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The Quality and Quantity of Ewe's Milk as Affected by Breed, Stage of Lactation, and Somatotropin

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THE QUALITY AND QUANTITY OF EWE'S MILK AS AFFECTED BY BREED, STAGE OF LACTATION, AND SOMATOTROPIN

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This thesis is approved as a creditable independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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VITA

Darold Dean Shaffhausen was born June 22, 1925, at Tyndall, South Dakota. He spent his early life on a farm near Tyndall and graduated from Tyndall High School in May, 1942. He entered the Armed Forces in May, 1943, and served for three years, being honorably discharged in May, 1946. During the next four years he was employed by the Railway Express Company at Rapid City, South Dakota. After resigning this position, he entered South Dakota State College and received his bachelor of science degree in December, 1952. Since that time he has been doing graduate work in Animal Husbandry at South Dakota State College.

INTRODUCTION

Lactation, a process specific to mammals for nuturing their young, has been highly developed in some species, notably the dairy cow. Abundant milk secretion is essential for the success of all farm livestock enterprises. Insufficient milk supply by the range cow and ewe is probably one of the causes for high infant mortality suffered by these two species. Weaning weights of pigs are highly correlated with the milk yield of their dam.

The period of time that young mammals depend upon milk varies from 6-8 weeks for young pigs to 4-5 months for lambs, calves and colts. While dairy cows have been developed to an extremely high point of efficiency in milk production, other farm animals have received less attention from this viewpoint which may be due to an antagonism between high milk production and meat production.

Some beef cows are hardly capable of producing enough milk to rear a calf, and the same holds true for many ewes. On the average, a lamb makes about 75 percent of its growth the first year, and 50 percent of this growth is obtained the first 3 months while nursing. Since a young lamb is not able to use sufficient quantities of roughage because of the lack of rumen development, the major part of the lamb's nutrients must come from milk during the first 2 to 3 months. Therefore, the amount of milk the ewe secretes has a direct effect upon the lamb's growth rate. Some evidence is available suggesting that the quantity of milk produced has more effect upon the growth rate than does either the fat percentage or the protein content of the milk. The milking capacity of mutton-producing sheep is of greater importance than is generally realized, for the lamb's weight and condition depends largely on the quantity of milk its dam provides. Apart from the question of producing milk for dairy purposes from some special breeds of sheep, more information is needed on lactation in nursing ewes than is available at present. Fraser (1951) stated there could be no more useful and profitable line of sheep research at the present time than a study of milk production of different breeds and crosses of breeds. It is known that a lamb's inherited capacity to grow contributes much to its rate of gain as is shown by having a lamb of one breed nurse a ewe of another breed. Little information is available on the portion of growth attributed to the amount of milk received and the portion attributed to the lamb's inherited capacity to grow.

This experiment was undertaken to obtain additional data relative to the quality and quantity of milk produced, and to study the effect of breed, stage of lactation, and somatotropin on these two factors. Some of the questions to be answered relative to milk let-down and composition are: (1) can an accurate sample be obtained by hand-milking without removing the lambs for a period of time prior to sampling, (2) what effect does removing the lambs from the ewes prior to milking have on milk quality, (3) can an accurate sample be obtained without the aid of oxytocin to cause milk let-down, (4) does oxytocin enable one to obtain the entire quantity of milk from the mammary gland, (5) is the quality of the milk affected by breed or stage of lactation? The answers to these specific questions were sought in the first experiment conducted with Columbia, Hampshire, and Southdown ewes. Since the manner of obtaining a sample (milking while lambs remained or were removed from the ewes) had an effect on the composition of the milk, a second experiment was conducted with the No-tail ewes in which only one controlled procedure was followed throughout the study. The milk yield, fat content, solids-not-fat, and globule size were determined at weekly intervals for a 9-week period. In addition, the effect of somatotropin on milk quantity and quality was studied during advanced lactation.

REVIEW OF LITERATURE

The published literature concerning milk production in sheep raised for mutton and wool is limited and may be due to difficulties in obtaining the milk sample. Much of the information available refers to milk yields of dairy sheep since they are accustomed to let-down their milk by hand-milking, and the amount of milk taken can be weighed directly. In sheep unaccustomed to hand-milking, it is difficult to obtain reliable data on actual milk yields. Although it is possible to draw some milk from any lactating ewe, she will not let-down all her milk until well accustomed to hand-milking. Consequently, in order to determine the milk yield of ewes, other than those of dairy breeds, it is customary to estimate milk yield indirectly by weighing lambs before and after suckling.

Milk Let-Down

The accuracy of hand-milking over weighing of lamb before and after nursing was shown to be extremely variable by Wallace (1948). He reported a difference of 1.78 pounds in favor of the lamb suckling its mother. By hand-milking, an average daily yield of 1.02 pounds was obtained as compared to 2.80 pounds of milk as determined by allowing the lamb to nurse and weighing the lamb before and after nursing. Because of greater accuracy most workers have relied upon this method for estimating milk yield of sheep. Barnicoat et al (1949) tried hand-milking, a milking machine, pituitrin hormone injections, and weighing the lamb before and after nursing 6 times during a 24-hour period. All methods were discarded except the latter. Whiting et al (1951) relied on the method of weighing the lamb before and after nursing every 4 hours for a 24-hour period, with a sample being taken for analysis by hand-milking just prior to the last nursing period.

Individual ewes vary in ease and completeness of milking which influences the accuracy of lactation records. Fraser (1951) found the range of variation among animals of the same breed to be more extreme than the range of variation among breed averages.

Oxytocin has been used by various workers to initiate let-down of milk. Smith (1947) found that cows, which failed to give a normal let-down of milk when milked at 2 hour intervals, gave fairly uniform let-down and milk yield when oxytocin was injected intravenously. Knodt and Petersen (1944) reported that cows which varied erratically in milk yield between milkings, produced uniformly and averaged higher in yield following large injections of oxytocin. Ragsdale et al (1924) and Garrison and Turner (1936) studied the rate of milk secretion by milking cows at increasing intervals of 1 to 32 and 1 to 24 hours, respectively. These authors concluded the rate of milk secretion is quite constant at milking intervals of 12 hours.

Whittlestone (1953) in checking milk-ejection response in sows, noted the average elapse of time to initiate response was 15 seconds, and the duration was 27 seconds. These sows were injected periodically with 0.5 I. U. of oxytocin into the ear vein. There were no trends in the response time as the lactation advanced.

Barnicoat et al (1949) administered injections of pituitrin at the rate of 10 units in 5 milliliters of physiological saline, and found it facilitated letting-down of milk for hand-milking. With a group of 17 ewes, 14 yielded to hand-milking 80-100 percent with an average of 94 percent from 6-hour accumulations, while 3 yielded only 75 percent. These percentages were derived by comparing amount consumed by lamb to the amount obtained by hand-milking. Willett and Maruyama (1946) collected samples of milk from sows by injecting oxytocin into the ear vein and then placed 2 or 3 of the pigs with the sow to nurse. The samples were obtained from the unclaimed teats.

Milk Composition

The fat content of milk varies considerably between species and between animals within the species. Fat percentages vary from about 1 percent for mare's milk (Holmes, 1947) to about 50 percent for whale's milk (White, 1953). Wallace (1948) observed a fat variation of 2.4 to 12.1 percent in 158 samples from 95 ewes of 17 different breeds and crosses. The breed averages ranged from 4.7 to 8.4 percent with a mean of 6.8 percent, but the individual variations within each were so great that these breed averages were not considered reliable. Barnicoat et al (1949) found the fat content of Romney ewes averaged 6.0 percent. Morrison (1951) states the range to be from 3.8 to 12.1 percent fat with an average of 6.9 percent. Goat's milk averages 7.3 percent fat and 17 percent total solids (Thompson, 1903). Fraser (1951) noted the dairy breeds of sheep (East Friesian for example) averaged 5.6 percent fat over an average lactation of 120 days.

