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Title CERTAIN GENETIC AND MATERNAL ENVIRONMENTAL INFLUENCES ON GROWTH RATE AND BODY COMPOSITION OF LAMBS

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Abstract approved
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The present study was designed to investigate the relationship of milk production and milk quality to growth rate and certain organoleptic measurements of lambs of mutton breeds. Nine mature ewes in their fourth lactation of the Border Cheviot, Dorset Horn, Columbia, Suffolk, and Willamette breeds were acquired making a total of 45 ewes.

An attempt was made to synchronize parturition. The reason for synchronizing parturition was to have all the ewes lamb during a narrow interval of days so that milk production and its effects on growth could be measured under environmental conditions that were as similar as possible.

The ewes were milked by use of oxytocin to cause them to eject the milk in the udder after which they were kept separate from their lambs for six hours and milked again. The milk obtained for

the six-hour period was weighed and the quantity recorded. A representative sample was taken from milk of each ewe for composition analyses. The average percentage composition of the milk from ewes was found to be: protein, 5.46; lactose + ash, 5.40; solids-not-fat, 10.86; fat, 8.43; total solids, 19.29; and water, 80.71. There were no significant differences ($P > .05$) between breeds for the percentage of milk components studied.

During the first eight weeks of lactation the breeds studied had produced 74 percent and by ten weeks they had produced 87 percent of the milk yield for the total lactation period. The breeds ranked in the following order on the basis of milk yield and milk quality: Suffolk, Willamette, Dorset Horn, Border Cheviot, and Columbia. The latter two breeds were approximately equal. Ewes nursing twin lambs produced 25 percent more milk than ewes nursing single lambs. The peak of lactation occurred in the third and fourth weeks of lactation. The average grams of milk produced per day for ewes nursing single and twin lambs, respectively, are as follows for the five breeds: Border Cheviot 1,016, 1,669; Dorset Horn 1,617, 1,778; Columbia 1,366, 1,684; Suffolk 1,527, 2,287; and Willamette 1,552, 1,951.

A set of twins gained on the average 40.7 percent more than a single lamb. Single lambs gained 15.7 percent more weight than the average of a set of twins. The Willamette had the highest average daily gain and was followed in order by the Suffolk, Columbia, Dorset Horn, and Border Cheviot.

The average grams of milk consumed for each gram of gain for single and twin lambs, respectively, are as follows: Border Cheviot 3.964, 3.455; Dorset Horn 5.472, 3.424; Columbia 4.406, 3.716; Suffolk 4.326, 3.882; and Willamette 4.193, 3.114. It was concluded that a large portion of the nutrients required for lamb growth and fattening must be supplied by foods other than milk.

Highly significant differences among breeds of sheep ($P < .01$) were found to exist for weaning weight. Weight differences between sexes within a breed were not significant, and there appeared to be no significant interaction between breed and sex.

A correlation coefficient of 0.84 between total gain of the lamb and total grams of milk produced by its dam was highly significant. Seventy percent of the variation in total gain is accounted for by variation in total milk yield.

The breeds ranked in the following order for carcass tenderness and composite preference of meat; Columbia, Willamette, Dorset Horn, Border Cheviot, and Suffolk.

It was postulated that lamb weight at eight to ten weeks of age would be a better criterion by which to cull low producing ewes and to select replacement females and males than the 120-day weight. The conformation score, composite preference score, tenderness score, and the percentage of protein, solids-not-fat, milk fat, and total days nursed, were not affected by the breed, sex or rearing of the lambs studied. Only 100-day weight and condition scores were affected by breed. Total gain of the lamb was affected by the quantity of milk and milk components produced by the dam.

CERTAIN GENETIC AND MATERNAL ENVIRONMENTAL INFLUENCES ON GROWTH RATE AND BODY COMPOSITION OF LAMBS

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CERTAIN GENETIC AND MATERNAL ENVIRONMENTAL INFLUENCES ON GROWTH RATE AND BODY COMPOSITION OF LAMBS

INTRODUCTION

Individual animals of a given breed and species differ in their ability and efficiency to gain weight or to produce milk or wool. Animals with the inherited capacity for a rapid rate of growth or production usually require less feed per unit of production and are therefore more efficient than their slower performing relatives. It is well established that to some degree these differences in rate and efficiency of gain are inherited. In practically all cases it can be demonstrated that this is a quantitative type of inheritance where many pairs of genes are presumed to influence the attributes which contribute to such differences.

The growing importance of performance in the breeding of sheep for meat during recent years has placed a great deal of emphasis on the weaning weight of lambs. The extreme variation observed in weaning weights at a standard age indicates that the potentials for heavy weaning weights are great and have certainly not been fully realized.

The heritability for weaning weight is estimated to be in the medium range with milk production of the dam being the greatest single factor influencing it (10, p. 379). Milk production also has a heritability estimate that falls within the medium range.

The quantity of milk required to raise a lamb to 70, 80, 90, or 100 pounds at 120 days of age has not been determined. Little is known concerning the influence of differences in composition of milk upon growth rate, weaning weight, and the finish of lambs nursing their dams.

The fat lamb industry is based upon the assumption that a high percentage of the ewes in the population will produce one or two large, highly finished lambs at weaning time. Probably one of the greatest gaps in our knowledge of fat lamb production lies in the area of milk production by mutton breeds and the milk requirements of lambs for various levels of production.

Many breeders make use of creep feeding as a method of improving weaning weight, condition, and hence, salability of their lambs. The effectiveness of this method is unquestioned but the practice also definitely tends to shield females of poor milking ability from culling. This in turn perpetuates poor milk production characteristics in the sheep population. If weaning weights of 80-100 pounds can be attained by ewes under good conditions without creep feeding, the lambs may be slaughtered at weaning time with considerably less expense to the producer and with greater efficiency of production.

The sheep industry is passing through a critical time, in that it is becoming of utmost importance that a desirable product be produced at a price that will compete with other kinds of meats and with foreign imports. At the present time fat lambs are being sold directly off the ewe while those that are not fat are sold as feeders. Lambs that are sold as fat lambs directly off the ewe are usually produced efficiently with the main expenses being the maintenance of the ewe with some additional feed or grass for the lamb. While in contrast feeder lambs require large quantities of grass or concentrates to finish them to a desirable grade.

Rapid growth is highly desirable in fat lamb production because 1) rate of gain is correlated with efficiency of feed utilization, 2) per unit costs are reduced when lambs are on the farm for a shorter length of time, 3) cyclic market trends usually favor spring lambs that reach the market earlier. In addition, the rate of gain is usually positively related with condition, the most important single criterion of market grade. A knowledge of the conditions essential for most rapid growth of lambs is therefore important from an economic viewpoint and also as an aid in selection when weight gain and condition are the endpoints.

There is an abundance of literature concerned with production and composition of milk from dairy sheep and cattle, but a relatively small amount of work has been reported for mutton sheep. In view of these facts, an attempt has been made to determine the amount of variability in milk yield and milk components (protein, lactose + ash, solids-not-fat, fat, total solids, and water) of individual ewes of the Border Cheviot, Dorset Horn, Columbia, Suffolk, and Willamette breeds of sheep.

It was the aim of this investigation to make the observations as fair as possible with respect to all breeds studied. The results are not given with the intent of comparing the desirability or undesirability of the breeds included in this investigation.

The study was designed to develop and provide new insight into the phenomenon of milk production of ewes of the mutton breeds normally kept in the Willamette Valley of Oregon. It included the influence of a given quantity of milk consumed, of a given composition upon the weaning weight of mutton lambs. It also involved the normal lactation pattern and the effect that milk yield and milk components have upon pre-weaning growth of the lamb.

The objectives of this experiment were:

1. To determine the milk yields under similar nutritional conditions of purebred ewes of the Border Cheviot, Dorset Horn, Columbia, Suffolk, and Willamette breeds.

2. To determine the individual variation in yield and composition of milk produced within and between breeds.

3. To determine the relationship of the stage of lactation with the level and composition of milk produced by mutton ewes.

4. To determine the effect of breed upon the production and composition of milk ignoring the effects of age and weight of the ewe.

5. To determine the relationship of the quantity and composition of milk produced by ewes of mutton breeding with the growth rate, weaning weight, and quality of their lambs.

6. To determine the factors influencing milk yield, and to assess the effects of genetic and environmental factors such as sex, breeding, and rearing.

7. To develop simplified methods for assessing the milk yields of ewes under farming conditions.

The Willamette breed, was formed by mating Columbia ewes with rams from Dorset Horn and Border Cheviot breeds. Reciprocal matings were made between these two crosses for two years. The line was then closed and subsequent offspring were rigidly selected for growth rate during several years in forming the Willamette breed. In the present study Willamette ewes were compared for production traits with the foundation breeds, Columbia, Dorset Horn, and Border Cheviot of the same general source as the original breeding stock that was used in forming the breed.

REVIEW OF LITERATURE

Milk production of the ewe has been the subject of considerable research because it is the main factor affecting the growth of the lamb, particularly during the first few weeks of life. One of the main difficulties encountered in these studies has been the development of a suitable technique for measuring the milk yield of the ewe. The first attempt to determine the milk production of a group of non-dairy ewes was made in 1904 (30). Over a period of two days the lambs, seven weeks old, were separated from their mothers and weighed before and after they had suckled on each of six occasions during each day. On the third day the ewes were milked five times by hand, and this gave an average daily yield of only 1.02 pounds compared to the 2.80 pounds which had been obtained by the lambs.

The lamb-suckling technique has since been the basis of the studies on the lactation of the non-dairy breeds of sheep. Several workers (6; 7; 17; 23; 24; 30; 32; 45; 48; 50; 51; 52; 54; 58; 62; 64; 66) have measured milk yield under pen-feeding and/or pasture conditions.

The procedure followed has varied in detail from worker to worker, but usually the milk yield has been measured at weekly intervals by recording the sum of the milk intake of lambs during several sucklings over a 24 hour period. The main difference in the detail of the procedure used by the various workers has been in the number of sucklings and the intervals between these sucklings over the period that data were recorded. One of the main problems with this technique was the separation of the ewe from the lamb which caused an upset of the ewe and probable deleterious effects on milk secretion and ejection. This was more likely to occur under grazing conditions, where, because of her disinclination to leave the lamb, the grazing time of the ewe could be seriously limited. Owen (50, p. 357) overcame this problem by fitting his ewes with udder covers, so that ewes and lambs could graze together during the intervals between sucklings. These covers have since been used successfully by Davies (23; 24, p. 824-838).

There are several difficulties with the suckling technique. The method is tedious and time consuming. As lactation proceeds the milk intake of the lamb decreases and its live weight increases. Under these conditions the accurate measurement of the gain in weight of a lamb after suckling becomes increasingly difficult. These are the reasons why most lactation studies, based on this technique, have only been carried out over the first ten weeks of the lactation period (6, p. 237-248).

Barnicoat, Logan and Grant (6, p. 237-248) investigated two methods for measuring the milk yield of ewes. For reasons not stated, a small milking machine with teat cups adapted to fit the ewe proved unsatisfactory. They also used intravenous injections of Pituitrin (posterior pituitary extract, PPE), administered at the rate of ten units in five ml of physiological saline, to facilitate hand milking. Of 17 Romney Marsh ewes tested 14 yielded 80 to 100 percent and the other three ewes yielded only 75 percent or less of their accumulated milk, as compared with what the lamb obtained by suckling. The method of measuring the residual milk was not described, but because of the incomplete emptying of the udder the technique was discarded. McCance (38, p. 840) has reported an extensive study into the use of such a technique for the estimation of milk yield of the ewe with successful results. Lambs placed with ewes that had been hand milked after two doses of five i.u. of PPE, could obtain little or no milk.

The milk intake of single lambs mothered by Merino ewes was estimated by lamb suckling and by hand milking after oxytocin injections. The oxytocin estimate was significantly higher for a period of 1/2 to 10-1/2 weeks after parturition ($P < .01$) but for the first four weeks of this period the difference was not significant ($P > .10$). It was suggested that the oxytocin technique might be a better estimate of the lamb's intake than lamb suckling (44). Yield depended on the interval between milkings, the rate of secretion being apparently faster in the first two hours. The effect was less marked as lactation declined. Yields were independent of time of day and speed of milking. When successive yields were used to rank ewes in order of performance, the rankings were always significantly concordant. Earlier applications of the method had no detectable effect on later lactation. Coombe, Wardrop and Tribe (20) and McCance (38, p. 839) concluded that PPE provides a simple means of obtaining useful estimates of milk production.

The lamb-suckling technique does not remove all the ewe's milk, but this does not appear to be the reason, as suggested by Coombe, Wardrop and Tribe (20), for differences in the milk production of ewes rearing singles and those rearing twins (24, p. 824-838). Differences in milk production in favor of ewes nursing twin lambs over those nursing singles have been reported (2; 6; 26; 48; 58; 64). Using McCance's technique (38, p. 840) in pen-feeding experiments with lactating ewes, Davies (24) obtained more milk from twin-bearing ewes than from those rearing singles. The onset of lactation is somewhat slower in ewes bearing twins than in ewes bearing singles. The milk production rate during the first 12 hours after parturition is independent of the number of lambs born.

Comparisons between twin lambs and singles show that during the period when the lamb is not a functional ruminant (0 to 4 weeks) the growth rate of twins was considerably slower than that of single lambs. There was no difference in the growth rate of Merino single and twin lambs after six weeks, but it was eight weeks before the difference in growth rates of single and twin crossbred lambs disappeared (24, p. 838).

Davies (24, p. 824) found that milk production by ewes tends to be, in part at least, an expression of the sucking activity of lambs. Nutrition, however, does affect lactation and the shape of the lactation curve. Ewes given supplementary feed during the lactation period produce more milk in the sixth, seventh, and eighth weeks of lactation than when grazed on pasture alone. This suggests that feeding even in the later stages of lactation may enhance the milk supply to the lamb. Well-fed ewes suckling twins usually produce more milk than ewes suckling single lambs (6; 32; 61; 64), although Burris and Baugus (17) observed no difference. Alexander and Davies (2) found milk yield to be greatly influenced by the number of lambs suckled and not by the number of lambs born.

Wallace (64, p. 93-153) and Barnicoat, Logan and Grant (6, p. 237-248) suggested that differences in milk production between ewes rearing one lamb and ewes rearing two lambs were probably due to one of two factors. One of the factors could be the capacity of the single lamb to draw off the formed milk to a lesser extent than that of twins. In this case the pressure created by accumulated milk would reduce the rate of milk secretion. The second factor might be the external stimulus of sucking by twins is greater than that of single lambs. Barnicoat, Logan and Grant (6) based their conclusions on observations in which twin-bearing ewes rearing single lambs yielded on the average no more milk than single-bearing ewes. Alexander and Davies (2) published data which included the milk production of ewes suckling twins, which supports the conclusion that the milk yield is influenced by the number of lambs suckled. Their observations support the suggestion of Wallace (64), that the best estimate of the potential level of production would be obtained when ewes suckled twins, when the milk production was not greater than the lambs' appetite, and where maximal suckling stimulus was applied.

There have been very few comparative studies on the influence of milk production on lamb growth in different breeds of sheep. Neidig and Iddings (48, p. 19-32) compared six breeds of sheep and found that the Hampshire ranked first in milk production while differences between Cotswold, Shropshire, Rambouillet, Lincoln, and Southdown were not as large. Slen, Clark and Hironaka (58) compared the growth of lambs and milk production from ewes of five breeds of sheep (Suffolk, Hampshire, Rambouillet, Canadian Corriedale, and Romnelet). They did not consider the sex of the lambs in selecting ewes for measuring the milk production as they believed that any difference due to sex would be expected to be small. Ewes nursing twins produced more milk than those nursing singles ($P < .01$). They also found that among ewes nursing single lambs breed differences were evident with the difference being greatest during the first two weeks of lactation. Among ewes nursing singles, Suffolks produced the greatest amount of milk ($P < .01$). The Suffolk produced significantly more milk than the Rambouillet ($P < .05$) and Canadian Corriedale and Romnelet ($P < .01$), with no difference between the Suffolk and Hampshire breeds. The only breed differences of ewes nursing twins were that the Canadian Corriedale and Suffolk produced more milk ($P < .05$) than the Hampshire. The gain in body weight of single lambs was greater than that of twins in all breeds ($P < .01$). However, among twin lambs, no differences in body weight gains between breeds were evident. Correlations between daily milk production and lamb gains were more variable in single lambs than in twins.

It appeared that milk drawn by twins is a measure of the milk production of the ewe while that drawn by singles, especially in the first few weeks of lactation, is a measure of the *ad libitum* consumption of milk (58). Such a conclusion is also supported by the results of Alexander and Davies (2) who found that actual milk production based on milk obtained following an injection of posterior pituitary extract was similar in ewes bearing single or twin lambs. The use of ewes with twin lambs, where milk yield is much greater, would appear to provide a more adequate measure of production.

Although significant differences in milk production between breeds existed among ewes nursing twin lambs, no differences existed between the gain in weight by the lambs. It appeared that the lambs receiving less milk were either able to utilize it more efficiently or that they received sufficient nutrients from the creep feed to support the gain in body weight. It was concluded that the quantity of milk produced by the ewe is an important factor in determining the gain of the lambs. It also should be recognized that creep feeding is a contributing factor in the gains made by the lambs.

