AN ABSTRACT OF THE THESIS OF

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Title EFFECT OF CERTAIN BLOOD ENZYMES AND CELLULAR CONSTITUENTS ON GROWTH IN DIFFERENT GENETIC GROUPS OF SHEEP

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In the present study, five breeds of ewes and their lambs were utilized. The breeds used were: Border Cheviot, Dorset Horn, Columbia, Suffolk and Willamette. In all, 31 ewes and 42 lambs were involved.

The blood constituents which were determined for the ewes and lambs were: acid and alkaline phosphatase, hematocrit, hemoglobin and red and white blood cell numbers.

Blood samples were taken and analyzed for each ewe and lamb, at two-week intervals, from the ninth or tenth day of lactation until approximately 94 days subsequent to lambing. At 100 days of age the lambs were scored for conformation and condition. Then the lambs were slaughtered and a sample of each carcass was cooked and submitted to a taste panel to obtain scores for tenderness and preference.

Acid phosphatase levels of activity were approximately three times higher for lambs than for ewes at 10 days following lambing, and two times higher than the level for ewes for the entire testing period. Highly significant breed and period differences were observed for acid

phosphatase levels in lambs. No breed differences for this enzyme were noted in ewes.

Alkaline phosphatase levels of activity were higher in lambs than in ewes throughout the testing period. The average alkaline phosphatase value for lambs was 8.07 units compared to 2.96 units for the ewes. The average alkaline phosphatase value of lambs was highest at 10 days (11.00 units) and lowest at 80 days (6.36 units). Alkaline phosphatase levels were affected statistically ($P<.01$) by breed, sex and period, and ewe values were affected ($P<.01$) by breed, period and type of birth.

Hematocrit values were only slightly higher in lambs than in ewes. At the first testing period the ewe values slightly exceeded the lamb values, but from the second period until the end of the test the lamb values were higher than the ewe values. Highly significant ($P<.01$) differences were found in ewes according to breed and period, whereas, lamb hematocrit values differed according to age of dam and period ($P<.01$).

Hemoglobin levels followed a pattern similar to that found for hematocrit in lambs and ewes. Hemoglobin values for lambs and ewes reached the highest level at 24 days subsequent to lambing. Hemoglobin levels differed significantly ($P<.01$) in ewes according to breed and period, and in lambs according to period ($P<.01$) and sex ($P<.05$).

Average red blood cell counts were higher for ewes (9,690,000) than for lambs (8,920,000) at 10 days subsequent to lambing, but by 94 days the average ewe red blood count was 8,440,000 compared to 10,680,000 for lambs. No breed differences could be found in red

blood cell numbers for ewes or lambs. However, period and birth type differences were observed in lambs.

White blood cell numbers were slightly more than one thousand lower for lambs than for ewes at 10 days following lambing. The lamb values were still lower than the ewe values at 24 days, but by 38 days the lamb values exceeded the ewe values. White blood cell numbers differed significantly ($P<.01$) for ewes according to breed and according to breed, birth type and period for lambs. A slight sex difference in white blood cell numbers was observed in lambs.

The Columbia lambs had the lowest conformation and condition scores of any of the breeds. The Border Cheviots and the Willamettes had the highest scores for conformation and condition, respectively. However, the Columbias had the highest preference and tenderness scores of any of the breeds, while the Border Cheviots had the lowest preference and tenderness scores of any of the breeds.

The breeds ranked in the following order for average weight gains of lambs: Willamettes, Suffolks, Columbias, Dorest Horns and Border Cheviots. Body weight of lambs differed significantly ($P<.01$) according to breed, birth type and period and ($P<.05$) according to sex.

None of the variables studied seemed to be highly related to growth rate in lambs.

EFFECT OF CERTAIN BLOOD ENZYMES AND CELLULAR CONSTITUENTS ON GROWTH IN DIFFERENT GENETIC GROUPS OF SHEEP

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EFFECT OF CERTAIN BLOOD ENZYMES AND CELLULAR CONSTITUENTS ON GROWTH IN DIFFERENT GENETIC GROUPS OF SHEEP

INTRODUCTION

Fat lamb production has been traditionally a system based on the selling of lambs at weaning time. In many cases the lambs receive only the milk produced by the dams and whatever pasture is available. Some producers provide a creep feeding program, whereby the lambs receive supplemental feeding, which strives for lambs that reach market age in the best possible condition. Even then, many lambs are not ready for market at weaning time and have to be sold as feeders. Supplemental feeding could, in reality, be covering-up the true weaning weight potential of many lambs.

Since most lambs are marketed at weaning time, selection of breeder animals based on performance of the lambs up to this period is of utmost importance. The significance of weaning weight has been pointed out by various researchers. Hazel and Terrill (1943) estimated the heritability of weaning weight of sheep at 30 percent and according to Bogart (1959) this would indicate that considerable progress could be expected in a breeding program by selecting larger lambs at weaning time.

A certain amount of emphasis should be placed on birth weight of lambs in a fat lamb program. It has been suggested that birth weight of lambs is highly related to rate of gain. This was revealed in a study by Cadmus (1949) in which he found that each pound of increase in birth weight of lambs was associated with a 2.5 pound increase in

weaning weight. This might indicate that the genes controlling growth rate prior to birth are the same as the ones controlling growth rate between birth and weaning time.

Although birth weight and weaning weight are of great significance and are used in most breeding programs, great variations in lamb weaning weights are still observed. This would lead one to suspect that other factors play important roles in the final expression of growth in lambs. It can be assumed that many differences in growth of lambs might be due to nutritional and other environmental factors. In some cases it might be that the animal is unable to utilize certain nutrients. Under such conditions, especially the latter, genetics probably plays a major role. Genetic weaknesses could exist which might inhibit proper function of entire organs or they could possibly go beyond organ function and extend into specific enzymes or complete enzyme systems.

Historically, selection in sheep has been based, for the most part, on physical characteristics and the pedigree of the individuals. These physical factors are essentially based upon certain standards set forth by breed associations or individual breeders. Many of these characteristics have little or no association with items of value in lamb production. Thus, it becomes apparent that means of improving selection practices other than visual appraisal are needed.

One such tool that is available to modern breeders is a selection index which can be used to estimate the overall merit of animals in evaluating their true performance. By knowing the heritabilities and the economic importance of most traits, indices can be developed which should allow considerable progress to be made in a breeding program.

For this type of system to be of any significance to the breeder it is imperative that the breeder recognize the traits which are of the greatest economic value to his program and include these in the index.

Perhaps selection in sheep should go beyond the realm of the index and extend into the areas which attempt to expose the true makeup of the animal - more toward the cellular and enzymatic levels of the individual. For these types of observations, it is only fitting that factors which are in the blood be examined. Since the blood of the animal is the "lifeline" of that individual, changes or differences in blood constituents might reflect differences in performances between animals.

Since enzymes and enzyme systems are so essential to the many complex chemical reactions within the body it becomes apparent that levels of activity of certain blood enzymes be studied to determine if any relationship exists between enzyme activity and the performance of the animal, particularly, growth of the animal. Other blood constituents, such as cell numbers, hematocrit or cell volume and hemoglobin values should reveal significant information concerning the well-being of sheep.

Five genetic groups of sheep were utilized in this study. These groups were: Border Cheviot, Dorset Horn, Columbia, Suffolk and Willamette. All, except the Willamette, are standard breeds and are well established in the Willamette Valley of Oregon. However, the Willamette will be referred to as a breed throughout this study. The Willamette breed was established by mating Columbia ewes to Dorset Horn and Cheviot rams, reciprocally crossing the resulting crossbreds to

establish a genetic pool and subsequently intermating in a closed population of about 100 breeding females and four to six males. Selection has been based on weaning weight adjusted to 120 days X 2 + score for conformation + score for condition as a means of selecting replacements. Ewes are culled on the basis of fertility and weaning weights of their lambs.

The Suffolk sheep used were from a closed line of 45 breeding females and three males in which selection as outlined for the Willamette had been practiced for eight years.

This study was undertaken in order to gain as much knowledge as possible on each breed. Further, it was considered that a comparison of these breeds would not only reveal breed differences but might give some information regarding the effects of selection in flocks varying in the initial gene material. It was particularly interesting to compare a sample of the Willamette sheep with samples of the breeds of sheep from which the Willamette was developed.

The objectives of this study were to determine:

1. The levels of activity for serum acid and alkaline phosphatase of the five breeds of sheep as the animals increase in age from two weeks to 14 weeks.

2. The hematocrit and hemoglobin values of each breed of sheep as the animals increase in age from two weeks to 14 weeks.

3. The erythrocyte and leucocyte counts of each breed of sheep as the animals increase in age from two weeks to 14 weeks.

4. The relationship between each factor studied and growth of lambs.

5. The relationship(s) of the factors studied and the tenderness and preference scores obtained by the taste panel.

6. The relation(s) among all the factors studied.

REVIEW OF LITERATURE

The blood of an individual performs many essential functions. Dukes (1955) summarized these functions as follows: (1) carries nutrients from the alimentary canal to the tissues, (2) picks up oxygen from the lungs and transports it to the tissues, (3) takes the waste products of metabolism and delivers them to the excretory organs, (4) carries the secretions of the endocrine glands, (5) helps in the equalization of the water content of the body, (6) functions in the regulation of body temperature, (7) aids in the regulation of the pH of the organism and (8) assists in the regulation of the body defenses against microorganisms.

Body cells and organs require a rather constant environment for carrying out their proper tasks and many of the functions of the blood are directed toward the maintenance of the constancy of the internal environment of the organism.

Enzymes, which are found in the blood, organs and tissues of the body, must play important roles in the chemical reactions within the blood, between the blood and tissues and within tissues. Since enzymes are specific for temperature, substrate and pH it is apparent that the blood of an individual must perform its functions in an optimum manner.

This review of literature will cover the following subjects: serum acid and alkaline phosphatases, hematocrit and hemoglobin levels and erythrocyte and leucocyte counts.

Acid Phosphatase

It was shown by Cantarow and Schepartz (1962) that normal plasma contains small amounts of acid phosphatase with optimum pH of 4.9. This apparently originates mainly in the liver and spleen. The activity of this enzyme is present in several organs of the body but in the prostate of adult humans it is at least 100 times that of other tissues. It is formed by mature prostatic epithelial cells and is passed into the prostatic secretion.

This enzyme has been shown by several workers to have a clinical significance. Cantarow and Schepartz (1962) pointed out that prostatic carcinoma results in increased activity in serum acid phosphatase. The prostatic enzyme gains access to the blood stream and causes increased activity in the serum.

According to Williams (1959) the normal level of acid phosphatase activity for 10 normal human adults was found to range from 0.6 to 2.0 units. In certain diseased conditions the values were higher, up to 5.0 units in an advanced case of Paget's disease.

Wojnas and Bester (1963) showed that there was a relationship between the prostatic serum acid phosphatase activity and size of the prostate of rats. Prostatic serum acid phosphatase activity increased markedly until prostate weight reached approximately 200 mg. Then, little or no change in its activity was noticed. Therefore, in young animals prostatic serum acid phosphatase activity is indicative of normal prostatic growth and not necessarily indicative of abnormality as noted by Wojnas and Bester.

It is possible that this serum enzyme might have some relationship to growth of domestic animals. Johnston and Anglemier (1963) studied the effects of estrogen on blood phosphatase levels of lambs. During the first 16 days of the test a marked decline in acid phosphatase activity was noted for all lambs. After 16 days on test the faster gaining lambs (diethylstilbestrol implanted animals) had higher acid phosphatase activity levels than the slower gaining lambs. Also, the faster gaining animals showed less change in enzyme activity levels during the last half of the experiment than did the slower gainers.

In a study with Hereford and Angus cattle it was found that serum acid phosphatase activity was higher at an early stage, around 500 pounds body weight, then dropped off for males and females of both breeds according to Johnston et al. (1961). In a different study involving blood enzymes and rate of gain in Hereford and Angus cattle, it was found by Johnston and coworkers (1962) that on the basis of age females generally maintained the higher activity for acid phosphatase. However, when the activities were evaluated on a weight basis the males had the highest activity. This study indicated breed differences for levels of this enzyme in that Herefords had a higher level of activity, regardless of sex, than did Angus. Acid phosphatase activity was higher for males than for females after approximately 450 pounds body weight. On the basis of age, fast gaining females and males maintained a lower average acid phosphatase activity than the slower gaining animals.

Alexander (1958) and Alexander et al. (1958) reported a highly significant positive correlation between rate of gain and serum acid phosphatase activity levels in beef cattle. These workers also showed

that a significant difference existed between sexes for acid phosphatase levels in that all males had higher levels of activity than did females.

It was found by Blincoe and Marble (1960) that no differences for acid phosphatase could be observed between normal sheep and those which had white muscle disease. In a study by Allcroft and Folley (1941) it was pointed out that phosphatase at an acid pH was present in such small quantities in the blood of sheep and cattle as to be of little significance.

Using p-nitrophenyl phosphate as a substrate, Andersch and Szczypinski (1947) determined normal acid phosphatase values of 25 women and 75 men. The values obtained were 0.1 to 0.56 millimol units for women and 0.13 to 0.63 units for men.

Alkaline Phosphatase

The alkaline phosphatase of normal individuals originates largely in the bones, being formed chiefly by osteoblasts according to Cantarow and Schepartz (1962). Further, an increase in the plasma in skeletal disorders is regarded as a reflection of increased osteoblastic activity. This in itself is of great clinical value in differentiating between osteomalacia (high phosphatase activity) and osteoporosis (normal activity), as well as in the diagnosis of other skeletal diseases which are characterized by osteoblastic proliferation.

According to Cantarow and Schepartz this enzyme is also increased in biliary obstruction (obstructive jaundice) and to a lesser degree in certain cases of hepatic diseases. These workers further pointed out

that serum alkaline phosphatase activity occurs in hypophosphatosis, a familial and probably genetically determined condition, characterized by defective skeletal mineralization. The enzyme activity is low in the bones and other tissues with this condition.

It was further suggested that alkaline phosphatase, in addition to its role in hydrolysis of phosphate monoesters in the digestive tract probably plays a part in the absorption of sugars from the intestine, the reabsorption of glucose in the kidney and the calcification of bones and teeth.

Finegan (1963) reported that alkaline phosphatase in the mammalian kidney had a multiple nature and that each alkaline phosphatase has the capacity to utilize a range of phosphate esters as substrate. This would indicate that this enzyme is more important in the mammalian system than had been previously thought. This multiple nature of alkaline phosphatase was also demonstrated by Taswell and Jeffers (1963). Using a starch gel electrophoresis technique, multiple isoenzymes of alkaline phosphatase were obtained from 202 hospital patients. Eight separate zones of activity were found and these were arranged into three distinct patterns. Each of these patterns were associated with specific disease conditions.

It was reported by Talbot (1939) that the level of phosphatase in the serum was believed to be an index of osteoblastic activity and as such was related to bone formation. Hypothyroidism during childhood resulted in retarded osseous development and dwarfing of stature. Thyroid therapy tended to repair this retardation by stimulating bone growth and development.

The serum phosphatase of untreated hypothyroid children tended to be abnormally low (average of 3.0 units) according to Talbot (1939). It was restored to normal levels (average of 8.5 units) by thyroid therapy.

Williams (1959) gave an overall range, for alkaline phosphatase activity of 600 humans, of 1.29 to 14.00 units. In some disease conditions the levels may rise from 10 to 50 times the normal average value. This enzyme's activity did not increase in humans during an 18-hour fast. Also, a high protein meal had little or no effect on alkaline phosphatase activity and neither did a period of a 40-hour high fat intake. Further, Williams pointed out that alkaline phosphatase values increased during rickets in humans. These values were lowered after the subjects were treated nutritionally. Also, Bessey et al. (1946) pointed out that there is an increase in serum alkaline phosphatase activity during rickets. However, serum alkaline phosphatase activity returns to normal levels when healing is complete.

In a study conducted with rachitic chicks, Motzok (1950) found that the phosphatase activity of the plasma and of bone extracts increased markedly and in an approximately parallel manner with diminishing consumption of vitamin D. It was assumed that the increase in plasma phosphatase under rachitic conditions was chiefly the result of "leakage" of the enzyme from the bones into the blood stream. On the other hand, Wiese et al. (1939) reported that blood and bone phosphatase activity of chicks was lower with perosis than with non-perotic chicks. Manganese was shown to have an activating influence on the enzyme during in vitro experiments.

Apparently normal ewes showed variations in serum phosphatase activity from 3.0 to 166.1 units per 100 ml. of serum according to Allcroft and Folley (1941). Due to this wide range in values, these workers suggested that this enzyme would be of little diagnostic significance. Serum phosphatase remains rather constant for individual animals over a long period of time and in general will decrease with advancing age in cattle and sheep. In this study, Allcroft and Folley could find no correlation between milking capacity and serum phosphatase activity in dairy cows.

Hackett et al. (1957) also found wide variations in the alkaline phosphatase levels for adult sheep. While working with ewes, a downward trend in the enzyme level was noted as age increased. It was suggested that this trend might be due to pregnancy rather than age. An increase in alkaline phosphatase was observed for lambs during their first year of life.

In white muscle disease and muscular dystrophy cases induced by the feeding of cod liver oil to lambs, the alkaline phosphatase level decreased to half its normal value according to Blincoe and Marble (1960).

Fletcher et al. (1956) found the relationship of serum alkaline phosphatase activity to subsequent gain in cattle to be quite variable. However, gross correlations between the enzyme and gain were positive.

In a study, using estrogen implants, it was found by Johnston and Anglemier (1963) that during the first 28 days of the trial, the gain or loss in weight of lambs was accompanied by a similar increase or decrease in the alkaline phosphatase activity levels. The

diethylstilbestrol implanted lambs which were the faster gaining animals generally had the higher alkaline phosphatase activities over the testing period. According to Johnston and coworkers (1961) the levels of alkaline phosphatase of male cattle began to exceed that of females at 500 pounds with a significant difference ($P<.01$) at 800 pounds. Also, Angus cattle showed higher levels of activity for this enzyme than did Hereford cattle. Alexander (1958) and Alexander et al. (1958) obtained a highly significant positive correlation between rate of gain and alkaline phosphatase levels of activity in cattle. Further, it was revealed that Angus males had significantly higher serum alkaline phosphatase levels than did Angus females. In another study involving Hereford and Angus cattle, Johnston et al. (1962) found that females, on a size basis, had higher average phosphatase levels of activity than males. On a weight basis, fast gaining females maintained higher levels than slow gaining females.

