses, breed, year and age appeared to be important sources of variation. In the raised ewes, these three sources of variation accounted for 7.2 percent, 15.9 percent and 5.1 percent of the total variation of the grease wool; and 3.1 percent, 33.9 percent and 8.3 percent of the variation of the clean wool, respectively. In the purchased ewes only year accounted for an appreciable percentage of the total variation, 13.7 percent for the grease fleece and 21.4 percent for the clean fleece. The estimated least squares constants for the effects of breeds, years and age groups on the grease and clean wool production of ewes are shown in Appendix Tables XLI and XLII. Like the other traits, wool production fluctuated from year to year and the highest production in terms of both grease and clean fleece was obtained in 1965 and 1966. As was expected, the 3/4 Rambouillets produced the most wool in the raised ewes, while the straight Rambouillet outyielded the 3/4 Rambouillet in the purchased ewes.

The least squares means and standard deviations for the grease and clean wool production of the different age groups of ewes are presented in Tables XXIII and XXIV and in Figure 8. In the raised ewes, a definite pattern of change in both grease and clean wool yield with age existed. Maximum production was reached at four years of age but the increase from two years to this age was small. The greatest variability in grease wool production was also observed at this age. After the fourth year, there was a steady decrease in

TABLE XXI

ANALYSES OF VARIANCE FOR GREASE FLEECE WEIGHT OF THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Breed	2	87.22*	0.42	1	48.78*	0.05
Year	8	135.25*	0.92	8	115.15*	0.58
Age	8	45.14*	0.30	8	14.43*	0.08
Error	1287	4.17	4.17	1727	3.56	3.56

*P < .005

TABLE XXII

ANALYSES OF VARIANCE FOR CLEAN FLEECE WEIGHT OF THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Breed	2	7.71*	0.04	1	32.06*	0.04
Year	8	65.11*	0.49	8	40.22*	0.21
Age	8	16.16*	0.12	8	5.72*	0.03
Error	1190	0.79	0.79	1725	0.70	0.70

*P < .005

TABLE XXIII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR GREASE FLEECE PRODUCTION BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb.	Standard deviation	Least square mean[2], lb.	Standard deviation
1	9.29±.14	1,43	11.37±.17	1.84
2	9.62±.16	1.58	11.17±.16	1.83
3	9.64±.17	3.38	10.92±.15	1.50
4	8.89±.21	1.73	11.51±.15	1.76
5	8.65±.24	1.60	11.05±.15	1.55
6	8.14±.29	1.79	10.87±.15	1.97
7	7.70±.32	1.90	10.59±.16	1.63
8	7.39±.39	1.62	10.30±.21	1.66
9	7.02±.55	1.57	11.12±.57	2.10

[1]Coded as in Table IX.

[2]±Standard error.

TABLE XXIV

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR CLEAN FLEECE BY AGE GROUP

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb.	Standard deviation	Least square mean[2], lb.	Standard deviation
1	4.87±.07	.77	5.06±.03	.78
2	5.17±.08	.75	5.22±.03	.78
3	5.26±.08	.98	5.07±.03	.95
4	4.92±.10	1.07	5.15±.03	.77
5	4.84±.11	.95	5.05±.03	.65
6	4.64±.14	.80	4.83±.03	.66
7	4.00±.15	1.04	4.72±.03	.74
8	3.78±.18	1.17	4.43±.04	.72
9	3.19±.25	1.17	4.48±.11	1.54

[1]Coded as in Table IX.

[2]±Standard error.

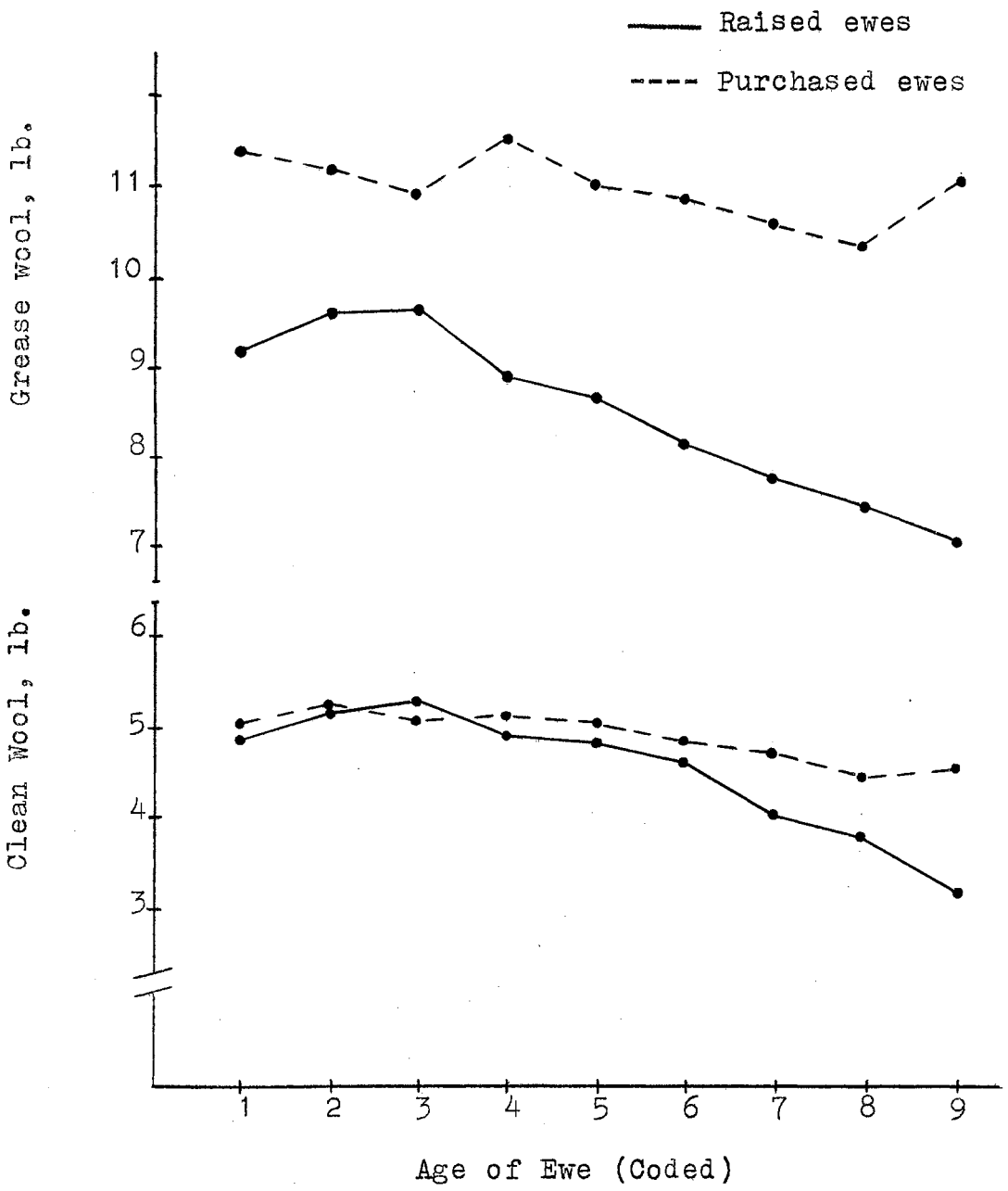

Figure 8. Influence of Age on Grease and Clean Wool Production.

wool production until the tenth year where the ewes produced on the average 7.02 pounds of grease wool corresponding to 3.19 pounds of clean wool. These results agree closely with those reported in the literature (Spencer et al., 1928; Johansson and Berg, 1940; Jones et al., 1944; Slen and Banky, 1959; Bennet et al., 1963; Vesely et al., 1965).

In the purchased ewes, the pattern of grease fleece production changes with age was not clear cut. The ewes started off with a decreasing trend from 11.37 pounds for the 2.5-year-old ewes to 10.92 pounds for the ewes 4.5 years of age. Then, there was a significant increase to 11.51 pounds for the 5.5-year-old ewes. This was followed by a steady decrease until the 9.5 years of age. The increase in grease wool production for the 10.5-year-old ewes as well as the relatively high standard deviation could be attributed to chance. The general pattern of change of grease wool production with age, however was one in which the younger ewes tended to shear more wool than the older ewes. The same trend was true for the clean fleece production.