Holmes et al (1947) observed a variation in solids from 9.8 percent to 11.3 percent when analyzing milk from 5 mares. Whole milk from cows normally contains 12 to 14 percent solids, and fat percentage varying between breeds of from 3.5 percent to 5.3 percent. With dairy cattle, as the fat percentage increases, the solids-not-fat increase due to an increase in protein and ash content. Maynard (1951) shows the increase amounts to about 0.2 percent for each 0.5 percent increase in fat content. Barnicoat et al (1949) concluded that solids-not-fat in sheep's milk remained fairly constant regardless of the variations in fat content.

Petersen et al (1944) using 4 cows, 2 of which were injected with 1cc oxytocin following milking during the second and third day of 14-day periods, and the other 2 injected only during the second day of 14-day periods, found 3 of the cows showed an increase in milk fat. A higher total milk production was noted during the periods of injection as compared to periods of non-injection.

Adams and Allen (1952) found that normally drawn milk from cows tested higher when oxytocin had not been used at the previous milking than when it had been used. This indicated that high testing residual milk is secured with oxytocin at the expense of the fat content of the subsequent milking. These authors claim that residual milk is not static, and most of the fat is secured under normal milking conditions at the following milking. A part of the fat in milk secured under normal milking conditions may regularly come from residual milk which was present in the gland at the time of the previous milking.

Apparently the type of ration fed affects the fat percentage as well as the yield. Whiting et al (1952) fed 3 lots of 40 ewes, a ration containing 7.3 percent protein throughout pregnancy and lactation; 7.3 percent protein 6 weeks before lambing followed by 10.5 percent during lactation; and a ration of 10.5 percent protein throughout pregnancy and lactation. Milk fat percentages averaged 7.9, 8.5 and 8.5 percents respectively, over a 6 weeks milking period.

Willett and Maruyama (1946) reported the fat percentage of sow's milk increased when fed a high fat diet. This was substantiated by feeding one lot a dry concentrate mixture containing 2.8 percent fat and the other lot garbage containing 27.1 percent fat. Fifty-two samples from 18 sows were collected during the third and seventh week of lactation. The average fat content of the milk from those in the dry lot was 6.1 percent while those on garbage averaged 9.6 percent.

Milk Yield

According to Ensminger (1952) a good milking goat will average 3 quarts of milk per day over a lactating period of 10 months. Fraser (1951) found that dairy breeds of sheep yield approximately 600 kilos (1320 pounds) of milk in an average lactation of 120 days. He also reported a yield of 20 to 30 gallons for the mutton breeds. Wallace (1948) obtained an average daily yield from Suffolk ewes of 2.03 pounds per day (42.8 ounces or 1241 milliliters) when sampled for 14 lactations of 20 weeks duration. It was postulated by Wallace (1948) that about 38 percent of the total yield was produced during the first month, 30 percent and 21 percent during second and third months respectively, and only 11 percent during the last month of lactation.

Whiting et al (1952) found that ewes on different levels of protein yielded from 29.6 to 42.5 ounces of milk per ewe daily on the average over a 6 weeks period. Barnicoat et al (1949) in milking 3 and 4 year old Romney ewes obtained an average daily yield of 65 ounces per day for the first 12 weeks of lactation for ewes nursing twins, and 48 ounces per day for ewes nursing single lambs. Ewes 6 years old, and nursing singles, yielded 53 ounces per day. In one experiment these authors noted that 6 year old ewes yielded 15 percent more milk over a 12-week lactation than 2 year olds. They concluded a ewe nursing twin lambs will produce about one-third more milk than a ewe nursing a single lamb.

Barnicoat et al (1949) noted the peak of lactation between the second and sixth week. Also during this period the lamb receives about 50 percent of the ewe's total milk yield during the 12-week lactation.

Sirry et al (1950) reported that 6 Rahmani Egyptian sheep produced on the average of 47.4 liters in an average lactation of 177 days, and 8 other Ausimi ewes produced 21.6 liters in 114 days. When milked for 70 days after weaning, 10 Rahmani ewes gave an average of 16.2 liters, and 3 Ausimi ewes 11.5 liters. These data suggest a difference in milking ability of the two breeds. Whether similar differences exist in our popular breeds is not definitely known.

Wallace (1948) states that each additional pound of milk a lamb consumes between birth and 28 days of age increases the live weight at 1 month by 0.25 pound. In the following months the correlation between live weight increase and milk consumption, though still high, declines progressively as other food forms an increasingly greater portion of the lamb's diet. Whiting (1952) found that for each one ounce increase of milk produced daily by the ewe during the first week of lactation, caused the lamb to gain 0.48 pound more during the first 7 weeks.

Studies by various workers have revealed that quantity rather than quality of the milk produced is of more importance in the growth of a lamb (Barnicoat, 1949). The amount produced was influenced by feed fed during lactation, and the growth rate of the lamb was closely related with the amount of milk produced by its mother up to 120 days of age. Milk yields are not significantly influenced by the weight of the ewe (Barnicoat, 1949). Conversely every 100-pound increase in body weight of the dairy cow results in an annual increase of 250 pounds of milk (Morrison, 1951). Milk yields are influenced by age of ewe, number of lambs nursing ewe, and the level of nutrition of the ewe. Many workers have reported the level of nutrition during lactation is of more importance than the level of nutrition during pregnancy but maximum yields resulted from a combination of the two (Jordan, 1950).

Several hormones are responsible for the secretion and let-down of milk. Many are interrelated and act indirectly while others act directly. Prolactin, secreted by the anterior lobe of the pituitary gland, is necessary for the maintenance of lactation. Estrogen is necessary for building of the mammary gland. Oxytocin is secreted by lactating animals to initiate the actual let-down of milk. This hormone originates in the posterior lobe of the pituitary gland and causes contraction of the muscle cells around the alveoli thereby forcing the milk down.

Thyroprotein or thyroxine has been used and found to increase milk yield by about 20 percent. Thomas and Moore (1953) fed 20 cows thyroprotein for 300 days. These authors found it to cause an immediate increase in the level of milk production and butterfat test. However, the butterfat test showed an increase for only 2 months. Without the feeding of extra nutrients the increases shown were only transient. It was concluded from the experiment, that feeding extra nutrients and thyroprotein did not result in a greater amount of milk produced over an entire lactation than in cows fed extra nutrients only. General metabolism is increased which may account for the increase in milk yield. More work needs to be done on the use of thyroprotein as it is not known whether cows can stand this increase in metabolism over a long period of time. The use of this hormone has been very effective over short periods of feeding.