It was shown by Bogart et al. (1963) that faster gaining male calves had a higher serum acid phosphatase-serum alkaline phosphatase activity ratio than did slower gaining male calves. A similar relationship was observed for fast and slow gaining female calves.

Anglemier et al. (1961) conducted an experiment which involved the determination of enzyme activity of loin tissue from steers. This study revealed that the alkaline phosphatase activity was higher for the tissue of the tender group than for the tough group. This was significant at the five percent level. Also, a correlation coefficient of 0.78 was obtained for tissue alkaline phosphatase activity and tenderness score. Similarly, Johnston et al. (1963) found that lambs producing the

more desirable meat (taste panel preference) had a significantly higher ($P<.01$) alkaline phosphatase levels of activity from 50 to 100 days of age than did the lambs having the less desirable meat.

Research by Reid and coworkers (1948) revealed that the plasma alkaline phosphatase concentrations of bulls appeared to be largely dependent upon the frequency of semen ejaculation. The rations used did not have any noticeable influence on the plasma phosphatase. However, Jackson and Wightman (1952) showed that fasting reduced the serum and intestinal phosphatase of rats. Also, the feeding of mixed rations of fat and protein elevated both the serum and intestinal phosphatase of these rats. Similarly, Auchinachie and Emslie (1933) indicated that the plasma phosphatase of sheep on a ration low in calcium and high in phosphorous increased progressively to three of four times its normal value while serum calcium fell. Further, it was suggested that plasma phosphatase determinations could be used as an early indicator of disordered calcium and phosphorous metabolism. These workers also pointed out that plasma phosphatase seemed to be lower in pregnant than in non-pregnant ruminants.

Hematocrit

The volume of blood cells is usually less than that of plasma. The relationship between the volume of blood cells and plasma is readily determined by means of the hematocrit. The volume of packed red blood cells, or hematocrit reading, is normally directly related to the erythrocyte count and hemoglobin content of blood according to Dukes (1955).

A wide range in hematocrit values for sheep has been reported by various researchers. Dukes (1955) showed a hematocrit value of 32 percent for sheep. Work by Stubbs and Boyer (1954) revealed a range in hematocrit values of 31.9 to 40.1 percent for 10 healthy sheep. The average value obtained for these sheep over a period of 33 months was 36.8 percent. In an investigation with several breeds of sheep and at several locations in South Africa, Stubbs (1963) reported an average hematocrit value of 38 percent. This worker suggested that some of the variation observed might have been due to environmental or other factors.

Whitlock (1963) suggested that maximum hematocrit values in sheep are influenced by heredity and environment. A study in which observations were conducted on 222 ewes over two shearing periods revealed that 83 percent of the ewes had a postshearing hematocrit value larger than the level during the preshearing period. Becker and Smith (1950) studied the hematocrit levels for several breeds of sheep and found an average value of 37.9 $\pm$ 0.36 percent. The values determined for the breeds utilized were: 36.6, 40.5 and 36.6 percent for Corriedales, Dorset Horns and Hampshires, respectively. These workers concluded that although these breed differences were not significantly different, these values indicated that possibly breeds do differ for this factor. A breed difference for packed cell volume was observed in sheep by Cresswell (1962). This work showed that Cheviots had higher hematocrit values than Romneys. Work by Rao *et al.* (1962) revealed a hematocrit value of 30.25 $\pm$ 0.25 percent for one breed of sheep in India.

Apparently, a difference in hematocrit values of sheep is detectable at different ages. Evans and Blunt (1960) reported that

packed cell volume decreased in lambs from 56.0 percent at birth to 35.8 percent at 42 days of age. Then packed cell volume rose to 40 percent. According to these workers this drop is probably an expression of the physiological anemia observed in other animals when growth rate of the body exceeds the rate of production of red blood cells. Similarly, Ullrey et al. (1962) found that hematocrit values in lambs dropped rapidly after birth to a low value around 14 days. This low period was followed by a rise to a second high value around two to three months. It was reported by Bhannasiri (1960) and Bhannasiri et al. (1961) that hematocrit decreased in value with an increase in age in beef cattle. Further, Bhannasiri (1960) found no sex difference for hematocrit values in beef cattle. However, Hereford calves showed lower hematocrit values at 500 lbs. body weight than Angus calves.

It was observed by Grunsell (1955) that sheep with worm infestation and on a low plane of nutrition had reduced hematocrit levels as compared to worm-free sheep on the same ration. Also, the hematocrit values were lower for sheep during the first two years of life and he attributed this to the worm burden encountered by this group of sheep. Gallagher (1963), in a study on Trichostrongylosis in sheep, found that the hematocrit value dropped from 30.1 percent before infection to 24 percent after infection with the lowest value obtained being 17 percent. Again, it would appear that worm infestation alters hematocrit levels in sheep.

Hemoglobin

Hemoglobin, the pigment of the erythrocytes, is a complex, iron-containing protein composed of a pigment and a simple protein. According to Dukes (1955) hemoglobin has important physiological relationships with oxygen. During the passage of erythrocytes through the pulmonary capillaries, hemoglobin combines with oxygen to form oxyhemoglobin, which, as it moves through the systemic capillaries, loses its oxygen to the tissues and again becomes hemoglobin. This reaction can be shown in the following equation:

$$Hb + O_2 \rightleftharpoons HbO_2$$

Since this relationship exists between hemoglobin and oxygen any drastic changes in the hemoglobin level of an individual should reflect some change in the well-being of that individual.

Dukes further pointed out that in the normal animal one would expect to find a positive correlation between the number of red blood cells and the hemoglobin content of the blood. Also, this author suggested that the amount of hemoglobin in the blood is influenced by factors such as: age, sex, activity, season, barometric pressure, life habits of the species and disease.

Hemoglobin values for sheep have been reported by various researchers: Dukes (1955) gave 12.4 $\pm$ 1.4 gm. per 100 ml. of blood as the average hemoglobin content of sheep blood. Schalm (1961) showed a range of 8.0 to 16.0 gm. per 100 ml. with an average range of 11.0 to 13 gm. per 100 ml. for sheep. This author further reported a normal value of 12.2 for 134 lambs. Spector (1956) listed 10.9 as an average hemoglobin value for sheep with a range from 10.0 to 11.8. It was

indicated by Hudson and Osborne (1954) that normal adult sheep had a hemoglobin content of 12.25 with a range from 8.5 to 15.5. Similarly, a value of 12.41 $\pm$ 0.13 for normal sheep was reported by Becker and Smith (1950). Stubbs and Boyer (1954) found the hemoglobin values of 10 sheep to range from 10.6 to 12.8 with an overall average of 11.7 for these sheep over a 33-month period.

It was pointed out by Watson (1953) that hemoglobin not only varies from animal to animal but also it varies from location to location. In this study sheep were subject to various altitudes in order to observe the change in hemoglobin content of the blood. It was found that sheep held at 10,500 ft. to 15,000 ft. showed values above 14.00 which was higher than normal values reported at lower altitudes. In a study with human subjects, involving altitudes from 13,000 ft. to 19,000 ft., Pugh (1964) found that red cell volume and hemoglobin content rose progressively and reached mean values of 49 percent above the sea level controls. Hemoglobin concentrations rose 30 percent in the first 18 weeks and 8 percent during the following 9 to 14 weeks.

Stubbs (1963) reported that sheep in heavy rainfall areas of South Africa had an average hemoglobin value of 9.6 gm. per 100 ml. of blood. This value was obtained from several breeds which were held at several locations. A study conducted in India by Rao *et al.* (1962) revealed a hemoglobin value of 9.76 $\pm$ 0.15 for 12 healthy yearling sheep.

It has been shown by various sources that sheep of different ages have different hemoglobin values. Ullrey *et al.* (1962) reported that the hemoglobin concentrations dropped rapidly after birth in lambs and reached a low point at approximately 14 days. This drop was followed

by a second high value at two to three months. Cresswell (1962) reported a low for mean corpuscular hemoglobin in sheep just prior to lambing and this value was still low right after lambing. In an experiment in which I^{131} was administered to Suffolk sheep over an 18-month period, Hackett and coworkers (1957) found no change in hemoglobin levels. However, hemoglobin values did decrease appreciably during or subsequent to lambing. Watson (1953) found no essential difference in hemoglobin levels between two-year old, three-year old and aged (fifth lamb) ewes. However, differences did show up one week after lambing with the older ewes showing the highest hemoglobin values. Bhannasiri (1960) and Bhannasiri and coworkers (1961) reported that hemoglobin values increased steadily in beef cattle from 500 to 800 pounds body weight.

Hemoglobin has been shown to vary with the season in sheep. Holman (1944) observed a seasonal variation in hemoglobin content for adult sheep. Hemoglobin values were as follows: spring 9.6, summer 11.7, autumn 10.6 and in winter 11.7. The low levels shown during spring and fall were attributed to inanition. In an experiment with goats, Kiaser and Cummings (1958) found that hemoglobin concentrations varied during the year. In early November the range for hemoglobin, prior to breeding, was from 8.6 to 15.0 gm. percent, but after breeding the values tended to approach the mean value for many goats of about 10.5 gm. percent. This would suggest that there may be a seasonal and nutritional influence, as well as effect of pregnancy on normal hemoglobin of goats.

In a study with lambs and ewes, Britton (1946) reported that hemoglobin remained within a normal range for several lots of lambs

that had been subjected to various feeds. However, in five of eight fatal cases of acute indigestion due to sudden feed changes and overloading of forestomachs in sheep hemoglobin increased from 13 to 16.1 gm. per 100 ml. of blood.

Work by Grunsell (1955) revealed that when parasites (worms) were present in sheep on a half-maintenance diet, hemoglobin values were lowered. Similarly, Gallagher (1963) reported that intestinal worm infestation caused the hemoglobin level of sheep to drop. This drop was from approximately 9.0 to around 6.3 gm. per 100 ml. of blood.

Stewart, McCallum and Taylor (1945) found that in sheep and cattle which showed clinical symptoms of Johne's disease, the hemoglobin and calcium content of the blood was low.

Cresswell (1962) could find no differences in hemoglobin level between Cheviot and Romney sheep. Likewise, Becker and Smith (1950) showed no difference in hemoglobin values for different breeds of sheep. These workers reported average hemoglobin values of 12.11, 12.94 and 12.18 for Corriedales, Dorset Horns and Hampshires, respectively.

Erythrocytes

It has been shown by several investigators that the average erythrocyte count in sheep varies somewhat with the age of the animal. Dukes (1955) pointed out that lambs had an average number of 10.1 million erythrocytes per cu. mm. of blood and that sheep over one year old had an average number of 8.1 million. Schalm (1961) reported a mean number of erythrocytes for lambs up to one year old as varying between 11.0 and 13.0 million and one to two million less for adult

sheep. A value of 10.3 million was reported by Spector (1956) while Hudson and Osborne (1954) listed a value of 8.9 million with a range of 4.8 to 12.2 million for sheep. The values given by Spector and Hudson and Obsorne did not reveal the age of animals being reported.

A study by Todd et al. (1952) showed that Southdown ewes averaged 12.65 ± 0.214 million, whereas Hampshires averaged 12.47 ± 0.316 million. Similarly, Cresswell (1962) could find no differences in erythrocyte numbers between Cheviot and Romney sheep. Rao et al. (1962) reported an average value of 9.58 ± 0.25 million erythrocytes for a breed of Indian sheep and a value of 7.8 million was shown by Stubbs (1963) for a group of mature ewes in South Africa. These values might indicate some degree of breed differences but probably the plane of nutrition and other environmental conditions are also influencing red blood cell counts in sheep.

In a study with beef cattle, Bhannasiri (1960) showed that the total number of red blood cells decreased with an increase in age of calves. No sex difference was observed at the younger ages, but at 800 lb. body weight male calves had higher red blood cell counts than the female calves.

When I^{131} was given to Suffolk sheep during a prolonged experiment, Hackett et al. (1960) found a downward trend in erythrocyte counts. It was shown by Gallagher (1963) that all sheep which were infected with intestinal worms developed a moderate to severe degree of anemia due to decreased numbers of erythrocytes.

In an experiment by VanDyke et al. (1957) it was observed that the anterior pituitary furnishes a factor which exerts some control on red

blood cell production. These workers suggested that this factor was apparently a hormone distinct from other trophic hormones and was similar to ACTH but is not the same as ACTH. However, it was shown to be allied chemically only to ACTH.

Leucocytes

Leucocyte numbers are indicative, in many cases, of physiological disturbances which affect the health of an individual. Leucocytosis is a pathological increase in the numbers of any or all of the different classes of leucocytes. Leucopenia is a decrease in the number of leucocytes. It may involve one or all of the classes of white blood cells. This condition is seen in most virus diseases, for example, hog cholera according to Dukes (1955).

It was shown by Todd et al. (1952) that there was only a slight difference between breeds for white blood cell counts. These workers reported that Southdown and Hampshire ewes had counts of 7.26 ± 0.264 and 7.74 ± 0.365 thousand per cu. mm. of blood, respectively. However, Cresswell (1962) indicated that there was a possible breed difference in leucocyte numbers in that Cheviots had a higher number of leucocytes than did Romneys. On the other hand, Romneys had a 25 percent higher blood volume than Cheviots.

Schalm (1961) pointed out that leucocyte counts in sheep were quite variable. A range of 4 to 12 with an average of 7 to 10 thousand per cu. mm. was given as a normal value for sheep. Dukes (1955) listed 4 to 10 thousand as a normal range for leucocyte counts in sheep. These data were in agreement with the values listed by Spector (1956). Spector

gave 4 to 10 thousand as the normal range for leucocyte counts in sheep. However, Hudson and Osborne (1954) reported a range of 3.2 to 10.2 with an average count of 5.1 thousand cells per cu. mm. of adult sheep blood.

A study by Ullrey et al. (1962) indicated that leucocyte concentrations increased rapidly in lambs during the first six hours after birth. Total leucocyte counts did not appear to be influenced by age according to Grunsell (1955).

It was reported by Hackett et al. (1957) that continued administration of I^{131} over an extended period depressed the leucocyte count in various ewes. Further, Hackett and coworkers (1960) found a significant downward trend with time in the total leucocyte numbers when I^{131} was administered to Suffolk sheep in a prolonged experiment.

Martin (1932) showed that the leucocyte count in humans was steadiest and at a minimum when the subjects were almost at absolute physiological rest. Mental and physical activity caused an increase in leucocyte numbers. Further, injections of adrenaline caused an increase in all types of leucocytes but the greatest increase was in lymphocytes.

MATERIALS AND METHODS

This study began with nine mature ewes and one ram from each of five breeds of sheep. The breeds utilized were: Border Cheviot, Dorset Horn, Columbia, Suffolk and Willamette.

Prior to the breeding season, an attempt was made to synchronize the estrous period of the ewes by feeding 50 to 60 mg. of an orally effective Progestogen, 6 α methyl - 17 α - Acetoxyprogesterone, "Provera," per animal, per day for 14 days. By employing this procedure, it was hoped that a majority of the lambs would be born over a narrow interval of time; thus making the experiment as uniform as possible. The ewes were separated according to breed on the fifteenth day and mated to a ram of the same breed.

Thirty-one of the original 45 ewes provided the data for this study. Fourteen of the ewes were dropped from the study for reasons such as: death before parturition, death of ewe or lamb early after parturition, barren ewes and bad udders. The ewes varied in age from three to eight years. Data were also collected from 42 lambs produced by the 31 ewes.

The lambs used in this experiment were born during February and March of 1962, at the Oregon Experiment Station. At the time of birth the lambs were weighed, ear-tagged and branded on both sides with a paint-brand. The branding made it easier to identify the lambs during the testing period.

An average plane of nutrition was provided the ewes during this study. During the first four months of gestation, the ration was mainly one of a grass-lotus pasture and alfalfa hay. The ewes received an addition of one pound of an oats and barley mixture per ewe per day during the fifth month of gestation.

The lambs were allowed to run on pasture with their dams during the testing period. Also, the lambs were creep-fed with calf manna and a rolled oats and barley mixture, ad libitum, during the growing period.

The blood study began in February and continued to early June. The first blood sample was taken from each ewe and her lamb(s) on the ninth or tenth day of lactation. Sampling continued, at 14-day intervals, until the lambs were slaughtered at approximately 100 days of age. In all, seven samples were used from each lamb and ewe. In order to obtain a good measure of growth, each lamb was weighed at each sampling period.

At the end of the testing period, live animal quality scores were determined for each lamb. A conformation and a condition score was computed for each lamb. The conformation score was based mainly on the breed characteristics while condition was determined by the external finish shown by the lambs. These scores for conformation and condition were divided into five grades: Prime, score of 90 - 100; Choice, score of 80 - 89; Good, score of 70 - 79; Utility, score of 60 - 69; and Cull, a score of 50 - 59. Each animal was scored by four people and an average score was recorded.

After the lambs had been slaughtered, a trained taste panel was utilized to determine a composite preference score and a tenderness

score for each carcass. A Hedonic type scale was utilized for determining these scores. The scale values ranged from one to seven with one being the least desirable and seven the most desirable. These scores were determined by standard organoleptic procedures using the rack which consisted of the portion from the fifth through the twelfth ribs of each lamb carcass.

Blood Collection

Blood samples were taken from the jugular vein of each lamb and ewe with a stainless steel bleeding needle. Two samples were taken from each animal at each sampling period. One sample, approximately 35 ml., was collected into a 50 ml. centrifuge tube, without an anticoagulant. This sample was cooled and then chilled to 34°F. Then this sample was centrifuged at 2500 rpm and the serum was separated from the plasma. The sera were then stored at 30°F. until the alkaline and acid phosphatase determinations were made. These determinations were made as quickly as possible on the same day of collection. Another sample was collected into a 10 ml. pyrex test tube which contained neutral potassium oxalate at the rate of one mg. per ml. as an anticoagulant. Hemoglobin, hematocrit, erythrocyte and leucocyte values were made from this sample. The sample remained at 34°F. until all determinations had been completed.

Serum Acid Phosphatase

Stock substrate (p-nitrophenyl phosphate) tubes were removed from the freezer and placed in a water bath at 38°C. for a few minutes. Then

0.2 ml. water was pipetted into one tube (reagent blank) and 0.2 ml. serum was pipetted into all other tubes (serum samples). Each tube was shaken slightly, time noted, and placed back into the water bath to incubate for 30 minutes. A serum blank was prepared by mixing 6.0 ml. 0.1N NaOH and 0.2 ml. serum. The serum blank was read against the water sample and the optical density recorded. The units of acid phosphatase corresponding to this reading was determined from the calibration curve.