Influence of Age of Dam on Lamb Performance

Birth Weight of Lambs

The analyses of variance for the birth weight of lambs from raised and purchased ewes presented in Table XXV show that all the variables included in the model were significant sources of variation except for the breed of dam in the purchased group. Type of birth contributed a large portion to the total variation (31.1 percent in the raised ewes and

TABLE XXV

ANALYSES OF VARIANCE FOR BIRTH WEIGHT OF LAMBS FROM THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Sex	1	120.20*	0.13	1	187.19*	0.17
Type of birth	1	1,240.41*	1.50	1	1,740.73*	1.71
Breed of dam	2	57.95*	0.20	1	0.20	0.00
Year	8	31.68*	0.15	8	23.34*	0.09
Age of dam	8	20.28*	0.09	8	9.68*	0.03
Error	1759	2.75	2.75	2015	2.67	2.67

*P < .005

36.5 in the purchased ewes). Age of dam accounted for only 1.9 percent and 0.7 percent of the total variation of birth weight of lambs from the raised and purchased ewes, respectively. Appendix Table XLIII shows the least squares estimates of the constants for the effects of sex, type of birth, breed of dam, year of lambing and age of dam on the birth weight of lambs. Male lambs outweighed the females by about 0.6 pounds while single lambs were about 1.9 pounds heavier than the twin lambs on the average.

The least squares means and standard deviations for the birth weight of lambs classified according to different age groups of dams are shown in Table XXVI. Figure 9 shows the least squares means in graphical form. Birth weight of lambs tended to fluctuate from age to age. However, the general trend indicated that ewes produced heavier lambs as they grew older. In the raised ewes, the heaviest lambs were produced by the eight-year-old ewes, although their weights were not significantly different from the weights of lambs from ewes that were six, nine and ten years old. The difference in the birth weight of lambs from the different age groups of ewes ranged from 0.17 to 0.35 pounds. In the purchased ewes, the heaviest lambs were produced by the 10.5-year-old ewes, but only eleven lambs were involved in the estimate rendering the figure not very reliable. In both groups, lambs from the youngest ewes were lighter than those from the older ewes. Reports in the literature (Nelson and Venkatachalam, 1949; Hunter, 1956; Peters et al., 1961, Sidwell et al., 1964; Bennet et al., 1963; Smith and Lidvall,

TABLE XXVI

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR BIRTH WEIGHT OF LAMBS BY AGE GROUP OF DAM

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb.	Standard deviation	Least square mean[2], lb.	Standard deviation
1	8.24±.11	1.60	8.62±.15	1.58
2	9.01±.11	1.58	9.07±.13	1.57
3	9.06±.12	1.54	8.94±.13	1.60
4	9.09±.14	1.63	9.29±.12	1.36
5	9.42±.17	1.64	9.31±.12	1.55
6	9.00±.20	1.76	9.43±.12	1.46
7	9.60±.22	1.68	9.23±.13	1.64
8	9.25±.28	2.16	9.03±.19	1.50
9	9.43±.42	2.00	9.79±.55	1.82

[1]Coded as in Table IX.

[2]±Standard error.

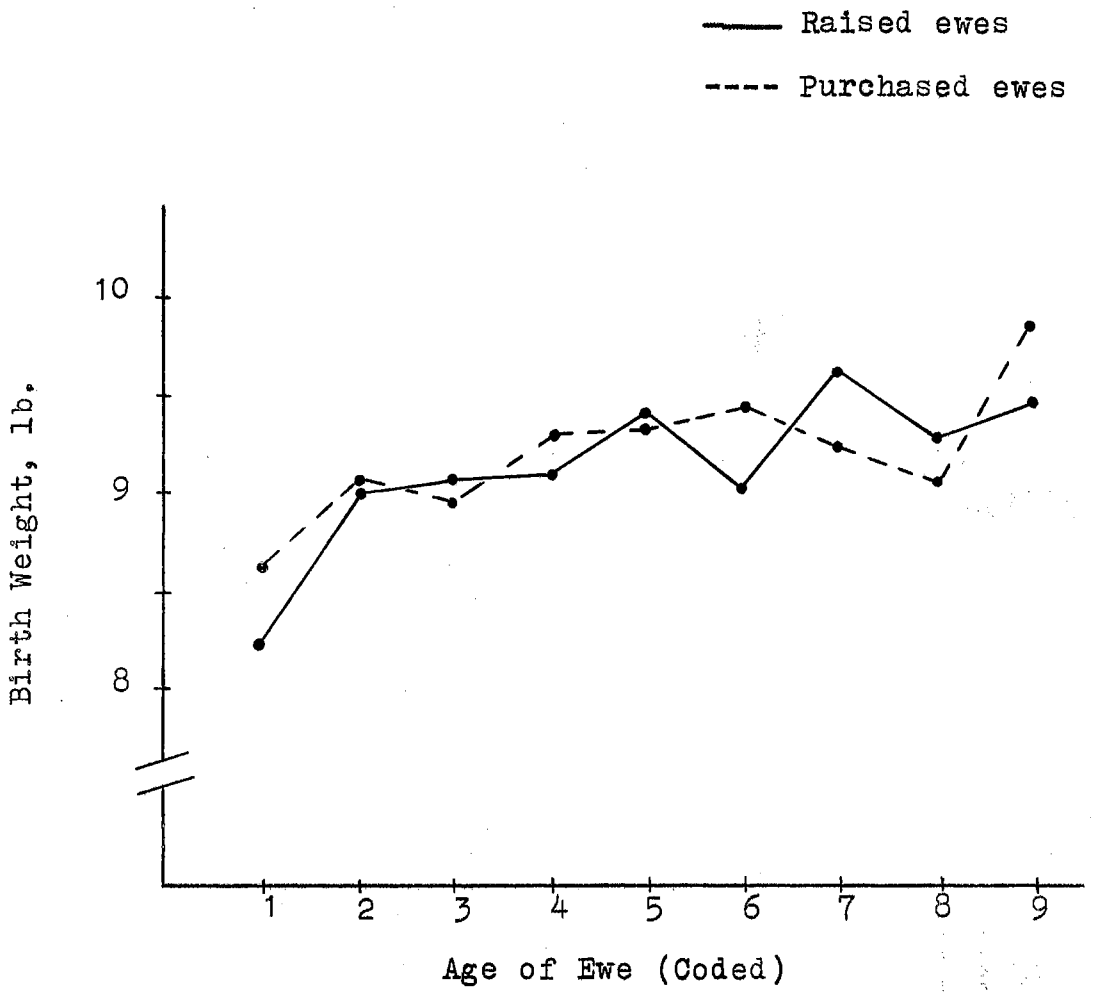

Figure 9. Influence of Age of Dam on the Birth Weight of Lambs.

1964; Vesely and Peters, 1964; Vesely et al., 1966) supported this observation. In addition, the reports indicated that the heaviest lambs were generally produced by ewes about four to six years of age.

Yalcin and Bichard (1964) and Coop and Hayman (1962) stated that the increasing birth weight of lambs with increasing age of dam may actually be due to the increasing weight of ewes as they grow older. It would be expected then that the pattern of change in weight of ewes with age would be similar to the pattern of change of lamb's birth weight with age of dam. Such a relationship, however, was not observed in the present study. This can be verified by the inspection of Figures 6 and 9. Apparently, in the flock under study, birth weight of lambs did not vary with age of ewe in the same way as weight of ewe did. This observation seem to indicate that no definite relationship between birth weight of lambs and weight of ewes existed.