The data presented by Slen, Clark and Hironaka (58) show that, on a given ration, the protein and fat contents of ewes' milk were similar for the five breeds studied. However, since consistent differences in fat or protein content of the milk were not found between breeds or between ewes nursing single or twin lambs, it appeared that the quantity of milk was the major factor influencing the weight gains of the lambs.

The shape of the lactation curves reported for sheep is a short increase to an early peak, depending on breed and level of yield, with a subsequent gradual decline (50, p. 387-412). Bonsma (11, p. 65) found that ewes of low-producing breeds tend to have an earlier peak than ewes of high-producing breeds. Wallace (64, p. 93-153) showed that ewes suckling a single lamb have lower yields and flatter lactation curves than those suckling twins. In the Hampshire ewes recorded by Burris and Baugus (17), those rearing twins showed little difference in their lactation curve from those rearing singles.

Leaving two lambs on the ewe for a few days to establish a high level of milk yield did not benefit the remaining lamb after its twin was removed nor did it change the shape of the lactation curve (2; 6; 26; 64).

When the lactation period was divided into three equal portions, 40 to 41 percent of the total milk yield was in the first period, 32 to 34 percent was in the second and 25 to 27 percent was in the last period (62, p. 263-274). Many workers (17; 64, p. 108), have described milk production by periods as being approximately 38 percent in the first month about 30 and 21 percent in the second and third respectively and only about 11 percent in the last month of a four month lactation period. They further suggest that, though nutrition during late pregnancy greatly affects the vitality of the new born lamb, it has perhaps an even greater effect on the milk supply of the ewe. The work by Thomson and Thomson (62, p. 263-274) indicated that when milk production of Cheviot ewes was altered by depressed levels of feeding during the last six weeks of pregnancy, the growth rate of lambs was markedly decreased.

Wallace (64, p. 152) observed correlation coefficients of 0.88 to 0.90 between milk consumption of lambs and their live weight increase between birth and 28 days of age, when both single and twin lambs were included. This inclusion would tend to increase the correlation coefficient since both milk consumption and weight increase were lower for the twin lambs than for single lambs. The work of

Barnicoat, Logan and Grant (6, p. 237-248) with high producing Romney ewes indicated that early growth (birth to three weeks) was not correlated with milk production of the ewe when production was in excess of the amount that the lamb could consume. The work of the authors reviewed indicates that a considerable amount of variation in milk production exists between ewes within a breed. Milk production was closely associated with weight gains of the lambs. The correlation coefficients between milk consumption and growth of the suckling lambs were of such magnitude that the statistical efficiency of most trials designed to measure other factors affecting growth of suckling lambs would be increased by milk consumption determinations.

Bonsma (11, p. 191) recorded positive correlations of milk production with live weights of ewes, birth weight of lambs, and rate of gain of lambs. He also reported a highly significant correlation between milk yield of the ewe and the weight of the lamb from one week of age through eleven weeks. The correlation declined progressively from the beginning until the eleventh week of lactation.

Wallace (64, p. 129) estimated that during the first month over 80 percent of the variations in growth rates of lambs were related to differences in milk intake. This relationship declined as the lambs became increasingly dependent on supplementary foodstuffs. He noted that both birth weights of lambs and milk yields were markedly affected by the plane of nutrition of the ewes, particularly during the late stages of pregnancy.

Barnicoat, Logan and Grant (6, p. 237-248) presented correlation coefficients relating to the period between 0 and 12 weeks. Correlation coefficients were highest during the third through the ninth weeks. They also found a high correlation between milk yields and lamb gains from birth to six weeks of age. The correlation between milk production and lamb growth declined during the seven to nine week stage and at 10 to 12 weeks was of little value. From the data obtained over an eight year period, correlations between milk yields and lamb gains at 12 weeks were found to range between 0. 61 to 0. 81 (all highly significant), and to average 0. 72. Variations in milk consumption during the first 12 weeks were associated with one-third to two-thirds (average one-half) of the variations in growth rate. In another experiment where ewes were stall fed and their lambs were restricted in grazing the correlation was 0. 90, or about 80 percent of the variations in gain were controlled by differences in milk intake. Under fat lamb conditions, milk intake is the most important factor governing lamb growth rate (48, p. 19-32).

Barnicoat _et al_. (7, p. 9-35) reported that correlation coefficients between milk yield and live weight gains are highest during the first six weeks of lactation. The gain from zero to six weeks would be expected to be closely related to the gain from 0 to 12 weeks and results from several seasons indicate that the correlation coefficient is 0.90 or higher. Rates of gain of lambs to 12 weeks or longer are usually linear, or nearly so. The rate of gain to six weeks is therefore a good indication of the expected rate of gain to weaning.

Correlation coefficients between the milk consumed and the gains in live weight of lambs vary from one period to the next. For instance from birth to three weeks the correlation coefficients were in generally irregular because the lambs were not able to consume all of the milk being produced. From four to six weeks they were highest because lambs were able to consume all of the milk produced, and milk secretion was also at its peak. From 7 to 12 weeks they were low, except in the case of underfed lambs, because lambs then normally obtained most of their sustenance from grass.

Apparently under fat lamb farming conditions the milk intake was of most importance during the first six to eight weeks, after which pasture nutrients were of greater importance. Nevertheless, even at 12 weeks of age the effect of milk nutrients on lamb growth was still significant, for about one-third to two-thirds of the variations found in rate of gain were related to variations in milk intake (32, p. 70).

Many investigators (6; 29; 36; 45; 50; 57; 62) working in different countries with different breeds under varying conditions, found that the average quantity of milk required to produce one kg of live weight ranges from 3.5 to 6.0 kg. Lambs differ but little in their efficiencies as converters of milk to body tissue. During the first 12 weeks of lactation, it was found that on the average 5.5 ounces of milk were ingested for each one ounce gain in live weight (6, p. 237-248). Bonsma (11, p. 102) reported that the ratio of milk consumed to live weight gain was as follows: 1 to 3 weeks, 5.92; 3 to 6 weeks, 4.96; 6 to 9 weeks, 4.19; and 9-12 weeks, 3.83.

Barnicoat et al. (7, p. 9-35) concluded that the milk production of the ewe is the major factor influencing the rate of live weight gain of the lamb. Also the weight of milk rather than its nutritive value estimated from composition gives the best index of its lamb fattening qualities. They further noted that the factor most capable of influencing the quantity of milk produced is the plane of nutrition. Thus adequate feeding during lactation maintains milk production in the important early stages of the lamb's existence. Therefore, liberal feeding during pregnancy helps to sustain milk flow, particularly in the later stages of lactation, and would presumably exert a dominant influence on the production of colostrum.

Selection for milk production where based on lamb gains alone will not be a successful method for improving the milk producing ability of a ewe flock. Also the influence of the sire on the milking qualities of its ewe progeny might prove to be of additional value.

It has been shown that milk yields of ewes are affected by the following factors: age, condition, breed, individuality, inheritance, nutrition, time of lambing, number of lambs suckled, and disease. Growth of the young lamb is governed by the amount of milk consumed. Since the body form and composition depend on the rate at which growth takes place, it is reasoned that the carcass quality of lambs depends, in some measure, on the milking ability of the ewe (60; 12; 64).

MATERIALS AND METHODS

Nine mature ewes in their fourth lactation and one ram from each of the following breeds of sheep: Border Cheviot, Dorset Horn, Columbia, Suffolk, and Willamette were utilized for this study making a total of 45 ewes and five rams from the five breeds. The ewes were handled as a special unit during the pre-breeding period. During the pre-breeding period each ewe received 50 to 60 mg of an orally effective progestogen, 6 α-methyl-17 α-acetoxyprogesterone, "Provera", per day for 14 days (1). On the fifteenth day the ewes were separated by breed and mated to a ram of the same breed.

The reason for using a progestogen compound was to attempt to have all the ewes lamb within a narrow interval of days. Milk production and its effects on growth could then be measured under as similar environmental conditions as possible.

Of the 45 ewes that started the experiment in the fall one Dorset Horn and one Willamette ewe died before parturition and one Suffolk, one Willamette, and two Columbias died after lambing. There were two Dorset Horn and one Suffolk barren and one Suffolk, and two Border Cheviots had bad udders and were discarded from the experiment at the time of parturition; therefore, the study started with 33 ewes.

The milk study commenced in February and continued into

June. Colostrum samples were drawn 12 hours after parturition for component analysis. Colostrum flow usually ceased after three days and the ewes were then made available for routine milkings. The first milkings usually took place on the ninth or tenth day of the lactation period, and the ewe was then milked every fourteen days or seven times until her lamb was slaughtered at approximately the one-hundredth day of the lactation period. Lactation was divided into seven periods. The average length in days for each period and the average day of lactation when samples were collected are presented in Tables 1, 2, 3, and 4.

The following describes the procedures and events that occurred during the testing period. Milkings took place two days each week. Each ewe was milked every 14 days; therefore, one-fourth of the ewes were milked at each milking date. The lambs were separated from the ewes and weighed just prior to 11 p.m. The ewes were then given one ml or 20 i.u. of Purified Oxytocic Principle (POP) in the right jugular vein and were then immediately milked out completely. The milk from this milking was discarded without weighing. The important factor being that the udder was completely milked out. There was then a six-hour waiting period during which the lambs were kept separate from the ewes but were allowed to be in the adjacent pen, to cut down on excitement caused by the lamb being separated from its dam, after which the ewes were milked again at

Table 1. Average day of lactation for each period when milk samples were collected from ewes nursing single lambs.

Breeds	Periods 1	2	3	4	5	6	7
Border Cheviot	11.4	23.6	39.0	53.0	67.0	81.0	94.4
Dorset Horn	11.0	23.5	41.0	55.0	69.0	83.0	97.0
Columbia	10.8	24.4	38.4	52.4	66.4	81.2	93.8
Suffolk	8.0	22.0	36.0	50.0	64.0	78.0	92.0
Willamette	10.0	23.4	37.4	51.4	65.4	79.2	91.8

Table 2. Average day of lactation for each period when milk samples were collected from ewes nursing twin lambs.

Breeds	Periods 1	2	3	4	5	6	7
Border Cheviot	12.0	23.0	37.0	51.0	65.0	79.0	93.0
Dorset Horn	12.9	23.6	38.8	52.8	66.8	80.8	94.8
Columbia	9.5	18.7	32.5	46.5	60.5	79.0	93.0
Suffolk	7.0	18.7	32.7	47.0	61.0	74.5	88.0
Willamette	7.0	20.0	34.0	48.0	62.0	76.0	89.0

Table 3. Average length in days for each of the seven periods of lactation and the percentage that each period is of the total lactation period for ewes nursing single lambs.

	PERIODS														
	1		2		3		4		5		6		7		
Breeds	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Total Days
Border Cheviot	15.6	16.5	14.3	15.1	16.2	17.1	14.0	14.8	14.0	14.8	13.7	14.5	6.9	7.3	94.4
Dorset Horn	14.0	14.4	14.8	15.3	19.2	19.7	14.0	14.4	14.0	14.4	14.0	14.4	7.0	7.2	97.0
Columbia	16.4	17.5	15.1	16.1	14.0	14.9	14.0	14.9	14.0	14.9	13.3	14.2	6.3	6.7	93.8
Suffolk	15.0	16.3	14.0	15.3	14.0	15.3	14.0	15.3	14.0	15.3	14.0	15.3	7.0	7.6	92.0
Willamette	16.8	18.2	13.7	14.9	14.0	15.2	14.0	15.2	13.9	15.1	13.2	14.4	6.3	6.9	91.8
Weeks	2	--	4	--	6	--	8	--	10	--	12	--	13	--	13 weeks

Table 4. Average length in days for each of the seven periods of lactation and the percentage that each period is of the total lactation period for ewes nursing twin lambs.

	PERIODS														
	1		2		3		4		5		6		7		
Breeds	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Days	Percent	Total Days
Border Cheviot	16.0	17.2	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	7.0	7.5	93.0
Dorset Horn	16.3	17.2	14.1	14.9	15.3	16.1	14.0	14.8	14.0	14.8	14.0	14.8	7.0	7.4	94.8
Columbia	14.6	16.5	11.4	12.9	13.5	15.2	14.0	15.8	14.0	15.8	14.0	15.8	7.0	7.9	88.5
Suffolk	12.8	14.6	12.8	14.6	14.0	15.9	14.0	15.9	13.8	15.7	13.5	15.3	6.8	7.7	88.0
Willamette	13.5	15.2	13.5	15.2	14.0	15.7	14.0	15.7	14.0	15.7	13.5	15.2	6.5	7.3	89.0
Weeks	2	--	4	--	6	--	8	--	10	--	12	--	13	--	13 weeks

5 a.m. following the same procedure as that at the 11 p.m. milking. This milk was weighed and the quantity given in the six-hour period was recorded.

When observations were being made on a number of ewes, the ewes were taken in the same order for the first and the second milking. In order to ensure that the average period of collection was six hours, the first milkings were commenced at 11 p.m. and were completed by midnight. The second milkings were started at 5 a.m. and finished by 6 a.m. This allowed approximately one hour for the milking of eight ewes.

A second injection of POP was given immediately after the first milking was completed so that all of the residual milk would be removed. The same procedure was followed after the second milking. The second injections were continued throughout the experiment, but were found to be of no value because little additional milk was obtained.

A standard dairy milking machine with a modified manifold was used for the milkings. The pulsator mechanism was not suitable for milking the ewes, however, the machine was used as a source of suction. By manipulating the teat cups and udder a continuous stream of milk could be obtained from the udder until it was completely empty.

The milk that was collected from each ewe following this six hour period was weighed, stirred and a representative sample was taken for composition analyses. The quantity of milk obtained from a ewe in six hours was multiplied by four to estimate the quantity of milk that would be produced in 24 hours. The quantity of milk produced from one test period to the next test period was calculated by multiplying the 24-hour milk yield by the interval in days between the mid-points of any two consecutive test periods, and these quantities were accumulated to arrive at a complete lactation yield. This is the standard method used by the Dairy Herd Improvement Association to arrive at yearly milk yields for cows.

The following milk components were studied: protein, lactose + ash, solids-not-fat, fat, and total solids. Total nitrogen was determined by the Kjeldahl method and the results multiplied by the factor 6.38 to arrive at the percentage of protein. Fat was determined by the Babcock method, and total solids were obtained by the standard Mojonnier method. All of these methods are standard chemical methods used by the Dairy Industry for precise analyses.

The percentages for water, lactose + ash and solids-not-fat were calculated in the following manner. One hundred percent minus the percentage of total solids equals the percentage of water. The percentage of total solids minus the percentage of fat equals the percentage of solids-not-fat. The percentage of solids-not-fat minus the percentage of protein equals the percentage of lactose + ash. When each of these percentages is multiplied by the grams of milk produced during each period of lactation, and these are accumulated, one can compute the quantity of each milk component that was produced by an individual ewe for a complete lactation period. Total milk yield is divided into the totals for each of the components to arrive at the average percentage of each component for a complete lactation. This can be done on the basis of per ewe, per breed, or total of all breeds.

The efficiency of gains by the lambs were calculated for each period of lactation and for the total lactation period. These efficiencies were computed by dividing the total gain for each period or for the total lactation period into the quantity of milk and milk components produced during these times.

Live animal quality scores were given to each lamb completing the milk study. There were two scores for each animal; one for conformation and one for the condition of the animal. Conformation is judged primarily according to breed standards, and the condition score depends to a large extent upon the external finish of the animal. The scores for both conformation and condition range from 50 to 100 with the following grades being assigned numerical values: Prime, 90-100; Choice, 80-89; Good, 70-79; Utility, 60-69; and Cull, 50-59. Conformation and condition scores from four evaluators were averaged and recorded for each lamb at weaning.

The composite preference score and the tenderness score were given values that range from one to seven with seven being the most desirable and one the least desirable. These are determined by standard organoleptic procedures using the rack which consists of the portion from the fifth through the twelfth ribs of each lamb carcass.

The ewes were maintained on a medium plane of nutrition. The ration consisted primarily of "Lotus" pasture and alfalfa hay for the first four months of gestation. They received an additional one pound of an oats and barley mixture per ewe per day for the fifth month of gestation. This was continued throughout lactation or until grass became so abundant that the ewes no longer desired additional feed which occurred in the month of May.

The lambs were supplied with a creep feeder and received calf manna and a rolled oats and barley mixture *ad libitum* throughout the growing period. It would have been more desirable to limit the nutrient consumption of the lambs to that of the ewe's milk, but this was impossible if the lambs were to be ready for slaughter by the end of the lactation period. Thus it was deemed desirable to supply additional feed so that all lambs would have an equal opportunity for supplementary feed.

Statistical Treatment of the Data

Simple correlation coefficients were computed between each of the possible pairs for the production traits, carcass measurements, milk yield, and the milk components. Analysis of variance was used to study the effects of breeds on the percentages of the various milk components for the total milk produced by the ewes. The analysis of variance was also utilized in studying effects of period, breed, sex, and rearing on lamb weights. Least significant difference was used to differentiate between the treatment means.