Thirty minutes after adding the serum to substrate, 5 ml. 0.1N NaOH was added to each tube. A stopper was inserted into each tube and the tube was inverted to mix material. With the optical density of the spectrophotometer (Beckman Model B) set at zero and the reagent blank used as a reference (410 mu) the optical density of the serum was recorded. The units of acid phosphatase corresponding to this reading (from the calibration curve) was determined. Then the corrected total acid phosphatase activity was determined by subtracting the acid phosphatase activity of the serum blank from the activity determined for the serum sample.

Alkaline Phosphatase Determination

Into each of two tubes was pipetted 0.5 ml. alkaline buffer solution and 0.5 ml. stock substrate (p-nitrophenyl phosphate) solution. Then the tubes were placed into a water bath at 38°C. for a few minutes. After the tubes had warmed-up, 0.1 ml. water was pipetted into one tube (reagent blank) and 0.1 ml. serum was pipetted into the other tube (serum sample). The tubes were quickly placed back into the water bath and the time recorded.

Exactly 30 minutes after adding the serum, 10 ml. of 0.02N NaOH was added into each tube. The tubes were stoppered and mixed by inversion. A sample of each was placed in a cuvette. Then, with the spectrophotometer set at zero optical density, the reagent blank was read at 410 mu. The serum sample was read at the same setting and the alkaline phosphatase units corresponding to this reading on the calibration curve were determined. One drop of concentrated HCl was then added to each cuvette to remove the color due to p-nitrophenol, thus, leaving optical density due to the serum itself. Then each serum sample was read against the blank and the optical density recorded. The blank was used as a reference at 100% transmission. The alkaline phosphatase units corresponding to the reading from the calibration curve was determined. This alkaline phosphatase unit determination was then subtracted from the previous determination to obtain the corrected alkaline phosphatase activity of the serum (in Sigma Units).

Hemoglobin Determination

Whole oxalated sheep blood was treated with saponin to cause hemolysis of the sample. Then a Spencer Hemoglobinometer was used to estimate the hemoglobin content of each blood sample. This is a direct method of determining hemoglobin content of blood by matching the color of the blood sample with that of the standard. The Spencer Hemoglobinometer has the slight advantage of comparing green colors rather than brown. The maximum absorption of hemoglobin occurs for visual light in the green band of the spectrum.

Hematocrit Determination

For these determinations, the microhematocrit method was employed. This method makes use of a high speed centrifuge which permits a corresponding reduction in the time required for complete packing of the erythrocytes. Capillary tubes, prepared with heparin, were filled between two-thirds to three-fourths with whole oxalated blood. The outside of each tube was wiped off and sealed with a blue gas flame. The sealed tube was centrifuged at 16,500 rpm for a period of two minutes.

The hematocrit value of each tube was determined by the use of a reader which measured the column of packed cells as a percentage of the total column.

Erythrocyte Counts

In the determination of the red blood cell counts, red blood counting pipettes and Spencer Counting Chambers were employed. The oxalated blood was diluted in the pipette at the rate of 1 to 200, with normal saline as the diluting agent. The pipette was then placed on a mechanical shaker for two minutes in order to obtain maximum dispersion of blood cells in the diluent. A small portion of the sample was blown out of the pipette before filling the red blood portion of the counting chamber. Five primary squares, on a diagonal line, were counted for each sample and this total was multiplied by 10,000 to obtain the number of red blood cells for one cubic millimeter of undiluted blood.

Leucocyte Counts

In general, the same procedure as for erythrocyte counts was employed. The oxalated blood was diluted at the rate of 1 to 20 in white blood counting pipettes. A one percent HCl solution was used as the diluting agent. After allowing the sample to be shaken for two minutes, a portion was blown out of the pipette before filling the counting chamber. A total of eight squares were counted and this total was divided by two, thus obtaining an average value for four squares. The total was then multiplied by 50 to obtain the number of cells in one cubic millimeter of undiluted blood.

These data were analyzed by the Least-Square Analysis method with unequal subclass numbers as outlined by Harvey (1960).

RESULTS

The values obtained for the factors studied on ewes and lambs of the five breeds utilized in this study are presented in a series of tables in which the mean values for each breed are shown according to periods. In addition, tables of means are presented in the Appendix for the lambs by sex and by periods. Several graphs are included which show a comparison for the values obtained on ewes and lambs over the entire testing period.

Data on Ewes

The results for ewes are presented in the following order: acid phosphatase, alkaline phosphatase, hematocrit, hemoglobin, red blood cell counts and white blood cell counts.

Acid Phosphatase

The average acid phosphatase values for ewes are shown in Table 1. It can be observed from this table that only slight breed differences in acid phosphatase activity were found for ewes over the testing periods. The Border Cheviots had the lowest values and the Dorset Horns showed the highest values. No particular pattern of enzyme activity was shown for any of the breeds. However, in general, the enzyme activity was slightly lower for all breeds during period two. After period two there seemed to be a slight increase in the acid phosphatase level of activity with period seven having the highest average value.

Table 1. Average acid phosphatase values[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Ave.
Border Cheviot	.033	.041	.039	.047	.046	.057	.058	.045
Dorset Horn	.063	.034	.026	.059	.048	.051	.087	.052
Suffolk	.027	.042	.043	.058	.077	.055	.055	.051
Columbia	.055	.026	.054	.040	.048	.059	.066	.049
Willamette	.055	.041	.068	.045	.065	.045	.043	.051
Average	.047	.037	.046	.050	.057	.053	.062	.050

[1]Expressed in Sigma Units (Sigma Chemical Company. Determination of serum acid and alkaline phosphatase and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Table 2. Average alkaline phosphatase values[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Ave.
Border Cheviot	1.67	2.04	2.43	2.70	2.26	2.29	2.41	2.26
Dorset Horn	0.92	1.86	2.32	3.18	2.74	2.18	2.18	2.19
Suffolk	1.84	2.80	3.32	3.84	3.40	3.54	3.28	3.14
Columbia	3.29	3.40	2.43	3.81	3.73	3.71	3.84	3.46
Willamette	2.73	3.71	3.20	4.69	4.10	4.14	3.60	3.74
Average	2.09	2.76	2.74	3.64	3.25	3.17	3.06	2.96

[1]Expressed in Sigma Units (Sigma Chemical Company. Determination of serum acid and alkaline phosphatase and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Alkaline Phosphatase

The average alkaline phosphatase levels of activity for ewes of the five breeds are shown in Table 2. It appears that breeds do differ in the level of activity for this enzyme. Border Cheviots and Dorset Horns were found to have lower levels than did the Suffolks, Columbias or Willamettes. It was interesting to note that the Willamettes had higher levels than any of the other breeds. Also, the level for the Willamettes was much higher than for the Border Cheviots and Dorset Horns, two breeds which were used in the establishment of the Willamette breed. Further, it was noted that there was a definite drop in the level of activity for this enzyme immediately after lambing. A high value was established for this enzyme around the fourth testing period and a slight drop was observed around the fifth period. Then the level of activity for alkaline phosphatase was rather constant for the remainder of the test.

Hematocrit

Very small breed differences were observed for hematocrit values in the ewes. As can be seen from Table 3, the Dorset Horns were lower than any of the breeds in hematocrit levels. In general, all breeds had higher hematocrit values immediately after lambing after which these values leveled off and remained fairly constant during the remaining six periods. However, there appeared to be a slight reduction in the hematocrit values after the third period. This would suggest that possibly there could be a period difference in the level of hematocrit for ewes.

Table 3. Average hematocrit values[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	31.07	30.71	31.79	30.93	30.86	29.57	30.07	30.71
Dorset Horn	30.90	28.40	28.60	27.40	24.50	25.80	25.90	27.35
Suffolk	30.70	29.90	31.40	29.00	28.30	28.30	26.20	29.11
Columbia	30.29	28.79	30.29	28.07	29.57	29.14	29.07	29.31
Willamette	32.79	31.93	32.93	29.79	28.43	28.21	29.29	30.48
Average	31.15	29.95	31.00	29.04	28.33	28.20	28.11	29.39

[1]Expressed in percent

Table 4. Average hemoglobin values[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	11.86	12.53	12.44	10.99	10.71	9.77	10.20	11.21
Dorset Horn	12.80	12.30	11.64	9.78	8.70	9.04	8.98	10.46
Suffolk	11.84	11.54	10.68	10.28	10.08	9.86	8.40	10.38
Columbia	11.14	12.20	10.43	10.01	10.16	10.83	9.94	10.67
Willamette	13.64	13.64	11.41	10.84	10.00	9.84	9.73	11.30
Average	12.26	12.44	11.32	10.38	9.93	9.87	9.45	10.80

[1]Expressed in mg. per 100 gm. of blood

Hemoglobin

A pattern similar to that of hematocrit was observed for the hemoglobin levels found in the five breeds of ewes. The average value was slightly higher for the Border Cheviots and Willamettes than for the other breeds. Further, the hemoglobin values tended to be higher from period one through period three than for the remaining periods. These findings might indicate that hemoglobin levels vary from breed to breed and from period to period. The average hemoglobin values for the ewes are shown in Table 4.

Red Blood Cell Counts

It appears from Table 5 that the breeds of ewes did not differ greatly in red blood cell counts. However, the Dorset Horns had a slightly lower average count than the other breeds. This breed also tended to be low for hematocrit and hemoglobin levels. All breeds appeared to have higher counts for several weeks after lambing than toward the end of the testing period. In general, the Willamette breed had the highest count of all the breeds studied.

White Blood Cell Counts

The Suffolk breed generally had a higher white blood cell count than any of the breeds as can be seen from Table 6. This difference is more obvious during the first periods than during the later periods. Immediately after lambing, the Suffolks were quite high for leucocyte counts. The other breeds showed white blood cell counts which were rather similar and lower than the Suffolks.

Table 5. Average red blood cell count[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	9.46	10.04	9.61	8.57	10.17	8.93	9.24	9.43
Dorset Horn	9.74	10.02	8.96	9.33	6.97	7.24	7.46	8.53
Suffolk	9.06	10.22	9.91	8.72	9.16	9.17	7.28	9.07
Columbia	9.65	8.78	9.29	9.41	9.18	9.93	9.09	9.33
Willamette	10.54	10.39	10.50	10.15	9.09	8.58	9.14	9.77
Average	9.69	9.89	9.65	9.24	8.91	8.77	8.44	9.23

[1]Expressed as millions per cubic millimeter of undiluted blood

Table 6. Average white blood cell count[1] for ewes of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	7.78	7.81	6.98	6.62	6.52	6.66	6.77	7.02
Dorset Horn	8.87	8.18	7.59	7.93	6.81	7.76	6.97	7.73
Suffolk	10.21	9.36	8.46	8.11	7.93	7.78	8.19	8.58
Columbia	6.81	8.08	7.38	8.09	8.01	8.32	7.57	7.75
Willamette	7.85	7.74	7.42	7.01	6.67	6.61	6.38	7.10
Average	8.30	8.24	7.57	7.55	7.19	7.43	7.18	7.64

[1]Expressed as thousands per cubic millimeter of undiluted blood

Analysis of Ewe Data

Simple coefficients of correlation for certain blood constituents of ewes and body weight of lambs were calculated. These correlation coefficients are shown in Table 7. From this table it can be seen that several values appear to have some degree of significance. A highly significant positive correlation of 0.67 was found between hematocrit and hemoglobin. This can be interpreted to mean that approximately 45 percent of the differences in hemoglobin values are due to the variations in hematocrit values. It was also found that both hematocrit and hemoglobin values showed a highly significant positive correlation of 0.64 with red blood cell numbers. Forty percent of the variation in hemoglobin and hematocrit values is accounted for by variation in red blood cell numbers. None of the other coefficients of correlation seem to have much biological significance. It was interesting to note that acid and alkaline phosphatase levels of activity were positively correlated, though slight, with body weight of lambs while all other variables were negatively correlated with body weight of lambs. A highly significant negative correlation of -.48 existed between the hemoglobin values of ewes and body weight of lambs.

The various factors studied in ewes were analyzed by analysis of least squares according to breeds, periods and type of birth (single or twin lambs.). The F values for these variables are shown in Table 8. The analysis of variance data for each variable according to breeds, periods and type of birth are shown in Appendix Tables 15 through 31.

Table 7. Correlation coefficients for certain blood constituents of ewes and body weight of lambs.

	Alkaline Phosphatase	Hematocrit	Hemoglobin	Red Blood Count	White Blood Count	Body Weight of Lambs
Acid Phosphatase	-.04	-.03	-.11	-.12	-.05	0.23
Alkaline Phosphatase		-.05	-.05	0.07	-.06	0.15
Hematocrit			0.67	0.64	-.09	-.26
Hemoglobin				0.64	0.14	-.49
Red Blood Count					-.03	-.30
White Blood Count						0.23

Correlation coefficients of 0.456 or greater are significant at P of .01 and 0.355 or greater are significant at P of .05 (29 degrees of freedom)

Table 8. Analysis of variance F values for the variables studied in ewes.

Items	Breed	Period	Type of Birth
Acid Phosphatase	0.36	3.25**	0.62
Alkaline Phosphatase	11.52**	4.77**	3.88**
Hematocrit	6.09**	4.51**	0.91
Hemoglobin	4.09**	19.95**	1.23
Red Blood Cell Count	2.35	3.39**	1.80
White Blood Cell Count	9.35**	3.19**	2.81*
Degrees of Freedom	4 and 202	6 and 202	4 and 202

* exceeds the .05 percent level
**exceeds the .01 percent level

There were no statistical differences in acid phosphatase levels and red blood cell counts due to breed or type of birth. On the other hand, highly significant differences ($P<.01$) were found in the level of alkaline phosphatase activity according to breed, period and birth type. Hematocrit and hemoglobin values showed significant differences ($P<.01$) for breed and period but no differences were found for these variables due to type of birth. White blood cell count was affected ($P<.01$) by breed and period.

Data on Lambs

The results for lambs will be taken up in the following order: live weights, acid phosphatase, alkaline phosphatase, hematocrit, hemoglobin, red blood cell counts, white blood cell counts and conformation, condition, preference and tenderness scores.

Live Weights

It can be seen from Table 9 that all breeds did not grow in a similar manner. The Suffolks and Willamettes were similar in average birth weight but the Suffolks and the Willamettes outgained the Columbias

Table 9. Average body weights[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Birth Wt.	Periods 1	2	3	4	5	6	7	Ave. Gain
Border Cheviot	3.92	6.44	9.34	12.67	15.62	18.99	23.63	27.36	23.44
Dorset Horn	4.08	6.77	9.82	13.38	16.51	20.86	25.25	29.13	25.05
Suffolk	4.87	7.01	11.27	15.46	19.76	24.49	29.87	34.21	29.34
Columbia	4.92	7.63	11.66	15.11	18.93	24.04	28.29	32.26	27.34
Willamette	4.91	7.74	11.96	16.27	20.26	26.20	31.50	36.18	31.27
Average	4.54	7.12	10.81	14.58	18.22	22.92	27.71	31.83	27.29

[1]Expressed in kilograms

Table 10. Average acid phosphatase levels[1] of activity for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Ave.
Border Cheviot	.1900	.1036	.1124	.1284	.1153	.0950	.1072	.1217
Dorset Horn	.1481	.1106	.1062	.0783	.1067	.0756	.1107	.1051
Suffolk	.1992	.1275	.1084	.1385	.1376	.1045	.0875	.1290
Columbia	.2172	.0985	.1048	.0712	.0944	.0932	.0941	.1104
Willamette	.1445	.1144	.0787	.0898	.1131	.0790	.0792	.0998
Average	.1798	.1109	.1021	.1012	.1134	.0894	.0957	.1132

[1]Expressed in Sigma Units (Sigma Chemical Company. Determination of serum acid and alkaline phosphatase and "prostatic" acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

by the third period. The Border Cheviots were the lightest at birth and remained lighter than any of the breeds throughout the test. It was interesting to note that the Willamettes showed an average gain which was approximately two kilograms higher than that for the Suffolks and almost four kilograms higher than that of the Columbias. This is especially important since the two lightest breeds, namely the Border Cheviots and Dorset Horns, were used along with the Columbias in establishing the Willamette breed.

Acid Phosphatase

There appeared to be some breed difference in the level of acid phosphatase activity in lambs as can be observed from Table 10. Even immediately after birth, the Willamettes had a lower level of acid phosphatase activity than the Cheviots, Suffolks and Columbias; whereas, the Dorset Horns had a level which was only slightly higher than that of the Willamettes. All breeds showed a much higher level of enzyme activity immediately after birth than during subsequent periods. The Suffolks followed a pattern similar to that of the other breeds shortly after birth but showed an increase for the fourth and fifth periods. This increase was not observed for the other breeds.

Alkaline Phosphatase

The average alkaline phosphatase levels of activity, as shown in Table 11, were highest for all breeds shortly after birth; after which there was a progressive decline or a leveling off, except for isolated cases, for the remainder of the test. This decline amounted to a 40

Table 11. Average alkaline phosphatase levels[1] of activity for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	9.85	7.67	6.29	6.31	5.19	4.89	4.52	6.38
Dorset Horn	12.96	11.01	7.73	9.45	9.33	7.84	8.52	9.54
Suffolk	11.66	11.51	9.74	8.64	7.89	7.27	6.98	9.10
Columbia	10.50	8.04	6.46	8.08	7.63	6.40	6.61	7.68
Willamette	10.53	9.01	7.83	7.27	7.32	5.43	6.22	7.65
Average	11.10	9.44	7.61	7.97	7.47	6.36	6.57	8.07

[1]Expressed in Sigma Units (Sigma Chemical Company. Determination of serum acid and alkaline phosphatase and "Prostatic" acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Table 12. Average hematocrit values[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	32.21	31.88	33.66	29.66	30.60	30.10	30.16	31.18
Dorset Horn	30.38	34.33	33.49	33.44	31.55	34.11	33.33	32.94
Suffolk	27.92	30.00	34.00	33.35	31.85	31.64	31.64	31.49
Columbia	29.24	31.87	32.18	30.37	30.62	30.37	29.40	30.57
Willamette	29.28	33.01	32.83	31.16	30.83	30.99	30.49	31.22
Average	29.81	32.22	33.23	31.59	31.10	31.44	31.00	31.48

[1]Expressed in percent

percent drop in the average enzyme activity from period one to period seven. There also appeared to be a slight breed difference observed for the activity of this enzyme. The Border Cheviots had the lowest average value for enzyme activity of any breed for all seven periods. Also, the Dorset Horns and Suffolks showed values which were higher than those of any of the other breeds. In general, except for a few cases, the breeds that had the higher or lower values after birth maintained a similar position throughout the test. The Columbias had a slightly lower alkaline phosphatase level than did the Willamettes at the beginning but exceed the Willamettes from period four to the end of the testing period.