Ajdusted 70-day Weight of Lambs

Except for breed of dam, all the variables involved in the analyses of the adjusted 70-day weight of lambs from the two groups of ewes were significant as evidenced in Table XXVII. The differences in type of birth and rearing and the differences in birth weight accounted for a large portion of the total variation. In the raised ewes, type of birth and rearing and birth weight contributed 10.7 percent and 16.7 percent, respectively, to the total variation. The corresponding figures in the purchased ewes were 18.7 and

TABLE XXVII

ANALYSES OF VARIANCE FOR ADJUSTED 70-DAY WEIGHT OF LAMBS FROM THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Sex	1	2,44.76*	3.26	1	1,892.28*	2.10
Type of birth and rearing	2	3,864.23*	10.58	2	8,063.16*	17.19
Regression on birth weight	1	24,147.87*	16.43	1	18,651.95*	10.61
Breed of dam	2	89.42	0.14	1	26.05	0.00
Year	8	1,104.54*	6.56	8	897.67*	4.42
Age of dam	8	607.74*	3.55	8	334.94*	1.49
Error	1443	57.98	57.98	1731	55.96	55.96

*P < .005

11.6 percent. Age of dam accounted for 3.6 percent and 1.6 percent of the total variation of the 70-day weight of lambs from the raised and purchased ewes, respectively. The estimated least squares constants for the effects of the various variables on the adjusted 70-day weight of lambs are given in Appendix Table XLIV.

Table XXVIII shows the least squares means and standard deviations for the adjusted 70-day weight of lambs arranged according to different age groups of dams. The means are plotted in Figure 10. In the raised ewes, the lambs from the four-year-old ewes were the heaviest. They were significantly heavier than the lambs from the two-year-old ewes by about three pounds. After the fourth year of age, there was a consistent decrease in the 70-day weight of lambs. The lightest lambs were produced by the ten-year-old ewes and these lambs were over eleven pounds lighter than the lambs from the four-year-old ewes. The standard deviations indicate that lambs from younger ewes were less variable in weaning weight than those from older ewes. In the purchased ewes, the same pattern of 70-day weight changes with age of dam existed. The 70-day weight of lambs increased from 51.7 pounds for lambs from 2.5-year-old ewes to 55.4 pounds for lambs from 5.5-year-old ewes. The 10.5-year-old ewes produced the lightest lambs which were about eight pounds lighter than the heaviest lambs.

The published reports indicate that weaning weight of lambs which is measured mostly at 120 days of age, is generally greater for those from ewes that are four to six

TABLE XXVIII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR ADJUSTED 70-DAY WEIGHT OF LAMBS BY AGE GROUP OF DAMS

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb.	Standard deviation	Least square mean[2], lb.	Standard deviation
1	51.96±1.12	5.67	51.67±1.18	6.05
2	54.21±1.21	5.87	53.62±1.18	5.97
3	55.65±1.24	5.94	54.26±1.16	5.65
4	53.74±1.34	6.14	55.37±1.18	5.23
5	51.97±1.39	5.96	54.01±1.19	5.47
6	50.32±1.50	5.52	52.68±1.20	5.97
7	49.14±1.62	6.47	53.65±1.24	5.12
8	46.63±1.85	8.19	48.68±1.44	7.33
9	43.64±2.66	6.97	47.21±3.17	7.25

[1]Coded as in Table IX.

[2]±Standard error.

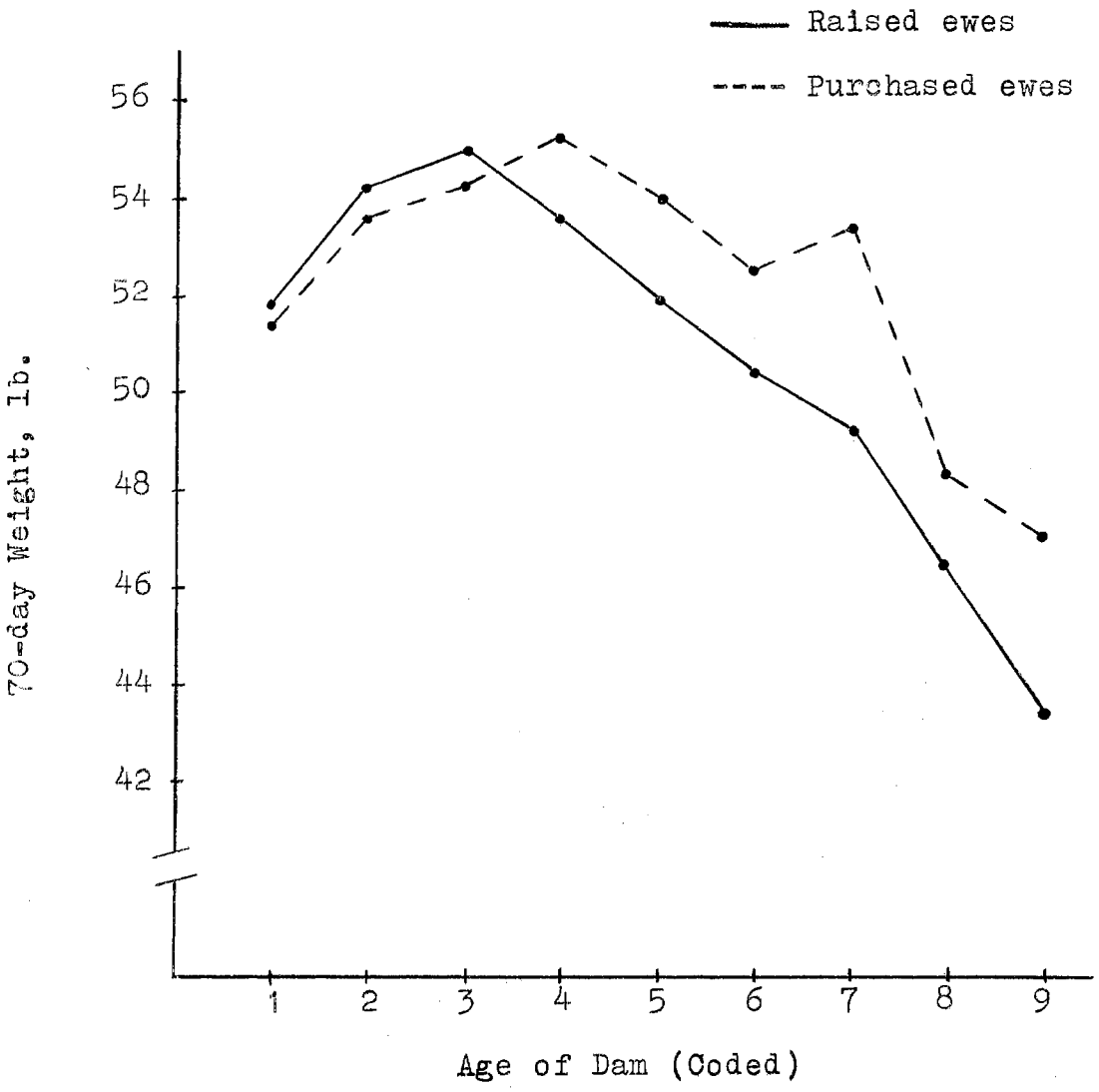

Figure 10. Influence of Age of Dam on the Adjusted 70-day Weight of Lambs.

years of age than for those from young and old ewes. Sidwell and Grandstaff (1949) observed that lambs from four- to seven-year-old ewes were 3.5 pounds and 3.1 pounds heavier than those from two-year-old ewes and eight- to eleven-year-old ewes, respectively. Larger differences in weaning weights of lambs from ewes of different ages were reported by Shelton and Campbell (1962). They reported a difference of about five pounds between the weaning weights of lambs from three- to seven-year-old ewes and the weaning weight of lambs from two-year-old ewes. Lambs from three- to seven-year olds were about eight pounds heavier than those from older ewes (eight to ten years of age). Other workers (Sidwell et al., 1964; Vesely and Peters, 1964; Vesely et al., 1966) reported essentially similar findings. In general, these reports are in close agreement with the result obtained in the present study.