Analysis of covariance was used to examine effects of breed and period on various milk components with the quantity of milk as a covariate. Breeds and periods constituted a factorial arrangement of the experimental conditions; however, this fact was ignored in the preliminary analysis of covariance.

Because of the outcome of the preliminary analysis involving the covariate, quantity of milk, the factorial effects of breeds, periods, and their interaction were analyzed by the analysis of variance involving unequal but proportional numbers in the subclass. This was performed on the percentages of protein, lactose + ash, solids-not-fat, fat, total solids, and water.

Effects of breed, sex, rearing, milk yield, and the milk components on each of several measures of performance (total gain, condition score, conformation score, composite preference score, and tenderness score) were determined by least-squares analysis. Measures of performance used in this study were: total gain, conformation score, condition score, composite preference score, tenderness score and grams of total protein, lactose + ash, solids-not-fat, fat, total solids, and total milk yield. The general least-squares approach was required by the fact that there were unequal numbers in the subclasses of a three-factor experiment. The analysis of variance in this study provided the basis for determining the significance of the effects studied.

RESULTS

The findings relative to milk yield, milk composition, stage of lactation in relation to growth, efficiency of gains, and synchronization of estrus will be presented in that order.

Milk Yield

In order to provide a general picture of the levels of milk production and the shapes of the lactation curves of the five breeds of ewes, the average amounts of milk produced during the successive periods of lactation have been calculated, Table 8, and lactation curves constructed, Figures 1 and 2. The ranking of each breed for milk yield and the milk components is shown in Table 5. The milk yields by periods of ewes nursing single and twin lambs are presented in Table 6. The Dorset Horn breed with one single lamb produced the greatest quantity of milk. However, this should not be emphasized, because there was only one Dorset Horn ewe in this group. Following in the order of greatest milk production are the Willamette, Suffolk, Columbia and Border Cheviot breeds. The percentage of the total milk produced within each period is shown in Table 7. By the end of the fourth period the Border Cheviot, Dorset Horn, Columbia, Suffolk, and Willamette breeds with single lambs had produced 75.4, 76.4, 75.6, 68.3, and 73.9 percent of their total milk yields, respectively. By

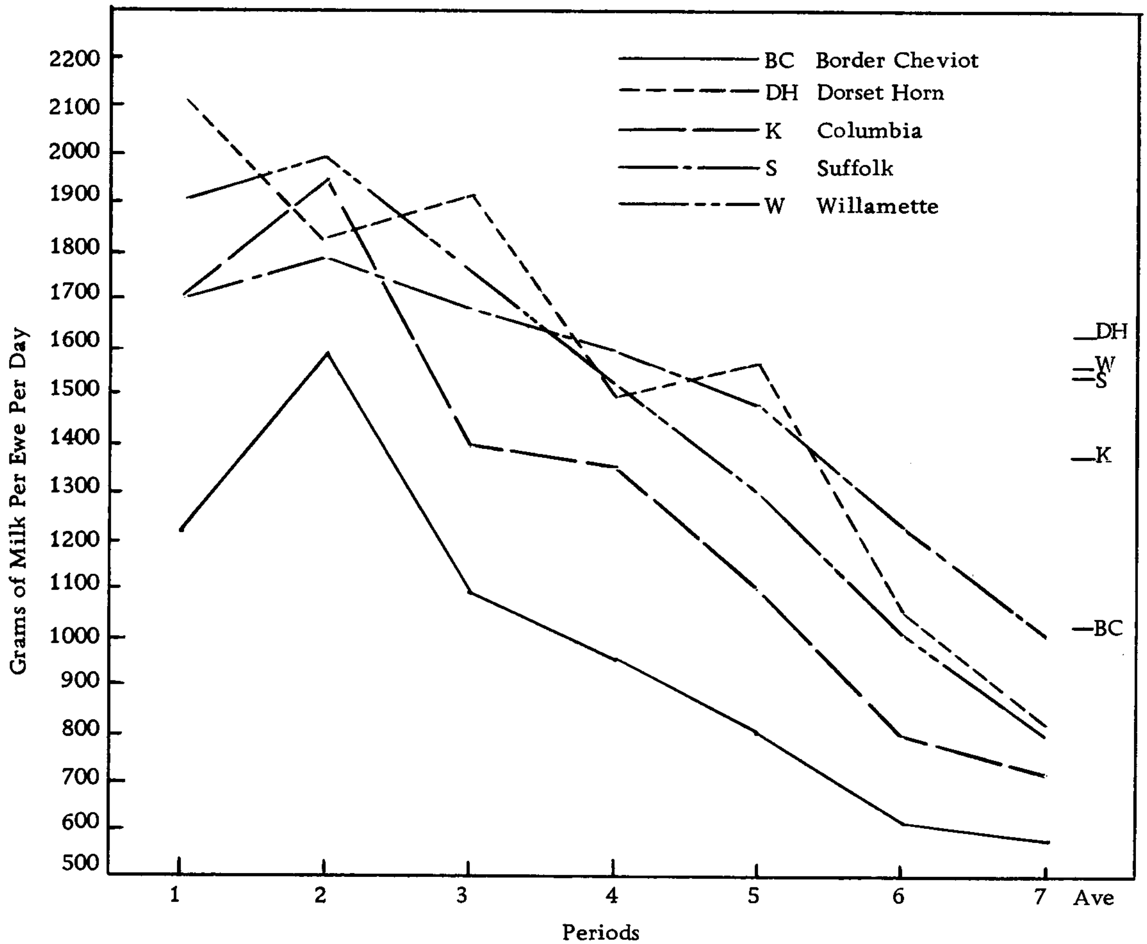

Figure 1. Average grams of milk produced per ewe per day by various breeds of sheep over seven periods of lactation for ewes nursing single lambs.

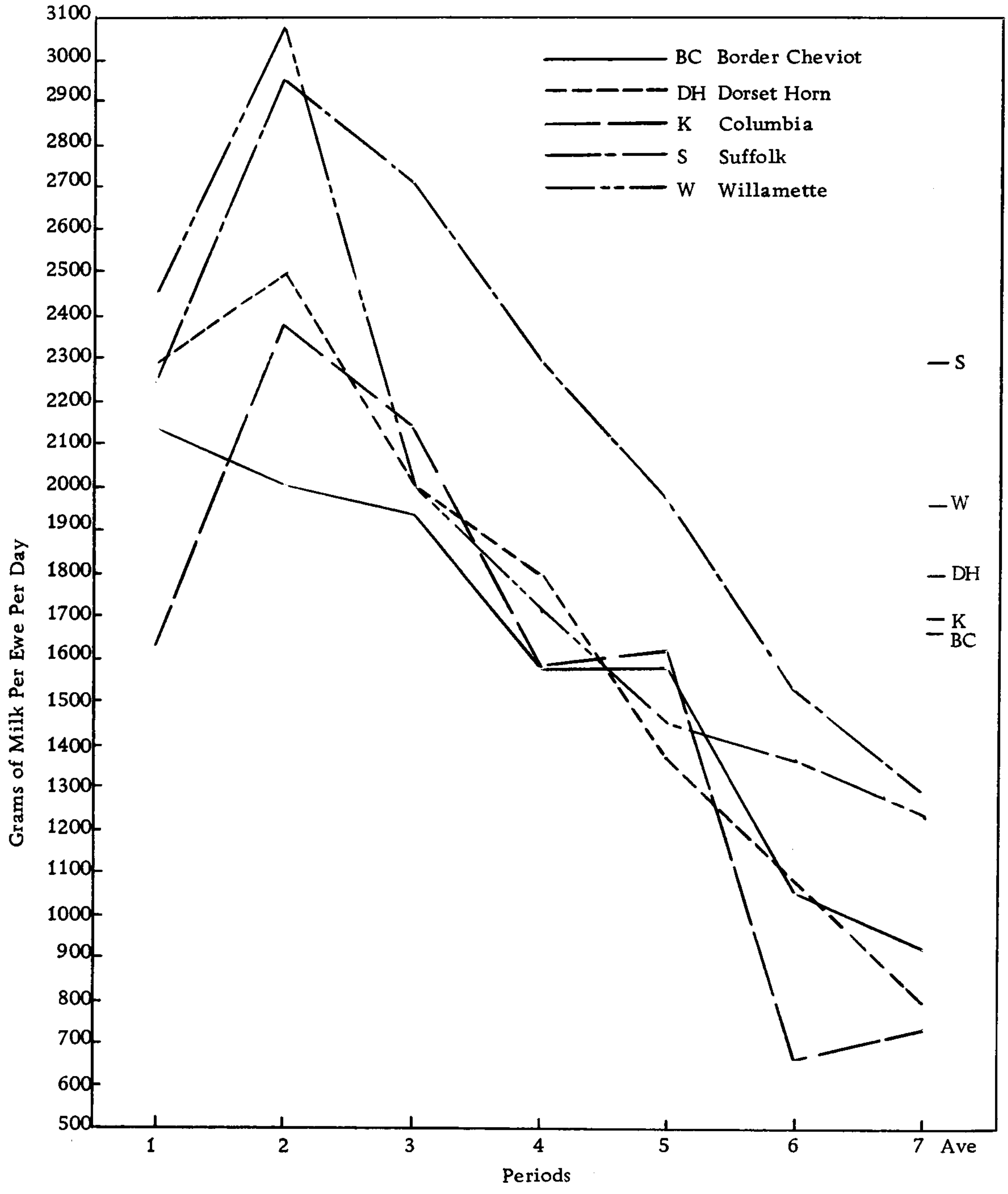

Figure 2. Average grams of milk produced per ewe per day by various breeds of sheep over seven periods of lactation for ewes nursing twin lambs.

Table 5. Ranking of the breeds according to average milk yield and average milk composition data.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water	Milk
			For ewes nursing single lambs				
Border Cheviot	5	5	5	5	5	5	5
Dorset Horn	3	1	1	1	1	1	1
Columbia	4	4	4	4	4	4	4
Suffolk	2	2	3	2	3	3	3
Willamette	1	3	2	3	2	2	2
			For ewes nursing twin lambs				
Border Cheviot	4	5	4	4	4	5	5
Dorset Horn	3	3	3	3	3	3	3
Columbia	5	4	5	5	5	4	4
Suffolk	1	1	1	1	1	1	1
Willamette	2	2	2	2	2	2	2

Table 6. Average grams of milk produced per period by ewes of various breeds.

Breeds	No. of Ewes	Periods 1	2	3	4	5	6	7	Total
		For ewes nursing single lambs							
Border Cheviot	5	18,991	22,404	17,629	13,345	11,376	8,393	3,925	96,063
Dorset Horn	1	29,739	26,977	36,937	20,714	22,114	7,342	5,692	149,516
Columbia	6	27,454	29,108	19,400	19,013	15,477	10,459	4,622	125,534
Suffolk	3	25,261	24,969	23,401	22,278	20,458	17,192	6,950	140,510
Willamette	5	31,934	27,947	24,947	21,235	18,053	14,005	5,078	142,528
		For ewes nursing twin lambs							
Border Cheviot	2	34,067	28,773	27,135	21,994	22,075	14,650	6,488	155,181
Dorset Horn	4	37,201	30,771	35,194	25,501	19,188	14,956	5,510	168,322
Columbia	1	23,665	27,017	28,798	21,944	22,767	9,173	5,130	138,493
Suffolk	2	28,682	37,829	38,014	32,295	27,234	20,722	8,678	193,455
Willamette	2	33,179	41,634	28,185	24,094	20,140	18,409	8,012	173,653

Table 7. Percentage of the total milk produced per period by ewes of various breeds.

Breeds	Periods 1	2	3	4	5	6	7
	For ewes nursing single lambs						
Border Cheviot	19.8	23.3	18.4	13.9	11.8	8.7	4.1
Dorset Horn	19.9	18.0	24.7	13.8	14.8	4.9	3.8
Columbia	21.9	23.2	15.4	15.1	12.3	8.3	3.7
Suffolk	18.0	17.8	16.6	15.9	14.6	12.2	5.0
Willamette	22.4	19.6	17.0	14.9	12.7	9.8	3.6
	For ewes nursing twin lambs						
Border Cheviot	22.0	18.5	17.5	14.2	14.2	9.4	4.2
Dorset Horn	22.1	20.9	18.3	15.2	11.4	8.9	3.3
Columbia	17.1	19.5	20.8	15.8	16.4	6.6	3.7
Suffolk	14.8	19.6	19.6	16.7	14.1	10.7	4.5
Willamette	19.1	24.0	16.2	13.9	11.6	10.6	4.6

Table 8. Average grams of milk produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
	For ewes nursing single lambs							
Border Cheviot	1, 217	1, 567	1, 088	953	813	613	569	1, 016
Dorset Horn	2, 124	1, 823	1, 924	1, 480	1, 580	1, 049	813	1, 617
Columbia	1, 674	1, 928	1, 386	1, 358	1, 106	786	734	1, 366
Suffolk	1, 684	1, 784	1, 672	1, 591	1, 461	1, 228	993	1, 527
Willamette	1, 912	2, 040	1, 730	1, 517	1, 299	1, 061	806	1, 552
	For ewes nursing twin lambs							
Border Cheviot	2, 129	2, 055	1, 938	1, 571	1, 577	1, 046	927	1, 669
Dorset Horn	2, 282	2, 496	2, 011	1, 822	1, 371	1, 068	788	1, 778
Columbia	1, 621	2, 370	2, 133	1, 567	1, 626	655	733	1, 684
Suffolk	2, 241	2, 955	2, 715	2, 307	1, 974	1, 535	1, 276	2, 287
Willamette	2, 458	3, 084	2, 013	1, 721	1, 439	1, 364	1, 233	1, 951

the end of the fifth period the values were 87.2, 91.2, 87.9, 82.9, and 86.6 percent.

The order of the breeds in quantity of milk produced when nursing twin lambs differs from that reported for ewes with single lambs. The breeds ranked in the following order: Suffolk, Willamette, Dorset Horn, Border Cheviot, and Columbia. They produced 72.2, 76.5, 73.2, 70.7, and 73.2 percent respectively of their total milk yield by the end of the fourth period. By the end of the fifth period the breeds had produced 86.4, 87.9, 89.6, 84.8, and 84.8 percent, respectively of their total lactation yield.

The Dorset Horn breed produced the highest average daily yield for the seven periods and was followed in order by the Willamette, Suffolk, Columbia, and Border Cheviot breeds of sheep. The average grams of milk produced per ewe per day for each period of lactation by ewes raising singles or twins is presented in Table 8, and the production curves by periods are shown in Figure 1. For ewes nursing twin lambs the Suffolk shows the highest average yield for the complete lactation, and they were followed in order of production by the Willamette, Dorset Horn, Columbia, and Border Cheviot breeds (Figure 2). The ewes nursing twin lambs produced 24.4 percent more milk than ewes nursing single lambs. The percentage breakdown by breed is the following: Border Cheviot 39.1, Dorset Horn 9.0, Columbia 18.9, Suffolk 33.2, and the Willamette 20.5.

The peak of lactation generally occurred during the second period for ewes nursing either single or twin lambs. This was followed by a gradual decline through the fifth period and an even sharper decline during the sixth and seventh periods (Figures 1 and 2).

The average grams of the milk components produced per ewe per day by various breeds of sheep for ewes nursing either single or twin lambs is presented in Table 9. The averages for the milk components by periods are found in Appendix Tables 1 through 6. The ranking for each breed according to the quantity of the milk components produced is shown in Table 5. The ewes nursing twins produced 24 percent more protein, 23.8 percent more lactose + ash, 23.9 percent more solids-not-fat, 27.5 percent more fat, 25.5 percent more total solids, and 24.2 percent more water than did ewes rearing single lambs.

In summary, the one Dorset Horn ewe raising a single lamb ranked first among breeds for the quantity of milk, lactose + ash, solids-not-fat, fat, total solids, and water, but was third in protein content. However, the Dorset Horn ewes raising twins ranked third in all categories. The Suffolk ewes rearing single lambs ranked second in protein, lactose + ash, and fat. While they were third for the quantity of milk, solids-not-fat, total solids, and water produced. The Suffolk ewes raising twin lambs ranked first in all categories. The Willamette ewes raising single lambs were highest in protein;

Table 9. Average grams of milk components produced per ewe per day by various breeds of sheep over a complete lactation.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water
			For ewes nursing single lambs			
Border Cheviot	58.4	53.8	112.2	88.5	200.8	815.7
Dorset Horn	81.3	92.4	173.7	134.3	308.0	1,309.1
Columbia	69.4	75.0	144.3	114.0	258.4	1,107.2
Suffolk	84.1	84.3	168.5	121.3	289.8	1,237.5
Willamette	86.4	83.7	170.1	119.8	289.9	1,262.1
			For ewes nursing twin lambs			
Border Cheviot	87.8	87.0	174.8	153.1	327.9	1,340.7
Dorset Horn	96.5	97.0	193.5	153.7	347.2	1,430.6
Columbia	84.6	89.3	173.9	134.8	308.7	1,374.9
Suffolk	125.4	130.2	255.6	179.3	434.9	1,851.8
Willamette	105.0	107.2	212.2	176.3	388.5	1,562.7

second in quantity of milk, solids-not-fat, total solids, and water; and third in the quantity of lactose + ash and fat produced. While Willamette ewes raising twin lambs ranked second in all seven categories. The Columbia ewes raising singles ranked fourth in all seven categories. While the Columbia ewes with twins ranked fourth in the quantity of milk, lactose + ash, and water produced. They also were ranked fifth for protein, solids-not-fat, fat, and total solids. The Border Cheviot ewes raising singles ranked fifth in all seven categories. While the ewes suckling twins were fourth in the quantity of protein, solids-not-fat, fat, and total solids produced. They were also fifth in the yield of milk, lactose + ash, and water. The rankings of the breeds are clearly demonstrated in Table 5. The ewes nursing twins produced 25 percent more milk components than the ewes nursing singles.