Hematocrit

It can be observed from Table 12 that the hematocrit values for these lambs did not vary greatly from birth to approximately 14 weeks of age. However, there were increases and decreases in these values from breed to breed and from period to period. The average values obtained for all breeds tended to be highest during period two and three than at any of the other periods. The Columbia breed had an average value slightly lower than that for the other breeds, whereas, the Dorset Horns had the highest average hematocrit value.

Hemoglobin

Hemoglobin values, as shown in Table 13, followed a breed pattern quite similar to that for hematocrit levels. The Dorset Horns had the highest average value with the Columbias showing the lowest value. The

Table 13. Average hemoglobin values[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	11.83	12.77	12.72	10.31	10.51	10.47	10.39	11.29
Dorset Horn	12.66	12.91	13.54	11.93	11.44	11.44	11.45	12.19
Suffolk	11.38	12.36	12.48	11.63	11.17	10.62	10.95	11.51
Columbia	11.62	13.43	11.11	10.22	9.80	9.88	10.09	10.88
Willamette	11.82	14.07	11.18	11.24	10.99	10.84	11.32	11.64
Average	11.86	13.11	12.21	11.06	10.78	10.65	10.84	11.50

[1]Expressed in gm. per 100 ml. of blood

Table 14. Average red blood cell count[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	9.02	10.33	10.38	10.00	9.87	10.60	10.65	10.12
Dorset Horn	8.89	9.88	10.10	10.80	11.37	11.46	10.93	10.48
Suffolk	8.41	9.59	9.68	11.19	11.31	11.47	11.43	10.44
Columbia	8.93	10.80	9.93	9.67	9.48	10.09	9.01	9.70
Willamette	9.34	10.19	11.59	11.44	11.42	11.62	11.37	10.95
Average	8.92	10.16	10.33	10.62	10.69	11.05	10.68	10.34

[1]Expressed in millions per cubic millimeter of undiluted blood

Willamettes had a hemoglobin value only slightly higher than that observed for the Suffolks, whereas, the opposite was the case for hematocrit values. The hemoglobin values tended to be highest for most breeds during periods two and three, then decreased slightly during the remaining periods. It also appeared that hemoglobin levels were lower immediately after birth which was also the case for hematocrit values.

Red Blood Cell Counts

The average number of red blood cells were lowest for all breeds immediately after birth and by the second period all breeds had shown an increase in red cell numbers (Table 14). From period two through period seven very little change in red cell numbers were observed for any of the breeds. Some degree of breed differences might be indicated since the Columbias had the lowest average count of any of the breeds and the Willamettes had the highest count. In general, the Border Cheviots, Dorset Horns and Suffolks were quite similar for red blood cell numbers.

White Blood Cell Counts

The average white blood cell counts for the five breeds studied are shown in Table 15. The Border Cheviots had an average white cell count higher than that of any other breed while the Dorset Horns had the lowest count. In general, the white blood cell counts were lower immediately after birth than at any other period. After period one all average values increased slightly, with period seven having the highest average value of all periods. However, period seven was only slightly higher

Table 15. Average white blood cell count[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods							Ave.
	1	2	3	4	5	6	7	
Border Cheviot	7.12	8.99	8.57	9.02	8.89	9.57	9.40	8.74
Dorset Horn	6.75	6.22	7.07	7.36	7.16	8.90	7.26	7.12
Suffolk	6.73	6.91	8.48	8.17	7.79	7.72	8.65	7.77
Columbia	6.08	8.40	8.96	8.72	7.63	7.87	8.04	7.95
Willamette	6.84	7.79	7.64	7.46	6.87	7.10	7.85	7.36
Average	6.70	7.66	8.14	8.15	7.67	8.07	8.24	7.79

[1]Expressed in thousands per cubic millimeter of undiluted blood

than period three, four and six. These values might indicate a possible breed and period difference in white blood cell numbers.

Live Animal and Carcass Evaluation Values

At the end of the testing period, each lamb was scored for conformation and condition. Then the lambs were slaughtered and a sample of meat from each carcass was cooked and submitted to a trained taste panel for obtaining preference and tenderness scores. These average scores are shown in Table 16.

Table 16. Average live animal and carcass evaluation scores for lambs of five breed of sheep.

Breeds	Conformation	Condition	Preference	Tenderness
Border Cheviot	88.3	81.8	4.5	4.1
Dorset Horn	86.6	86.1	4.9	4.7
Suffolk	86.5	88.2	4.6	4.8
Columbia	79.3	79.3	5.2	5.1
Willamette	88.0	84.8	4.9	4.9
Average	85.8	84.9	4.8	4.7

There appears to be some differences between breeds in conformation as evidenced by the values shown in this table. The Border Cheviots had the highest value and was followed very closely by the Willamettes. Both of these breeds had a value which was approximately 10 percent above the value found for the Columbias. The Dorset Horns and Suffolks were similar and had scores which tended to be close to the average of all breeds.

For condition, the Willamettes and Suffolks were highest and were approximately 10 percent above the Columbias. The Border Cheviots were also below the average of the breeds in condition. From Table 16, it can be seen that all breeds were rather similar for preference and

tenderness. However, the Columbias, which had the lowest conformation and condition scores, were slightly better than any of the other breeds for preference and tenderness. The Willamettes also showed rather high values for these factors.

Analysis of Lamb Data

Simple coefficients of correlation were determined between all variables studied and live animal and carcass evaluation scores. These relationships are shown in Table 17. Several of these values probably have biological significance worthy of note.

It can be observed that a highly significant positive correlation of 0.91 was found between conformation and condition. This can be interpreted to mean that 81 percent of the difference in conformation is due to variation in condition. Further, 53 percent of the difference in conformation scores is due to variation found in body weight and 39 percent of the difference found in condition scores is due to variation found in body weight. The relationship between preference scores and tenderness scores is highly significant ($r = 0.95$). Approximately 90 percent of the variation in preference scores is accounted for by tenderness of the sample of meat.

Only a few of the blood determinations show biological significance. Neither acid phosphatase nor alkaline phosphatase were highly related to any of the other variables studied. However, the highly significant positive correlations of 0.81 between hematocrit and hemoglobin and 0.79 between hematocrit and red blood cell counts are important. Similarly, the highly positive correlation of 0.62 which was found between hemoglobin

Table 17. Correlation coefficients for certain blood constituents and live animal and carcass characteristics of lambs.

	Confor-mation	Condi-tion	Pref-erence	Tender-ness	Acid Phos-phatase	Alkaline Phospha-tase	Hemato-crit	Hemo-globin	Red Blood Count	White Blood Count	Body Weight
Age	0.45	0.35	0.26	0.24	0.00	0.21	-.04	-.006	0.13	0.39	0.31
Conformation		0.91	0.31	0.32	-.02	-.06	0.42	0.43	0.29	0.30	0.73
Condition			0.25	0.28	0.01	-.08	0.39	0.42	0.16	0.21	0.63
Preference				0.95	0.02	0.04	0.01	0.06	-.05	0.21	0.02
Tenderness					-.08	0.13	-.01	0.11	-.04	0.25	0.11
Acid Phos-phatase						-.05	-.21	-.24	-.16	-.15	0.08
Alkaline Phosphatase							-.10	-.05	0.07	0.33	0.08
Hematocrit								0.81	0.79	0.12	0.38
Hemoglobin									0.62	0.04	0.37
Red Blood Cell Count										0.13	0.39
White Blood Cell Count											0.39

Correlation coefficients of 0.393 or greater are significant at P of .01 and 0.304 or greater are significant at P of .05 (40 degrees of freedom)

and red blood cell count has some biological significance. It was interesting to note that no significant negative correlations were found between any of the variables.

The lamb data were analyzed statistically by an analysis of least squares on the basis of breed, sex, birth type, age of dam and period. These values are shown in Table 18.

Table 18. Analysis of variance F values for the variables studied in lambs.

Items	Breed	Sex	Birth Type	Age of Dam	Period
Acid Phosphatase	4.72**	0.02	2.02	2.07	18.89**
Alkaline Phosphatase	29.33**	8.13**	0.58	2.43*	46.90**
Hematocrit	1.33	3.37	2.31	4.57**	5.23**
Hemoglobin	2.21	4.72*	0.97	1.63	20.95**
Red Blood Cells	1.54	2.33	4.11*	1.31	10.20**
White Blood Cells	4.05**	4.55*	9.40**	1.51	5.44**
Body Weight	27.72**	6.44*	148.08**	8.99**	528.85**
Degrees of Freedom	4 & 276	1 & 276	1 & 276	5 & 276	6 & 276

* exceeds the .05 percent level
**exceeds the .01 percent level

There were highly significant breed and period differences found for acid phosphatase levels of activity in lambs. Acid phosphatase values were not affected by sex, birth type and age of dam. Significant differences ($P<.01$) were found for alkaline phosphatase activity for breed, sex and period while a difference ($P<.05$) was found for alkaline phosphatase activity due to age of dam. Alkaline phosphatase was not affected by birth type of the lambs. Highly significant ($P<.01$) differences were observed for hematocrit values according to age of dam and period; however, differences due to breed, sex and birth type were non-significant. Hemoglobin, on the other hand, had significant differences due to period ($P<.01$) and sex ($P<.05$) but non-significant differences for the other factors. Differences in red blood cell count were noted

for birth type ($P<.05$) and period ($P<.01$). White blood cell counts were affected by breed, birth type and period ($P<.01$) and by sex ($P<.05$). This variable was not affected by age of dam, however.

Differences ($P<.01$) in body weight were found for breed, sex, birth type, age of dam and period.

It was interesting to note that highly significant differences were found in conformation and condition scores by breed and birth type and only significant differences ($P<.05$) were found for these variables according to age of dam. No differences were observed for these variables that were due to sex differences. Also, no differences were found for tenderness and preference scores according to breed, sex, birth type or age of dam. The analysis of variance F values for these variables are shown in Table 19.

Table 19. Analysis of variance F values for live animal and carcass evaluation scores.

Items	Breeds	Sex	Birth Type	Age of Dam
Conformation	4.24**	0.01	27.61**	3.81*
Condition	4.56**	1.48	23.35**	3.03*
Preference	0.58	3.27	3.10	0.74
Tenderness	0.53	3.02	2.53	0.54
Degrees of Freedom	4 & 30	1 & 30	1 & 30	5 & 30

* exceeds the .05 percent level
**exceeds the .01 percent level

The analysis of variance data for each variable studied in lambs are shown in Appendix Tables 15 through 31.

Graphic Presentation of Results

A series of graphs were made in order to show a comparison of adult ewes and lambs for the various factors studied.

Acid Phosphatase

The average acid phosphatase values for the five breeds of ewes and lambs are shown graphically in Figure 1. From this graph it can be seen that acid phosphatase values differ for adult sheep and lambs. At the beginning of the test the lambs had an average level of activity approximately three and one-half times greater than that for ewes. The lambs showed values much higher at the beginning but these values began to level off by the second period. From the second period until the end of the testing period lamb values varied slightly but remained higher than the values for the ewes. The ewe values remained rather constant throughout the test. However, the ewe values did rise slightly toward the end of the testing period.

Alkaline Phosphatase

A comparison of the alkaline phosphatase activity of ewes and lambs is shown in Figure 2. It can be observed from this graph that the lamb values were higher at the beginning than at the end of the test. The lambs had alkaline phosphatase levels of activity which were slightly over five times higher than that for ewes at period one. Even at the end of the trial the lamb values were more than two times higher than the values for the ewes. The ewes had values which were lower at the beginning but increased slightly up to the fourth period. After the fourth period the ewes showed a slight decline in alkaline phosphatase activity. However, the ewe values were slightly higher at the end of the test than at the beginning. It is obvious from this graph that

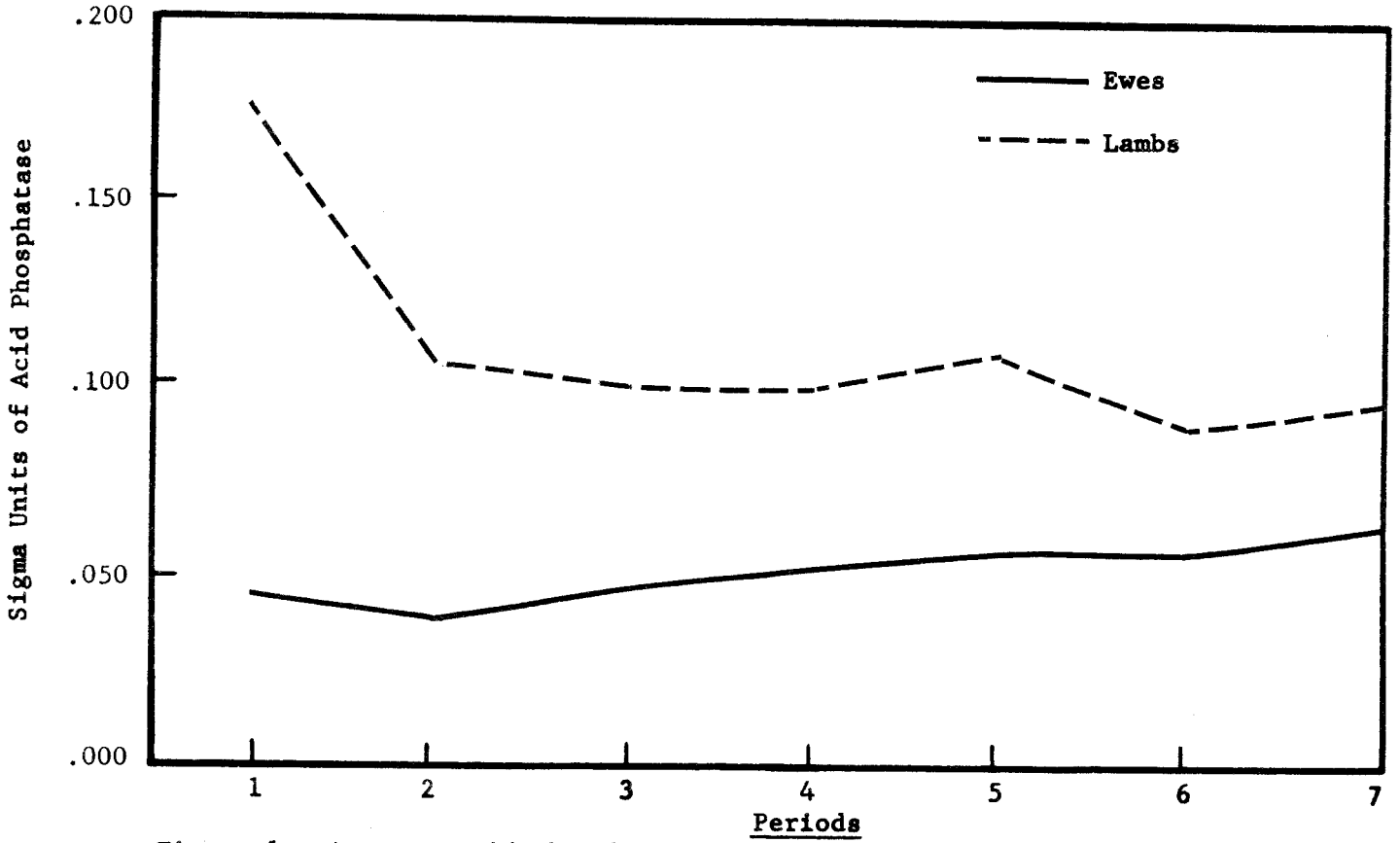

Figure 1. Average acid phosphatase values for all ewes and all lambs of five breeds of sheep over seven periods.

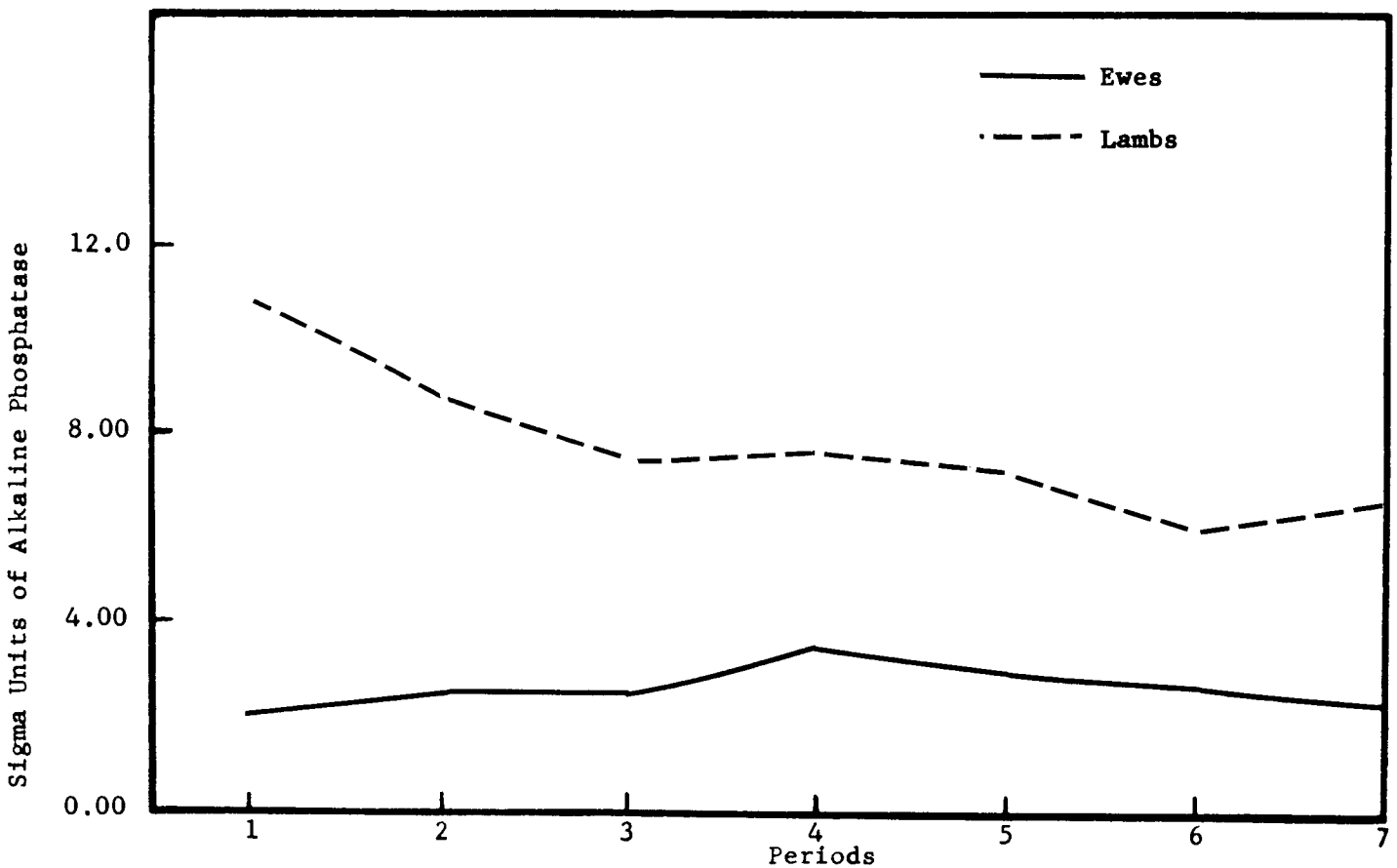

Figure 2. Average alkaline phosphatase values for all ewes and all lambs of five breeds of sheep over seven periods.

lambs and ewes of the same breed do differ greatly in levels of alkaline phosphatase activity.