It has been widely acclaimed that weaning weight of lambs is largely a function of the milking ability of ewes. This is so because the ewes play an important role in the nourishment of the lambs during the period from birth to weaning. It would be expected then that ewes would wean the heaviest lambs at ages where they produce the most milk. Bosma (1939), Montanaro (1940) and Barnicoat et al. (1949, 1956) stated that milk production increased with age of ewe and that maximum yield occurred in ewes about four to six years of age. In the present study, the four and five-year-old ewes weaned the heaviest lambs which would indicate that these ewes also produced the most milk. This result agrees

favorably with the aforementioned reports. It also appeared that considerable reduction in milk yield occurred as the ewes grew older as reflected on the weight of the lambs they weaned.

Pre- and Post-weaning Rates of Gain

The analyses of variance for the pre-weaning rate of gain of lambs are presented in Table XXIX. All the variables were significant sources of variation except for breed of dam. Type of birth and rearing accounted for 13.5 percent of the total variation of the pre-weaning rate of gain of lambs from the raised ewes and 22.5 percent of the total variation of the pre-weaning rate of gain of lambs from the purchased ewes. The corresponding figures for age of dam were 4.3 percent for lambs from the raised ewes and 2.0 percent for lambs from the purchased ewes. The least squares estimates of the constants for the effects of the various factors on the pre-weaning rate of gain of lambs from the two groups of ewes are given in Appendix Table XLV.

The least squares means and standard deviations for the pre-weaning rate of gain of lambs by age groups of dams are presented in Table XXX and the means are graphically illustrated in Figure 11. In the raised ewes, the lambs from the four-year-old dams gained about 0.660 pound per day on the average. These represented the fastest gaining lambs and were about 0.044 pound per day higher than the lambs from two-year-old ewes. Beyond this age group, there was a consistent decline in the rate of gain of lambs. The slowest

TABLE XXXIX

ANALYSES OF VARIANCE FOR PRE-WEANING RATE OF GAIN OF LAMBS FROM THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component
Sex	1	0.3802*	0.0004	1	0.5197*	0.0007
Type of birth and rearing	2	1.6136*	0.0034	2	0.7840*	0.0022
Regression on birth weight	1	1.1833*	0.0007	1	1.8790*	0.0013
Breed of dam	1	0.0060	0.0000	2	0.0199	0.00004
Year	8	0.1868*	0.0009	8	0.2274*	0.0014
Age of dam	8	0.0697*	0.0003	8	0.1212*	0.0007
Error	1731	0.0094	0.0094	1443	0.0100	0.0100

*P < .005

TABLE XXX

LEAST SQUARES MEANS AND STANDARD DEVIATION FOR PRE-WEANING RATE OF GAIN OF LAMBS BY AGE GROUP OF DAMS

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb./day	Standard deviation	Least square mean[2], lb./day	Standard deviation
1	0.616±.015	.083	0.610±.015	.087
2	0.648±.016	.083	0.637±.015	.083
3	0.660±.016	.085	0.647±.015	.080
4	0.641±.017	.087	0.662±.015	.086
5	0.617±.018	.085	0.643±.015	.078
6	0.593±.020	.079	0.623±.016	.086
7	0.580±.021	0.91	0.637±.016	.076
8	0.540±.024	.007	0.565±.019	.104
9	0.497±.035	.099	0.542±.041	.102

[1]Coded as in Table IX.

[2]±Standard error.

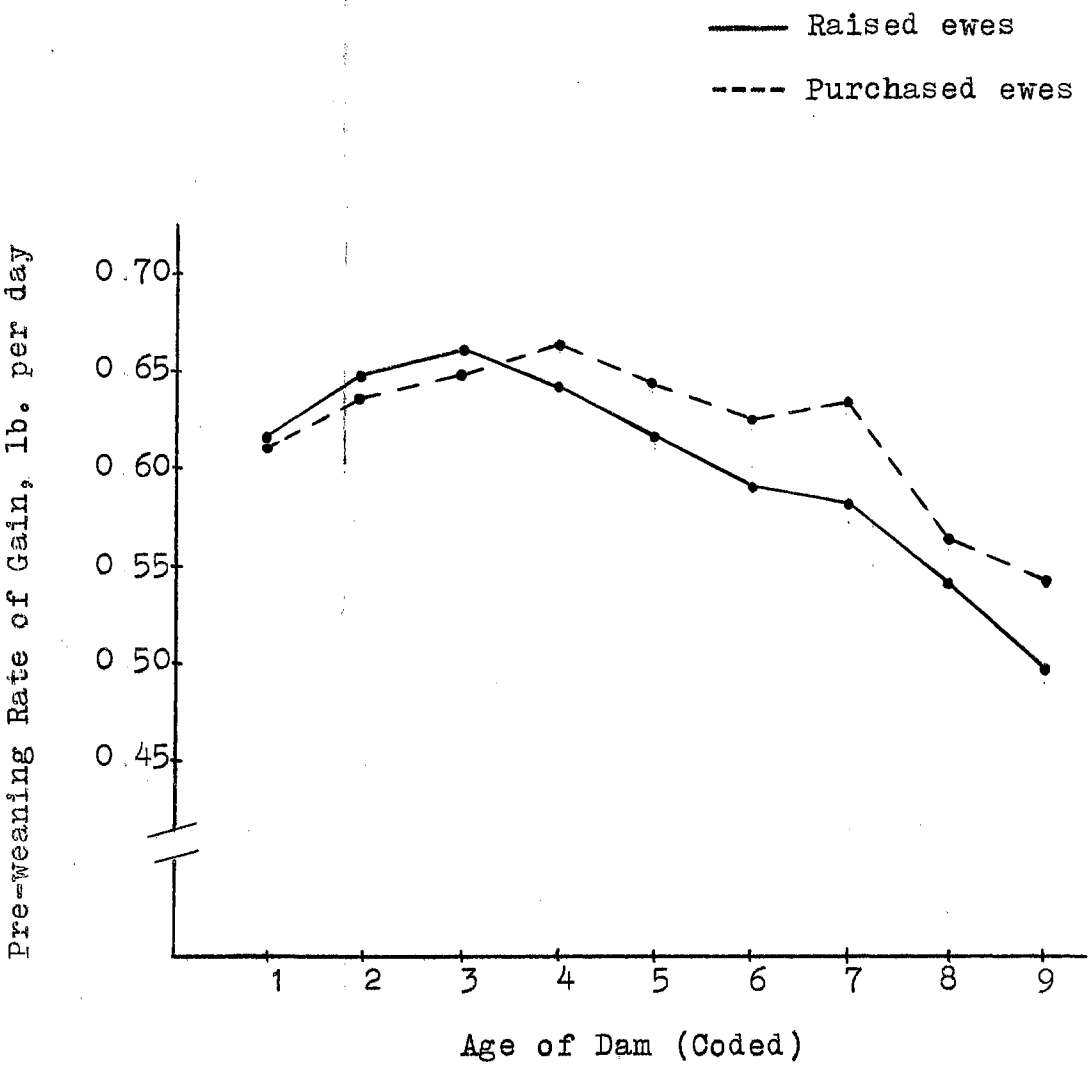

Figure 11. Influence of Age of Dam on the Pre-weaning Rate of Gain of Lambs.

gaining lambs were those born to ten-year-old ewes. In the purchased ewes, there was an increase in rate of gain of lambs from 0.610 pound per day for lambs from 2.3-year-old ewes to 0.662 pound per day for those from 5.5-year-old ewes. Then a general decline in rate of gain of lambs followed in the subsequent age group of dams. These results agree favorably with the findings reported by Brown et al. (1961) and Sidwell et al. (1964). These men concluded that as ewes reached the age of four to six years, their lambs gained considerably better than lambs from younger and/or older ewes.

Like weaning weight, rate of gain from birth to weaning largely depends upon the milk supply of the ewes. The greater rate of gain of the lambs from the four-year-old ewes (raised) and 5.5-year-old ewes (purchased) probably have resulted from the higher milk yield of the ewes at these ages as compared to the ewes in other age categories. This statement is supported by the report of several researchers cited earlier that milk production of ewes was at the maximum at ages from four to six years.