Somatotropin from the anterior lobe of the pituitary has been found to increase milk yield in cows when injected periodically. Donker and Petersen (1952) injected 30-35 milligrams of somatotropin into 7 cows for a 4-day period and showed an increase in milk production of 10.4 percent when comparing 4 days post-injection milk production to a 4-day pre-injection period. Injecting 35 milligrams of thyrotropic hormone into 3 animals at the time of the increase from the somatotropin resulted in no change. There were no changes in milk composition due to treatment. Prolactin, at the rate of 50 milligrams daily depressed production by 50 and 35 percent in 2 cows. In another trial cows receiving 2 multiple intramuscular injections of somatotropin increased 36.4 percent in average milk yield during a 4-day period. Intramuscular injections were more effective than subcutaneous injections and multiple injections were more effective than single injections. Two single intramuscular injections increased milk yield by 11.6 percent as compared to 9.1 percent increase for 2 single subcutaneous injections. Two multiple intramuscular injections brought a 36.4 percent average increase compared to an average increase of 21.2 percent for 2 multiple subcutaneous injections. Four single injections resulted in an average increase of 10.3 percent while 4 multiple injections increased milk yield by an average of 28.6 percent over a 4-day period. Chung <u>et al</u> (1953) reported an increase of 50 percent both in yield and fat content when injecting 6 cows in late lactation with 100 milligrams of somatotropin for 6 days. Two cows in early lactation increased 50 percent in milk production after 14 days of daily injections.

EXPERIMENTAL PROCEDURE

This study was conducted with 4 of the breeds of sheep maintained at South Dakota State College: Columbia, Hampshire, Southdown, and No-tail. All animals used in this experiment had sound udders and were in healthy condition. Samples from the first 3 milkings of the Southdown, Hampshire, and Columbia were obtained when the ewes were receiving alfalfa hay free choice and one pound of concentrates daily. All milkings obtained with oxytocin injections were done when the ewes were on pasture, which consisted mainly of bromegrass.

A 9-week lactation period (May 20 to July 20, 1953) on the No-tail breed was studied beginning 1 to 2 weeks following parturition. Only ewes nursing single lambs were used in this phase of the experiment. The lambs were weighed at the time of separation from the ewes in order to determine growth rate.

Method of Obtaining Sample.

The Southdown, Hampshire, and Columbia ewes, nursing either single or twin lambs, were milked at random during 5 various stages of lactation and in the following manner: (1) sample obtained without removing the lambs from the ewes prior to milking the ewes, (2) sample obtained after removing lambs from the ewes for 12 hours, and (3) sample obtained by using oxytocin and removing the lambs for 12 hours prior to milking. The first sample was taken about 7 days after parturition. The lambs were not removed from the ewes. In some cases the lambs were keeping the ewes milked out to the extent that a sample large enough for analysis could not be obtained. Sufficient milk for a 2-ounce sample was obtained from some ewes without milking the ewes dry, however in the majority of cases complete milking was necessary in order to obtain the sample. The second sample was taken 8 weeks post-partum and the lambs were separated from the ewes 12 hours before milking. In obtaining the third sample, (9-10 weeks post-partum), the lambs were not removed before milking. During the collection of the first 3 samples, the milk was always obtained from one-half of the udder and consisted of the first milkings, usually consisting of about 2 ounces and as stated above it usually necessitated complete milking. During the fourth and fifth collections, which were done at 16 and 20 weeks post-partum, respectively, the lambs were removed 12 hours prior to milking. Oxytocin was injected intravenously 1 to 2 minutes prior to each milking and one-half of the udder was milked completely dry with a 60-milliliter sample retained for analysis.

Samples were collected from the No-tail ewes at weekly intervals for 9 weeks. The first 4 samples were collected after the lambs were removed for 6 hours. The fifth sample was collected using the same procedure with the exception that lambs were removed for a period of 8 hours prior to milking. The remaining 4 samples were collected with the lambs removed 12 hours prior to milking. The complete milking of one-half of the udder was made possible by the use of 1cc oxytocin injected intravenously 1 to 2 minutes prior to milking. Plates I and II show the appearance of the udder before the injection of oxytocin, after injection, and after milking one-half of the udder. Oxytocin was used as an aid in obtaining the milk sample as it required considerably less labor than weighing the lambs at 4-hour intervals during a 24-hour period. In addition, a more representative sample of milk was drawn by the use of

EXPLANATION OF PLATE I

Fig. 1. Shows the appearance of a normal udder before the injection of oxytocin.

Fig. 2. The appearance of the udder 1 to 2 minutes after the injection of oxytocin.

Fig. 3. The appearance of the udder after one-half had been milked dry.

Plate I

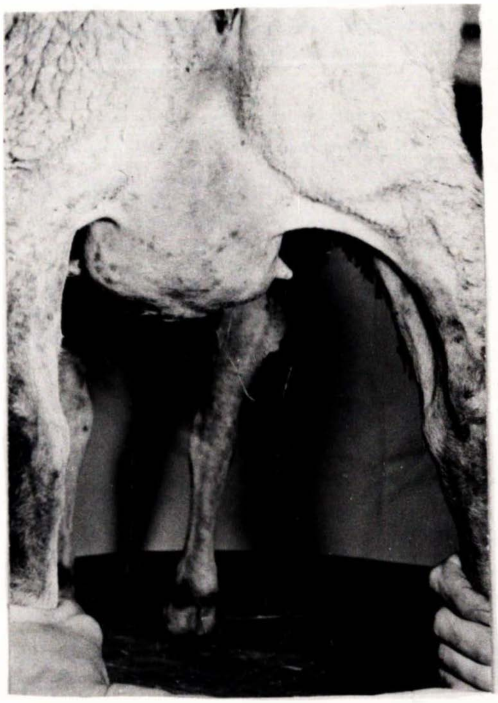

Fig. 1

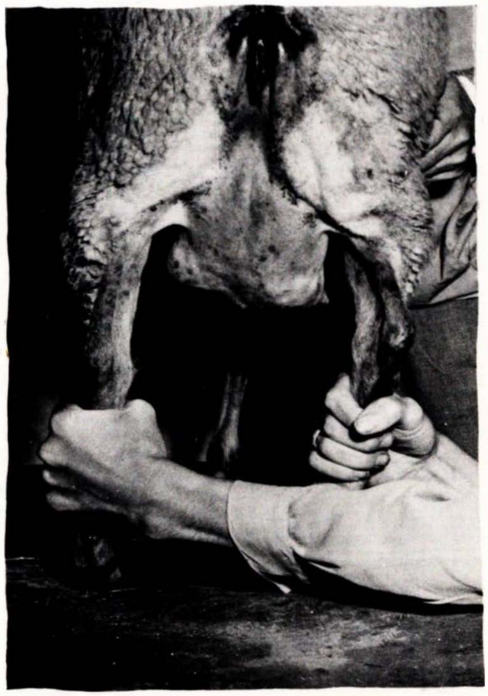

Fig. 2

Fig. 3

EXPLANATION OF PLATE II

Fig. 1. The appearance of the normal udder prior to the injection of oxytocin.

Fig. 2. The appearance of the udder 1 to 2 minutes after the injection of oxytocin.

Fig. 3. The appearance of the udder after one-half had been milked dry.

Plate II

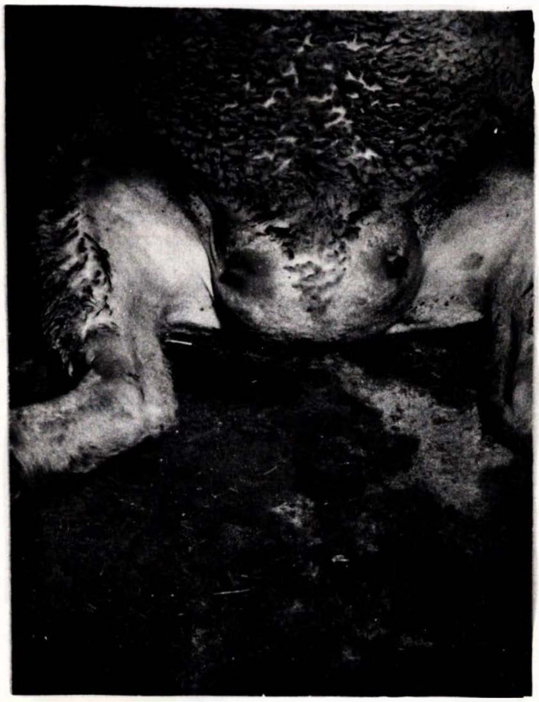

Fig. 1

Fig. 2

Fig. 3

oxytocin based on the assumption that the fat percentage remained more uniform and physical examination of the udder showed the gland was completely evacuated. One-half of the udder was milked dry by hand-milking and a 60-milliliter sample retained for analysis.