Hematocrit

A comparison of hematocrit values for ewes and lambs is shown in Figure 3. It can be observed that ewes and lambs of the breeds studied had similar hematocrit values. However, the lambs had slightly lower average values during the first testing period than those observed for ewes. After the first period the lambs tended to exceed the ewes for hematocrit. It was interesting to note that although the lambs were slightly higher at the second period, the graph showed both groups to follow a similar pattern for the remainder of the testing period. The ewes showed a slight decline in percent hematocrit from period three until the end of the test, whereas, by period four until the last period the lambs showed values which were rather constant.

Hemoglobin

The hemoglobin levels of ewes and lambs seem to follow a pattern similar to that shown for hematocrit. From Figure 4 it can be observed that the lambs were slightly lower than the ewes in hemoglobin but from period two until the test had been completed the lambs exceeded the ewes in hemoglobin values. Also, the graph shows that the lambs and ewes follow a similar pattern from period two until period six. At the seventh period the lambs experienced an increase in hemoglobin while the ewes continued to show a declining value. The difference at period seven was approximately one and one-half gm. per 100 ml. in favor of the lambs.

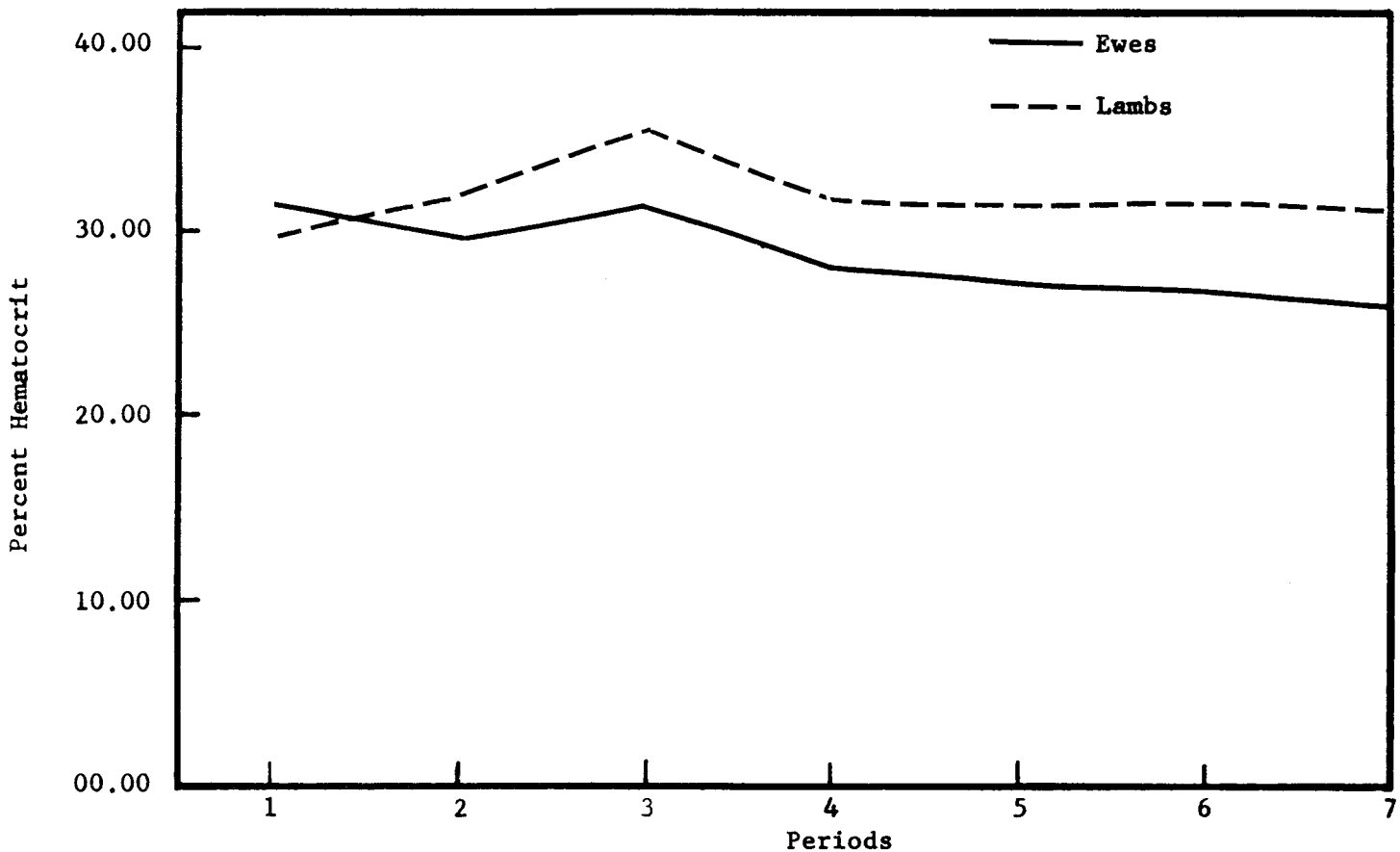

Figure 3. Average hematocrit values for all ewes and all lambs of five breeds of sheep over seven periods.

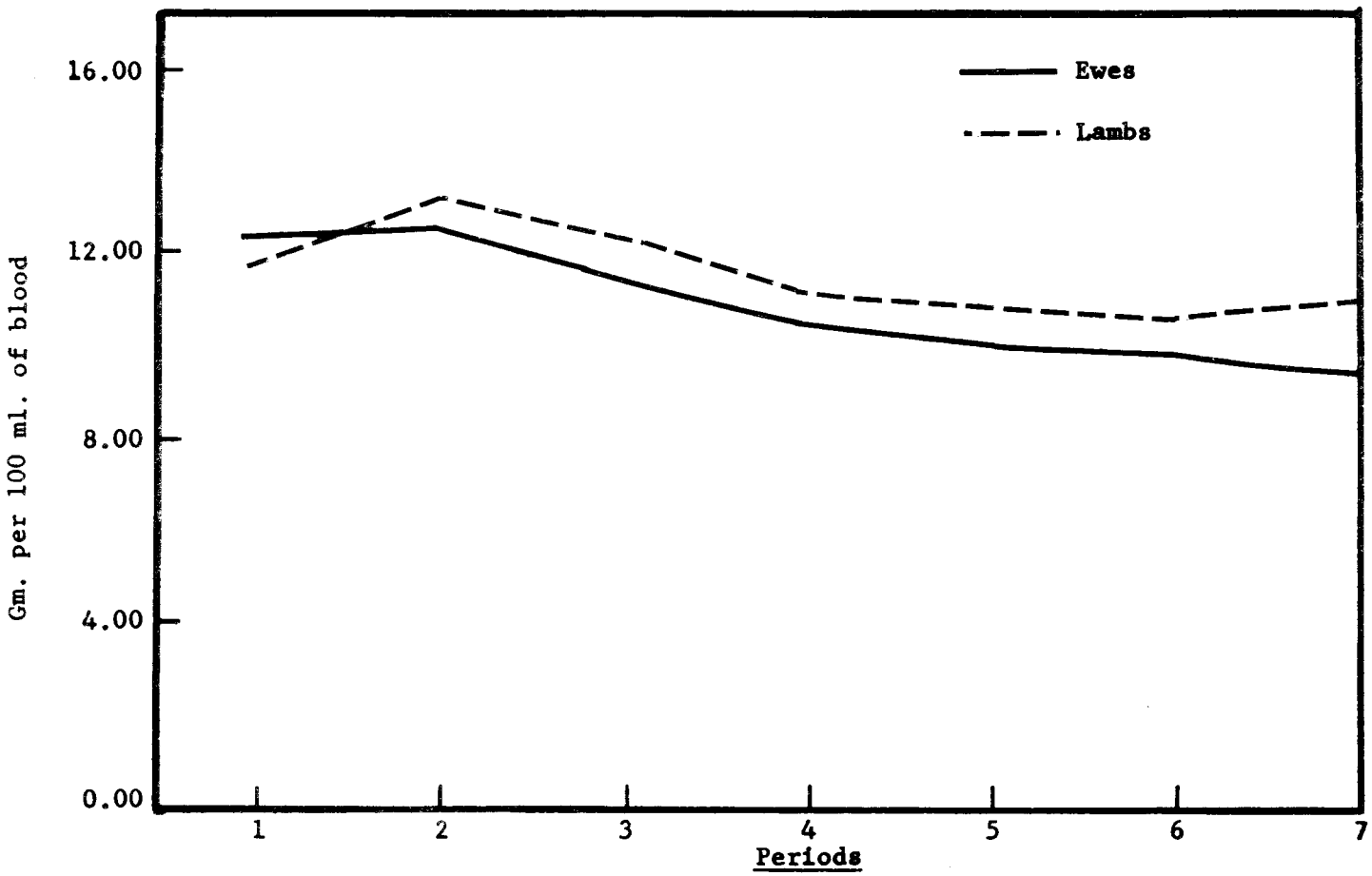

Figure 4. Average hemoglobin values for all ewes and all lambs of five breeds of sheep over seven periods.

Red Blood Cells

A comparison of red blood cells for ewes and lambs of five breeds of sheep is shown in Figure 5. This graph shows a lower red blood cell count for lambs than for the ewes at the beginning of the test. However, from the second period until the end of the test the lambs showed higher counts than the ewes. Also, from the second period until the sixth period the lambs displayed an increasing red cell count, whereas, the ewes showed decreasing values. At period six, the average red blood cell count for lambs was approximately two million higher than that for the ewes. From period six to period seven, the lambs still exceeded the ewes by a red cell count of two million. At this period the lambs began to show a decline in red cell numbers similar to that shown for the ewes.

White Blood Cells

Only slight differences could be observed between ewes and lambs for white blood cell counts. This comparison is shown in graphic form in Figure 6. In general, after the second period the lambs had higher cell counts than did the ewes but not as great as was observed for red blood cell counts. However, at period one the white blood cell count for the lambs was approximately one and one-half thousand lower than the values for the ewes. At period six the ewes showed a decline in white cell numbers while the lambs showed an increase. From period three until period six the two groups of sheep followed similar patterns for white cell numbers.

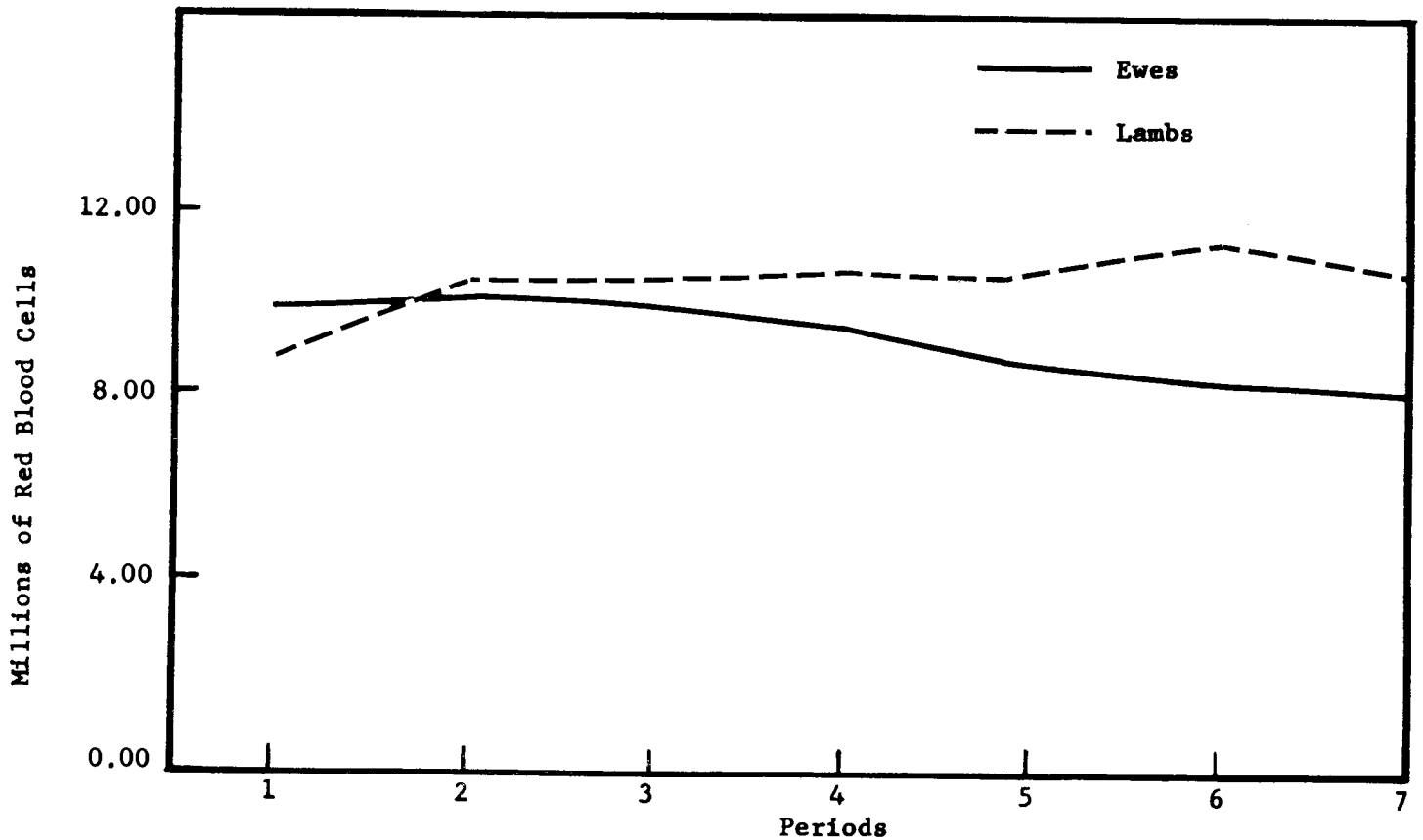

Figure 5. Average number of red blood cells for all ewes and all lambs of five breeds of sheep over seven periods.

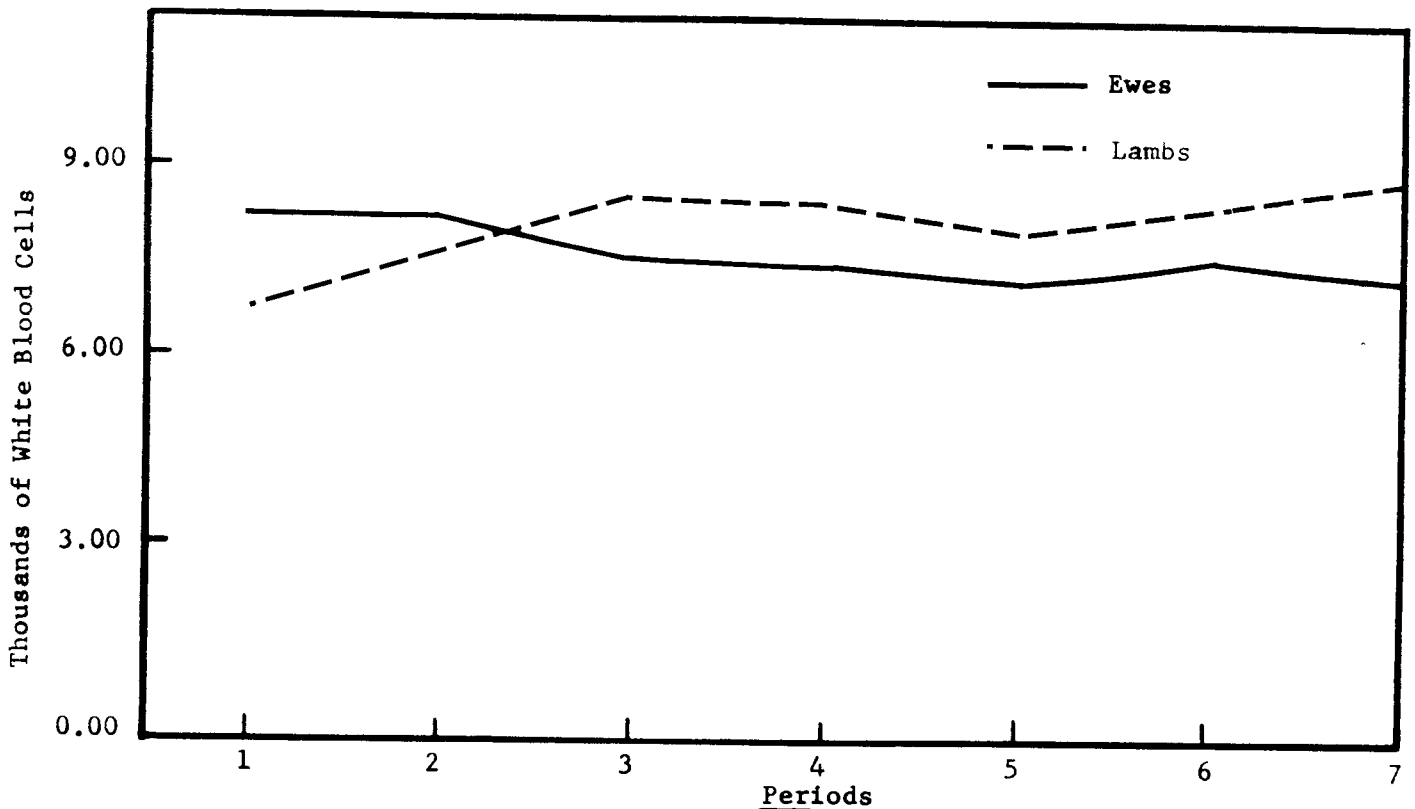

Figure 6. Average number of white blood cells for all ewes and all lambs of five breeds of sheep over seven periods.