The rate of gain of lambs after weaning showed a different picture as far as its dependency on age of dam was concerned. The analyses of variance of the rate of gain of lambs from 70-days of age to market shown in Table XXXI indicate that age of dam was not an important source of variation. It accounted for practically zero percent of the total variation. It can be noted that year accounted for a large percentage of the total variation (14.8 percent in

TABLE XXXI

ANALYSES OF VARIANCE FOR POST-WEANING RATE OF GAIN OF LAMBS FROM THE TWO GROUPS OF EWES

Source of variation	Raised ewes			Purchased ewes		
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance components
Sex	1	0.5716*	0.0008	1	1.0748*	0.0013
Regression on weaning weight	1	1.5422*	0.0011	1	0.8196*	0.0005
Breed of dam	2	0.0724*	0.0003	1	0.1231*	0.0001
Year	8	0.3338*	0.0021	8	0.3254	0.0018
Age of dam	8	0.0155	0.00004	8	0.0244*	0.0001
Error	1376	0.0099	0.0099	1602	0.0088	0.0088

*P < .005

raised ewes and 14.3 percent in purchased ewes). The reasoning behind this is that lamb growth during the period from weaning to market is more dependent upon the quantity and quality of feed available than the milk supply of the ewe (Harrington, 1963). The least squares means in Table XXXII reveal that, for all practical purposes, there was no appreciable differences in the post-weaning rate of gain of lambs from different age groups of dams.

Correction Factors for Adjusting Various Traits for the Effect of Age of Ewe

Differences other than those being measured tend to reduce the accuracy and/or precision of a comparison. In a selection program where comparison of genetic potential among individuals is involved, the presence of some environmental forces may render such a comparison not valid. One way of reducing environmental variations is by the use of correction factors in such a manner as to be able to compare different individuals on a common basis relative to a certain classification.

Additive and multiplicative correction factors have been generally used for adjusting data for the influence of some known sources of variation. With additive adjustment, the mean difference between the subclass chosen as a standard and the subclass represented by a particular individual is added to that individual's measurement. With multiplicative adjustment the measurement is multiplied by the ratio of the respective subclass means, with the standard as the numerator usually. Brinks et al. (1961) stated that satis-

TABLE XXXII

LEAST SQUARES MEANS AND STANDARD DEVIATIONS FOR POST-WEANING RATE OF GAIN OF LAMBS BY AGE GROUP OF DAMS

Age group[1]	Raised ewes		Purchased ewes	
	Least square mean[2], lb./day	Standard deviation	Least square mean[2], lb./day	Standard deviation
1	0.574±.017	.151	0.541±.017	.144
2	0.583±.017	.156	0.546±.017	.170
3	0.582±.018	.165	-.520±.107	.132
4	0.568±.018	.165	0.539±.017	.144
5	0.565±.018	.136	0.522±.016	.160
6	0.568±.120	.181	0.541±.016	.146
7	0.576±.021	.196	0.536±.017	.187
8	0.528±.025	.180	0.486±.019	.164
9	0.530±.036	.202	0.532±.040	.271

[1]Coded as in Table IX.

[2]±Standard error.

factory correction factors should be able to equalize means between subclasses and variances within subclasses. They further indicated that additive adjustments were more appropriate when standard deviations of the different subclasses were equal, and multiplicative adjustments were more appropriate when coefficients of variation were equal. From the practical standpoint, however, such equalities of standard deviations or coefficients of variation do not usually exist as to be able to determine which kind of correction factor to use. In light of this, both additive and multiplicative correction factors were derived in this study. The usefulness of each was assessed by determining how effective each was in equalizing the variances or standard deviations.

Table XXXIII shows the additive and multiplicative correction factors derived form the present data for those traits that were influenced significantly by age of ewe. Both correction factors were effective in equalizing the means of a particular trait among the different age groups. The age groups within a row that have 0.00 for additive adjustment and 1.00 for multiplicative adjustment were the classes chosen as standards. In this particular case, they were the age groups that excelled in performance relative to a particular trait. It should be noted that no one age group excelled in all the traits considered. This goes to show that an age group that may be the best as far as a certain trait is concerned may not be such relative to some other traits.

The standard deviations of each of the traits in each

TABLE XXXIII

ADDITIVE AND MULTIPLICATIVE CORRECTION FACTORS FOR ADJUSTING VARIOUS TRAITS FOR THE EFFECT OF AGE OF EWE

Trait	Age of ewe, years								
	2	3	4	5	6	7	8	9	10
Prolificacy									
Additive	0.40	0.18	0.11	0.15	0.00	0.00	0.21	0.31	0.41
Multiplicative	1.31	1.12	1.07	1.03	1.00	1.00	1.15	1.23	1.32
Rearing ability									
Additive	.32	.12	.07	0.00	0.00	.13	.26	.45	.60
Multiplicative	1.29	1.08	1.05	1.00	1.00	1.10	1.21	1.46	1.69
Breeding weight									
Additive	26.36	9.72	0.00	0.00	0.00	0.00	0.00	8.43	13.82
Multiplicative	1.22	1.07	1.00	1.00	1.00	1.00	1.00	1.06	1.10
Grease fleece									
Additive	0.33	0.00	0.00	0.73	0.97	1.49	1.02	2.24	2.60
Multiplicative	1.04	1.00	1.00	1.08	1.11	1.18	1.25	1.30	1.37
Clean fleece									
Additive	0.35	0.00	0.00	0.30	0.38	0.90	1.22	1.24	2.03
Multiplicative	1.07	1.00	1.00	1.06	1.08	1.12	1.30	1.38	1.64
Lamb 70-day weight									
Additive	2.37	0.00	0.00	0.00	2.36	4.01	5.19	7.70	10.69
Multiplicative	1.05	1.00	1.00	1.00	1.04	1.08	1.11	1.16	1.24
Lamb pre-weaning rate of gain									
Additive	0.03	0.00	0.00	0.00	0.03	0.06	0.07	0.11	0.15
Multiplicative	1.05	1.00	1.00	1.00	1.05	1.10	1.12	1.20	1.31

age group that would be expected after adjusting for the effect of age of ewe using additive and multiplicative correction factors are shown in Table XXXIV. The additively adjusted standard deviation would be the same as the unadjusted standard deviation because the variance does not change when additive corrections are used. Multiplicative corrections, on the other hand, change the variance in proportion to the square of the correction factor. The information from the table reveals that multiplicative corrections generally caused further changes in the variances instead of equalizing them. This would indicate that additive corrections are more appropriate in adjusting the traits under consideration.

How well the given correction factors would work was not tested because of the unavailability of similar data or data collected in flocks reared under the same environment and management as the flock involved in this study. It is hoped, however, that the correction factors will prove useful in the future.

Theoretically, the application of a particular set of correction factors is limited only to the flock or herd where the data used in deriving the factors are obtained. Even within a flock, correction factors that are effective at one time may not be satisfactory at some other times. This is probably due to the changes in environment and/or to genetic changes (improvement or otherwise) made in the flock. However, Koch et al. (1959) believed that when it is not practical to derive adjustment factors in a flock, an ad-

TABLE XXXIV

STANDARD DEVIATIONS OF EACH TRAIT ON EACH AGE GROUP AFTER ADJUSTING FOR THE EFFECT OF AGE OF EWE USING ADDITIVE AND MULTIPLICATIVE CORRECTION FACTORS

Trait	Age of ewes, years								
	2	3	4	5	6	7	8	9	10
Prolificacy									
Additive	.46	.50	.52	.54	.52	.54	.50	.52	.51
Multiplicative	.60	.56	.56	.56	.52	.54	.58	.64	.67
Rearing ability									
Additive	.41	.50	.51	.53	.53	.53	.49	.45	.44
Multiplicative	.53	.54	.54	.53	.53	.58	.59	.66	.74
Breeding weight									
Additive	10.97	12.86	13.75	13.08	12.77	12.40	12.89	15.35	14.84
Multiplicative	13.38	13.76	13.75	13.08	12.77	12.40	12.89	16.27	16.32
Grease fleece									
Additive	1.43	1.58	3.38	1.73	1.60	1.79	1.90	1.62	1.57
Multiplicative	1.48	1.58	3.38	1.87	1.78	2.11	1.37	2.11	2.15
Clean fleece									
Additive	.77	.75	.98	1.07	.95	.80	1.04	1.17	1.17
Multiplicative	.82	.75	.98	1.13	1.03	.90	1.35	1.61	1.92
Lamb 70-day wt.									
Additive	5.67	5.87	5.94	6.14	5.96	5.52	6.47	8.19	6.97
Multiplicative	5.95	5.87	5.94	6.14	6.20	5.96	7.18	9.50	8.64
Lamb pre-weaning rate of gain									
Additive	.083	.083	.085	.087	.085	.079	.091	.117	.099
Multiplicative	.087	.083	.085	.087	.090	.087	.102	.141	.129

justment factor developed from a flock or area where environmental conditions are similar can be reasonably used.