The milk yield was converted to a 24-hour basis for the entire udder as is done with dairy cows (Rice and Andrews, 1951). These conversions are somewhat arbitrary and used for comparison purposes. A 3 times a day milking compared to a 2 times a day milking increases milk yield by about 20 percent, whereby a 4 times a day milking compared to a 2 times a day milking increases milk yield by about 5 percent. For example, when the lambs were removed for a period of 6 hours, the amount obtained from one-half of the udder was doubled to estimate yield from entire udder. This figure was then multiplied by 4 because there are four 6-hour intervals in 24 hours. The answer obtained is the milk yield for 24 hours. The formula used when the lambs were removed for a period of 8 hours is as follows: milk obtained x 2 x 3 x 113 percent equals milk yield for 24 hours. When the lambs were removed for 12 hours the amount obtained in 24 hours was determined by: milk obtained x 2 x 2 x 135 percent.

Determining Fat Percentage.

A modification of the Babcock method was used because of the high fat test which could not be measured in standard 8 percent test bottles. The test was performed by using 9 milliliters of the sample and adding 9 milliliters of sulfuric acid. The fat reading was then doubled to give the fat percentage.

The samples were stored under refrigeration before testing for a period of no longer than 7 days. All samples were thoroughly mixed and warmed to room temperature before testing.

Determining Total Solids.

The total solids were found by weighing 2 grams of the sample. The moisture was removed by heating the sample to a temperature of 180 degrees centigrade until a light brown color appeared. The sample was then dried in a vacuum oven for 10 minutes at 20 inches of vacuum. Upon cooling, the sample was weighed to determine amount of moisture loss. Solids-not-fat were determined by subtracting the fat percentage from the total solids.

Determining Fat Globule Size.

The fat globule size was determined by using a Howard type micrometer disc placed in the eyepiece of a microscope. The micrometer disc was standardized with a stage micrometer to determine the size of the small squares. The size of the squares was 54 microns in diameter. A slide was prepared of each milk sample by placing a droplet on a slide and adding a cover glass to make a thin film. The fat globules were measured by viewing through this eyepiece and measured by comparison with the squares.

Administering Somatotropin.

Twenty-five milligrams of somatotropin (Armour and Company) suspended in 5cc of physiological saline was administered per ewe daily to 6 of the No-tail ewes during the declining stage of lactation. The injections were begun on July 20, 1953, and terminated July 25, 1953. These injections were given intramuscularly for 6 days at 24-hour intervals and the ewes sampled on the seventh day. The ewes which received the hormone were chosen at random. The remaining 6 ewes served as the controls and received 5cc of physiological saline per ewe daily. All sampling was performed as stated previously with the lambs removed for 12 hours before milking. Fat content, solids-not-fat, and globule size were determined as previously stated.

The ewes were milked on the second, fourth, and eighth days following termination of the somatotropin injections to determine the lasting effect of the hormone.

RESULTS AND DISCUSSION

Milk Quality

Tables I, II, and III show the average fat percentage, solids-not-fat, globule size, and milk yield obtained from Columbia, Hampshire, and Southdown ewes during 5 different stages in their lactation. The data in these tables was assembled as obtained.

Fat Content. The results from the first 3 tables show the fat content of the milk drawn one week post-partum was considerably higher than the fat content of the milk drawn 8 weeks post-partum. In the first samples obtained when the lambs were left on the ewes, the Columbias averaged 6.5 percent, Hampshires 10.0 percent, and the Southdowns 6.9 percent. In the second sample where the lambs were removed 12 hours prior to milking, the Columbias averaged 3.7 percent, Hampshires 2.2 percent, and the Southdowns 2.5 percent. The fat content obtained from milk drawn at 10 weeks post-partum (third sample lambs with the ewes) was considerably higher for all three breeds than was the case during the second sampling. For example, the Columbias averaged 10.4 percent, the Hampshires 6.5 percent, and the Southdowns 10.5 percent. The erratic results obtained during these 3 samplings show that the amount of milk in the udder at the time the sample is obtained and the portion of that milk obtained, has a direct effect upon the resulting fat test. Samples obtained without removing the lambs prior to milking the ewes resulted in a milk sample that was considerably higher in fat than the first drawn milk. Conversely milk samples drawn from a ewe that had not been suckled for 12 hours resulted in obtaining milk that was considerably lower in fat. Milk obtained from a ewe with the lamb removed for a period of time was the fore milk and if similar to dairy cows should be low in fat. If the entire accumulation of milk that was present in the gland could be obtained when the sample was taken, then an accurate sample would be obtained. The shortcoming of taking milk samples either without removing the lamb prior to milking the ewe or after removing the lamb for a period of about 12 hours, is the failure to know whether one is obtaining a representative sample.

The higher fat tests which resulted when the sample was taken while the lambs remained with the ewes may be explained by the fact the lambs were keeping the gland emptied to the extent that only strippings were obtained. It is known that the strippings from dairy cows are higher in fat. The strippings of sow's milk are not richer in fat than first drawn milk (Whittlestone, 1953). These results suggest that ewe's milk is similar to cow's milk.

Milk samples obtained 16 and 20 weeks post-partum (lambs removed 12 hours prior to milking) were secured with the administration of oxytocin. This hormone, which contracts the muscle cells around the alveoli, enabled one to obtain all of the milk that the ewe had in the gland at the time of milking and to obtain a sample that was representative. By this method the Columbias averaged 8.9 percent, Hampshires 9.1 percent, and the Southdowns 7.6 percent at 16 weeks post-partum. At 20 weeks post-partum, the Columbias averaged 9.7 percent, the Hampshires 9.0 percent, and the Southdowns 8.9 percent. The average fat test obtained from these last 2 samplings varied slightly, but were not as erratic as the first 3 samplings and suggest that representative samples were being obtained.

Solids-not-Fat. Tables I, II, and III show the solids-not-fat remained relatively constant throughout the experiment. Whether the lambs remained with the ewes during sampling or were removed seemed to make little difference as to the results obtained. Less variation occurred between breeds and between the various stages of lactation for solids-not-fat than was true for the fat percentage. These results agree with Barnicoat (1949) and Wallace (1948). Since the percent of solids-not-fat is not affected by the manner of sampling, it would not be necessary in future studies to milk ewes dry in order to study water-soluble vitamins, minerals, carbohydrates, or proteins in ewe's milk. Conversely, in determining the fat-soluble vitamins (A,D,E,K) content, a representative sample of milk must be taken.

At one week post-partum, the solids-not-fat obtained from the Columbias and the Hampshires were higher than at any of the other samplings. The difference was small, however, being 1 percent. The remaining 4 samplings were uniform. This was not true for the Southdowns as their highest solids-not-fat occurred during the third sampling at 10 weeks post-partum. The range for the 3 breeds during the 5 different samplings varied from 11.3 percent to 13.7 percent. The solids-not-fat were not affected by the fat test.