DISCUSSION

The marketing of lambs is generally divided into two phases. Some lambs are in a high state of condition at weaning time so that they can be slaughtered without an extra feeding period while others have to be fattened before slaughtering.

The variability in lamb growth would lead one to suspect that our present methods of selection are not capable of predicting or evaluating completely the genetic factors which determine the growth of the individual lamb. Also, the role played by environment in the expression of growth has not been completely understood. Obviously, there are interactions between the genetics of the animal and the environmental factors which cause much of the variation observed in lamb growth. When these interactions are completely uncovered then and only then will the breeder be able to produce uniform growth in a flock of sheep. Even then, some degree of variation will probably still exist in growth rates of lambs.

After fertilization takes place, the producer has no control over the true genetic makeup which is responsible for much of the growth potential of the individual. However, environmental changes, such as the amount and type of feed received by the mother, certainly can modify the growth pattern of the developing fetus and may still be an influencing factor affecting post natal growth of lambs.

Selection of replacement ewes should include the mothering ability of the dam of the lamb. The amount and quality of milk received by the newborn lamb will influence the growth pattern of the young lamb. This

would certainly be true up to the time the lamb is able to eat grain and roughages. It is also important to consider the possibility of uncovering genetic or physiological markers which might be related to growth patterns of sheep, especially during the period from birth to weaning. This would be especially important in reducing some of the variation in growth rates found in sheep.

In order to study physiological or genetic traits in sheep, with the ultimate goal in mind of improvement, it is apparent that the study should include data not only on the lambs but on the dams as well.

The factors investigated in the present study will be discussed in the same order that the results were presented except that the ewes and lambs will be discussed together. Growth and live animal and carcass evaluations of lambs will be discussed last.

Acid Phosphatase

It was quite apparent that ewes did not show any significant breed, period, or type of birth differences for the level of acid phosphatase activity. On the other hand, lambs showed differences ($P<.01$) due to breeds and periods. However, no difference due to sex, birth type or age of dam was observed for acid phosphatase levels of lambs. It was evident in this study that the acid phosphatase levels of activity of lambs were more variable from period to period than the levels observed for the ewes. The lamb values were much higher in the early periods than they were toward the sixth and seventh periods, whereas, the ewes' values tended to remain rather constant over the entire testing period. This might

indicate that acid phosphatase plays a very minor role in the physiological functions of adult female sheep.

In the study reported by Wojnas (1963) there appeared to be a high acid phosphatase level in the young male rat. However, after the prostate gland was mature, the acid phosphatase value seemed to level off or even decrease. This would lead one to postulate that acid phosphatase levels are higher in young male animals than in the young female animals. This was not evident in the present study since no difference in the level of this enzyme could be found in lambs which was due to sex. Also, it is probable that when determining serum acid phosphatase levels of activity the values obtained are only indicative of the acid phosphatase produced by the liver and spleen and are not indicative of the amount produced by the prostate.

There was no indication in this study that the levels of acid phosphatase activity of the ewes were in any way related to growth of the lambs. This was also true as shown by a lack of correlation between the acid phosphatase activity of lambs and growth in lambs. The work by Johnston and Anglemier (1963) indicated that the more rapidly gaining lambs had higher levels of acid phosphatase activity than did the slower gaining lambs. Likewise, Alexander (1958) and Alexander et al. (1958) reported a highly significant positive correlation between acid phosphatase activity and rate of gain in beef cattle. Alexander (1958) and Alexander et al. (1958) also reported higher levels of this enzyme for males than for females. It is quite possible that if correlations between acid phosphatase and lamb growth had been analyzed within each breed instead of within all breeds a significant positive correlation

might have been found in the present study. An interesting aspect which was observed in this study was that there were no significant differences found between breeds or periods for this enzyme in the ewes, whereas, a significant difference due to breeds and periods was found in the lambs. This might indicate that when sheep reach maturity the level of activity of this enzyme is extremely low and will remain low throughout the year. Some support for this assumption can be drawn from the work of Allcroft and Folley (1941) in which it was pointed out that the phosphatase at an acid pH was in amounts too small to be of any significance in the blood of sheep and cattle.

Alkaline Phosphatase

The average alkaline phosphatase values for five breeds of ewes ranged from a low of 2.19 units for the Dorset Horns to a high of 3.74 units for the Willamettes. In the lambs the values ranged from a low of 6.38 for the Border Cheviots to a high of 9.54 for the Dorset Horns. The average value for lambs was approximately three times higher than the average value observed for the ewes.

The simple coefficients of correlation showed no relationships between this enzyme and other factors studied in ewes and lambs. The significant positive correlation of 0.33 which was found between the level of alkaline phosphatase and white blood cell counts in lambs probably has no biological significance.

The alkaline phosphatase values for ewes tended to be slightly lower immediately after lambing, after which the values increased or remained rather constant until approximately 100 days subsequent to

lambing. The lamb values were highest at approximately two weeks of age. The values for lambs declined slightly by the fourth week after which the values remained rather constant until the end of the testing period. The wide range in alkaline phosphatase values in ewes which was reported by Allcroft and Folley (1941) was not observed in this study. However, the present study does agree with that of Allcroft and Folley in that the level of this enzyme diminishes with an increase in age in sheep.

A highly significant ($P<.01$) effect due to breeds, periods and type of birth was found for alkaline phosphatase levels of activity of ewes. The most important of these results is probably the breed difference. It is highly probable that breeds of adult sheep do differ in their levels of alkaline phosphatase activity.

The analysis of variance also revealed that there were significant ($P<.01$) effects due to breeds, sex and periods in alkaline phosphatase levels of lambs. Also there was a significant ($P<.01$) difference due to age of dam. These findings suggest that breeds differ in their levels of alkaline phosphatase and that there is a difference between male and female lambs in the level of this enzyme. It was expected that there would be a difference in the activity of this enzyme from period to period especially if the level of the enzyme is indicative of osteoblastic activity as suggested by Talbot (1939), Williams (1959), Bessey (1946) and Hawk, Oser and Summerson (1948). If the level of alkaline phosphatase were indicative of osteoblastic activity then the level found in lambs would be expected to be much higher than those found for the ewes. Further, this might account for the higher alkaline phosphatase values which were observed in the lambs during the early phases of the testing

period. Extremely high alkaline phosphatase values would probably be more indicative of some abnormal condition, either bone or other organ diseases, in adult sheep than it would be in lambs.

This study was not in agreement with that of Johnston and Anglemier (1963) who reported that in general the more rapidly gaining lambs had higher alkaline phosphatase values than did the slower gaining lambs. In their study the lambs which gained the most rapidly had been treated with an estrogen implant, diethylstilbestrol. It is quite possible that the high values were due to the estrogen material rather than to the rate of gain of the lambs. Further, it should be pointed out that in the study of Johnston and Anglemier only one breed of sheep was used, whereas, five breeds were utilized in the present study.

Alexander (1958) and Alexander et al. (1958) reported a highly significant positive correlation between rate of gain and the level of alkaline phosphatase activity in beef cattle. Likewise, Johnston et al. (1962) reported that faster gaining female calves had higher alkaline phosphatase values than did the slower gaining female calves. No evidence of this relationship was observed in the present study.

Anglemier et al. (1961) reported a significant difference in tissue alkaline phosphatase activity between samples of steer meat which were classified as tender and tough. There was no indication, in the present study, that alkaline phosphatase was in any way related to tenderness of the cooked samples of lamb meat. There was a non-significant positive correlation of 0.13 found between tenderness and the level of alkaline phosphatase found in the blood. This would indicate, however, that the animals which had the higher alkaline phosphatase levels of activity also

were the animals which produced meat samples that were on the tender side of the rating scale. The work by Anglemier et al. (1961) involved only the alkaline phosphatase levels which were found in the tissue sample itself while in the present study the alkaline phosphatase levels were determined from the blood serum.

Hematocrit

Hematocrit values have been reported by many researchers and a wide range in the values are given. Dukes (1955) showed a hematocrit value of 32 percent for sheep. Apparently this value represented an average for all ages of sheep. A range in hematocrit values of 31.9 to 40.1 percent with an average of 36.8 percent over a 33-month period was reported by Stubbs and Boyer (1954) while Stubbs (1963) reported an average value of 38 percent for sheep. The values obtained for ewes in the present study were much lower than those presented by other investigators. Although the values obtained in the present study are slightly lower than values reported by many workers, they are in close agreement with the value of 32 percent which was reported by Dukes (1955).

The average hematocrit values for lambs were slightly higher than those found for the ewes. From birth until approximately 10 days of age the lambs had values which were slightly below the ewe values, 29.81 and 31.15 percent, respectively. However, by the second testing period or approximately 24 days after birth the lamb values had exceeded those for the ewes and remained at a level which was higher than the ewe values throughout the test. This early low value in lambs was also observed by Ullrey et al. (1962). Work by Evans and Blunt (1960) had previously

shown that packed cell volume dropped rapidly in lambs immediately following birth. Between one and two months of age the hematocrit values of lambs rose to its highest level, 32.25 percent. The work by Ullrey et al. (1962) also reported a high value for lambs at a slightly later stage, around two to three months of age.

It was shown that a highly significant positive relationship existed between hematocrit and hemoglobin and between hematocrit and red blood cell numbers in both ewes and lambs. These relationships were also pointed out by Dukes (1955). A negative relationship of $r = -.26$ was shown between hematocrit values of the ewes and body weight in the lambs, whereas, a significant positive relationship of $r = 0.38$ was found between the hematocrit values of the lambs and the body weight of lambs.

A highly significant ($P<.01$) breed and period difference was obtained for hematocrit values in the ewes. However, only highly significant differences were shown for age of dam and periods in the hematocrit levels of the lambs. It had been shown previously by Becker and Smith (1950) and Creswell (1962) that breeds of sheep do possibly differ in their hematocrit levels. In the present study, it was shown that the sexes did not differ in their hematocrit level. This was also shown to be the case in beef cattle by Bhannasiri (1960).

Hemoglobin

The hemoglobin levels of ewes and their lambs were determined over a 14-week period. The average values found for the ewes were higher at the beginning of the testing period or immediately after lambing than at later periods. These values remained high until the fourth to sixth

week after lambing at which time the values for the ewes dropped slightly. The average values for all breeds continued to decline progressively through the seventh period. The average hemoglobin values found in the present study are in agreement with those reported by Schalm (1961), Spector (1956) and Stubbs and Boyer (1954) while higher values were reported by Hudson and Osborne (1954) and Becker and Smith (1950).

Hemoglobin was highly correlated with red blood cell count ($r = .64$). This relationship was also reported by Dukes (1955). A highly significant negative relationship was found between hemoglobin levels of the ewes and body weight of the lambs.

It was found that there was a highly significant breed difference in hemoglobin levels in the ewes. However, a breed difference for hemoglobin levels in sheep was not shown by Becker and Smith (1950) and Creswell (1962). The mean values reported by Becker and Smith were almost the same for Corriedales, Dorset Horns and Hampshires.

Altitude had been shown by Watson (1953) to have an effect on the hemoglobin levels of sheep. Similarly, Pugh (1964) pointed out that altitude had an effect on the hemoglobin values of humans. These workers reported high hemoglobin values when subjects were held at high altitudes (10,000 to 19,000 ft.). The lower values which were reported in the present study would indicate that animals, living at or near sea level, do not require as much hemoglobin in the blood for transporting oxygen to the body cells.

The hemoglobin values of the lambs were lower after birth than those observed at around the third to fifth weeks after the lambs were born.

This drop immediately after birth had been reported by Ullrey et al. (1962). Ullrey also showed that there was a rise in hemoglobin levels of lambs at around two to three months of age. In the present study, the highest average values obtained were at around three to four weeks of age. The hemoglobin levels declined in lambs after the fourth period and remained low throughout the testing period.

A highly significant positive relationship was shown to exist between hemoglobin and hematocrit. This relationship was somewhat higher in lambs than it was in ewes. However, in both groups it was highly significant and positive. A highly significant positive relationship of $r = 0.62$ was found between hemoglobin and erythrocyte counts in lambs. Essentially the same relationship was found for these two variables in the ewes ($r = 0.64$). As was pointed out by Dukes (1955) these relationships were expected.

In the analysis of variance results it was found that breed, birth type and age of dam had no effect on the level of hemoglobin found in the lambs. However, there was a highly significant ($P<.01$) period difference in hemoglobin levels. This would be expected since it had been shown by Ullrey et al. (1962) that lambs had low values immediately after birth and high values around two to three months of age. A significant ($P<.05$) difference in hemoglobin levels was found between sexes. Thus, it appears that male and female lambs differ in hemoglobin levels. Dukes (1955) suggested that there might be a sex difference in the hemoglobin level of sheep.

The comparison between the hemoglobin values of ewes and lambs is shown in Figure 4. The values for the lambs were lower than those for

the ewes immediately after lambing but by the second period, which was around three to four weeks after lambing, the lambs showed values which exceeded those for the ewes. The hemoglobin values for the lambs and ewes were highest at the second period. A downward trend was noted thereafter for both groups with the lamb values tending to be higher than those for the ewes. Apparently the hemoglobin level of the animal is somewhat dependent upon the amount of iron available to the animal at a particular time. Work by Holz et al. (1961), Rice and Nelms (1964) and Carlson and coworkers (1961) showed that when supplemental iron was injected into lambs or calves an increase in the hemoglobin level of the animal was observed. Carlson et al. and Rice and Nelms also reported an increase in the hematocrit values of calves and lambs following injections of iron. It was also shown by Taylor (1966) that the feeding of an iron compound to sows and gilts 30 days prior to farrowing resulted in a significant increase in the hemoglobin levels of pigs at birth. From the work of Taylor it can be assumed that iron is rather transferable across the placental membranes. To account for the lower values obtained for lambs after birth it must be assumed that the iron content of milk is very low or practically negligible which results in an insufficient iron supply until the young animal begins to eat some type of feed which has an adequate supply of this mineral. It is apparent that iron does not cross the mammary barrier even though it does cross the placental barrier. It can be assumed that cow's milk is lacking in iron content as was shown in the data presented by Hammond (1957).

Red Blood Cell Count

The average number of red blood cells did not vary greatly from breed to breed or from period to period in ewes. The Willamette breed showed values which were slightly higher than those for the other breeds. The average red blood cell count for ewes was slightly lower at the end of the trial than at the beginning. The only relationship found which might be important is the highly significant positive correlation coefficient of $r = 0.64$ that was shown between red blood cell count and hemoglobin. The analysis of variance for red blood cell counts did not reveal any significant differences in ewes according to breeds, periods or type of birth.

The red blood cell numbers found for ewes are in close agreement with those reported by Dukes (1955). However, Schalm (1961) showed a higher value for adult sheep than was observed in the present study.

The lambs had lower red blood cell counts at the first testing period than during subsequent periods. The red blood cell values followed a pattern which was similar to the pattern found for hematocrit and hemoglobin values in lambs. By the second period the lambs had an average of approximately one million more red blood cells than was observed at the first period. In general, the highest values obtained for lambs were during period six. This might indicate that the numbers of red blood cells are quite variable from period to period in the young growing animals.

The analysis of variance results revealed a highly significant ($P<.01$) difference in red blood cell numbers due to periods and a significant difference ($P<.05$) due to type of birth. There was no

difference observed for this variable according to breed, sex or age of dam.

The values found for lambs in the present study generally are in agreement with those given for young sheep by Dukes (1955). However, Schalm (1961) reported values which were approximately one million higher than the values obtained in the present study. In the works by Creswell (1962) and Todd et al. (1952) no breed differences in red blood cell numbers were found. Similarly, Bhannasiri (1960) found no sex difference in young cattle for red blood cell counts. However, at 800 lb. body weight the male calves had higher erythrocyte counts than did the female calves.

It is obvious that there is a considerable difference in red blood cell numbers between ewes and lambs as can be seen in Figure 5. Again, as was shown for hematocrit and hemoglobin, the lambs had lower values than those found for the ewes subsequent to lambing. However, by three to four weeks after birth the lamb values exceeded the ewe values. Also, from this time until the end of the testing period, the lamb values remained higher than the ewe values. The ewes showed a downward trend in erythrocyte numbers from period two to period seven, whereas, the lambs showed an increase in average erythrocyte numbers up to period six, after which a slight drop in numbers was observed between period six and period seven. It would have been interesting to have obtained red blood cell counts on the lambs immediately after birth. In the work by Evans and Blunt (1960) it was shown that the hematocrit values were extremely high (56.0 percent) at birth but dropped to 35.8 percent at 42 days of age. At 63 days of age the lamb hematocrit values had increased to 38.7

percent and reached another high value of 40.0 percent at 105 days of age. This drop reported by these researchers was attributed to the physiological anemia described in other animals over the period when the growth rate of the body exceeds the rate of red blood cell production. This might account for the low values found in the present study at the first testing period. Further, in the present study it was found that the red blood cell numbers increased steadily and reached a high value at around 80 to 90 days of age.

White Blood Cell Count

The average white blood cell counts for ewes were found to range from a low of 7.02 to a high value of 8.58 thousand per cubic millimeter of undiluted blood. Leucocyte values for ewes were found to be higher from around one to three weeks after lambing than during the subsequent testing periods. These values agree, in general, with those given by Dukes (1955), Schalm (1961), Spector (1956) and Todd et al. (1952). On the other hand, Hudson and Osborne (1954) reported leucocyte values which were lower than those found in the present study.