When appropriately used, correction factors are an effective method of minimizing error due to some known environmental factors. Although correction factors in certain cases may undercorrect some records or overcorrect some, any variation removed by their use will increase the accuracy of an analysis or a comparison when no other bias is involved. Whenever known environmental sources of variation are suspected to operate, adjustment for such should be made if feasible.

SUMMARY

Data collected from the experimental sheep flock maintained at the Fort Reno Livestock Research Station near El Reno, Oklahoma were utilized to evaluate the influence of age of ewe on some economically important traits. Two general classes of production traits were included in this study, namely, those that were measured on the ewes and those that were measured on the lambs. The traits measured on the ewes were fertility (ewes lambing per 100 ewes bred), prolificacy (number of lambs per ewe lambing), rearing ability (number of lambs reared to two weeks per ewe lambing), breeding weight, breeding score, grease wool production and clean wool production. The traits measured on the lambs included birth weight, adjusted 70-day weight (weaning weight), rate of gain from birth to 70 days (pre-weaning rate of gain) and rate of gain from 70 days to market (post-weaning rate of gain). The data, which included only those from the main breeding and lambing periods, were analyzed by methods of least squares, and constants were fitted for each of the variables included in the models. Least squares means were estimated for each age group of ewes for each trait. The ewes were classified according to whether they were raised or purchased and all analyses were done within such classification. Correction factors (only for

raised ewes) were devised for adjusting some of the traits for the effects of age of ewe. Both additive and multiplicative corrections factors were derived and their usefulness were assessed by how well they equalized the variances within age groups.

The results indicate that age of ewe has a significant effect on the fertility of the raised ewes but not on that of the purchased ewes. Fertility of the raised ewes increased from 87.0 percent for the two-year-old ewes to 94.5 percent for the five-year-old ewes. Beyond this age there was a consistent decrease in fertility. The number of lambs born and the number of lambs reared to two weeks per ewe lambing tended to increase with age until the ewes were about five to seven years old and then declined. This trend was true for both groups of ewes but the purchased ewes had lower figures. In the raised ewes, the maximum number of lambs per ewe lambing was reached at seven years of age with 1.68 lambs; the six-year-old ewes reared the most lambs to two weeks with 1.49.

Weight at breeding was significantly influenced by age of ewe. Age accounted for over 20 percent of the total variation in weight. Weight of ewe increased with increasing age until the maximum was reached at the sixth age group (seven years old for raised ewes and 7.5 years old for purchased ewes). The ewes at this age group were about 30 pounds heavier than the youngest ewes. Age of ewe had also a significant influence on score at breeding. The five-year-old raised ewes and the 5.5-year-old purchased ewes repre-

sented the highest scoring or the fattest ewes. The raised and purchased ewes at these ages scored 6.95 and 6.72, respectively.

In the raised ewes, a definite pattern of change in both grease and clean wool production with advancing age was apparent, whereas the pattern in the purchased ewes was not clear. Maximum production in the raised ewes was reached at four years of age with an average yield of 9.64 and 5.26 pounds of grease and clean wool, respectively. It is interesting to note that the purchased ewes outyielded the raised ewes in grease fleece yield at all ages but there was no apparent difference in their clean fleece yield.

Age of dam accounted for a very low percentage of the total variation in birth weight of lambs. Birth weight of lambs tended to fluctuate from age to age but the general trend indicated that ewes produced heavier lambs as they grew older. The adjusted 70-day weight (weaning weight) of lambs was significantly influenced by age of dam. The heaviest lambs at weaning were those from the four-year-old raised ewes and the 5.5-year-old purchased ewes whereas the lightest lambs were those from the ewes at the oldest age classification. Similarly, the fastest gaining lambs as far as the rate of gain from birth to weaning was concerned were those from the four- and 5.5-year-old ewes and they were 0.163 and 0.120 pounds per day higher than the lambs from the ewes at the oldest age classification. Relative to rate of gain from weaning to market, age of dam was not an important source of variation.

Additive and multiplicative correction factors for adjusting for the effect of age of ewe were derived from the present data. Both types of corrections were effective in equalizing the means among the different age groups. However, the standard deviations that would be expected after adjusting for the effect of age of ewe using each of the two corrections indicated that multiplicative corrections generally caused further changes in the variances, hence, additive corrections would seem more appropriate to use.

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APPENDIX

TABLE XXXV

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE FERTILITY OF RAISED EWES

Classification	Number of proportion	Number of observations[2]	Least squares constant[3]
Mean	63	1315	.8681±.0205
Breed			
1/2 Dorset	39	1082	.0420±.0128
3/4 Dorset	12	142	-.0334±.0134
3/4 Rambouillet	12	91	-.0087±.0163
Year			
1958	1	36	.0326±.0546
1959	2	76	.0625±.0391
1960	3	110	-.0267±.0322
1961	4	150	-.0514±.0284
1962	7	201	-.0849±.0222
1963	10	222	-.0020±.0197
1964	12	192	.0200±.0194
1965	12	175	.0116±.0217
1966	12	153	.0385±.0243
Age of ewe[4]			
1	13	275	.0019±.0234[b]
2	13	280	.0532±.0109[b,c]
3	13	242	.0762±.0187[c]
4	9	160	.0768±.0209[c]
5	6	125	.0337±.0241[b,c]
6	3	88	.0344±.0328[b,c]
7	3	80	-.0233±.0324[b]
8	2	46	-.0411±.0393[b]
9	1	19	-.2116±.0550[a]

[1]See text, page 45.

[2]Refers to the number of observations that go into the computation of the proportions in the preceding column.

[3]±Standard error.

[4]Coded as in Table IX.

[a,b,c]Constants followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XXXVI

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE FERTILITY OF PURCHASED EWES

Classification	Number of proportion[1]	Number of observations[2]	Least squares constant[3]
Mean	65	1750	.8518±.0160
Breed			
Rambouillet	35	917	.0193±.0136
3/4 Rambouillet	30	833	-.0193±.0136
Year			
1958	4	217	.0439±.0571
1953	6	254	-.0203±.0464
1960	8	284	-.0398±.0400
1961	8	257	-.0462±.0395
1962	8	219	.0118±.0391
1963	9	172	.0780±.0378
1964	8	148	.0338±.0389
1965	8	135	.0402±.0401
1966	6	64	-.1014±.0597
Age of ewe[4]			
1	7	157	-.0169±.0480
2	9	172	.0125±.0392
3	9	301	.0316±.0407
4	8	277	.0102±.0416
5	8	270	.0191±.0407
6	8	250	.0242±.0405
7	8	200	-.0217±.0402
8	6	109	-.1086±.0469
9	2	14	.0496±.0878

[1]See text, page 45.

[2]Refers to the number of observations that go into the computation of proportions in the preceding column.

[3]±Standard error.

[4]Coded as in Table IX.