The quantities of the milk components from one period to the next period and for the total lactation period follow the lactation curve for milk yield very closely. There is one primary reason for this; that being, that the percentages for the milk components do not fluctuate very much over the entire lactation period. There is a relationship, however, between the percentages of milk components and milk yield. As yield increases the percentages for protein, solids-not-fat, fat, and total solids decrease, $(P < .01)$ and lactose + ash $(P < .05)$. While the percentage of water increases, $(P < .01)$. This relationship is supported by the fact that significant differences ($P < .01$) were obtained between periods. Also the significant interaction ($P < .05$) for fat, total solids, and water illustrates that all of the breeds did not perform the same from period to period.

Factorial analysis of breeds, periods, and breeds by periods was run on the percentages for protein, lactose + ash, solids-not-fat, fat, total solids, and water. For breeds the values for protein and fat are significant, $P < .01$ and $P < .05$, respectively. All of the milk components were significant ($P < .01$) for periods. Fat, total solids, and water were significant ($P < .05$) for the breed by period interaction. The F-values are presented in Table 10.

Table 10. Analysis of variance for percentages of the milk components by breed and period.

Items	Breeds	Periods	Interaction
Protein	4.96**	6.46**	1.33
Lactose + Ash	0.44	5.12**	0.95
Solids-Not-Fat	1.88	15.48**	1.49
Fat	3.03*	4.19**	1.53*
Total Solids	1.73	9.09**	1.67*
Water	1.73	9.09**	1.67*
	4 and 182 d.f.	6 and 182 d.f.	24 and 182 d.f.

*Indicates significance at the five percent level of probability.
**Indicates significance at the one percent level of probability.

Colostrum Milk

Colostrum samples were collected 12 hours after parturition from ewes of all five breeds and analyzed for the percentage of their various components. The quality of the colostrum as judged by the rankings of the breeds from highest to lowest is as follows: Suffolk, Willamette, Border Cheviot, Dorset Horn, and Columbia.

Milk Composition

Analysis of variance was run on the milk composition percentages for protein, lactose + ash, solids-not-fat, fat, total solids, and water to see if there were breed differences for the percentages of the milk components. The results are presented in Table 12. There were no significant differences ($P > .05$) between any of the breeds for the milk components studied. The percentage of each milk component for the five breeds of sheep over the seven periods of lactation are given in Appendix Tables 7 through 12. The percentages of the milk components by breed are shown in Table 13.

Lamb Growth

The average gain for single and twin lambs for each period is shown in Table 14. Percentages of gains for each period are presented in Table 15. The average daily gains for single and twin lambs

Table 11. Percentages of various components in sheep colostrum.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water	Quality Rank
Border Cheviot	11.80	3.19	14.99	15.80	30.79	69.21	3
Dorset Horn	8.02	3.44	11.46	14.18	25.64	74.36	4
Columbia	6.01	3.69	9.71	8.27	17.97	82.03	5
Suffolk	16.71	2.82	19.54	16.37	35.90	64.10	1
Willamette	13.25	4.05	17.30	13.08	30.38	69.62	2
Average	11.16	3.44	14.60	13.54	28.14	71.86	-

Table 12. Variance and mean table of milk components between breeds.

Components	Mean Squares		F-ratio	General Mean	Standard Deviation	Coefficient of Variation
	Within Breeds	Between Breeds				
Protein	0.2380	0.4891	2.06	5.462	0.4879	8.90
Lactose + ash	0.1743	0.0734	0.42	5.397	0.4175	7.70
Solids-not-fat	0.1432	0.3338	2.33	10.859	0.3784	3.50
Fat	0.9843	0.6834	0.69	8.431	0.9921	11.80
Total Solids	1.2874	0.7644	0.59	19.290	1.1350	5.90
Water	1.2874	0.7644	0.59	80.710	1.1350	1.40

There were no significant differences between the breeds for any of the milk components ($P > .05$).

Table 13. Percentage of milk components by various breeds of sheep.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water
		For ewes nursing single lambs				
Border Cheviot	5.75	5.30	11.04	8.71	19.75	80.25
Dorset Horn	5.02	5.72	10.74	8.31	19.05	80.95
Columbia	5.08	5.49	10.57	8.35	18.92	81.08
Suffolk	5.51	5.52	11.03	7.94	18.97	80.03
Willamette	5.57	5.39	10.96	7.72	18.68	81.32
		For ewes nursing twin lambs				
Border Cheviot	5.26	5.22	10.48	9.18	19.65	80.35
Dorset Horn	5.43	5.45	10.88	8.65	19.53	80.47
Columbia	5.02	5.31	10.33	8.00	18.34	81.66
Suffolk	5.48	5.70	10.18	7.84	19.02	80.98
Willamette	5.38	5.50	10.88	9.03	19.91	80.09

Table 14. Average grams of gain by various breeds of sheep for seven periods of lactation.

Breeds	No. of Lambs	Periods 1	2	3	4	5	6	7	Total
					Single lambs				
Border Cheviot	5	2, 917	3, 135	3, 977	2, 857	3, 175	4, 354	3, 810	24, 226
Dorset Horn	1	2, 381	3, 619	5, 654	3, 402	4, 082	4, 990	4, 536	28, 664
Columbia	6	2, 959	4, 243	3, 887	4, 341	4, 990	4, 675	4, 137	29, 232
Suffolk	3	2, 964	4, 340	5, 292	4, 309	4, 687	5, 900	4, 990	32, 482
Willamette	5	3, 520	5, 153	5, 261	4, 807	5, 350	4, 718	5, 171	33, 981
					Twin lambs				
Border Cheviot	4	4, 082	4, 207	6, 010	6, 124	7, 258	9, 979	7, 258	44, 917
Dorset Horn	8	5, 994	4, 912	7, 081	6, 350	8, 618	8, 618	7, 598	49, 172
Columbia	2	4, 415	3, 614	5, 874	5, 216	9, 866	5, 897	6, 804	41, 686
Suffolk	4	3, 665	7, 525	7, 258	8, 392	9, 561	9, 979	7, 768	54, 147
Willamette	4	3, 923	6, 147	6, 804	8, 051	10, 660	12, 020	8, 164	55, 769

Table 15. Percentage of the total gains made by lambs during each of the seven periods of lactation by various breeds of sheep.

Breeds	Periods 1	2	3	4	5	6	7
	Single lambs						
Border Cheviot	12.0	12.9	16.4	11.8	13.1	18.0	15.7
Dorset Horn	8.3	12.6	19.7	11.9	14.2	17.4	15.8
Columbia	10.1	14.5	13.3	14.8	17.1	16.0	14.2
Suffolk	9.1	13.4	16.3	13.3	14.4	18.2	15.4
Willamette	10.4	15.2	15.5	14.2	15.7	13.9	15.2
	Twin lambs						
Border Cheviot	9.1	9.4	13.4	13.6	16.2	22.2	16.2
Dorset Horn	12.2	10.0	14.4	12.9	17.5	17.5	15.4
Columbia	10.6	8.7	14.1	12.5	23.7	14.2	16.3
Suffolk	6.8	13.9	13.4	15.5	17.7	18.4	14.3
Willamette	7.0	11.0	12.2	14.4	19.1	21.6	14.6

for seven periods of lactation are found in Table 16. The Willamette breed had the highest average daily gain and was followed in order by the Suffolk, Columbia, Dorset Horn, and Border Cheviot for single lambs. For twin lambs the Willamette was again highest, followed by the Suffolk, Dorset Horn, Border Cheviot, and Columbia breeds in that order. A twin set on the average gained 40.7 percent more than a single lamb. For example this difference was as follows: Border Cheviot 46.9, Dorset Horn 43.1, Columbia 31.6, Suffolk 40.1, and Willamette 40.9 percent more weight than a single lamb from each of the respective breeds. The single and twin lambs gained more weight per day as they grew older and were utilizing a supplementary feed source to a greater extent. The growth curves by periods for single and twin lambs are shown in Figures 3 and 4.

In order to study the influence of the variation in milk yields on the growth of lambs in greater detail, the grams of milk required to produce one gram of gain over the seven periods of lactation and the average for the complete lactation is shown in Table 17. In the interpretation of the table it must be realized that a supplementary feed source was available to the animals at all times. As the animals grew and the rumen became functional additional feeds were utilized for growth, but it appears from the table that growth was obtained with very small quantities of milk. Table 18 contains the ranking of the breeds over the complete lactation period. Of ewes producing

Table 16. Average grams of gain per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	187	219	246	204	227	318	276	256
Dorset Horn	170	244	294	243	292	356	324	296
Columbia	180	281	278	310	356	352	328	310
Suffolk	198	310	378	308	335	421	356	353
Willamette	211	376	376	343	385	357	410	370
				Twin lambs				
Border Cheviot	255	300	429	437	518	713	518	483
Dorset Horn	368	348	463	454	616	616	543	519
Columbia	302	317	435	373	705	421	486	453
Suffolk	286	588	518	599	693	739	571	589
Willamette	291	455	486	575	761	890	628	627

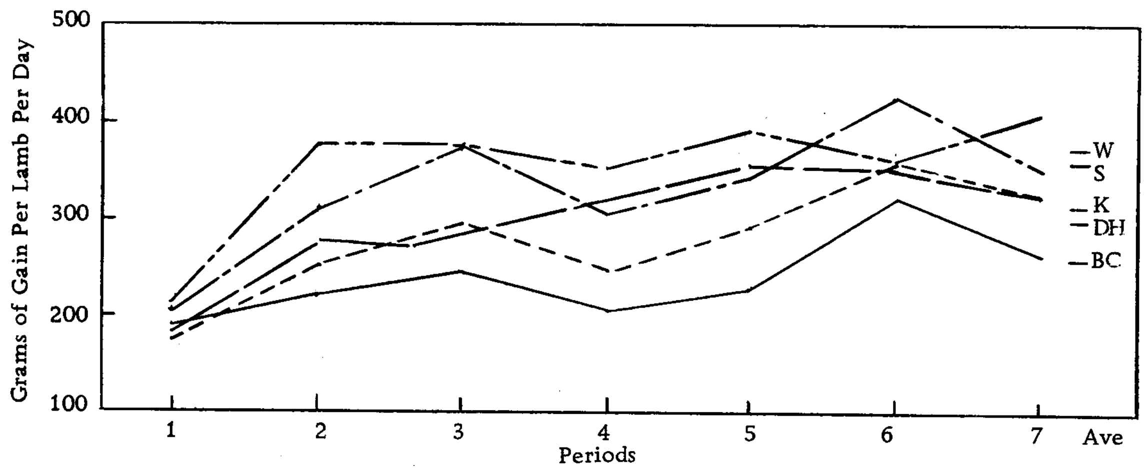

Figure 3. Average grams of gain in body weight per day by various breeds of sheep over seven periods of lactation for single lambs.

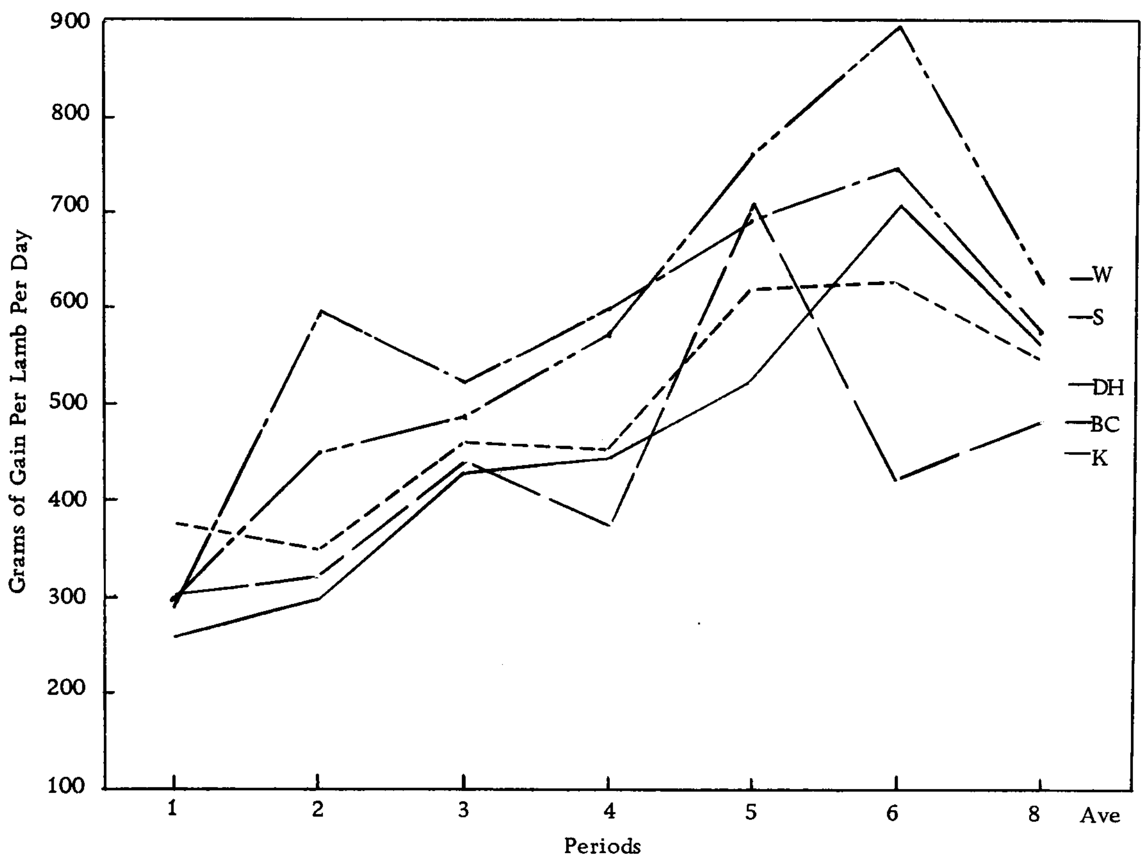

Figure 4. Average grams of gain in body weight per day by various breeds of sheep over seven periods of lactation for twin lambs.

BC Border Cheviot
DH Dorset Horn
K Columbia
S Suffolk
W Willamette

Table 17. Grams of milk required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	6.511	7.148	4.433	4.670	3.583	1.928	1.030	3.964
Dorset Horn	12.488	7.456	6.532	6.089	5.417	2.943	1.255	5.472
Columbia	9.277	6.861	4.990	4.379	3.102	2.237	1.118	4.406
Suffolk	8.524	5.754	4.422	5.170	4.365	2.914	1.393	4.326
Willamette	9.072	5.423	4.604	4.417	3.374	2.969	0.982	4.193
				Twin lambs				
Border Cheviot	8.345	6.839	4.515	3.592	3.042	1.468	0.894	3.455
Dorset Horn	6.206	7.164	4.345	4.016	2.226	1.735	0.725	3.424
Columbia	5.360	7.476	4.903	4.207	2.308	1.556	0.754	3.716
Suffolk	7.827	5.027	5.238	3.849	2.849	2.077	1.117	3.882
Willamette	8.456	6.774	4.142	2.993	1.889	1.532	0.981	3.114

Table 18. Ranking by breeds for efficiency of growth over the lactation period.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water	Milk
			Single lambs				
Border Cheviot	2	1	1	3	1	1	1
Dorset Horn	5	5	5	5	4	5	5
Columbia	1	4	3	4	3	4	4
Suffolk	4	3	4	2	2	3	3
Willamette	3	2	2	1	1	2	2
			Twin lambs				
Border Cheviot	2	2	2	5	3	3	3
Dorset Horn	3	3	3	2	2	2	2
Columbia	4	4	4	3	4	4	4
Suffolk	5	5	5	4	5	5	5
Willamette	1	1	1	1	1	1	1

1 = requires the smallest quantity per unit of growth.
5 = requires the largest quantity per unit of growth.

single lambs the Border Cheviot, Willamette, Suffolk, Columbia, and Dorset Horn breeds ranked in that order for efficiencies of lamb growth. The rank for ewes suckling twins was Willamette, Dorset Horn, Border Cheviot, Columbia, and Suffolk. Table 19 contains the average grams of milk components required to produce one gram of gain. Appendix Tables 13 through 18 contain the grams of milk components required per gram of gain for seven periods of lactation. The greater efficiency of twin lambs is shown as percentages in Table 20. The requirement for milk by single and twin lambs declined from one period to the next over the seven periods of lactation (Figures 5 and 6). The amount of the milk components required per unit of growth was less for twins than for single lambs. Twin lambs required 78 percent as much protein, lactose + ash, and fat and 82 percent as much total solids and milk as single lambs.