A highly significant breed difference in white blood cell numbers was found while no differences in white cell numbers were observed due to periods or type of birth. A possible breed difference had been suggested by Creswell (1962) and Todd et al. (1952). It was expected that a difference would be found according to periods but this difference was not observed.

The white blood cell numbers were lower for lambs at the beginning of the test with a slight increase in numbers being found by the second

period. From period three through seven the numbers were rather constant. However, white cell numbers dropped slightly during period five but returned to normal by period six.

Highly significant differences ($P<.01$) were found in white blood cell numbers in lambs due to breeds, birth type and periods while a significant difference ($P<.05$) was determined due to sex. It had been suggested by Creswell (1962) and Todd et al. (1952) that breeds might differ in white cell numbers. Since white blood cell counts might be indicative of the health of an animal, it was expected that a period difference in cell numbers would be found.

From Figure 6 it is evident that the lambs had leucocyte counts which were much lower than those for the ewes from period one through period two. However, by period three the lamb values had slightly exceeded the ewe values and the lamb values remained higher than the ewe values throughout the later testing periods. The low values found for the lambs immediately after birth were probably due to the lambs being born in a rather high state of health, whereas, the high numbers observed for the ewes might be due to the drain on the physiological state of the ewe during pregnancy and during parturition. By period three, the adverse effects of pregnancy and parturition had probably disappeared in the ewes while the lambs were probably becoming less dependent upon their dams and were being exposed, more and more, to climatic and other environmental influences such as disease and worm infestations.

Growth of Lambs

Mature body size is probably a factor which contributes much to the physical limitations imposed on many breeds. Therefore, it would not be expected that all breeds of sheep should grow in a similar manner or should be the same size when they reach maturity. It was shown in the present study that all breeds did not grow in a like manner. A highly significant ($P<.01$) breed difference was observed for body weight of lambs. Also, it would not be expected that male and female lambs would have a similar growth pattern. This was found to be the case in that a significant ($P<.05$) sex difference was observed in the growth rates of lambs. Further, one would expect to find differences in the growth curves of single and twin lambs and that lambs would show differences in growth rates between periods. Highly significant ($P<.01$) results were found in body weights of lambs due to type of birth and periods.

The breed which was the lightest at birth was still lighter than any of the other breeds at 100 days of age. The breed which was the second heaviest at birth, the Willamette, exceeded all other breeds in body weight at 100 days of age. This is especially interesting since it was originally formed by the intermating of three of the breeds used in the present study. Either a high state of heterosis still exists in this breed or selection within this large gene pool has been exceedingly effective in obtaining rapid growth.

Body weight of lambs showed highly significant positive correlations of $r = 0.73$ and $r = 0.63$ with conformation and condition, respectively. This was not too surprising since one would expect that if all lambs were the same age, the larger lambs would probably be in a higher state

of condition than the smaller lambs and would probably be picked by most people to have higher conformation scores than the smaller lambs providing all breed type characteristics had been met.

Live Animal and Carcass Evaluations

As the lambs reached approximately 100 days of age they were scored for conformation and condition. Immediately after these measurements were made, the lambs were slaughtered and preference and tenderness scores were determined from cooked samples of each carcass.

From Table 16 it can be seen that all breeds did not have similar conformation and condition scores. The Columbias had the lowest scores for these variables. The Border Cheviots had the highest conformation scores while the Willamettes had the highest condition scores. The Border Cheviots probably displayed more breed characteristics than any of the other breeds.

Conformation scores were highly related to condition scores as can be seen by the coefficient of correlation of $r = 0.91$ which is shown in Table 17. Conformation had significant correlations of 0.31 and 0.32 with preference and tenderness, respectively. A highly significant difference was found for conformation and condition due to breed and type of birth, whereas, a significant difference was found for these variables due to the age of dam. Sex had no effect on conformation or condition of lambs. It was expected that differences in conformation and condition would be found according to sex and birth type.

The preference and tenderness scores which are shown in Table 17 revealed high values for the breed which had the lowest conformation and

condition scores, namely, the Columbia breed. This is most interesting and would certainly indicate that the condition and conformation scores of lambs are in no way related to the tenderness or preference of the meat sample and that an animal does not necessarily have to be in a high state of condition to produce highly acceptable meat. Also, it was found that the Willamettes had the second highest preference and tenderness scores and approximated the Columbias in these factors.

No significant differences were found for preference and tenderness scores due to breed, sex, type of birth or age of dam. This would indicate that preference and tenderness of meat are more dependent upon factors such as nutrition, growth rate and other related factors rather than upon factors such as breed, sex, type of birth or age of dam.

Significance of Findings

This section will deal primarily with a comparison of breeds for the various factors studied in lambs and ewes. A comparison is also made for these factors between ewes and lambs. This is extremely important since, from a genetic standpoint, a wide range in variation exists between the four well established breeds utilized in the present study; namely, the Border Cheviots, Dorset Horns, Suffolks and Columbias. Since the Willamette breed was established by the utilization of the Border Cheviots, Dorset Horns and Columbias, a comparison of the Willamette with the other breeds should reveal significant findings.

In the adult female sheep, acid phosphatase level of activity was rather uniform and low. The level of acid phosphatase activity, from a biological and statistical standpoint, was non-significant in the ewes.

All breeds had an enzyme pattern which was quite similar. However, in the young lambs where both sexes were utilized, breed differences were observed. There was no evidence revealed which would indicate that the level of this enzyme activity was in any way related to growth in the young developing lamb. The Willamettes, the heaviest breed at 16 weeks of age, showed the lowest overall average acid phosphatase level of all the breeds during the trial period.

For the ewes, it was found that the Willamettes had an average alkaline phosphatase level of activity which was higher than the levels observed for the other breeds. However, in lambs the Willamettes had a value lower than the average value for all breeds and only exceeded the value observed for the Border Cheviots. It would appear that alkaline phosphatase level of activity was not related to growth in the lambs of this study even though it has been indicated by previous researchers that there is an association of growth with alkaline phosphatase activity.

It was evident that the levels of activity for acid and alkaline phosphatase were considerably higher and more important in the young developing animal than in the adult female. Also, there seemed to be some genetic basis for the activity of these enzymes in the young animal.

It was interesting to note that a breed difference was found in the ewes for hematocrit and hemoglobin values, whereas, this difference was not observed in the lambs. Since these two factors are rather closely related to the well-being of an individual, it would possibly be correct to assume that there was considerably more variation in the physiological state of the ewes than in the physiological state of the lambs.

The lambs had red blood cell counts which were higher than the red blood cell counts for the ewes. The average white blood cell counts were very similar for lambs and ewes; however, at the beginning of the testing period the ewes had slightly higher white cell counts than those observed for lambs. This might be indicative of the state of health or stress placed on the animals. The ewes were probably under a physiological stress which was due to pregnancy and parturition, while the lambs were born with a high degree of immunity to disease which limited their physiological stress. However, in general, the lambs and ewes had similar overall average white blood cell counts. This could possibly be explained on the basis of the lambs being subjected to greater stress periods during the growing period and the ewes recuperating from the physiological stress which had been placed upon them during pregnancy and parturition. It was also interesting to note that no statistically significant differences were found in ewes for red blood cell counts due to breed, period or type of birth; whereas, a significant breed difference was observed for white blood cell counts in the ewes. Red blood cell count differences were noted for lambs according to periods but only slight differences were observed for white blood cell counts according to breed, sex, type of birth and periods.

In lambs and ewes the Willamette breed had the highest average number of red blood cells. In these same animals a fairly low white blood cell count was found. This might be indicative of an animal which has the inherent ability to cope with changes in its environment without reflecting drastic changes in its blood components.

It was obvious that there was either a high degree of hybrid vigor in the Willamette breed for growth or that selection for growth from a crossbred foundation was quite effective. The average body weight for the Willamette lambs was considerably higher than the average weight for any of the breeds from which the Willamette originated.

It was evident that conformation and condition scores were not reliable indicators of preference and tenderness of a carcass. The Columbia breed which had the lowest conformation and condition scores of all breeds also had the highest preference and tenderness scores. This was most interesting since conformation and condition scores have been used extensively in most selection programs in sheep. The Willamettes showed rather high conformation and condition scores while scoring well for preference and tenderness. This would lead one to consider the possibility that the quality of meat could be related to genetic factors since the Willamettes more closely resembled the Columbias than the Border Cheviots or Dorset Horns from the standpoint of preference and tenderness.

SUMMARY AND CONCLUSIONS

From the results obtained in the present study the following conclusions seem to be worthy of mentioning.

1. Acid phosphatase levels of activity in ewes were not affected by breed, period or type of birth. The levels of activity of this enzyme in lambs were affected by breed and period ($P<.01$). No significant relationships were found to exist between acid phosphatase levels of activity in lambs or ewes and any of the other variables studied.
2. The level of acid phosphatase was approximately two times higher in lambs than it was in ewes.
3. Highly significant differences ($P<.01$) were found for alkaline phosphatase activity in ewes due to breed, period and type of birth. In lambs highly significant differences were found for this enzyme for breed, sex and period while a significant ($P<.05$) difference was found according to age of dam. In ewes and lambs no significant relationships were found between the level of this enzyme and other variables studied.
4. The five breeds of ewes tended to fall into two groups for alkaline phosphatase activity. The highest group included the Willamettes (3.74 units), the Columbias (3.46 units) and the Suffolks (3.14 units) while the lowest group was made up of the Border Cheviots (2.26 units) and the Dorset Horns (2.19 units).

5. The values for alkaline phosphatase for the five breeds of lambs were in the following order: Dorset Horns (9.54), Suffolks (9.10), Columbias (7.68), Willamettes (7.65) and Border Cheviots (6.38).
6. Highly significant differences ($P<.01$) were found for hematocrit values in ewes according to breed and period. Hematocrit values in lambs were statistically affected ($P<.01$) by age of dame and period. In ewes hematocrit was highly related to hemoglobin ($r = 0.67$) and the red blood cell counts ($r = 0.64$), while in lambs hematocrit was highly related to hemoglobin ($r = 0.81$) and to red blood cell numbers ($r = 0.79$).
7. The hematocrit levels were lower for the lambs than for the ewes immediately after birth but the lamb values tended to be higher than those of the ewes from period two until the 14-week period.
8. Hemoglobin values in ewes were significantly ($P<.01$) affected by breeds and periods. In lambs the hemoglobin levels were affected ($P<.01$) by period and by sex ($P<.05$). Highly significant positive relationships of $r = 0.64$ and $r = 0.62$ were found between hemoglobin and red blood cell counts in ewes and lambs, respectively.
9. The lambs showed hemoglobin levels which were lower than those of the ewes at the first testing period but at period two the lamb values had exceeded those for the ewes. The highest values observed for the ewes and lambs were during period two or at approximately 24 days after lambing. The hemoglobin levels diminished for lambs and ewes from period two until period six. However, the lamb values increased slightly from period six to period

seven, while the ewe values continued to decrease to period seven, or to approximately 100 days subsequent to lambing.

10. No significant differences were found for red blood cell counts in ewes which could be accounted for by breeds, periods or type of birth. Red blood cell counts were affected by period ($P<.01$) and by birth type ($P<.05$) in lambs.

11. Red blood cell numbers were lower for lambs at period one than for the ewes. By period two the erythrocyte numbers of lambs had surpassed those for ewes. From period two until approximately 100 days subsequent to lambing the ewe values decreased while the lamb values increased up to period six. The lamb values decreased slightly from period six to period seven.

12. White blood cell counts were affected ($P<.01$) by breed in ewes. Highly significant differences ($P<.01$) were found for leucocyte counts in lambs due to breed, type of birth and period, while a significant difference ($P<.05$) was found in lambs due to sex.

13. The white blood cell numbers were much lower in lambs than in ewes immediately after lambing. This could be due to the lambs being born in a high state of health, whereas, the high ewe values might have been influenced by pregnancy and parturition. As the lambs grew older, their white blood cell counts increased and exceeded the values obtained for the ewes. During this period the ewes had probably recuperated from the effects of pregnancy and parturition while the lambs were being exposed to various types of stresses.

14. Body weight in lambs were affected by breed, type of birth, age of dam and period ($P<.01$) and by sex ($P<.05$).

15. From birth to 100 days of age the Willamette breed had the highest average gain. This was interesting in light of the fact that the Willamettes originated by the intermating of the three breeds which had the lowest average gain, namely, the Columbias, Dorset Horns and Cheviots.

16. Conformation and condition in lambs were affected by breed and type of birth ($P<.01$) and by age of dam ($P<.05$). It was evident in the present study that breeds of lambs and single and twin lambs differ in condition and conformation.

17. Conformation and condition scores of lambs were highly related to body weight ($P<.01$).

18. No significant differences could be found for preference and tenderness scores of lamb carcasses due to breed, sex, type of birth or age of dam.

19. It was interesting to note that the breed which had the lowest conformation and condition scores, namely, the Columbias, had the highest preference and tenderness scores. This would indicate that an animal does not necessarily have to have superior conformation and condition to produce a carcass which is highly acceptable for preference and tenderness.

20. None of the factors studied in the ewes had any significant effect upon body weights of lambs.

21. Likewise, none of the blood enzymes or blood components studied showed any significant relationships with body weights of lambs.

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A P P E N D I X

Appendix Table 1. Average acid phosphatase levels[1] of activity for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	.1714	.1027	.1063	.0970	.1039	.0870	.0999	.1097
Dorset Horn	.2135	.1048	.1200	.1678	.1295	.1053	.1163	.1367
Suffolk	.2113	.1300	.1123	.1030	.1356	.1050	.1026	.1285
Columbia	.1715	.0921	.1020	.0748	.0910	.0905	.0950	.1024
Willamette	.1442	.1276	.0784	.0932	.0910	.0752	.0824	.0988
Average	.1824	.1114	.1038	.1072	.1102	.0926	.0992	.1152
				Twin lambs				
Border Cheviot	.2135	.1048	.1200	.1678	.1295	.1053	.1163	.1367
Dorset Horn	.1402	.1033	.0987	.0731	.1036	.0752	.1096	.1005
Suffolk	.1902	.1257	.1055	.1652	.1392	.1042	.0762	.1294
Columbia	.3545	.1180	.1135	.0605	.1050	.1015	.0915	.1349
Willamette	.1450	.0980	.0792	.0857	.1412	.0840	.0755	.1012
Average	.2087	.1099	.1034	.1105	.1237	.0940	.0938	.1205

[1]Expressed as Sigma Units. (Sigma Chemical Company. Determination of serum acid and alkaline phosphate and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Appendix Table 2. Average alkaline phosphatase levels[1] of activity for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	10.14	7.94	6.23	6.15	5.20	4.74	4.76	6.45
Dorset Horn	13.50	11.70	10.50	12.00	11.20	8.70	7.90	10.78
Suffolk	12.17	11.62	10.12	8.99	8.57	7.85	7.05	9.48
Columbia	10.93	7.95	6.58	8.13	7.51	6.33	6.43	7.69
Willamette	9.78	9.50	7.34	7.00	7.30	6.04	6.22	7.59
Average	11.30	9.74	8.15	8.45	7.96	6.73	6.47	8.40
				Twin lambs				
Border Cheviot	9.50	6.68	6.38	6.50	5.20	5.08	4.25	6.22
Dorset Horn	12.91	10.92	7.38	9.13	9.10	7.73	8.59	9.39
Suffolk	12.17	11.62	10.12	8.99	8.57	7.85	7.05	9.48
Columbia	9.20	8.35	6.10	8.35	8.00	6.65	7.15	7.68
Willamette	11.47	8.40	8.45	7.62	7.35	7.15	6.22	8.90
Average	11.05	9.19	7.69	8.12	7.64	6.89	6.65	8.17

[1]Expressed as Sigma Units. (Sigma Chemical Company. Determination of serum acid and alkaline phosphate and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Appendix Table 3. Average hematocrit values[1] for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	31.59	33.29	33.49	31.69	31.80	29.90	31.29	31.86
Dorset Horn	31.00	34.50	33.00	37.00	34.50	36.00	36.00	34.57
Suffolk	26.16	27.50	34.66	34.50	31.50	31.16	31.00	30.92
Columbia	28.25	32.16	32.91	30.50	30.08	30.75	30.25	30.70
Willamette	31.08	32.40	32.70	31.80	31.20	30.50	30.80	31.49
Average	29.62	31.97	33.35	33.10	31.82	31.66	31.87	31.91
				Twin lambs				
Border Cheviot	33.00	30.13	33.80	27.13	29.13	30.38	28.75	30.34
Dorset Horn	30.31	36.81	33.56	32.99	31.18	33.87	33.00	33.10
Suffolk	29.25	32.00	33.50	32.49	32.12	32.00	32.12	31.92
Columbia	32.25	31.00	30.00	30.00	32.25	29.25	27.00	30.25
Willamette	32.25	33.62	33.00	30.37	30.37	31.62	30.12	31.62
Average	31.41	32.71	32.77	30.60	31.01	31.42	30.20	31.45

[1]Expressed as percent.

Appendix Table 4. Average hemoglobin values[1] for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	12.19	12.80	13.28	11.28	11.00	10.63	10.93	11.73
Dorset Horn	11.50	12.00	15.00	12.50	12.50	12.00	12.00	12.50
Suffolk	12.81	13.02	13.36	11.86	11.31	11.37	11.38	12.15
Columbia	11.25	13.66	10.87	10.21	9.95	10.23	10.43	10.94
Willamette	11.90	14.14	11.20	11.20	10.98	10.74	11.58	11.67
Average	11.93	13.12	12.74	11.41	11.15	10.99	11.26	11.80
				Twin lambs				
Border Cheviot	11.38	12.75	12.05	9.10	9.90	10.28	9.78	10.74
Dorset Horn	12.81	13.02	13.36	11.86	11.31	11.37	11.38	12.15
Suffolk	13.05	12.75	12.16	11.47	10.87	10.80	11.25	11.76
Columbia	12.75	12.75	11.85	10.25	9.35	8.85	9.10	10.70
Willamette	14.22	14.00	11.17	11.30	11.02	10.97	11.00	11.95
Average	12.84	13.05	12.12	10.80	10.49	10.45	10.50	11.46

[1]Expressed as grams per 100 ml. of blood.