TABLE XXXVII

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE PROLIFICACY OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant	Number involved	Least squares constant
Mean	1215	1.489±.045	1512	1.320±.021
Breed of ewe				
1/2 Dorset	1006	-.009±003		
3/4 Dorset	126	.021±.036		
3/4 Ramb.	83	-.012±.042	700	.009±.013
Ramb.			812	-.009±.013
Year				
1958	34	.087±.084	198	.091±.047
1959	76	.122±.058	223	.068±.043
1960	102	-.029±.050	241	.078±.039
1961	136	-.102±.044	218	-.101±.040
1962	175	-.210±.038	184	-.109±.040
1963	208	-.090±.036	152	-.075±.043
1964	180	.045±.040	132	.141±.042
1965	162	.000±.046	120	.086±.044
1966	142	.168±.054	44	-.179±.080
Age of ewe[2]				
1	245	-.210±.047[a]	133	-.229±.048[a]
2	260	.005±.049[b]	148	.049±.045[b]
3	231	.072±.039[b,c]	270	-.061±.045[b]
4	152	.138±.045[c,d]	248	.136±.045[c]
5	115	.180±.048[d]	240	.047±.043[b,c]
6	84	.194±.056[d]	221	.132±.045[c]
7	73	-.026±.059[b]	161	.068±.046[b,c]
8	41	-.129±.077[a]	81	-.006±.058[b]
9	14	-.223±.127[a]	10	-.039±.155[b]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XXXVIII

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE REARING ABILITY OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1215	1.237±.053	1512	1.202±.024
Breed of ewe				
1/2 Dorset	1006	.062±.039		
3/4 Dorset	126	.022±.043		
3/4 Ramb.	83	-.084±.049	700	.018±.015
Ramb.			812	-.018±.015
Year				
1958	34	.095±.100	198	.064±.054
1959	76	-.021±.068	223	.059±.050
1960	102	-.026±.059	241	.024±.045
1961	136	-.146±.052	218	-.081±.046
1962	175	-.218±.046	184	-.122±.046
1963	203	-.080±.043	152	-.072±.049
1964	180	.078±.048	132	.113±.049
1965	162	.089±.054	120	.056±.051
1966	142	.337±.064	44	-.041±.093
Age of ewe[2]				
1	245	-.103±.056[b]	133	-.169±.055[a]
2	260	.100±.050[c,d]	148	.007±.052[b,c]
3	231	.149±.047[c,d]	270	.011±.052[b,c]
4	152	.183±.053[d]	248	.134±.051[c]
5	115	.250±.057[d]	240	.054±.050[b,c]
6	84	.083±.067[c,d]	221	.132±.051[b,c]
7	73	-.039±.070[b,c]	161	-.027±.053[a,b]
8	41	-.238±.092[b]	81	.016±.068[b,c]
9	14	-.381±.151[a]	10	-.157±.179[a]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XXXIX

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE WEIGHT AT BREEDING OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1315	140.30±1.40	1750	135.55±.51
Breed of ewe				
1/2 Dorset	1082	3.09±1.03		
3/4 Dorset	142	-1.20±1.13		
3/4 Ramb.	91	-1.89±1.30	833	3.42±0.33
Ramb.			917	-3.42±0.33
Year				
1958	36	12.45±2.68	217	15.53±1.25
1959	76	-13.34±1.87	254	-2.14±1.12
1960	110	-10.66±1.56	284	-4.36±1.02
1961	150	-3.89±1.37	257	-2.95±1.05
1962	201	-2.54±1.18	219	-6.38±1.05
1963	222	-4.32±1.15	172	-8.76±1.14
1964	192	3.42±1.28	148	2.24±1.13
1965	175	5.97±1.46	135	2.97±1.16
1966	153	12.89±1.73	64	3.85±1.92
Age of ewe[2]				
1	275	-19.88±1.48[a]	157	-24.35±1.23[a]
2	280	-3.24±1.30[b]	172	-8.74±1.15[b]
3	242	4.22±1.23[c]	301	0.61±1.18[c]
4	160	6.91±1.39[c]	277	6.00±1.14[d]
5	125	7.36±1.49[c]	270	6.81±1.12[d]
6	88	8.13±1.78[c]	250	7.06±1.16[d]
7	80	5.77±1.85[c]	200	4.98±1.18[d]
8	46	-1.95±2.39[b]	109	7.26±1.46[d]
9	19	-7.33±3.64[b]	14	0.35±3.71[c]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XL

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE SCORE AT BREEDING OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1315	6.52±.07	1750	5.96±.04
Breed of ewe				
1/2 Dorset	1082	.82±.05		
3/4 Dorset	142	.06±.05		
3/4 Ramb.	91	-.13±.06	833	.27±.03
Ramb.			917	-.27±.03
Year				
1958	36	1.53±.13	217	.95±.10
1959	76	.45±.09	254	.76±.09
1960	110	-.51±.07	284	-.31±.08
1961	150	.15±.06	257	-.13±.09
1962	201	-.39±.06	219	-.55±.09
1963	222	-.53±.05	172	-.76±.09
1964	192	-.28±.06	148	-.11±.09
1965	175	-.39±.07	135	-.06±.10
1966	153	-.03±.08	64	.21±.16
Age of ewe[2]				
1	275	-.40±.07[a]	157	-.53±.10[a]
2	280	.23±.06[b,c]	172	.07±.10[b]
3	242	.41±.06[c]	301	.44±.10[c]
4	160	.43±.07[c]	277	.75±.09[d]
5	125	.30±.07[c]	270	.24±.09[b,c]
6	88	.21±.08[b,c]	250	.13±.10[b]
7	80	.03±.09[b]	200	-.26±.10[a]
8	46	-.53±.11[a]	109	-.36±.12[a]
9	19	-.67±.17[a]	14	-.48±.31[a]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLI

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE GREASE FLEECE PRODUCTION OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1306	8.47±.18	1745	10.99±.07
Breed of ewe	1077	.36±.13		
1/2 Dorset	140	-.90±.14		
3/4 Dorset	89	.54±.16		
3/4 Ramb.			830	-.17±.05
Ramb.			915	.17±.05
Year				
1958	36	.07±.33	215	.38±.18
1959	76	-.90±.23	253	.24±.16
1960	110	-1.29±.20	283	-.55±.14
1961	150	-1.56±.17	257	-1.36±.15
1962	201	-.01±.15	219	.22±.15
1963	219	-.39±.14	172	-1.34±.16
1964	188	.71±.16	148	.15±.16
1965	175	2.30±.18	135	1.49±.16
1966	151	1.09±.22	63	.78±.27
Age of ewe[2]				
1	275	.81±.18[e,f]	156	.38±.17[c,d]
2	277	1.14±.16[f]	172	.18±.16[c,d]
3	241	1.16±.15[f]	299	-.07±.16[b,c]
4	158	.41±.17[d,e]	276	.52±.15[d]
5	123	.17±.19[c,d]	270	.06±.16[b,c]
6	87	-.35±.22[b,c]	250	-.12±.16[b,c]
7	80	-.78±.23[a,b]	199	-.40±.17[a,b]
8	46	-1.10±.30[a,b]	109	-.69±.20[a]
9	19	-1.46±.45[a]	14	.13±.52[c,d]

[1]Standard error.

[2]Coded as in Table IX.

[a,b,c,d,e,f]Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLII

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS ON THE CLEAN FLEECE PRODUCTION OF EWES

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1209	4.48±.08	1743	4.89±.01
Breed of ewe				
1/2 Dorset	1034	.20±.06		
3/4 Dorset	109	-.26±07		
3/4 Ramb.	66	.06±.08	830	-.14±.01
Ramb.			913	.14±.01
Year				
1958	36	-.12±.15	214	.15±.03
1959	76	.13±.10	252	.29±.03
1960	110	-.51±.09	283	-.49±.03
1961	150	-.61±.08	257	-.49±.03
1962	201	-.63±.07	219	-.61±.03
1963	219	-.74±.06	172	-.78±.03
1964	188	.12±.07	148	-.01±.03
1965	78	.41±.13	132	.20±.03
1966	151	1.95±.10	64	1.43±.05
Age of ewe[2]				
1	275	.39±.08[d]	156	.17±.03[e]
2	241	.69±.09[e]	170	.33±.03[g]
3	211	.78±.07[e]	298	.18±.03[e]
4	127	.44±.09[d]	276	.26±.03[f]
5	123	.36±.08[d]	270	.16±.03[d]
6	87	-.20±.10[c]	250	-.06±.03[c]
7	80	-.48±.10[b]	200	-.17±.03[b]
8	46	-.70±.14[b]	109	-.46±.04[a]
9	19	-1.20±.20[a]	14	-.41±.10[a]

[1]Standard error.