The order of monetary return was greatest for the Suffolk breed and it was followed by the Willamette, Columbia, Dorset Horn, and Border Cheviot breeds, respectively (Table 21). This was calculated on a total ewe basis. If this return were calculated on a per lamb basis the Willamette would rank highest with the Suffolk, Columbia, Dorset Horn, and Border Cheviot ranking in that order.

The Border Cheviot breed had the highest conformation scores, but for all practical purposes the Willamette, Suffolk, and Dorset Horn breeds were equal to the Border Cheviot, as all were

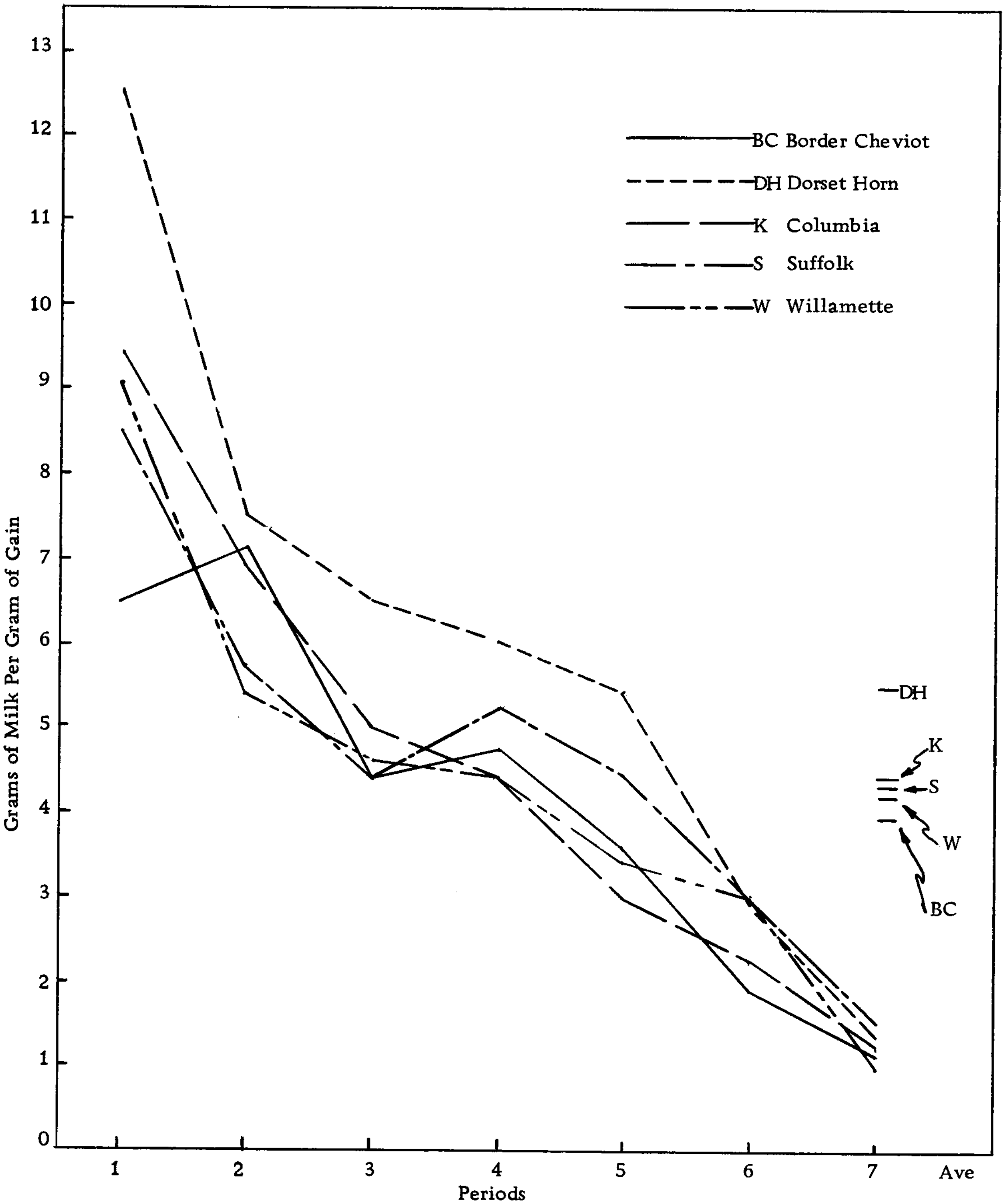

Figure 5. Grams of milk required to produce one gram of gain for various breeds of sheep over seven periods of lactation for single lambs.

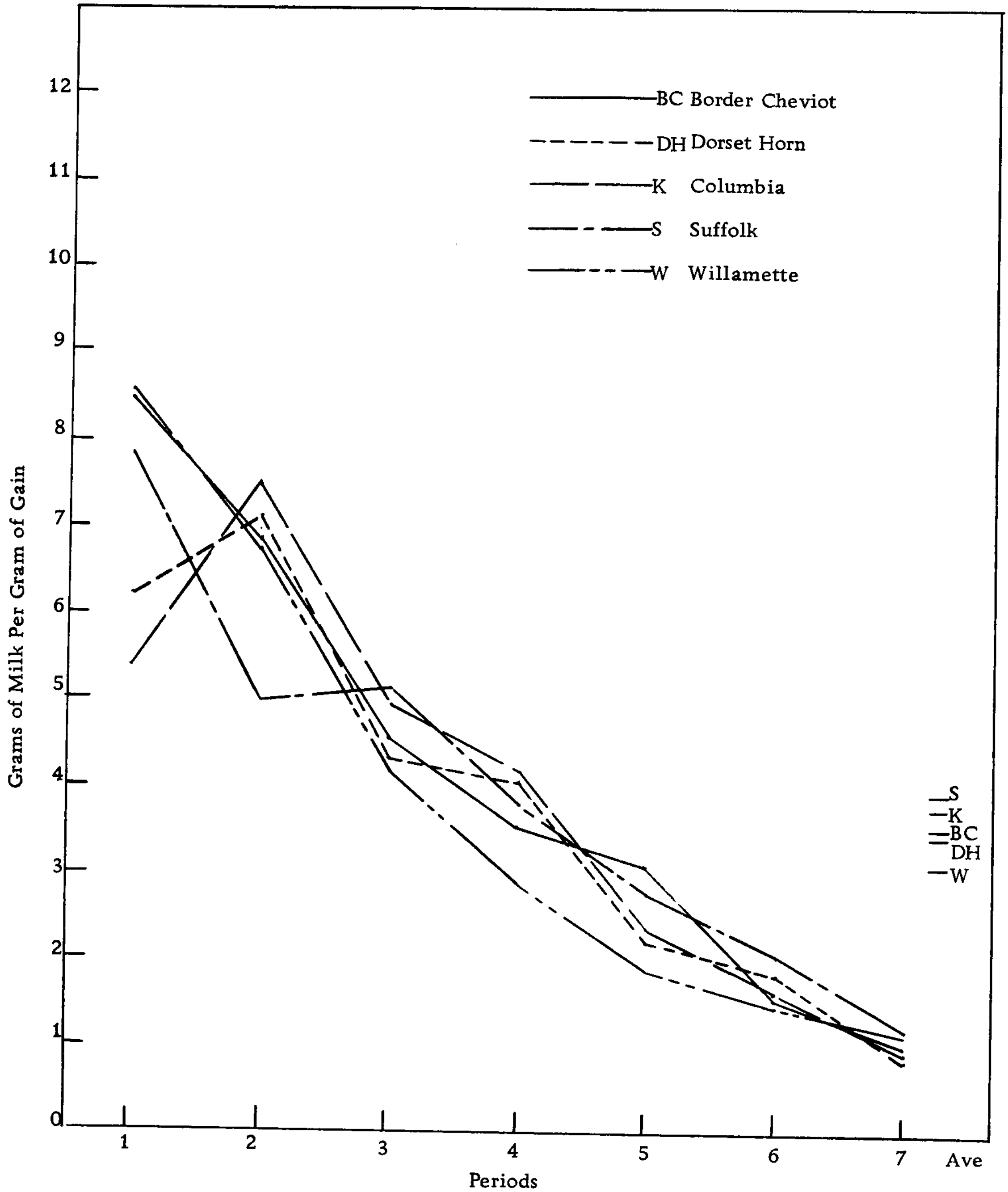

Figure 6. Grams of milk required to produce one gram of gain for various breeds of sheep over seven periods of lactation for twin lambs.

Table 19. Average grams of milk components required to produce one gram of gain for various breeds of sheep over a complete lactation.

Breeds	Protein	Lactose + Ash	Solids-Not-Fat	Fat	Total Solids	Water
			For ewes nursing single lambs			
Border Cheviot	0. 228	0. 210	0. 438	0. 345	0. 783	3. 181
Dorset Horn	0. 275	0. 313	0. 588	0. 455	1. 042	4. 430
Columbia	0. 224	0. 242	0. 466	0. 368	0. 833	3. 572
Suffolk	0. 238	0. 239	0. 477	0. 344	0. 821	3. 506
Willamette	0. 233	0. 226	0. 460	0. 324	0. 783	3. 409
			For ewes nursing twin lambs			
Border Cheviot	0. 182	0. 180	0. 362	0. 317	0. 679	2. 776
Dorset Horn	0. 186	0. 187	0. 373	0. 296	0. 669	2. 755
Columbia	0. 187	0. 197	0. 384	0. 298	0. 681	3. 035
Suffolk	0. 213	0. 221	0. 434	0. 304	0. 738	3. 144
Willamette	0. 168	0. 171	0. 339	0. 281	0. 620	2. 494

Table 20. A set of twin lambs requires less milk and milk components per gram of gain than single lambs by the following percentages.

Milk and Components	Breeds					
	Border Cheviot	Dorset Horn	Columbia	Suffolk	Willamette	Average
Protein	20.2	32.4	16.5	10.5	27.9	21.9
Lactose + Ash	14.3	40.3	18.6	7.5	24.3	22.3
Solids-Not-Fat	17.4	36.6	17.6	9.0	26.3	22.1
Fat	8.1	35.0	19.0	11.6	13.3	18.5
Total Solids	13.3	35.8	18.2	10.1	20.8	20.5
Water	12.7	37.8	15.0	10.3	26.8	21.5
Milk	12.8	37.4	15.7	10.3	25.7	21.3

Table 21. Summary of breed performance.

Breeds	No. of Ewes	Lambing Percentage	Average Birth Weight	Lengths of Gestation	Income	
					Dollars Per Lamb	Dollars Per Breed
Border Cheviot	9	133.3	8.63	150.1	8.79	79.09
Dorset Horn	9	122.2	9.10	147.0	9.93	99.34
Columbia	9	133.3	10.93	150.3	10.10	100.96
Suffolk	9	122.2	10.57	151.8	11.86	118.62
Willamette	9	111.1	10.90	148.1	12.68	114.08
Average	9	124.4	10.03	149.5	10.67	102.42

Breeds	Conformation Scores	Condition Scores	Average 120 Day Weight	Average Grams of Gain/Lamb/Day		Average Grams of Gain Per Lamb		Tenderness Scores	Composite Scores
				Single	Twins	Single	Twins		
Border Cheviot	88.2	81.8	72.3	256.4	483.0	24,225.6	44,916.8	4.13	4.50
Dorset Horn	86.6	86.1	78.1	295.5	519.2	28,664.4	49,171.7	4.71	4.91
Columbia	78.1	78.3	86.9	310.0	453.0	29,232.1	41,685.6	5.06	5.09
Suffolk	86.4	87.7	94.2	353.0	589.0	32,481.6	54,147.0	4.09	4.44
Willamette	88.0	88.8	100.2	370.2	626.6	33,980.6	55,769.1	4.89	4.95
Average	85.5	84.5	86.3	317.0	534.2	29,716.9	49,138.0	4.58	4.78

graded choice. The Columbia was a grade lower in conformation than the other four breeds. With respect to the condition scores the grades were high choice for the Willamette, Suffolk, and Dorset Horn, low choice for the Border Cheviot and high good for the Columbia lambs. The carcasses that rated the highest on tenderness and composite preference scores as determined by organoleptic tests were Columbia, Willamette, Dorset Horn, Border Cheviot, and Suffolk, respectively.

When the weaning weights were adjusted to 120 days the differences in growth rates between breeds became very evident. The Willamette and Suffolk breeds were by far the best growing breeds. The Columbia had a very satisfactory 120-day body weight but the Dorset Horn and Border Cheviot were average or below being 78.1 pounds and 72.3 pounds respectively (Table 21).

The quantity of milk and the number of days required to produce lambs of a given weight based on the average efficiencies of growth and the average daily gain for each of the five breeds studied is postulated in Table 22. The figures are quite revealing when one multiplies the average grams of milk produced per ewe per day per breed by 120 days and compares this with the quantities listed in the table. The grams of milk produced in 120 days for each of the breeds raising both single and twin lambs are as follows: Border Cheviot, singles 121,968, twins 200,232; Dorset Horn, singles 194,052,

Table 22. The grams of milk and number of days required to produce lambs of a given weight based on average efficiencies of growth and average daily gain for each of the five breeds studied.

Breeds	70 Pounds		80 Pounds		90 Pounds		100 Pounds	
	Milk	Days Required	Milk	Days Required	Milk	Days Required	Milk	Days Required
Single lambs								
Border Cheviot	125, 862	124	143, 824	142	161, 822	159	179, 803	177
Dorset Horn	173, 743	107	198, 563	123	223, 384	138	248, 204	154
Columbia	139, 896	102	159, 881	117	179, 866	132	199, 851	146
Suffolk	137, 356	90	156, 978	103	176, 600	116	196, 223	128
Willamette	133, 133	86	152, 152	98	171, 171	110	190, 190	122
Twin lambs								
Border Cheviot	219, 401	132	250, 744	150	282, 087	169	313, 430	188
Dorset Horn	217, 432	122	248, 494	140	279, 556	157	310, 618	175
Columbia	235, 975	140	269, 686	160	303, 397	180	337, 108	200
Suffolk	246, 517	108	281, 733	123	316, 950	139	352, 167	154
Willamette	197, 747	101	225, 996	116	254, 246	130	282, 495	145

twins 213, 324; Columbia, singles 163, 872, twins 202, 032; Suffolk, singles 183, 276, twins 274, 404; and Willamette, singles 186, 240, twins 234, 144. According to these figures the Border Cheviot does not yield enough milk in 120 days to raise one 70 pound lamb. The other four breeds met this requirement quite easily. For twins only the Suffolk and Willamette produce enough milk in 120 days to raise a set of twins averaging 70 pounds per lamb. The Columbia, Suffolk, and Willamette breeds produce enough milk to raise one lamb to 80 pounds, however, only the Willamette produce enough milk to raise a set of twins to 80 pounds. Both the Suffolk and Willamette produce enough milk to raise 90 pound single lambs. However, none of the breeds produced enough milk to average either 90 pound twin lambs or 100 pound singles or twins.

Live Weights

Highly significant differences were found to exist between the breeds of sheep at 100 days of age (Table 23). In the order of decreasing body weights, the breeds are ranked as follows: Willamette, Suffolk, Columbia, Dorset Horn, and Border Cheviot. The calculated Least Significant Difference ($LSD_{.05}$) at the five percent level is equal to 9. 239 for the breeds. When the mean breed weights are compared using this LSD (Table 24), it is evident that statistically significant differences exist when comparing the Willamette with the

Table 23. Analysis of variance of the adjusted 100-day live weights.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	3406.7346	4	851.6836	9.11**
Sex	181.3407	1	181.3407	1.94
Breed x Sex	278.2495	4	69.5623	.74
Error	3455.6599	37	93.3962	
Total	7321.9847	46		

**Indicates significance at the one percent level of probability.

Table 24. Least significant difference between the 100-day live weights of the five breeds of sheep.

Comparisons	Difference
Willamette - Suffolk	4.99
Willamette - Columbia	11.11*
Willamette - Dorset Horn	18.70**
Willamette - Border Cheviot	23.63**
Suffolk - Columbia	6.12
Suffolk - Dorset Horn	13.71**
Suffolk - Border Cheviot	18.64**
Columbia - Dorset Horn	7.59
Columbia - Border Cheviot	12.52**
Dorset Horn - Border Cheviot	4.93

* Indicates significance at the five percent level of probability.
** Indicates significance at the one percent level of probability.

Columbia, Dorset Horn, or Border Cheviot. The same is true when comparing the Suffolk with the Dorset Horn, or Border Cheviot, and when comparing the Columbia with the Border Cheviot breed. The differences between the Willamette and Suffolk, Suffolk and Columbia, Columbia and Dorset Horn, and Dorset Horn and Border Cheviot are not statistically significant. However, there is a rather uniform five to seven pound difference between each of these breeds. The body weight differences between sexes within a breed were not found significant, and there appeared to be no significant interaction between the breed and sex.