Appendix Table 5. Average red blood cell count[1] for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	9.07	10.50	9.96	10.78	10.60	10.99	11.12	10.43
Dorset Horn	7.08	9.79	10.93	11.45	10.47	12.82	11.20	10.53
Suffolk	8.39	9.79	9.61	12.32	11.69	11.24	11.67	11.67
Columbia	8.09	10.40	10.33	9.56	9.87	10.24	10.13	9.80
Willamette	8.89	10.03	11.69	11.96	11.76	11.83	11.79	11.14
Average	8.30	10.10	10.50	11.21	10.88	11.42	11.18	10.71
				Twin lambs				
Border Cheviot	8.97	10.14	10.90	9.06	8.96	10.11	10.07	9.74
Dorset Horn	9.13	9.89	10.00	10.72	11.48	11.29	10.90	10.49
Suffolk	7.83	9.45	9.74	10.36	11.03	11.65	11.25	10.19
Columbia	11.48	11.99	8.76	9.99	8.33	9.64	8.65	9.89
Willamette	10.01	10.36	10.74	10.86	11.00	11.36	10.84	10.74
Average	9.48	10.37	10.03	10.20	10.16	10.81	10.34	10.21

[1]Expressed as millions per cu. mm. blood.

Appendix Table 6. Average white blood cell count[1] for single and twin lambs over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Single lambs				
Border Cheviot	7.27	9.62	9.89	9.91	9.81	9.81	10.03	9.48
Dorset Horn	8.40	5.90	7.27	8.20	6.77	7.62	7.37	7.36
Suffolk	6.39	6.79	6.33	8.92	7.40	7.38	8.42	7.38
Columbia	5.85	8.37	8.72	8.52	7.46	7.46	8.08	7.78
Willamette	7.38	8.32	7.90	7.75	7.16	7.46	8.61	7.80
Average	7.06	7.80	8.02	8.66	7.72	7.95	8.50	7.96
				Twin lambs				
Border Cheviot	6.94	8.21	6.92	7.91	7.76	9.26	7.80	7.83
Dorset Horn	6.54	6.26	7.04	6.01	7.21	8.15	7.25	6.92
Suffolk	6.98	7.01	7.59	7.64	8.07	7.97	8.82	7.72
Columbia	6.76	8.51	9.70	9.32	8.17	9.09	7.90	8.49
Willamette	6.16	7.62	7.31	7.09	6.51	6.65	6.91	6.89
Average	6.68	7.52	7.71	7.59	7.54	8.22	7.74	7.57

[1]Expressed as thousands per cu. mm. blood.

Appendix Table 7. Average acid phosphatase levels[1] of activity for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Male lambs				
Border Cheviot	.1957	.1075	.1137	.1360	.1157	.0964	.1137	.1255
Dorset Horn	.1457	.0870	.0970	.0843	.0887	.0743	.1057	.0975
Suffolk	.1533	.1023	.1123	.1023	.1270	.1270	.0863	.1157
Columbia	.1962	.1139	.0890	.0777	.0947	.1070	.1000	.1112
Willamette	.1580	.1255	.0791	.0910	.1136	.0788	.0741	.1028
Average	.1698	.1072	.0982	.0983	.1079	.0967	.0959	.1105
				Female lambs				
Border Cheviot	.1705	.0900	.1080	.1020	.1140	.0905	.0845	.1085
Dorset Horn	.1493	.1225	.1108	.0753	.1157	.0763	.1133	.1090
Suffolk	.2337	.1465	.1055	.1657	.1457	.0877	.0885	.1390
Columbia	.2382	.0832	.1207	.0647	.0942	.0794	.0882	.1098
Willamette	.1176	.0923	.0780	.0876	.1123	.0796	.0896	.0938
Average	.1818	.1069	.1046	.0991	.1164	.0827	.0928	.1120

[1]Expressed as Sigma Units. (Sigma Chemical Company. Determination of serum acid and alkaline phosphate and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Appendix Table 8. Average alkaline phosphatase levels[1] of activity for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
Border Cheviot	9.53	7.57	6.05	6.21	5.37	4.96	4.81	6.35
Dorset Horn	13.57	11.27	9.10	10.77	10.40	9.50	9.63	10.60
Suffolk	10.76	11.13	10.13	8.86	8.36	7.30	7.96	9.21
Columbia	10.50	9.52	6.95	8.44	7.30	6.87	6.65	8.03
Willamette	10.42	9.45	7.77	7.20	7.53	5.05	6.25	7.66
Average	10.96	9.79	8.00	8.30	7.79	6.74	7.06	8.37
				Female lambs				
Border Cheviot	11.00	8.05	7.15	6.65	4.60	4.65	3.55	6.52
Dorset Horn	12.66	10.88	7.05	8.80	8.80	7.01	7.96	9.02
Suffolk	12.35	11.80	9.45	8.49	7.55	7.25	6.25	9.02
Columbia	10.50	6.57	5.97	7.92	7.97	5.94	6.57	7.34
Willamette	10.76	8.13	7.96	7.43	6.90	6.20	6.16	7.64
Average	11.45	9.09	7.52	7.86	7.16	6.21	6.10	7.91

[1]Expressed as Sigma Units. (Sigma Chemical Company. Determination of serum acid and alkaline phosphate and prostatic acid phosphatase. Sigma Technical Bulletin 104. Sigma Chemical Company, St. Louis, Missouri. 1958)

Appendix Table 9. Average hematocrit values[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Male lambs				
Border Cheviot	31.85	31.71	33.64	29.14	30.57	30.07	29.42	30.91
Dorset Horn	29.83	33.83	29.83	31.33	30.33	34.17	32.50	31.68
Suffolk	25.33	26.33	34.00	33.83	30.50	30.50	30.66	30.16
Columbia	29.62	30.25	32.12	29.87	30.37	30.25	28.80	30.18
Willamette	32.17	34.35	33.50	32.08	31.58	31.16	31.08	32.27
Average	29.76	31.29	32.62	31.25	30.67	31.23	30.49	31.04
				Female lambs				
Border Cheviot	33.50	32.50	33.75	31.50	30.75	30.25	32.75	32.14
Dorset Horn	30.66	34.58	35.33	34.50	32.16	34.08	33.75	33.58
Suffolk	29.87	32.87	34.00	32.99	32.87	32.50	32.37	32.49
Columbia	28.87	33.49	32.24	30.87	30.87	30.50	30.00	30.97
Willamette	23.50	30.33	31.50	29.33	29.33	30.66	29.33	29.14
Average	29.28	32.75	33.36	31.84	31.20	31.60	31.64	31.66

[1]Expressed as percent.

Appendix Table 10. Average hemoglobin values[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Male lambs				
Border Cheviot	11.57	12.50	13.01	9.94	10.37	10.51	9.94	11.12
Dorset Horn	12.50	12.17	12.73	11.57	11.07	11.13	11.17	11.76
Suffolk	9.90	11.33	12.73	11.07	11.06	9.90	10.23	10.88
Columbia	11.75	13.00	11.62	9.97	9.35	9.75	9.67	10.73
Willamette	11.90	14.53	11.45	11.42	11.23	10.90	11.70	11.87
Average	11.52	12.71	12.31	10.79	10.62	10.44	10.54	11.27
				Female lambs				
Border Cheviot	12.75	13.75	11.75	11.60	11.00	10.35	12.00	11.88
Dorset Horn	12.75	13.28	13.95	12.11	11.63	11.60	11.60	12.41
Suffolk	12.50	13.13	12.29	12.05	11.25	11.17	11.50	11.98
Columbia	11.49	13.87	10.60	10.47	10.25	10.02	10.52	11.03
Willamette	11.66	13.16	10.66	10.90	10.53	10.73	10.56	11.17
Average	12.23	13.44	11.85	11.43	10.93	10.77	11.24	11.69

[1]Expressed as grams per 100 ml. blood.

Appendix Table 11. Average number[1] of red blood cells for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Male lambs				
Border Cheviot	8.85	10.27	10.30	9.86	9.35	10.47	10.28	9.91
Dorset Horn	8.09	10.01	9.94	10.54	11.11	11.53	11.64	10.40
Suffolk	8.97	9.16	8.64	11.05	10.57	10.51	11.21	10.01
Columbia	9.01	10.12	9.68	9.74	8.68	10.42	7.66	9.33
Willamette	9.58	10.53	11.36	11.63	11.79	11.80	11.51	11.17
Average	8.90	10.02	9.98	10.56	10.30	10.95	10.46	10.16
				Female lambs				
Border Cheviot	9.63	10.56	10.65	10.53	11.68	11.07	11.93	10.86
Dorset Horn	9.30	9.81	10.18	10.93	11.50	11.43	10.58	10.53
Suffolk	8.00	9.91	10.47	11.31	11.87	12.19	11.60	10.76
Columbia	8.86	11.48	10.19	9.60	10.29	9.76	10.37	10.07
Willamette	8.86	9.52	11.07	11.15	10.67	11.26	11.09	10.51
Average	8.93	10.26	10.51	10.70	11.20	11.14	11.11	10.55

[1]Expressed as millions per cu. mm. blood.

Appendix Table 12. Average number[1] of white blood cells for lambs of five breeds of sheep over seven testing periods.

Breeds	Periods 1	2	3	4	5	6	7	Average
				Male lambs				
Border Cheviot	7.34	8.98	8.29	9.07	8.42	9.44	9.38	8.70
Dorset Horn	6.54	6.68	8.36	7.95	7.35	8.75	7.67	7.61
Suffolk	6.42	8.27	6.51	9.15	7.57	7.98	8.67	7.79
Columbia	6.86	8.39	8.86	8.31	7.25	7.88	8.16	7.95
Willamette	7.44	7.81	8.00	7.66	7.23	7.12	8.26	7.64
Average	6.92	8.03	8.00	8.43	7.56	8.23	8.43	7.94
				Female lambs				
Border Cheviot	6.37	9.04	9.56	8.86	10.57	10.02	7.85	8.89
Dorset Horn	6.85	5.99	6.42	7.07	7.07	7.76	7.05	6.88
Suffolk	6.96	5.89	9.96	7.43	7.95	7.52	8.64	7.76
Columbia	5.31	8.42	9.07	9.13	8.02	7.86	7.92	7.96
Willamette	5.63	7.75	6.92	7.05	6.16	7.07	7.03	6.80
Average	6.22	7.42	8.39	7.91	7.95	8.05	7.70	7.66

[1]Expressed as thousands per cu. mm. blood.

Appendix Table 13. Average body weights[1] for lambs of five breeds of sheep over seven testing periods.

Breeds	Number of Lambs	Birth Weight	Periods 1	2	3	4	5	6	7	Total Gain
						Male lambs				
Border Cheviot	7	3.86	6.31	9.03	12.28	15.16	18.53	23.52	27.73	23.87
Dorset Horn	3	3.94	7.23	9.98	13.46	17.39	22.38	27.22	31.45	27.51
Suffolk	3	5.03	6.61	10.89	15.80	19.96	25.10	30.24	35.08	30.05
Columbia	4	4.71	7.10	10.55	13.66	17.69	22.34	27.44	31.75	27.04
Willamette	6	4.96	8.04	12.85	17.54	21.10	27.67	33.19	37.80	32.84
Average		4.50	7.06	10.66	14.55	18.26	23.20	28.32	32.76	28.26
						Female lambs				
Border Cheviot	2	4.17	6.92	10.43	14.06	17.24	20.64	24.04	26.08	21.91
Dorset Horn	6	4.15	6.55	9.75	13.34	16.07	20.11	24.27	27.97	23.82
Suffolk	4	4.76	7.31	11.57	15.21	19.62	24.04	29.60	33.56	28.80
Columbia	4	5.14	8.16	12.78	16.56	20.18	25.74	29.14	32.77	27.63
Willamette	3	4.81	7.14	10.20	14.14	18.60	23.28	28.12	32.96	28.15
Average		4.61	7.22	10.95	14.66	18.34	22.76	27.03	30.67	26.06

[1]Expressed as kilograms.

Appendix Table 14. Live animal and carcass scores for lambs of five breeds of sheep at 100 days of age.

Breeds	Number of Lambs	Conformation	Condition	Preference	Tenderness
		Male lambs			
Border Cheviot	7	88.27	81.85	4.314	3.813
Dorset Horn	3	84.67	83.20	4.250	4.143
Suffolk	3	86.40	86.60	4.500	4.206
Columbia	4	75.53	75.25	5.112	5.080
Willamette	6	89.23	89.20	4.991	4.886
Average		84.82	83.22	4.633	4.426
		Female lambs			
Border Cheviot	2	88.30	81.70	5.130	5.250
Dorset Horn	6	87.60	87.60	5.241	5.000
Suffolk	4	86.64	89.45	4.750	4.687
Columbia	4	83.20	83.25	5.205	5.062
Willamette	3	85.66	88.06	4.876	4.896
Average		86.28	86.01	5.040	4.979

Appendix Table 15. Analysis of variance of acid phosphatase levels for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	8.32	4	2.08	0.36
Period	112.70	6	18.78	3.25**
Type of Birth	14.24	4	3.56	0.61
Error	1,164.13	202	5.76	

**indicates significance at the one percent level of probability

Appendix Table 16. Analysis of variance of alkaline phosphatase levels for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	66.97	4	16.74	11.52**
Period	41.63	6	6.93	4.77**
Type of Birth	22.57	4	5.64	3.88**
Error	293.48	202	1.45	

**indicates significance at the one percent level of probability

Appendix Table 17. Analysis of variance of hematocrit values for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	261.21	4	65.30	6.09**
Period	290.31	6	48.38	4.51**
Type of Birth	39.05	4	9.76	0.91
Error	2,163.78	202	10.71	

**indicates significance at the one percent level of probability

Appendix Table 18. Analysis of variance of hemoglobin values for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	35.66	4	8.91	4.09**
Period	260.66	6	43.44	19.95**
Type of Birth	10.70	4	2.67	1.22
Error	439.89	202	2.17	

**indicates significance at the one percent level of probability

Appendix Table 19. Analysis of variance of red blood cell counts for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	20,755.530.00	4	5,188,883.00	2.35
Period	44,877,490.00	6	7,479,582.00	3.39**
Type of Birth	15,935,290.00	4	3,983,822.00	1.80
Erro	445,191,243.00	202	2,203,917.04	

**indicates significance at the one percent level of probability

Appendix Table 20. Analysis of variance of white blood cell counts for ewes of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	66,145,620.00	4	16,536,405.00	9.35**
Period	33,883,090.00	6	5,647,181.66	3.19**
Type of Birth	19,854,230.00	4	4,963,558.50	2.81*
Error	356,976,486.00	202	1,767,210.33	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 21. Analysis of variance of acid phosphatase levels for lambs of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	.0377997	4	.0094499	4.72**
Sex	.0000437	1	.0000437	0.02
Birth Type	.0040473	1	.0040473	2.02
Age of Dam	.0207055	5	.0041411	2.07
Period	.2265774	6	.0377629	18.89**
Error	.5514940	276	.0019981	

**indicates significance at the one percent level of probability

Appendix Table 22. Analysis of variance of alkaline phosphatase levels for lambs of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	279.67	4	69.91	29.33**
Sex	19.38	1	19.38	8.13**
Birth Type	1.39	1	1.39	0.58
Age of Dam	29.05	5	5.81	2.43*
Period	670.74	6	111.79	46.90**
Error	657.77	276	2.38	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 23. Analysis of variance of hematocrit values for lambs of five breeds of sheep.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	37.50	4	9.37	1.33
Sex	23.75	1	23.75	3.37
Birth Type	16.29	1	16.29	2.31
Age of Dam	161.13	5	32.22	4.57**
Period	221.30	6	36.88	5.23**
Error	1,943.47	276	7.04	

**indicates significance at the one percent level of probability

Appendix Table 24. Analysis of variance of hemoglobin levels for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	15.51	4	3.87	2.21
Sex	8.26	1	8.26	4.72*
Birth Type	1.69	1	1.69	0.97
Age of Dam	14.30	5	2.86	1.63
Period	219.86	6	36.64	20.95**
Error	482.62	276	1.74	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 25. Analysis of variance of red blood cell counts for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	12,939,450.00	4	3,234,861.00	1.54
Sex	4,892,228.00	1	4,892,228.00	2.33
Birth Type	8,610,052.00	1	8,610,052.00	4.11*
Age of Dam	13,793,060.00	5	2,758,612.00	1.31
Period	128,152,100.00	6	21,358,680.00	10.20**
Error	577,690,903.00	276	2,093,082.98	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 26. Analysis of variance of white blood counts for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	31,434,130.00	4	7,858,532.00	4.05**
Sex	8,814,492.00	1	8,814,492.00	4.55*
Birth Type	18,199,230.00	1	18,199,230.00	9.40**
Age of Dam	14,643,870.00	5	2,928,774.00	1.51
Period	63,249,280.00	6	10,541,550.00	5.44**
Error	534,340,093.00	276	1,936,014.83	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 27. Analysis of variance of body weights for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	703,340,800.00	4	175,835,200.00	27.72**
Sex	40,886,780.00	1	40,886,780.00	6.44*
Birth Type	939,045,600.00	1	939,045,600.00	148.08**
Age of Dam	285,059,300.00	5	57,011,870.00	8.99**
Period	20,121,950,000.00	6	3,353,658,000.00	528.85**
Error	1,750,206,520.00	276	6,341,327.97	

* indicates significance at the five percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 28. Analysis of variance of conformation scores for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	220.65	4	55.16	4.24**
Sex	0.12	1	0.12	0.01
Birth Type	359.17	1	359.17	27.61**
Age of Dam	247.89	5	49.57	3.81**
Error	390.19	30	13.00	

**indicates significance at the one percent level of probability

Appendix Table 29. Analysis of variance of condition scores for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	279.49	4	69.87	4.56**
Sex	22.64	1	22.64	1.48
Birth Type	357.27	1	357.27	23.35**
Age of Dam	232.22	5	46.44	3.03*
Error	458.91	30	15.29	

* indicates significance at one percent level of probability
**indicates significance at the one percent level of probability

Appendix Table 30. Analysis of variance of preference scores for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	0.94	4	0.23	0.58
Sex	1.31	1	1.31	3.27
Birth Type	1.24	1	1.24	3.10
Age of Dam	1.48	5	0.29	0.74
Error	12.07	30	0.40	

Appendix Table 31. Analysis of variance of tenderness scores for five breeds of lambs.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Breed	1.95	4	0.48	0.53
Sex	2.76	1	2.76	3.02
Birth Type	2.31	1	2.31	2.52
Age of Dam	2.46	5	0.49	0.53
Error	27.47	30	0.91	