Globule Size. Very little difference occurred in globule size during the various samplings. However, there was a tendency for larger fat globules to be secreted as lactation advanced, but globule size did not appear to be associated with the fat test. In some cases the highest testing ewe had the smallest fat globule. For example, the Columbias ranged from 1 to 10 microns in size for the first sampling while during the samplings at 16 and 20 weeks post-partum, globules up to 54 microns in size were secreted. This was true with all 3 breeds. This finding is contradictory to Petersen's (1950) findings. He concluded that fat globules in sow's milk decrease in size as lactation advances. Ewe's milk at 1 sampling contained many globules over 30 microns while the next sample contained only a few fat globules of this size. All samples contained various sizes of globules but a definite predominant size prevailed in each sampling. The average predominant fat globule size varied slightly between the 3 breeds. The variation was not great as the range for the entire period varied from 5 to 8 microns. The ranges among these breeds of sheep studied were found to be considerably larger than cow's milk or sow's milk. Petersen (1950) states fat globules in dairy cows range from 1 to 10 microns. Whittlestone (1953) found fat globules in sow's milk ranged from 0.5 micron to 7 microns. This same author also found fat globules of sow's milk to become larger with advanced lactation but no definite trends were found between breeds.

To make a more direct comparison between the 3 breeds the results of tables I, II, and III are summarized and the averages given in table IV. Due to the erratic fat test obtained during the first 3 samplings little importance can be placed on the first 3 averages. However, these data are worthwhile as they show very pointedly how milk samples from ewes should not be taken. The samples obtained at 16 and 20 weeks post-partum respectively, with the aid of oxytocin, strongly suggest that the fat content was little influenced by the breed. For example, at 16 weeks post-partum the Columbias averaged 8.9 percent, the Hampshires 9.1 percent, and the Southdowns 7.6 percent. At 20 weeks post-partum, the Columbias averaged 9.7 percent, the Hampshires 9.0 percent, and the Southdowns 8.9 percent. The lack of association of either high or low test with breed is somewhat surprising inasmuch as with dairy cows there is a significant difference in fat content between the various breeds with the Jersey testing the highest and the Holstein testing the lowest. Figure 1 shows the average fat content, solids-not-fat, as well as the milk yield for the 3 breeds, and shows graphically the extreme range in fat content as affected by the manner of obtaining the milk samples.

Milk Yield. As shown by the tables during the sixteenth and twentieth weeks post-partum there was a variation of milk yield between breeds. For example, at 16 weeks post-partum, the range for the Columbias was from 195 to 505 milliliters with an average of 339 milliliters; the Hampshires ranged from 170 to 590 milliliters with an average of 400 milliliters; and the Southdowns ranged from 120 to 370 milliliters and averaged 238 milliliters. All milk was obtained from one-half the udder with the use of oxytocin and the lambs were removed for a period of 12 hours prior to milking. The results of this sampling shows that on the average the Southdowns yielded the least, the Columbias next, and the Hampshires the most milk. The milk yields were not corrected for the age factor because such factors are not available.

A definite decline in milk yield was noted during the twentieth week of lactation as compared to the sixteenth week. The greatest decline occurred with the Southdowns. The average yield of the Southdowns at the fourth sampling was 238 milliliters and at the fifth sampling the average yield was 124 milliliters. On an individual ewe basis some declined as much as 300 milliliters during this 4-week period. These samplings were obtained during advanced lactation and the results may have been affected because some of the ewes were probably on the verge of weaning their lambs.

Table I. Columbia Milk

One week post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
927	6.0	17.6	6	1-9
50-129	7.6	12.0	6	1-10
4814	8.0	14.6	7	1-13
943	8.2	12.6	6	1-10
51-044	9.0	14.6	5	1-11
955	9.2	12.5	6	1-10
944	9.2	12.3	7	1-8
843	10.6	13.9	7	1-9
average	8.5	13.7	6	

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8 weeks post-partum (lambs removed 12 hours)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
925	2.2	13.1	6	1-14
955	4.8	12.8	7	1-18
52-180	2.8	13.2	5	1-10
843	7.6	12.9	7	1-15
4813	4.2	11.3	4	1-10
1221	3.2	9.3	5	1-16
926	1.8	11.7	5	1-14
50-015	5.0	11.7	5	1-10
1118	4.0	13.9	6	1-18
859	3.4	13.2	6	1-15
51-102	2.0	14.1	6	1-10
50-005	3.6	12.4	6	1-16
830	5.6	12.1	5	1-18
944	2.8	12.4	6	1-18
844	3.2	14.4	6	1-18
51-044	3.0	12.7	7	1-18
943	4.6	12.0	5	1-10
50-129	4.0	11.8	6	1-18
4817	4.6	12.3	7	1-14
4814	2.2	12.9	6	1-18
average	3.7	12.5	6	

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10 weeks post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
1118	11.6	12.3	7	1-18
944	9.8	11.6	8	1-18
50-005	10.8	12.1	6	1-18
4814	11.0	11.4	7	1-18
50-015	8.0	12.3	8	1-18
50-129	12.6	11.7	8	1-20
943	10.4	13.2	7	1-14
830	10.6	12.2	8	1-20
51-044	8.8	12.5	7	1-18
927	10.8	14.2	8	1-17
average	10.4	12.4	7	

Table I (Cont'd) Columbia Milk

16 weeks post-partum (lambs removed 12 hours). 1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	globule size (microns) range	milk quantity (ml.) obtained	milk quantity (ml.) converted*
50-129	9.6	11.6	9	1-20	380	2052
955	9.6	13.4	8	1-27	220	1188
51-044	8.8	12.0	7	1-27	450	2430
50-015	8.2	11.8	9	1-20	340	1836
50-005	8.2	12.0	7	1-18	330	1782
4814	9.6	12.0	9	1-27	505	2727
843	9.0	12.7	9	1-27	440	2376
830	10.6	12.3	7	1-20	195	1053
927	4.8	10.5	7	1-20	190	1026
944	10.4	11.5	10	1-30	380	2052
1118	9.4	14.5	10	1-18	240	1296
943	8.2	20.9	8	1-18	400	2160
average	8.9	12.9	8		339	1832

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20 weeks post-partum (lambs removed 12 hours). 1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	globule size (microns) range	milk quantity (ml.) obtained	milk quantity (ml.) converted*
955	8.8	11.8	7	1-27	240	1296
50-005	11.4	11.7	7	1-27	240	1296
1118	9.4	13.6	6	1-27	130	702
830	11.0	12.0	8	1-12	185	999
944	10.2	11.4	8	1-27	335	1809
4814	9.2	11.5	7	1-27	430	2322
50-015	9.6	11.8	7	1-14	200	1080
51-044	8.4	11.6	7	1-27	240	1296
50-129	10.0	12.1	7	1-54	380	2052
943	10.4	11.5	7	1-27	240	1296
843	12.0	12.8	7	1-12	120	648
927	5.4	6.8	5	1-27	105	567
average	9.7	11.6	7		237	1280

* Converted to 24-hour basis for entire udder.