[2]Coded as in Table IX.

a,b,c,d,e,f,gConstants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLIII

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF BREEDS, YEARS OF LAMBING AND AGE GROUPS OF DAMS ON THE BIRTH WEIGHT OF LAMBS FROM THE TWO GROUPS OF EWES

Classification	Raised ewes		Purchased ewes	
	Number of lambs	Least squares constant[1]	Number of lambs	Least squares constant[1]
Mean	1780	9.12±.12	2035	9.19±.07
Sex				
Male	876	.26±.04	938	.31±.04
Female	904	-.26±.04	1052	-.31±.04
Type of birth				
Single	651	.91±.04	984	.95±.04
Twin	1129	-.91±.04	1051	-.95±.04
Breed of dam				
1/2 Dorset	1465	.13±.09		
3/4 Dorset	192	-.64±.10		
3/4 Ramb.	123	.51±.11	955	.01±.04
Ramb.			1080	-.01±.04
Year of lambing				
1958	46	.33±.24	262	-.38±.15
1959	114	-.18±.16	319	-.26±.13
1960	144	-.43±.14	334	-.47±.12
1961	187	-.16±.12	281	.39±.12
1962	222	.37±.11	233	.43±.12
1963	301	-.66±.10	198	-.55±.13
1964	280	.11±.11	188	-.15±.12
1965	249	-.06±.12	169	.25±.13
1966	237	.68±.14	51	.73±.25
Age of dam[2]				
1	302	-.88±.14[a]	157	-.58±.15[a]
2	378	-.11±.12[b]	194	-.12±.15[b,c]
3	345	-.05±.11[b]	352	-.25±.14[a,b]
4	237	-.03±.12[b]	362	.10±.13[b,c,d]
5	188	.30±.13[b,c]	337	.12±.13[b,c,d]
6	139	-.12±.15[b]	308	.24±.13[c,d]
7	112	.48±.16[c]	214	.04±.14[b,c,d]
8	59	.13±.21[b,c]	100	-.16±.18[a,b,c]
9	20	.31±.35[b,c]	11	.60±.50[d]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLIV

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF THE VARIOUS FACTORS ON THE ADJUSTED 70-DAY WEIGHT OF LAMBS

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean (u)	1466	50.74±1.26	1753	52.35±1.06
Sex				
Male	709	1.32± .20	819	1.07± .18
Female	752	-1.32± .20	934	-1.07± .18
Type of birth and rearing				
Single-Single	501	2.90± .48	835	2.43± .42
Twin-Single	48	.09± .76	58	2.32± .68
Twin-Twin	917	-2.79± .44	860	-4.76± .36
Regression on birth weight	1466	2.66± .13	1753	2.20± .12
Breed of dam				
1/2 Dorset	1209	.79± .46		
3/4 Dorset	160	-.10± .51		
3/4 Ramb.	97	-.69± .64	835	.12± .18
Ramb.			919	-.12± .18
Year				
1958	41	-.67±1.20	244	2.15± .70
1959	97	-3.51± .79	292	-2.54± .63
1960	129	-2.74± .68	287	-1.68± .59
1961	133	-2.55± .67	264	-1.25± .60
1962	203	-3.82± .55	197	-4.96± .63
1963	259	1.72± .50	148	-.52± .65
1964	227	1.90± .56	149	.36± .64
1965	195	4.42± .64	137	3.07± .66
1966	182	5.24± .73	35	5.37±1.42
Age of dam[2]				
1	234	1.22± .74[d]	137	-.68± .76[a]
2	317	3.47± .60[e]	165	1.27± .70[a,b]
3	294	4.31± .56[e]	326	1.91± .70[a,b]
4	200	3.00± .62[e]	327	3.02± .68[b]
5	170	1.23± .64[d]	290	1.66± .67[a,b]
6	109	-.42± .77[c,d]	277	.33± .69[a]
7	89	-1.60± .84[b,c]	161	1.30± .75[a,b]
8	41	-4.11±1.17[b]	62	-3.67±1.00[a]
9	12	-7.10±2.06[a]	8	5.14±2.72[a]

[1] ±Standard error.

[2] Coded as in Table IX.

[a,b,c,d] Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLV

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF THE VARIOUS FACTORS ON THE PRE-WEANING RATE OF GAIN OF LAMBS

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean (u)	1466	.599±.018	1753	.618±.014
Sex				
Male	709	.019±.003	819	.015±.002
Female	757	-.019±.003	934	-.015±.002
Type of birth and rearing				
Single-Single	501	.041±.006	835	.033±.005
Twin-Single	48	.001±.010	58	.035±.009
Twin-Twin	917	-.042±.006	860	-.068±.005
Regression on birth weight	1466	.023±.002	1753	.018±.002
Breed of dam				
1/2 Dorset	1209	.012±.006		
3/4 Dorset	160	-.001±.007		
3/4 Ramb.	97	-.011±.008	834	.002±.002
Ramb.			919	-.002±.002
Year				
1958	41	-.003±.016	244	.030±.009
1959	97	-.051±.010	292	-.036±.008
1960	129	-.041±.009	287	-.025±.008
1961	133	-.037±.009	264	-.019±.008
1962	203	-.055±.007	197	-.072±.008
1963	259	.002±.007	148	-.007±.008
1964	227	.025±.007	149	.006±.008
1965	195	.063±.008	137	.044±.008
1966	182	.098±.010	35	.079±.016
Age of dam[2]				
1	234	.017±.010[c]	137	-.088±.-1-[a]
2	317	.049±.008[d]	165	.019±.009[b]
3	294	.061±.007[d]	326	.029±.009[b,c]
4	200	.042±.008[d]	327	.044±.009[c]
5	170	.017±.008[c]	290	.025±.009[b,c]
6	109	-.006±.-1-[b]	277	.004±.009[a,b]
7	89	-.019±.011[b]	161	.018±.010[a,b]
8	41	-.059±.015[a]	62	-.053±.013[a]
9	12	-.102±.127[a]	8	-.077±.045[a]

[1] ±Standard error.

[2] Coded as in Table IX.

a,b,c,d Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

TABLE XLVI

LEAST SQUARES CONSTANTS FOR THE EFFECTS OF THE VARIOUS FACTORS ON THE POST-WEANING RATE OF GAIN OF LAMBS

Classification	Raised ewes		Purchased ewes	
	Number involved	Least squares constant[1]	Number involved	Least squares constant[1]
Mean	1396	.564±.017	1622	.532±.015
Sex				
Male	671	.021±.003	759	.026±.002
Female	725	-.021±.003	836	-.026±.002
Regression on weaning weight	1396	.004±.000	1622	.003±.000
Breed of dam				
1/2 Dorset	1153	-.014±.006		
3/4 Dorset	150	-.016±.007		
3/4 Ramb.	93	.030±.008	772	.009±.002
Ramb.			850	-.009±.002
Year				
1958	41	.008±.016	205	.005±.009
1959	73	-.039±.012	235	-.038±.008
1960	129	-.036±.009	281	-.044±.008
1961	133	-.089±.009	247	-.071±.008
1962	210	-.018±.007	195	-.024±.008
1963	257	.066±.007	147	.062±.008
1964	224	-.008±.007	146	-.027±.008
1965	178	.042±.009	133	.068±.008
1966	160	.074±.010	33	.068±.019
Age of dam[2]				
1	225	.010±.010[b]	134	.009±.010[b,c]
2	295	.019±.008[b]	152	.014±.009[c]
3	291	.018±.008	284	-.012±.009[b,c]
4	193	.004±.009[a,b]	283	.007±.009[b,c]
5	165	.001±.008[a,b]	284	.012±.008[c]
6	102	.004±.010[a,b]	259	.009±.009[b,c]
7	79	.012±.011[b]	157	.004±.010[b,c]
8	35	-.036±.016[a]	61	-.046±.013[a]
9	11	-.033±.027[a]	8	-.000±.034[b]

[1]Standard error.

[2]Coded as in Table IX.

[a,b,c]Constants within a column followed by the same letter do not differ significantly from one another ($P < .05$).

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