The body weight of lambs varied significantly according to breed, type of birth, and period, but no sex difference could be observed (Table 25). Both the single and twin lambs of the five breeds showed a steady increase in body weight with age. The single lambs were heavier than the average of a set of twins throughout the seven periods. In general, at the end of the seventh period, the Willamette had the heaviest body weight as either a single or twin lamb. They were followed in turn by the Suffolk, Columbia, Dorset Horn, and Border Cheviot. The Columbia twin lambs had an average body weight less than that of Dorset Horn twins. The growth curves for the Willamette and Columbia breeds showed a marked difference between single and twin lambs, but this was not true of the other breeds as they did not show such a difference (Figures 3 and 4).

Table 25. Analysis of variance of weights of five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Period	9, 711, 842. 00	6	1, 618, 640. 33	39. 74**
Breed	638, 380. 00	4	159, 595. 00	39. 19**
Sex	89. 08	1	89. 08	0. 02
Birth Type	397, 096. 93	1	397, 096. 93	97. 52**
Error	1, 246, 022. 00	306	4, 071. 97	

**Indicates significance at the one percent level of probability.

Simple correlation coefficients among various live animal and carcass traits and the milk characteristics are presented in Table 26. Many of the correlation coefficients are statistically significant ($P < .01$), but have very little biological relationship with growth or carcass desirability of the lamb. One of the most important correlation coefficients is that of total gain with grams of total milk produced. Seventy percent of the differences in total gains are accounted for by variations in milk production. The high correlation coefficients of the milk components and the days nursed with the other characteristics studied are due to the fact that they are closely related to total milk yield. They by themselves are not of importance. The correlation coefficient of 0. 84 between conformation and condition scores tells us that 70 percent of the differences in conformation scores are due to variations in condition scores. Ninety percent of the variation in the composite preference score is accounted for by

Table 26. Correlation coefficients for various live animal, carcass and milk characteristics.

	Conformation Score	Condition Score	Preference Score	Tenderness Score	Protein gm	Lactose + Ash gm	Solids-Not-Fat gm	Fat gm	Total Solids gm	Milk gm	Days
Total Gain, gm	0.49	0.63	0.10	0.20	0.87	0.83	0.86	0.83	0.87	0.84	0.83
Conformation Score	----	0.84	0.12	0.14	0.56	0.49	0.53	0.52	0.54	0.52	0.54
Condition Score		----	0.17	0.22	0.63	0.64	0.65	0.60	0.64	0.64	0.64
Preference Score			----	0.95	0.16	0.05	0.11	0.08	0.10	0.13	0.14
Tenderness Score				----	0.25	0.14	0.19	0.15	0.18	0.20	0.21
Protein, gm					----	0.92	0.98	0.91	0.97	0.96	0.97
Lactose + Ash, gm						----	0.98	0.89	0.97	0.98	0.97
Solids-Not-Fat, gm							----	0.92	0.99	0.99	0.99
Fat, gm								----	0.97	0.92	0.94
Total Solids, gm									----	0.98	0.99
Milk, gm										----	0.99

Correlation coefficients of 0.304, or greater are significant at P of .01 and 0.393 or greater are significant at P of .05 (40 d. f.).

the tenderness of the meat sample. These are the only correlation coefficients that are of biological value.

The Effect of Breed, Sex, and Rearing on Lamb Performance

Several factors were studied with regard to their relationship to lamb performance after adjustments had been made for breed, sex, and rearing. The dependent variables were total gain, conformation score, condition score, composite preference score, and tenderness score. The independent variables were total grams of protein, solids-not-fat, fat, and milk, and the total days that the lambs were nursed.

Total live-animal gain was affected by the milk components and milk yield ($P < .01$), but not by any of the other variables studied. Conformation score, composite preference score, and tenderness score were not affected by any of the variables studied, while condition score was affected by breed ($P < .01$). None of the traits studied were affected by the sex or rearing of the lambs.

Synchronization of Estrus

The oral progestogen, 6 α-methyl-17 α-acetoxyprogesterone ("Provera", The Upjohn Company), was used to synchronize the estrus of the ewes from the five breeds utilized in this milk study. The breeding patterns for the ewes are shown in Table 27.

Table 27. Patterns of estrus for ewes following treatment with 50-60 mg Provera for 14 days. Based on breeding data.

Days after Cessation of Provera	Border Cheviot		Dorset Horn		Columbia		Suffolk		Willamette		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
1	9	100.0	1	11.1	3	33.3	0	0.0	1	11.1	14	31.1
2	0	0.0	0	0.0	2	22.2	0	0.0	3	33.3	5	11.1
3	0	0.0	4	44.4	2	22.2	3	33.3	1	11.1	10	22.2
4	0	0.0	4	44.4	1	11.1	5	55.6	4	44.4	14	31.1
5	0	0.0	0	0.0	1	11.1	1	11.1	0	0.0	2	4.4
Totals	9	100.0	9	100.0	9	100.0	9	100.0	9	100.0	45	100.0

It can be seen that 100 percent of the ewes came into estrus within the first five days following cessation of Provera feeding. The percentage of ewes that lambed from the matings at the first and second estrus following the cessation of Provera feeding is shown in Table 28.

Table 28. The percentage of ewes that lambed from matings at the first and second estrus.

Estrus	Border Cheviot		Dorset Horn*		Columbia		Suffolk*		Willamette*		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
First	3	33.3	6	100.0	7	77.8	3	37.5	1	12.5	20	50.0
Second	6	66.7	0	0.0	2	22.2	5	62.5	7	87.5	20	50.0
Totals	9	100.0	6	100.0	9	100.0	8	100.0	8	100.0	40	100.0

*Some of the ewes not lambing were accounted for by death and others were barren.

All of the Border Cheviot ewes showed a second estrus on the average 9.6 days (8-12 days) following the first estrus and one ewe had a third estrus 30 days after the second estrus. Three of the ewes lambed from the mating at the first estrus and six ewes lambed from breeding at the second estrus. It is of interest to note that the three Border Cheviot ewes that came into estrus a second time lambed from the first breeding and one came into estrus a third time but lambed from the breeding in the second estrus.

Three Dorset Horn ewes had a second estrus and one of these had a third estrus. The length of the estrous cycle between the first and second heats averaged 14 days (9-21 days) and the interval between second and third heat was 18 days. Seven ewes became pregnant from matings at the first estrus and one of these died before lambing and another had a second estrus 21 days later. Two of the ewes that had more than one estrus were barren and this includes the ewe that came into estrus three times.

Two Columbia ewes had a second estrus and one of them had a third estrus. The average length of time between the first and second estrus was 17.7 days (16-20 days) and between the second and third estrus was 22 days. Seven ewes lambed from matings at the first estrus, two lambed from matings at the second estrus and one showed a third estrus but lambed from the mating at the second estrus.

Seven Suffolk ewes came into estrus twice and one a third time. The length of the estrous cycle between the first and second heats was on the average 15 days (12-20 days) and the interval between the second and third was 16 days. Three ewes lambed from matings at the first estrus. One of which came into estrus again 15 days after she became pregnant. Five ewes lambed from matings during the second estrus. One ewe came into estrus three times but was barren at lambing time.

All nine Willamette ewes came into estrus twice and three came into estrus a third time. There was on the average a 12.8 day (9-17 days) estrous cycle between the first and second heats and the interval between the second and third heats averaged 20 days. One ewe lambed from matings during the first estrus but had a second estrus 14 days later. Seven ewes lambed from matings at the second estrus and three of these had a third estrus. One ewe that had had two estrous cycles and was pregnant died before lambing time.

Table 29. Percentage of ewes having two and three estrous cycles.

Estrous	Border Cheviot		Dorset Horn		Columbia		Suffolk		Willamette		Total	
Cycles	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Two	9	100.0	3	33.3	2	22.2	7	77.8	9	100.0	30	66.7
Three	1	11.1	1	11.1	1	11.1	1	11.1	3	33.3	7	15.6

The relationship of the five breeds of ewes pertaining to two and three estrous cycles is presented in Table 29. A total of 66.7 percent of the ewes had two estrous cycles and 15.6 percent had three estrous cycles.

The average lengths of gestation were: 150.1 days (142-171 days) for the Border Cheviot, 147.0 days (145-148 days) for the Dorset Horn, 150.3 days (147-155 days) for the Columbia, 151.8

days (144-163 days) for the Suffolk, and 148.1 days (143-157 days) for the Willamette. The overall average was 149.5 days.

DISCUSSION

The genetic or hereditary growth potentialities of livestock are predetermined at conception. The expression of the hereditary growth possibilities is, however, subject to the influence exerted by environmental agencies. The most important of these environmental factors influencing the course of growth are the nutritional conditions to which the animal is subjected. Following conception the foetus is entirely dependent upon the intra-uterine nourishment it receives. During the early post-natal stages it is dependent upon the development of the mothering qualities of the dam. Through selective breeding the hereditary growth rate of different types of livestock is being changed. In our modern breeds of livestock bred for meat production the main emphasis has been for growth in early life. The result has been an increase, genetically, in the growth stimulus amongst the various breeds. Since the hereditary aspect of growth cannot be separated from the environmental aspect, it is obvious that any increase in the hereditary growth rate of a breed must necessarily be accompanied by a corresponding improvement in the nutritional conditions in order to permit the optimum expression of its hereditary characteristics.

In all farm animals where the newly born animal is not artificially reared, it is dependent upon the milk of its dam for adequate nourishment during the early stages of its life. Thus it is apparent that the higher the hereditary level of milk production, the greater will be the nutritional demands of ewes if they are to express their optimum production. It may, therefore, be concluded that the successful production of fat lambs is dependent fundamentally upon the use of the right type of ewe. Such a ewe should be capable of maintaining a high level of milk production under a system of management which provides adequate high quality feed to meet increased nutritional demands. Therefore, inadequate nutritional conditions will restrict the possible expression of the hereditary potential for the production of milk. In the case of a high producing ewe, there will be a tendency to maintain the higher level of production at the expense of her body tissues when nutritional conditions are inadequate. A drop in condition will follow, and consequently a disturbance in the normal physiological functioning of her body will occur. This is one possible reason why ewes fail to breed during the next breeding season. With an inherent low level of milk production, optimum nutritional conditions cannot force the level of production above the limit of the hereditary potentialities.

Measurements of Milk Yields

It is obvious that data on milk yield cannot be obtained with a degree of reliability equal to that possible in animals kept for dairy purposes. McCance (38, p. 840) measured yield by hand milking following the injection of posterior pituitary extract to obtain milk ejection. Lambs put with ewes that had been hand milked after two doses of five international units of posterior pituitary extract could obtain little or no milk. Prior to this, most investigators estimated milk yield by measuring the total intake of the lamb during a 24 hour period. One criticism of this method is that results might depend on the appetite of the lamb rather than on the milking ability of its dam. It is known that very young lambs do not always empty the udder, and that older lambs may not take all the available milk even though hungry and deprived of water. Under conditions such as these, the appetite of the lamb determines the milk yield, and consequently correlations between the yields and lamb growth rates, particularly during the later stages of lactation, tend to be low.

In the present investigation Purified Oxytocic Principle proved to be very successful in allowing removal of all available milk from the udder. Thus, it was established as a very useful and accurate research tool for studies of this type.

Yield and Composition of Ewe's Milk in Relation to Growth of the Lamb

The variation in the shape of the lactation curves and the time after lambing at which the maximum milk production is reached are of great practical importance. In order to promote rapid growth and to meet the increasing maintenance requirements of the developing lambs it is essential that the dams show a steady increase in the daily milk production during the first three weeks of lactation. During this period the lambs are almost entirely dependent for their nourishment upon the milk supply of their dams.

Barnicoat, Logan and Grant (6, p. 47) arrived at the conclusion that the average daily yield of milk over a 12 week lactation for mature Romney ewes producing single lambs was 1220 grams. They found that the stage of the ewe's life where maximum milk production was obtained was in the fourth year during their third lactation. However, the influence of age on milk yield did not seem to be very pronounced. In the present study, it is shown that for ewes nursing single lambs the Border Cheviot averaged 1, 016 grams for a 13 week lactation. This is quite low when compared with Dorset Horn 1, 617 grams, Willamette 1, 552 grams, Suffolk 1, 527 grams, and Columbia 1, 366 grams for the same interval.

The effect of the number of lambs being suckled on milk yields is very important. Ewes with twins secrete on the average 425 grams more milk per day than ewes with singles (7, p. 15). In this study there are marked differences between breeds, but there is an overall average of 25 percent greater average milk yield for ewes with twins. The milk is shared between twins, but their slower growth rates, 15.7 percent, in comparison with singles are by no means proportional to their differences in milk intakes. A set of twins on the average gained 40.7 percent more than a single lamb. The lactation curves of ewes suckling twin lambs differ slightly in shape from those of ewes nursing single lambs. The peak of lactation is more pronounced in ewes nursing twins although it occurs during the same period of lactation. The decline in milk production is more gradual for ewes nursing single lambs.

All the breeds except the Dorset Horn and Suffolk show an increase in yield from the first to the second period and then a sharp decline in yield from the second to the third period. After the third period a gradual decline occurs until the end of lactation. The Suffolk does not show a sharp increase in the second period, but has a greater persistency throughout lactation. The Dorset Horn breed fluctuated up and down from period to period. For ewes suckling twin lambs all breeds peaked in the second period except the Border Cheviot which peaked in the first period. The Dorset Horn and Willamette breeds showed a sharp decline between the second and third periods which then tapered off to the end of lactation. The Suffolk showed a sharp increase in the second period and then had greater persistency throughout lactation. This greater persistency accounted for the advantage that the Suffolk breed possess in total milk yield.

Changes in the Milk Quality with Increased Quantities

A review of the published work emphasized the existence of a functional relationship between the quantity of milk and the percentage of milk fat. This general relationship may be stated thus: as the quantity of milk increases, the quantity of fat also increases, but at a slower rate. Therefore, the percentages of fat and other milk components fall as the volume of milk increases. This relationship exists both between the breeds and between the animals within the same breed and even at different levels of production within a single lactation. In general, the lower the yield the greater will be the concentration of fat and other milk components. The relationship of the average daily milk yield for each period of lactation with the percentage of the milk components in the present study is in complete agreement with the relationship as outlined above. Edwards (27, p. 122) investigated various factors influencing the relationship between the secretion of milk and milk fat. He found a fundamental inverse relationship between milk volume and fat percentage. Likewise he also found that there is no specific effect of the stage of lactation on the percentage of fat. These effects are attributed to a number of factors which affect the function of the mammary gland, such as nutrition and the activity of the animal at different times of the day and during the seasons of the year.

The percentages of the milk components investigated in this study are in good agreement with those found by Barnicoat (5), Fuller and Kleinheinz (30), and Godden and Puddy (31) on various breeds of sheep. There were no significant differences between the breeds for the average milk components studied in this investigation. The percentages of the milk solids decrease as milk yield increased. The percentage of water increased with the milk yield. The relationship of the milk components with the milk yield was significant at ($P < .01$), except for lactose + ash which was significant at ($P < .05$).

Barnicoat et al. (7, p. 15) studied the chemical composition of milk from ewes and found that the fat and protein contents were highest at the beginning and the end of lactation and that the ash content increased slightly as lactation advanced. This is understandable if the sampling is started before the colostrum flow has completely ceased. Also, during the latter stages of lactation the percentages of the components making up the total solids increase even though the total milk yield is decreasing. In addition, the percentage of water was also declining during the latter stages of lactation.

Lamb Growth

In considering the influence of the milk secretion of ewes on the growth of lambs it must be borne in mind, that apart from the influence of the differences in the total yield, the differences in the shape of the lactation curve may also have an important effect. The difference in total yield between the high and low producing ewes is represented by the area between the lactation curves. The variations in the shape of the area between any two lactation curves offers an explanation as to the nature of such differences, and this may have an important bearing on the growth of the lambs. The difference in the total yield between the high and low producing breeds, may be due either to a higher level of production in the former during the early part of the lactation, or to a greater persistency of milk secretion. For example, the milk flow is maintained better and the decline in the lactation curve is slower in the high producing ewes.

A possible explanation which may be advanced for the differences in the shape of the lactation curves for sheep during the first few weeks is that the lambs from the high producing ewes are not able to drain all of the available milk. Thus, the potential production of the ewes is higher than the actual milk intake by the lambs. The differences in the shape of the curves and in the time that the five breeds of ewes reach their maximum production are of fundamental practical importance. During the first few weeks following birth the growth rate of lambs is rapid and consequently their nutrient requirements rapidly increase. Young lambs start to consume food other than milk when they are two to three weeks old, but the quantity that they eat is at first very small. In order to promote rapid growth and to meet the demands of the increased nutrient requirements of the lambs, it is essential, therefore, that the milk yield of the ewe should show an increase during the first three weeks.

The differences between the breeds for lamb growth hardly needs further comment to emphasize the importance of the quantitative milk production of the ewes in relation to the growth rate of lambs. The greatest difference in the milk yields of the ewes was observed during the first two periods. The differences in lamb gains were greatest during the second and third periods and were then maintained at this relationship during the remainder of the time studied. These differences again emphasize the fact that it is mainly during the early post-natal stages when the growth of the lambs is almost entirely dependent upon the milk secretion of their dams. It is at this early state that the growth of the lambs from low yielding ewes suffer most. The inherent growth rate is most rapid during the first few weeks after birth, and it is therefore of fundamental economic importance that the maximum possible rate of growth during this period be attained.