Table II. Hampshire Milk

One week post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	globule size (microns) range
4763	8.3	12.6	8	1-9
52-159	[illegible]	12.6	8	1-13
52-186	9.2	13.5	8	1-9
50-001	9.2	16.1	7	1-14
52-196	9.6	11.9	7	1-10
52-157	11.0	11.9	7	1-13
846	12.0	13.0	8	1-13
52-181	12.4	12.9	7	1-18
average	10.0	13.1	8	

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8 weeks post-partum (lambs removed 12 hours)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	globule size (microns) range
50-58	1.0	11.7	6	1-12
51-30	3.2	12.4	5	1-18
50-001	1.0	11.9	7	1-18
52-181	3.8	12.4	6	1-18
52-185	8.2	13.6	8	1-20
51-34	2.0	13.4	5	1-18
846	1.4	10.9	6	1-20
51-3	1.4	13.4	7	1-10
51-111	2.2	13.2	6	1-14
52-178	2.0	11.0	7	1-12
52-156	1.4	11.0	7	1-18
52-192	1.0	10.4	6	1-18
52-186	1.4	11.7	6	1-20
4763	2.3	13.4	7	1-18
52-182	1.0	12.0	7	1-14
average	2.2	12.2	6	

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10 weeks post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	globule size (microns) range
50-001	7.0	11.7	7	1-18
52-181	8.0	11.8	8	1-18
52-196	6.6	11.4	6	1-20
52-192	7.0	11.0	7	1-16
846	6.8	11.8	7	1-18
4725	6.6	11.4	8	1-18
120	4.4	11.1	7	1-18
52-182	6.0	11.9	9	1-18
52-159	6.2	10.9	7	1-20
52-178	7.0	11.2	6	1-14
52-156	7.0	12.7	7	1-18
52-186	5.4	11.2	7	1-20
average	6.5	11.5	7	

Table II (Cont'd) Hampshire Milk

16 weeks post-partum (lambs removed 12 hours).
1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range	milk quantity (ml.) obtained	converted*
52-186	9.2	10.7	8	1-20	320	1728
52-185	9.4	11.2	7	1-20	380	2052
52-192	7.0	10.6	6	1-14	525	2835
50-001	8.4	11.3	9	1-27	400	2160
52-157	11.2	10.7	7	1-20	240	1296
52-181	14.0	12.8	7	1-30	170	918
52-178	7.8	10.0	7	1-20	440	2376
52-196	6.8	12.4	7	1-14	425	2295
4763	8.2	12.2	8	1-27	470	2538
52-182	8.4	12.1	7	1-20	395	2133
846	10.2	10.1	7	1-18	590	3186
52-159	8.8	10.9	8	1-20	440	2376
average	9.1	11.3	7		400	2158

20 weeks post-partum (lambs removed 12 hours).
1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range	milk quantity (ml.) obtained	converted*
52-186	6.8	11.9	7	1-54	285	1539
52-192	10.2	12.5	7	1-12	340	1836
52-185	9.2	12.0	8	1-30	235	1269
50-001	7.4	12.2	9	1-54	265	1431
52-181	14.6	12.9	8	1-30	170	918
52-157	9.0	11.3	7	1-27	170	918
52-182	10.2	12.0	8	1-54	155	837
4763	7.4	11.8	8	1-54	270	1458
52-178	6.8	11.5	9	1-54	355	1917
846	6.8	11.5	10	1-54	190	1026
52-159	11.8	12.1	8	1-27	185	999
52-196	7.4	12.1	8	1-30	200	1080
average	9.0	12.0	8		235	1269

* Converted to 24-hour basis for entire udder.

Table III. Southdown Milk

One week post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
130	5.5	12.8	6	1-9
51-012	5.6	12.5	6	1-9
51-016	5.9	12.5	6	1-8
51-017	6.6	12.0	5	1-7
4754	7.0	11.7	5	1-9
50-86	7.2	11.7	5	1-10
4768	7.2	11.9	5	1-9
4754	10.9	12.3	5	1-10
average	6.9	12.2	5	

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8 weeks post-partum (lambs removed 12 hours)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
51-016	1.4	13.3	5	1-14
52-183	3.6	13.9	6	1-16
50-079	1.4	12.7	5	1-14
455	7.8	12.4	6	1-20
4768	0.8	12.3	5	1-9
130	2.0	14.0	6	1-10
52-198	2.8	12.4	4	1-8
51-012	2.1	12.1	4	1-9
50-86	2.6	13.0	6	1-14
52-161	2.0	14.2	5	1-10
52-164	1.6	12.3	6	1-12
4754	1.6	12.7	5	1-12
average	2.5	12.9	5	

- -

10 weeks post-partum (lambs with ewes)

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range
52-198	15.6	14.4	6	1-14
50-079	11.6	14.9	6	1-14
130	8.2	13.6	5	1-14
50-086	9.0	14.3	5	1-14
4768	9.8	14.1	4	1-16
4754	10.8	12.6	6	1-11
52-164	9.0	12.8	6	1-14
51-012	10.2	12.9	5	1-9
average	10.5	13.7	5	

Table III (Cont'd) Southdown Milk

16 weeks post-partum (lambs removed 12 hours).
1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range	milk quantity (ml.) obtained	converted*
52-126	9.0	11.7	7	1-18	370	1998
51-012	8.0	13.7	7	1-20	210	1134
459	11.0	12.6	8	1-18	360	1944
4768	7.0	12.3	8	1-20	295	1593
50-086	7.2	12.9	8	1-27	220	1188
52-164	6.0	11.8	8	1-27	200	1080
51-017	7.0	12.7	7	1-14	140	756
50-079	6.8	12.7	8	1-18	200	1080
52-183	9.4	12.3	7	1-20	230	1242
4754	8.0	12.5	7	1-20	310	1674
51-016	7.0	12.0	6	1-20	195	1053
130	5.0	13.1	8	1-20	120	648
average	7.6	12.5	7		238	1283

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20 weeks post-partum (lambs removed 12 hours).
1cc. oxytocin injected intravenously

Ewe Number	fat %	solids-not-fat %	globule size (microns) predominant	range	milk quantity (ml.) obtained	converted*
52-164	8.8	12.0	7	1-27	105	567
130	9.0	13.0	8	1-15	115	621
4754	10.4	13.4	8	1-27	125	675
4768	8.4	13.0	8	1-54	150	810
51-016	7.4	12.8	7	1-12	110	594
50-086	9.4	11.8	8	1-54	120	648
52-183	8.0	12.7	8	1-30	180	972
50-079	4.8	9.5	8	1-27	10	54
51-017	10.0	11.7	7	1-54	70	378
52-126	8.6	11.4	7	1-12	240	1296
459	10.0	12.7	7	1-15	180	972
51-012	11.6	13.0	7	1-12	80	432
average	8.9	12.3	8		124	668

* Converted to 24-hour basis for entire udder.

Table IV. Summary of quality and quantity of Columbia, Hampshire, and Southdown ewe's milk during five different samplings.

One week post-partum (lambs with ewes)

Breed Average	fat %	solids-not-fat %	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*
Columbia	8.5	13.7	6		
Hampshire	10.0	13.1	8		
Southdown	6.9	12.2	5		

8 weeks post-partum (lambs removed 12 hours)

Breed Average	fat %	solids-not-fat %	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*
Columbia	3.7	12.5	6		
Hampshire	2.2	12.2	6		
Southdown	2.5	12.9	5		

10 weeks post-partum (lambs with ewes)

Breed Average	fat %	solids-not-fat %	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*
Columbia	10.4	12.4	7		
Hampshire	6.5	11.5	7		
Southdown	10.5	13.7	5		

16 weeks post-partum (lambs removed 12 hours)**

Breed Average	fat %	solids-not-fat %	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*
Columbia	8.9	12.9	8	339	1832
Hampshire	9.1	11.3	7	400	2158
Southdown	7.6	12.5	7	238	1283

20 weeks post-partum (lambs removed 12 hours)**

Breed Average	fat %	solids-not-fat %	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*
Columbia	9.7	11.6	7	237	1280
Hampshire	9.0	12.0	8	235	1269
Southdown	8.9	12.3	8	124	668

* Converted to 24-hour basis for entire udder.
** 1cc oxytocin injected intravenously 1 to 2 minutes prior to milking.