The apparently lower efficiency of the Dorset Horn single lamb is thus more likely to be due to the fact that it was less inclined to consume other food. Also, the increased earliness of maturity of the Dorset Horn and Border Cheviot lambs, further suggests that they were putting on fat at an earlier age. This would also apply to the Suffolk twins.

Efficiencies of Growth

One of the most interesting features of the results is the apparent increase in the average amount of milk consumed per unit of gain over the total period as the level of milk intake increased. One explanation is that with a lower milk supply a higher percentage of the milk intake was required for maintenance. The average amount of milk consumed per gram of gain during the first two periods, when the lambs were entirely dependent upon the milk secretion of their dams was 7.851 grams for single lambs and 6.947 grams for the twin lambs. These figures are higher than those reported by Bonsma (11, p. 103) by one gram for twins and two grams for single lambs.

Various factors are probably responsible for the apparent decrease in the efficiency of milk utilization over the entire period as the level of milk intake increases. The higher level of nutrition enjoyed by lambs from the high producing ewes promotes rapid growth. Consequently the difference in the weight and size between lambs from the high and low yielding ewes must of necessity be associated with a corresponding difference in their maintenance requirements. After the first two periods it follows that there will be an appreciable difference in the maintenance requirements between lambs of the same age, but reared on different levels of food intake. Since the milk consumed by the growing lamb must meet the requirements for both maintenance and production, it is to be expected that the amount of food required per gram of gain will increase according to the increase in the size and weight of the lamb, irrespective of its age. Also, when the ewes give only a small quantity of milk, its offspring is forced to utilize other food sources. This gives the appearance of a greater efficiency for lambs that nurse ewes that are not high producers.

Another reason for the greater quantity of milk consumed per unit gain in weight by lambs reared on a high level of nutrition is the fact that the increase in weight of suckling lambs is marked by two distinct processes, namely, growth and fattening. Only after the nutritional requirements for growth, skeletal and muscular development, have been satisfied will any surplus be available for converting into body fat. Since the amount of food required to produce one gram of body fat is considerably higher than that required for the production of the same amount of muscular growth, the amount of nutrients required per gram of gain in live weight will increase as the proportion of fat deposition to muscle growth increases. The higher milk intake per gram of gain may therefore be interpreted as being particularly due to the fact that the lambs reared by ewes producing large quantities of milk were in a position to promote fattening simultaneously with growth.

Ritzman (56, p. 20) has suggested that the increase in weight of lambs is almost directly proportional to milk yield. The results obtained in the present investigation do not support this view. There is an apparent decrease in the efficiency of utilization of milk with an increase in the level of milk intake, for reasons already explained.

Variations in the quality of the milk produced by different individual ewes and by the different breeds are not the probable causes for the differences observed in the amount of milk consumed per unit of gain by their lambs. This statement is supported by the fact that there are no significant differences in the overall percentages of the milk components between breeds.

Bonsma (11, p. 192) found highly significant ($P < .01$) correlation coefficients between the milk intake of the lambs and live weight gains over four periods of lactation. The correlation coefficients decreased from 0.882 in the first period to 0.784 in the second, 0.516 in the third, and 0.397 in the fourth period. The correlation coefficients for the total period of 77 days was 0.812. This clearly indicates the all-important association between milk intake and gain in body weight of the lambs, particularly during the first five weeks of the lambs life. The decrease in the size of this correlation as the lambs increase in age is no doubt due to the fact that as the lambs grow older they are able to consume and assimilate more food of other types so that their growth becomes less dependent upon the milk supply of their dams. This seems to suggest that a high level of milk secretion during the first few weeks after lambing is of greater importance than the persistency in milk secretion.

An interesting feature of the results obtained was the apparent increase in the average amount of milk consumed per gram of gain in live weight as the level of total milk intake increased. This would indicate that the increase in live weight was not directly proportional to the increase in milk intake. Various factors are probably responsible for this increase in milk intake per pound gain in live weight, or apparent decrease in the efficiency of milk utilization with an increase in the total milk yield of ewes. It is possible that an increased level of milk intake would promote an increase in the rate of growth, leading to larger and heavier lambs, with a higher maintenance requirement at any given age than lambs on a lower level of milk intake. Also lambs reared on a higher level of milk intake would be in a better position to promote fattening simultaneously with growth. Therefore the lambs from low milk yielding ewes would naturally be more prone to consume other food than those reared by good mothers whose milk supply would be more likely to satisfy their requirements.

A comparison of milk consumption per pound of gain in live weight, based on the first two periods only, when the lambs were entirely dependent upon milk provided by their dams and little or no fat was as yet being produced indicates that the difference between levels of milk intake does not greatly influence the efficiency of utilization. The results obtained indicate clearly that lambs from low milk yielding ewes suffer most during the early stages of post-natal growth.

Live Weights

The highly significant differences between breeds in 100-day weights of lambs were expected. It was obvious from visual appraisal and growth records that the Willamette and Suffolk were outstanding in performance when compared with the other breeds. This is primarily a result of the selection practices and breeding program that has been carried out at Oregon State University.

Weight differences between sexes within a breed were not found and there appeared to be no significant interaction between the breed and sex. Bonsma (11, p. 85) also found that there was no difference in the relative rate of growth between male and female lambs. Slen, Clark, and Hironaka (58) ignored the sex effect in their studies, because they had reason to believe that it would be small if present at all.

Simple correlation coefficients were calculated between the various live animal, carcass, and milk characteristics. The only one that was of major importance was the relationship between total gain and grams of total milk produced. Seventy percent of the variation in total gain is accounted for by the variation in milk production.

Genetic Factors

The difference between the milk yields of sheep of the different breeds under similar conditions seems to indicate the importance of genetic factors in milking ability. Bonsma (11, p. 189) has shown that the use of improved mutton breeds on the low yielding Merino sheep results in crossbred ewes with superior nursing qualities. This is what one would expect since milk yield has a low to medium narrow-sense heritability estimate.

In sheep, the repeatability of milk yield approximates 0. 44 for milk yield in successive lactations. If properly used, the heritability estimate could be a very useful genetic parameter. It is a measure of the ratio of the variance due to additive genetic causes to the total variance. There seems to have been very few estimates of the heritability of milk yield in sheep reported in the literature, but those presented range from 30-35 percent. Since the heritability estimate for milk production in ewes is in the medium range, an improvement in the average milk yield of a flock would be achieved most effectively by culling the low yielders. This would at the same time ensure that high producing ewes would be retained for breeding purposes. The progeny testing of rams and crossing of breeds and inbred lines would also increase the milk yield in the flock.

The conditions under which this investigation was carried out were very similar to those that would be found under actual farm-flock management conditions. The ewes were fed a ration that was capable of keeping them in a gaining condition throughout gestation and lactation. Mature ewes were used and their yields should be indicative of the maximum yields that would be obtained from ewes of these breeds. The birth weights of the lambs seemed to depend on the size and condition of the ewes. The Columbia had the heaviest lambs at birth, and was followed by the Willamette, Suffolk, Dorset Horn, and Border Cheviot in that order. The udder development was not studied in these ewes because the condition and development of the udder depends to a large extent on the plane of nutrition that the ewe is receiving and the previous production performance. The genetic factors other than breed differences and the effects of strenuous selection in the Willamette and Suffolk for increased lamb performance were not considered in this study.

Colostrum

Colostrum samples are comparable only if they are collected at the same stage of lactation. For this reason, all samples used in this study were collected 12 hours after parturition. The 12 hour period was used to insure that each lamb received some colostrum. If samples were taken immediately after birth it would sometimes take all of the colostrum present in the udder to provide a sufficient quantity for analyses. The early samples were less uniform as to consistency than were the 12-hour samples. No attempt was made to measure the quantity of colostrum present in the udder at any time during the first four days of lactation for the reasons mentioned above.

Even with these limitations, it is difficult to compare breeds as to the quality of the colostrum they produced. In comparing the results found by various investigators one is at a loss to find comparable data primarily from the standpoint of the stage of lactation. Most investigators have taken samples immediately following parturition. Barnicoat (5) analyzed 13 samples for the average percent composition of colostrum from Romney ewes. Our values for the Suffolk breed were more comparable to the Romney's values studied by Barnicoat (5) than were the values for the Willamette, Border Cheviot, Dorset Horn, and Columbia.

Synchronization of Parturition

The synchronization of estrus in ewes with no impairment to fertility would be of value in facilitating the selection of production traits if the lamb crop is born within a few days and can be raised under similar environmental conditions. It is well known that injected progesterone will prevent estrus and ovulation in the ewe and that both estrus and ovulation will follow the cessation of progesterone and oral progestogen treatment within a few days (1). The use of an orally effective progesterone has the advantage of not requiring successive injections but it must approach the efficiency of the injections in producing synchronized lambing.

In the present study 100 percent of the ewes came into estrus within a five day period following the cessation of Provera feeding. An overall efficiency of 50 percent was obtained from ewes lambing from the mating at the first estrus following the cessation of Provera feeding. These figures for the synchronization of lambing date are lower than the ones reported for Willamette and Suffolk ewes (1). Here it was found that the Willamette had a greater percentage of ewes that became pregnant from the first breeding (88 percent) than the Suffolk (78 percent). Also 15 percent of the Willamette and Suffolk lambed from breeding at the second estrus (1). In the present study 66.7 percent of the Border Cheviot, 22.2 percent of the Columbia, 62.5 percent of the Suffolk, and 87.5 percent of the Willamette lambed from matings that occurred in the second estrus following the cessation of Provera feeding. This was an overall efficiency of 50 percent.

Sixty-six percent of all ewes bred during the first estrus came into estrus twice and 15.6 percent came into estrus three times. The percentage of ewes that were bred during the first estrus but came into heat two or three times are approximately 37 percent higher than that reported in the literature (1).

The data from the present study support the hypothesis that oral progestogens are highly effective for synchronizing estrous cycles. Their effectiveness in synchronizing parturition, however, is only fair. It is possible that greater efficiency could be realized in synchronizing parturition by not breeding at the first estrus following the cessation of the feeding of oral progestogens and breeding all ewes at the second estrus. Data have been reported that would support this hypothesis (1). In the present study overloading the ram is not the cause of many returns to estrus as there were only nine ewes per ram in each of the breeds.

From the data obtained in this investigation one would have to arrive at the conclusion that Provera is not completely satisfactory as a research tool for synchronizing parturition. There also seems to be a slight upset in the hormone balance from orally administered progestogens as shown by two results; the greater variation in estrous cycle intervals and the greater number of pregnant ewes showing estrus. Thus in order to have a large percentage of ewes lambing within a short time one would have to rely upon progesterone injections.

SUMMARY AND CONCLUSIONS

From the results of the present study the following conclusions appear warranted.

1. During the first eight weeks of lactation the breeds studied had produced 74 percent of their total milk yield and by the tenth week they had produced 87 percent.
2. The breeds ranked from highest to lowest as follows on the basis of milk yield and milk quality: Suffolk, Willamette, Dorset Horn, Border Cheviot, and Columbia. The latter two were approximately equal.
3. Ewes nursing twin lambs produced 25 percent more milk than ewes nursing single lambs.
4. The peak of milk production occurred during the second period of lactation.
5. The average grams of milk produced per day for ewes nursing single and twin lambs by breed is as follows: Border Cheviot, single 1, 016, twin 1, 669; Dorset Horn, single 1, 617, twin 1, 778; Columbia, single 1, 366, twin 1, 684; Suffolk, single 1, 527, twin 2, 287 and Willamette, single 1, 552, twin 1, 951.
6. The breeds are ranked as follows according to the quality of colostrum when measured by percentage composition: Suffolk, Willamette, Border Cheviot, Dorset Horn, and Columbia.

7. There were no significant differences (P > .05) between any of the breeds for the percentage of the milk components studied.
8. A set of twins gained on the average 40.7 percent more than a single lamb.
9. The Willamette had the highest average daily gain for single lambs and was followed in order by the Suffolk, Columbia, Dorset Horn, and Border Cheviot. For twin lambs the Willamette was again highest, and the Suffolk, Dorset Horn, Border Cheviot, and Columbia breeds followed in that order.
10. Single lambs gained 15.7 percent more weight than the average lamb for a set of twins.
11. The average grams of milk required to produce one gram of gain is as follows for single and twin lambs: Border Cheviot, single 3.964, twin 3.455; Dorset Horn, single 5.472, twin 3.424; Columbia, single 4.406, twin 3.716; Suffolk single 4.326, twin 3.882, and Willamette, single 4.193, twin 3.114.
12. The breeds having the greatest monetary return were: Suffolk, Willamette, Columbia, Dorset Horn, and Border Cheviot, respectively.
13. The average 120-day weight by breed was: Border Cheviot 72.3 pounds, Dorset Horn 78.1 pounds, Columbia 86.9 pounds, Suffolk 94.2 pounds, and Willamette 100.2 pounds. The lambs in the Willamette and Suffolk breeds were by far the most rapid

in rate of growth.

14. The quantity of milk required to produce lambs of a given weight based on the average efficiencies of growth and average daily gain for each of the five breeds studied was postulated. It was found that the Border Cheviot does not yield enough milk in 120 days to raise one 70 pound lamb. The other four breeds met their requirement quite easily. For twins only the Suffolk and Willamette produce enough milk in 120 days to raise a set of twins averaging 70 pounds per lamb. The Columbia, Suffolk, and Willamette breeds produce enough milk to raise one lamb to 80 pounds, however, only the Willamette produce enough milk to raise a set of twins to 80 pounds. Both the Suffolk and Willamette produce enough milk to raise 90 pound single lambs. None of the breeds produced enough milk to average 90 pound twin lambs or 100 pound singles or twins.
15. A large portion of the nutrients required for lamb growth and fattening must be supplied by foods other than milk.
16. Highly significant differences in live animal weights were found to exist between the breeds of sheep at 100 days of age.
17. Weight differences between sexes within a breed were not found significant, and there appeared to be no significant interaction between breed and sex.
18. A simple correlation coefficient of 0.84 for total gain and total

grams of milk produced was highly significant ($P < .01$). Seventy percent of the variation in the total gain is accounted for by the variation in total milk yield.

19. It is postulated that the lamb's weight at ten weeks of age would be a better criterion by which to cull low producing ewes and for the selection of replacement females and males than is the weaning weight or 120-day weight.

20. The carcasses that rated the highest on tenderness and composite preference scores as determined by organoleptic tests were: Columbia, Willamette, Dorset Horn, Border Cheviot, and Suffolk, respectively.

21. The conformation score, composite preference score, tenderness score, and the percentage of protein, solids-not-fat, and milk fat, and the total days nursed were not affected by the breed, sex or rearing of the lambs studied. Only condition score and weight of the lambs were affected by breed. The total gain of the lambs was affected by the quantity of milk and the milk components produced by their dams.

22. Purified Oxytocic Principle proved to be very successful in allowing removal of all available milk from the udder. Thus, it was established as a very useful and accurate research tool for studies of this type.

23. The oral progestogen "Provera" is only 50 percent effective in synchronizing the time of parturition.

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APPENDIX

Appendix Table 1. Average grams of milk protein produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
	For ewes nursing single lambs							
Border Cheviot	67.6	88.9	61.8	56.4	48.1	36.1	34.0	58.4
Dorset Horn	98.9	83.0	88.2	85.0	84.7	59.0	53.0	81.3
Columbia	84.1	91.7	73.8	69.3	56.4	42.8	41.2	69.4
Suffolk	94.6	93.4	90.3	85.4	79.4	71.9	62.2	84.1
Willamette	102.2	109.6	100.6	81.3	74.6	62.4	49.8	86.4
	For ewes nursing twin lambs							
Border Cheviot	100.8	105.7	104.7	83.3	85.3	59.8	58.9	87.8
Dorset Horn	113.3	131.0	105.4	104.7	76.1	66.4	53.2	96.5
Columbia	73.4	115.6	105.9	87.2	83.6	44.3	22.0	84.6
Suffolk	135.9	154.9	138.7	122.9	110.6	90.8	74.1	125.4
Willamette	136.2	159.4	110.8	90.0	76.7	75.7	68.7	105.0

Appendix Table 2. Average grams of milk lactose + ash produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
	For ewes nursing single lambs							
Border Cheviot	60.8	82.9	54.3	52.0	59.1	34.9	34.6	53.8
Dorset Horn	111.4	101.1	116.4	86.2	89.0	61.1	52.1	92.4
Columbia	90.2	101.8	76.4	76.4	64.5	42.7	42.1	75.0
Suffolk	87.4	95.0	96.1	89.7	83.2	69.3	54.4	84.3
Willamette	87.3	112.2	97.1	88.8	73.3	59.5	45.2	83.7
	For ewes nursing twin lambs							
Border Cheviot	98.8	111.0	104.7	83.2	86.8	54.2	50.7	87.0
Dorset Horn	118.2	134.5	110.7	100.2	75.6	61.7	48.3	97.0
Columbia	71.2	129.7	115.4	83.6	87.9	38.6	63.5	89.3
Suffolk	119.1	176.8	158.6	134.8	107.3	85.4	67.8	130.2
Willamette	115.8	171.7	116.0	99.2	83.4	75.2	71.9	107.2

Appendix Table 3. Average grams of milk solids-not-fat produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	128.4	171.9	116.1	108.4	93.0	71.0	68.6	112.2
Dorset Horn	210.4	184.1	204.6	171.2	173.8	120.1	105.1	173.7
Columbia	174.3	193.4	150.2	145.7	120.9	85.5	83.3	144.3
Suffolk	182.0	188.4	186.4	175.1	162.6	141.3	116.6	168.5
Willamette	189.5	221.8	197.7	170.1	147.9	121.9	95.0	170.1
				For ewes nursing twin lambs				
Border Cheviot	199.6	216.7	208.9	166.5	172.1	114.0	109.6	174.8
Dorset Horn	231.5	265.5	216.1	204.9	151.7	128.0	101.5	193.5
Columbia	144.7	245.3	221.3	170.8	171.5	82.9	85.5	173.9
Suffolk	255.0	331.7	297.4	257.6	217.2	176.2	142.0	255.6
Willamette	252.0	331.1	226.7	189.2	160.1	150.9	140.6	212.2

Appendix Table 4. Average grams of milk fat produced per ewe per day by various breeds over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	111.8	131.4	97.4	79.4	67.3	57.5	46.8	88.5
Dorset Horn	172.0	164.5	148.1	124.3	120.0	94.4	86.2	134.3
Columbia	128.2	150.9	120.8	115.7	100.4	73.8	66.9	114.0
Suffolk	138.1	129.3	125.4	124.1	119.4	106.5	88.8	121.3
Willamette	160.0	142.4	136.2	116.5	95.9	83.5	64.5	119.8
				For ewes nursing twin lambs				
Border Cheviot	252.2	183.4	164.3	116.8	122.7	103.0	77.4	153.1
Dorset Horn	205.4	217.4	157.4	148.2	116.4	100.2	89.2	153.7
Columbia	155.1	146.2	160.8	117.1	113.8	77.3	70.3	134.8
Suffolk	207.0	214.6	194.6	178.9	148.5	127.9	117.9	179.3
Willamette	234.9	297.8	182.4	138.8	118.5	122.8	104.9	176.3

Appendix Table 5. Average grams of milk solids produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	240.2	303.3	213.6	187.8	160.3	128.5	115.4	200.8
Dorset Horn	382.4	348.7	352.6	295.5	293.8	214.5	191.3	308.0
Columbia	302.5	344.4	271.0	261.4	221.3	159.3	150.2	258.4
Suffolk	320.1	317.6	311.8	299.2	282.0	248.0	205.4	289.8
Willamette	349.4	364.2	333.9	286.6	243.7	205.4	159.5	289.9
				For ewes nursing twin lambs				
Border Cheviot	451.8	400.1	373.2	283.3	294.8	217.0	187.0	327.9
Dorset Horn	436.9	483.0	373.6	353.1	268.0	228.3	190.6	347.2
Columbia	299.8	425.8	382.1	287.9	285.3	160.2	155.9	308.7
Suffolk	462.0	546.2	492.0	436.6	366.4	304.1	259.9	434.9
Willamette	486.9	629.0	409.1	328.0	278.6	273.7	245.5	388.5

Appendix Table 6. Average grams of water produced per ewe per day by various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	977.3	1,263.4	874.6	765.4	652.4	484.1	453.5	815.7
Dorset Horn	1,741.7	1,474.2	1,571.2	1,184.1	1,285.8	834.3	621.9	1,309.1
Columbia	1,371.5	1,583.3	1,114.7	1,096.6	884.2	627.1	583.5	1,107.2
Suffolk	1,364.0	1,465.9	1,359.7	1,292.1	1,179.3	980.0	787.4	1,237.5
Willamette	1,562.7	1,675.7	1,396.5	1,230.2	1,055.0	855.6	646.6	1,262.1
				For ewes nursing twin lambs				
Border Cheviot	1,677.4	1,655.1	1,565.0	1,287.7	1,282.0	829.4	739.8	1,340.7
Dorset Horn	1,845.4	2,013.0	1,637.6	1,468.4	1,102.6	840.0	596.6	1,430.6
Columbia	1,321.1	1,944.1	1,751.0	1,279.5	1,340.9	495.0	576.9	1,374.9
Suffolk	1,778.8	2,409.2	2,223.3	1,870.2	1,607.5	1,230.9	1,016.2	1,851.8
Willamette	1,970.9	2,455.0	1,640.1	1,393.0	1,160.0	1,089.9	987.1	1,562.7

Appendix Table 7. Percentage of protein in the milk of various breeds of sheep by periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	5.55	5.68	5.68	5.92	5.92	5.90	5.98	5.75
Dorset Horn	4.66	4.56	4.59	5.75	5.36	5.62	6.52	5.02
Columbia	5.02	4.76	5.33	5.10	5.10	5.44	5.62	5.08
Suffolk	5.62	5.23	5.40	5.37	5.43	5.86	6.27	5.51
Willamette	5.35	5.37	5.81	5.36	5.74	5.88	6.18	5.57
				For ewes nursing twin lambs				
Border Cheviot	4.74	5.14	5.38	5.30	5.41	5.71	6.36	5.26
Dorset Horn	4.96	5.25	5.24	5.75	5.55	6.21	6.75	5.43
Columbia	4.53	4.88	4.97	5.56	5.14	6.76	3.00	5.02
Suffolk	6.07	5.24	5.11	5.33	5.60	5.92	5.81	5.48
Willamette	5.54	5.17	5.50	5.23	5.33	5.55	5.57	5.38

Appendix Table 8. Percentage of lactose + ash in the milk of various breeds of sheep by periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	5.00	5.29	4.99	5.45	5.52	5.70	6.07	5.30
Dorset Horn	5.25	5.55	6.05	5.82	5.64	5.83	6.41	5.72
Columbia	5.39	5.28	5.51	5.63	5.83	5.43	5.73	5.49
Suffolk	5.19	5.33	5.75	5.64	5.69	5.65	5.48	5.52
Willamette	4.56	5.50	5.61	5.86	5.64	5.61	5.60	5.39
				For ewes nursing twin lambs				
Border Cheviot	4.64	5.40	5.40	5.30	5.51	5.18	5.47	5.22
Dorset Horn	5.18	5.39	5.51	5.50	5.52	5.77	6.14	5.45
Columbia	4.40	5.47	5.41	5.34	5.41	5.89	8.66	5.31
Suffolk	5.32	5.98	5.84	5.84	5.44	5.56	5.32	5.70
Willamette	4.71	5.57	5.76	5.76	5.80	5.52	5.83	5.50

Appendix Table 9. Percentage of solids-not-fat in the milk of various breeds of sheep by periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	10.55	10.97	10.67	11.37	11.44	11.59	12.06	11.04
Dorset Horn	9.90	10.10	10.64	11.57	11.00	11.45	12.93	10.74
Columbia	10.41	10.03	10.84	10.73	10.94	10.88	11.35	10.57
Suffolk	10.81	10.56	11.15	11.00	11.12	11.50	11.74	11.03
Willamette	9.91	10.87	11.42	11.22	11.38	11.49	11.78	10.96
				For ewes nursing twin lambs				
Border Cheviot	9.37	10.54	10.78	10.60	10.91	10.89	11.83	10.48
Dorset Horn	10.14	10.64	10.75	11.25	11.07	11.98	12.89	10.88
Columbia	8.93	10.35	10.37	10.90	10.55	12.65	11.67	10.33
Suffolk	11.38	11.22	10.95	11.17	11.17	11.48	11.12	11.18
Willamette	10.25	10.74	11.26	10.99	11.13	11.07	11.40	10.88

Appendix Table 10. Percentage of fat in the milk of various breeds of sheep by period.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing twin lambs				
Border Cheviot	9.18	8.39	8.96	8.34	8.28	9.38	8.23	8.71
Dorset Horn	8.10	9.03	7.70	8.40	7.60	9.44	10.60	8.31
Columbia	7.66	7.83	8.72	8.52	9.08	9.38	9.12	8.35
Suffolk	8.20	7.25	7.50	7.80	8.17	8.69	8.94	7.94
Willamette	8.36	6.98	7.87	7.68	7.38	7.87	8.00	7.72
				For ewes nursing twin lambs				
Border Cheviot	11.84	8.92	8.48	7.43	7.78	9.84	8.36	9.18
Dorset Horn	9.00	8.71	7.83	8.14	8.49	9.38	11.33	8.65
Columbia	9.57	6.17	7.54	7.47	7.00	11.80	9.60	8.00
Suffolk	9.24	7.26	7.17	7.76	7.52	8.33	9.24	7.84
Willamette	9.56	9.66	9.06	8.07	8.24	9.00	8.51	9.03

Appendix Table 11. Percentage of total solids in the milk of various breeds of sheep by periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	19.73	19.36	19.62	19.70	19.72	20.98	20.29	19.75
Dorset Horn	18.00	19.13	18.33	19.97	18.60	20.45	23.53	19.05
Columbia	18.07	17.86	19.56	19.25	20.02	20.26	20.47	18.92
Suffolk	19.01	17.81	18.65	18.80	19.30	20.19	20.69	18.97
Willamette	18.28	17.85	19.29	18.89	18.77	19.36	19.79	18.68
				For ewes nursing twin lambs				
Border Cheviot	21.22	19.47	19.26	18.03	18.69	20.73	20.18	19.65
Dorset Horn	19.14	19.35	18.57	19.38	19.55	21.37	24.22	19.53
Columbia	18.50	17.97	17.91	18.37	17.54	24.45	21.27	18.34
Suffolk	20.62	18.48	18.12	18.93	18.56	19.81	20.37	19.02
Willamette	19.81	20.39	20.32	19.06	19.37	20.07	19.92	19.91

Appendix Table 12. Percentage of water in the milk of various breeds of sheep by periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				For ewes nursing single lambs				
Border Cheviot	80.27	80.64	80.38	80.30	80.28	79.02	79.71	80.25
Dorset Horn	82.00	80.87	81.67	80.03	81.40	79.55	76.47	80.95
Columbia	81.93	82.14	80.44	80.75	79.98	79.74	79.53	81.08
Suffolk	80.99	82.19	81.35	81.20	80.70	79.81	79.31	80.03
Willamette	81.72	82.15	80.71	81.11	81.23	80.64	80.21	81.32
				For ewes nursing twin lambs				
Border Cheviot	78.78	80.53	80.74	81.97	81.31	79.27	79.82	80.35
Dorset Horn	80.86	80.65	81.43	80.62	80.45	78.62	75.78	80.47
Columbia	81.50	82.03	82.09	81.63	82.46	75.55	78.73	81.66
Suffolk	79.38	81.52	81.88	81.07	81.46	80.19	79.63	80.98
Willamette	80.19	79.61	79.68	80.94	80.63	79.93	80.08	80.09

Appendix Table 13. Grams of milk protein required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	0.361	0.406	0.252	0.276	0.212	0.114	0.062	0.228
Dorset Horn	0.582	0.340	0.300	0.350	0.291	0.166	0.082	0.275
Columbia	0.466	0.326	0.266	0.223	0.158	0.122	0.063	0.224
Suffolk	0.479	0.301	0.239	0.277	0.237	0.171	0.087	0.238
Willamette	0.485	0.292	0.268	0.237	0.194	0.175	0.061	0.233
				Twin lambs				
Border Cheviot	0.395	0.352	0.243	0.190	0.164	0.084	0.057	0.182
Dorset Horn	0.308	0.376	0.228	0.231	0.124	0.108	0.049	0.186
Columbia	0.243	0.365	0.243	0.234	0.119	0.105	0.023	0.187
Suffolk	0.475	0.264	0.268	0.205	0.160	0.123	0.065	0.213
Willamette	0.554	0.350	0.228	0.156	0.101	0.085	0.055	0.168

Appendix Table 14. Grams of milk lactose + ash required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	0.325	0.378	0.221	0.255	0.198	0.110	0.063	0.210
Dorset Horn	0.655	0.414	0.395	0.355	0.305	0.171	0.080	0.313
Columbia	0.500	0.362	0.275	0.246	0.181	0.122	0.064	0.242
Suffolk	0.442	0.307	0.254	0.291	0.248	0.164	0.076	0.239
Willamette	0.414	0.298	0.258	0.259	0.190	0.166	0.055	0.226
				Twin lambs				
Border Cheviot	0.387	0.370	0.244	0.190	0.168	0.076	0.049	0.180
Dorset Horn	0.321	0.386	0.239	0.221	0.123	0.100	0.044	0.187
Columbia	0.236	0.409	0.265	0.224	0.125	0.092	0.065	0.197
Suffolk	0.416	0.301	0.306	0.225	0.155	0.116	0.059	0.221
Willamette	0.399	0.377	0.239	0.172	0.110	0.084	0.057	0.171

Appendix Table 15. Grams of milk solids-not-fat required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	0.687	0.784	0.473	0.531	0.410	0.224	0.124	0.438
Dorset Horn	1.237	0.753	0.695	0.704	0.596	0.337	0.162	0.588
Columbia	0.966	0.688	0.541	0.470	0.339	0.243	0.127	0.466
Suffolk	0.921	0.608	0.493	0.569	0.486	0.335	0.164	0.477
Willamette	0.899	0.590	0.526	0.495	0.384	0.341	0.116	0.460
				Twin lambs				
Border Cheviot	0.782	0.721	0.487	0.381	0.332	0.160	0.106	0.362
Dorset Horn	0.630	0.762	0.467	0.452	0.246	0.208	0.094	0.373
Columbia	0.478	0.774	0.509	0.458	0.243	0.197	0.088	0.384
Suffolk	0.891	0.564	0.574	0.430	0.314	0.238	0.124	0.434
Willamette	0.867	0.727	0.466	0.329	0.210	0.100	0.112	0.339

Appendix Table 16. Grams of milk fat required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	0.598	0.599	0.397	0.389	0.297	0.181	0.085	0.345
Dorset Horn	1.012	0.673	0.503	0.512	0.412	0.265	0.133	0.455
Columbia	0.710	0.537	0.435	0.373	0.282	0.210	0.102	0.368
Suffolk	0.699	0.417	0.332	0.403	0.357	0.253	0.125	0.344
Willamette	0.759	0.378	0.362	0.339	0.249	0.234	0.079	0.324
				Twin lambs				
Border Cheviot	0.988	0.610	0.383	0.267	0.237	0.144	0.075	0.317
Dorset Horn	0.558	0.624	0.340	0.327	0.189	0.163	0.082	0.296
Columbia	0.513	0.461	0.370	0.314	0.162	0.184	0.072	0.298
Suffolk	0.723	0.365	0.375	0.299	0.214	0.173	0.103	0.304
Willamette	0.808	0.654	0.375	0.241	0.156	0.138	0.084	0.281

Appendix Table 17. Grams of milk solids required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	1.284	1.384	0.870	0.920	0.707	0.404	0.209	0.783
Dorset Horn	2.248	1.426	1.197	1.216	1.008	0.602	0.295	1.042
Columbia	1.676	1.226	0.976	0.843	0.621	0.453	0.229	0.833
Suffolk	1.620	1.025	0.825	0.972	0.842	0.588	0.288	0.821
Willamette	1.658	0.968	0.888	0.834	0.633	0.575	0.194	0.783
				Twin lambs				
Border Cheviot	1.771	1.331	0.869	0.648	0.569	0.304	0.180	0.679
Dorset Horn	1.188	1.386	0.807	0.778	0.435	0.371	0.176	0.669
Columbia	0.991	1.343	0.878	0.773	0.405	0.380	0.160	0.681
Suffolk	1.614	0.929	0.949	0.728	0.529	0.411	0.228	0.738
Willamette	1.675	1.381	0.842	0.570	0.366	0.307	0.195	0.620

Appendix Table 18. Grams of milk water required to produce one gram of gain for various breeds of sheep over seven periods of lactation.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	5.227	5.764	3.563	3.750	2.876	1.523	0.821	3.181
Dorset Horn	10.240	6.030	5.334	4.873	4.410	2.341	0.960	4.430
Columbia	7.600	5.635	4.014	3.536	2.481	1.784	0.889	3.572
Suffolk	6.904	4.729	3.597	4.198	3.522	2.326	1.105	3.506
Willamette	7.414	4.455	3.716	3.582	2.741	2.394	0.788	3.409
				Twin lambs				
Border Cheviot	6.574	5.508	3.646	2.944	2.473	1.164	0.714	2.776
Dorset Horn	5.018	5.778	3.538	3.237	1.791	1.365	0.550	2.755
Columbia	4.369	6.132	4.024	3.434	1.903	1.175	0.594	3.035
Suffolk	6.213	4.098	4.289	3.120	2.320	1.665	0.890	3.144
Willamette	6.781	5.392	3.301	2.422	1.524	1.224	0.786	2.494