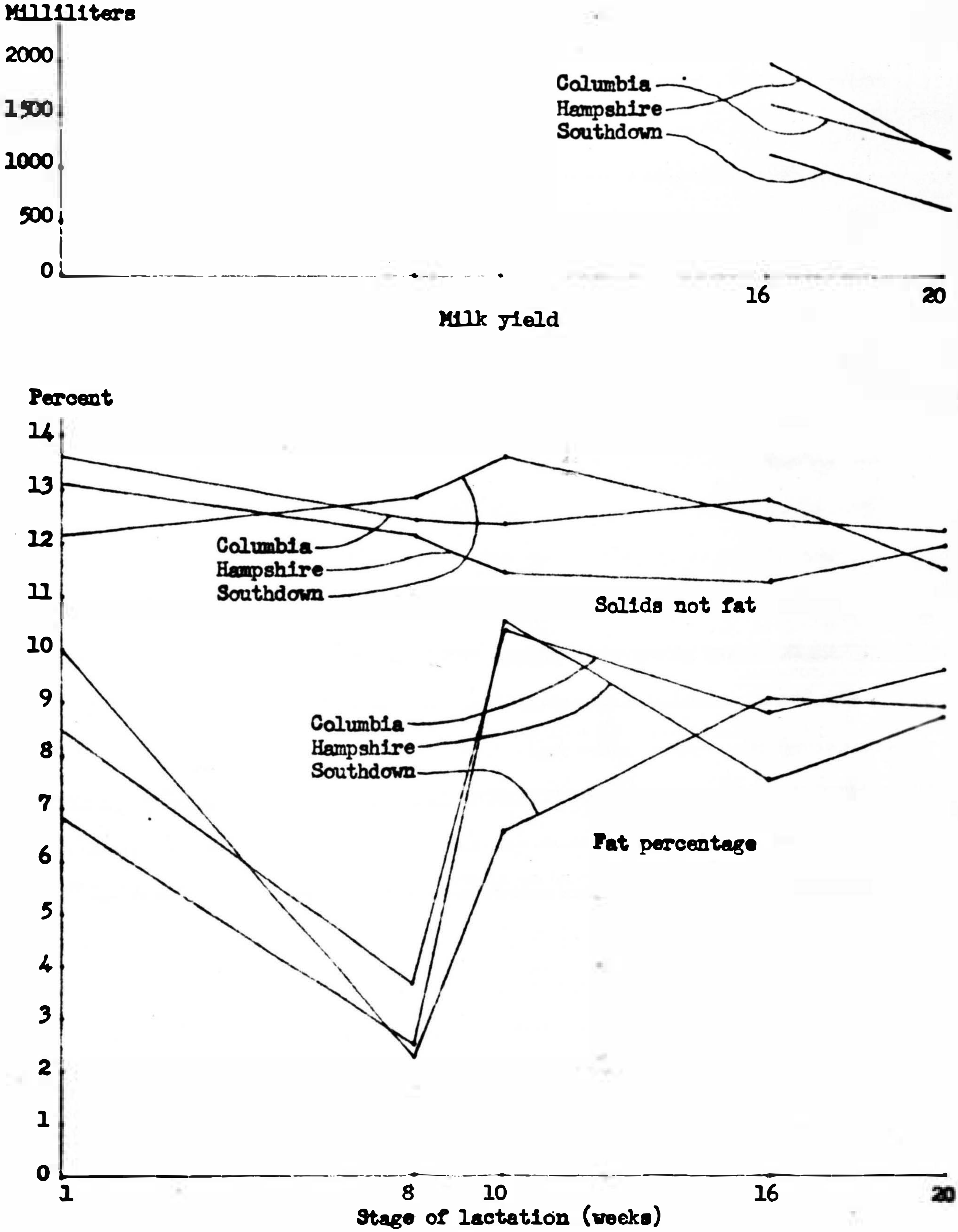


Fig. 1 Comparison of quality and quantity of Columbia, Hampshire, and Southdown ewe's milk.

Milk Quality and Quantity of No-tail Ewes

The data for the No-tail breed is presented in table V on an individual ewe basis.

Fat Content. Variations in fat content occurred among ewes with a tendency for the fat content to increase slightly as the lactation advanced, particularly during the last 2 weeks. The weekly variations were greater for individual ewes than among ewes. For example, ewe 50-27 had a fat variation of from 5.6 percent to 11.0 percent during the 9 milkings. Ewe 51-53 varied from 7.6 percent to 11.2 percent. The average fat content of the milk from the individual ewes during the entire period ranged from 7.3 percent to 10.8 percent. This variation is no more than might be expected as fat content of cows of the same breed and in the same herd vary similarly. The average fat content found in this experiment was somewhat higher than those reported in previous citations. The method of obtaining the sample is important if accurate results are to be obtained. The methods employed by other workers may not have produced a truly representative sample, and milk obtained by incomplete milking apparently does not provide a true picture of the average composition of milk normally produced by ewes. This may account for some of the variation reported and must be borne in mind when considering the compositions previously reported. Barnicoat (1949) obtained a sample of the ewe's milk by milking one-half of the udder while the lamb nursed the other one-half. He did not state whether the udder was completely emptied or if just enough milk was taken for analysis. Wallace (1948) separated the lambs from the ewes for a period of 4 hours and obtained a sample by hand-milking. Whiting (1951) obtained milk samples by hand-milking prior to the last suckling period. Results obtained in this study show that a representative sample cannot be obtained without some means of causing the ewe to let-down her milk. This was shown by the erratic results obtained from the first 3 samplings of milk from the Columbia, Hampshire, and Southdown ewes.

Solids-not-Fat. As was noted with the Columbia, Hampshire, and Southdown ewes, the solids-not-fat of the milk obtained from the No-tail ewes were quite uniform, not only for the individual ewe during the stage of her lactation, but also among ewes. It did not increase during the declining lactation as was true for the fat percentage. The range for the solids-not-fat among ewes was from 10.6 percent to 12.3 percent with most ewes averaging about 11.0 percent.

Globule Size. The predominant globule size for this breed averaged between 7 and 8 microns. Little difference existed among ewes as the range for the 12 ewes during the 9-week sampling period was from 6.8 microns to 8.3 microns. The results indicate that little variation existed among the 4 breeds relative to fat globule size. The No-tails averaged 7.5 microns, the Columbias 7 microns, Hampshires about 7 microns, and the Southdowns 6.5 microns.

Milk Yield. As might be expected a variation in milk yield was evident among the ewes during the lactation period. In some cases the ewes were slower in reaching their peak while others were at their peak at the start of the study. In general, the peak production came between the third and sixth week of lactation. On an individual ewe basis some of these ewes were heavier producers than any of the other 3 breeds studied. However, a direct comparison cannot be made because of different stages of lactation. The average yield for one-half of the udder per ewe for the 9-week period ranged from 189 milliliters to 446 milliliters. The milk was obtained from one-half of the udder by the use of oxytocin with the lambs removed before milking. Ewe 4952, which averaged 189 milliliters during the 9-week lactation, declined in yield rapidly after one month of production. Ewe 823, which yielded an average of 446 milliliters during the 9-week milkings, exceeded all others throughout the study. The remaining 10 ewes ranged from 241 to 357 milliliters.

The results of milking 12 ewes during a 9-week period are summarized in table VI and are shown graphically in figure 2. During the first 6 weeks the fat content of the milk from the 12 ewes remained relatively constant ranging from a low of 8.3 percent to a high of 8.7 percent. However, from the sixth week until the end of the ninth week the fat content increased from 8.7 percent to 10.0 percent. The high period occurred at the end of the ninth week. The solids-not-fat remained relatively constant and varied no more than 1 percent on the average during the 9-week period. Globule size fluctuated somewhat on an individual ewe basis but on an average the 12 ewes varied from 7.0 to 8.0 microns. These data suggest that as the stage of lactation advances there is a tendency for the fat content to increase slightly. This pattern is not evident with the solids-not-fat or globule size.

Lamb Growth

The weights of the single lambs nursing the ewes that were hand-milked each week are given in table VII. Growth rate of lambs is affected by several factors such as birth weight, amount of milk produced by the ewe, as well as genetic differences in their inherited capacity for growth. How milk production of the ewes affects the growth rate of the lamb is difficult to determine on the basis of 12 lambs. Comparing the average milk yield for the 6 heaviest producing ewes to the 6 lowest producing ewes resulted in amounts of 2293 and 1638 milliliters (corrected yield), respectively. The average total gain for the 2 groups of lambs was 38.5 and 31.1 pounds, respectively. Considering these data in detail the 5 heaviest producing ewes had the lambs that gained the most weight from birth until the end of the experiment. The lamb that grew the fastest was the heaviest at birth and nursed the ewe that produced the most milk. The second most rapidly gaining lamb was the second lightest lamb at birth, but apparently the abundant milk supply enabled it to make rapid growth. For the first 30 days the 7 highest producing ewes nursed the 7 heaviest lambs. During this period a lamb evidently relies largely upon the milk produced by its dam and the growth obtained depends largely on the amount of milk produced.

Table V. — The quantity and quality of No-tail ewe's milk (9-week period)

Ewe Number	date	fat%	solids-not-fat%	globule size (microns) predominant	globule size (microns) range	milk quantity (ml.) obtained	milk quantity (ml.) converted*
832	5/20	7.6	12.2	8	1-18	190	1520
	5/27	7.8	10.6	7	1-18	230	1840
	6/4	7.4	12.4	9	1-12	240	1920
(date	6/11	7.8	12.2	7	1-27	225	1800
lambed	6/18	7.4	12.7	7	1-14	260	1763
5/11)	6/25	7.0	12.7	6	1-27	300	1620
	7/2	6.6	12.2	7	1-12	315	1701
	7/9	6.6	13.3	6	1-27	285	1539
	7/20	8.6	12.4	7	1-12	250	1350
average		7.4	12.3	7		255	1673
4923	5/20	8.6	11.4	8	1-18	360	2880
	5/27	7.2	11.1	6	1-40	205	1640
	6/4	8.2	11.2	8	1-20	270	2160
(date	6/11	8.8	10.8	9	1-18	295	2360
lambed	6/18	8.8	11.2	8	1-12	265	1797
5/11)	6/25	7.6	12.1	7	1-27	315	1701
	7/2	9.4	11.9	8	1-27	295	1593
	7/9	8.6	11.9	7	1-30	250	1350
	7/20	9.6	11.9	7	1-20	205	1107
average		8.5	11.5	7		273	1843
51-10	5/20	8.8	10.9	9	1-27	340	2720
	5/27	6.4	10.4	8	1-18	330	2640
	6/4	8.0	10.4	7	1-18	450	3600
(date	6/11	6.6	10.3	7	1-54	355	2840
lambed	6/18	6.4	10.3	6	1-27	330	2237
5/11)	6/25	6.4	10.5	6	1-20	380	2052
	7/2	7.4	10.2	6	1-15	360	1944
	7/9	7.0	11.4	6	1-54	410	2214
	7/20	9.0	11.1	7	1-12	260	1404
average		7.3	10.6	7		357	2406
51-53	5/20	7.6	10.9	7	1-18	260	2080
	5/27	9.0	11.4	7	1-27	390	3120
	6/4	10.6	11.5	8	1-20	375	3000
(date	6/11	9.0	11.0	7	1-18	355	2840
lambed	6/18	9.6	11.1	7	1-27	330	2237
5/4)	6/25	9.4	11.7	7	1-20	310	1674
	7/2	10.2	11.3	7	1-54	390	2106
	7/9	11.2	12.0	6	1-27	290	1566
	7/20	10.0	12.8	6	1-12	245	1323
average		9.6	11.5	7		327	2216

* Converted to 24-hour basis for entire udder.

Table V (Cont'd) The quantity and quality of No-tail ewe's milk (9-week period)

Ewe Number	date	fat%	solids-not-fat%	globule size (microns) predominant	range	milk quantity (ml.) obtained	converted*
50-7	5/20	7.6	10.6	8	1-18	160	1280
	5/27	7.2	10.8	7	1-14	215	1720
	6/4	7.0	10.8	9	1-30	245	1960
(date	6/11	8.0	10.7	8	1-18	200	1600
lambed	6/18	7.3	10.3	7	1-18	220	1492
5/12)	6/25	7.6	11.8	8	1-18	270	1458
	7/2	7.0	11.4	5	1-27	250	1350
	7/9	9.2	12.0	7	1-27	350	1890
	7/20	9.6	11.6	7	1-40	260	1404
average		7.9	11.1	7		241	1573
50-27	5/20	8.8	10.3	6	1-12	240	1920
	5/27	5.6	13.5	6	1-18	265	2120
	6/4	10.4	10.3	8	1-20	280	2240
(date	6/11	11.0	10.0	7	1-27	290	2320
lambed	6/18	9.0	10.6	9	1-18	265	1797
5/7)	6/25	8.4	11.6	9	1-18	300	1620
	7/2	8.0	11.4	7	1-27	230	1242
	7/9	10.0	11.5	6	1-30	235	1269
	7/20	9.4	11.5	7	1-20	195	1053
average		10.0	11.2	7		256	1731
841	5/20	8.4	11.3	6	1-18	180	1440
	5/27	9.4	10.6	6	1-9	220	1760
	6/4	7.6	11.1	9	1-54	255	2040
(date	6/11	7.2	12.0	9	1-18	260	2080
lambed	6/18	8.4	11.4	9	1-27	285	1932
5/12)	6/25	8.4	12.9	9	1-20	350	1890
	7/2	8.6	11.9	8	1-54	330	1782
	7/9	9.0	11.9	8	1-27	360	1944
	7/20	10.8	12.1	7	1-15	280	1512
average		8.6	11.7	8		280	[illegible]
51-54	5/20	8.0	10.0	7	1-10	230	1840
	5/27	8.2	14.6	7	1-18	265	2120
	6/4	8.4	9.9	7	1-22	280	2240
(date	6/11	9.2	10.3	6	1-18	235	1880
lambed	6/18	7.6	10.7	8	1-18	280	1898
5/8)	6/25	9.0	11.2	6	1-27	310	1674
	7/2	9.0	10.9	5	1-10	295	1593
	7/9	10.4	11.2	7	1-30	300	1620
	7/20	10.0	11.2	8	1-30	260	1404
average		8.9	11.1	7		273	1808

* Converted to 24-hour basis for entire udder.

Table V (Cont'd) The quantity and quality of No-tail ewe's milk (9-week period)

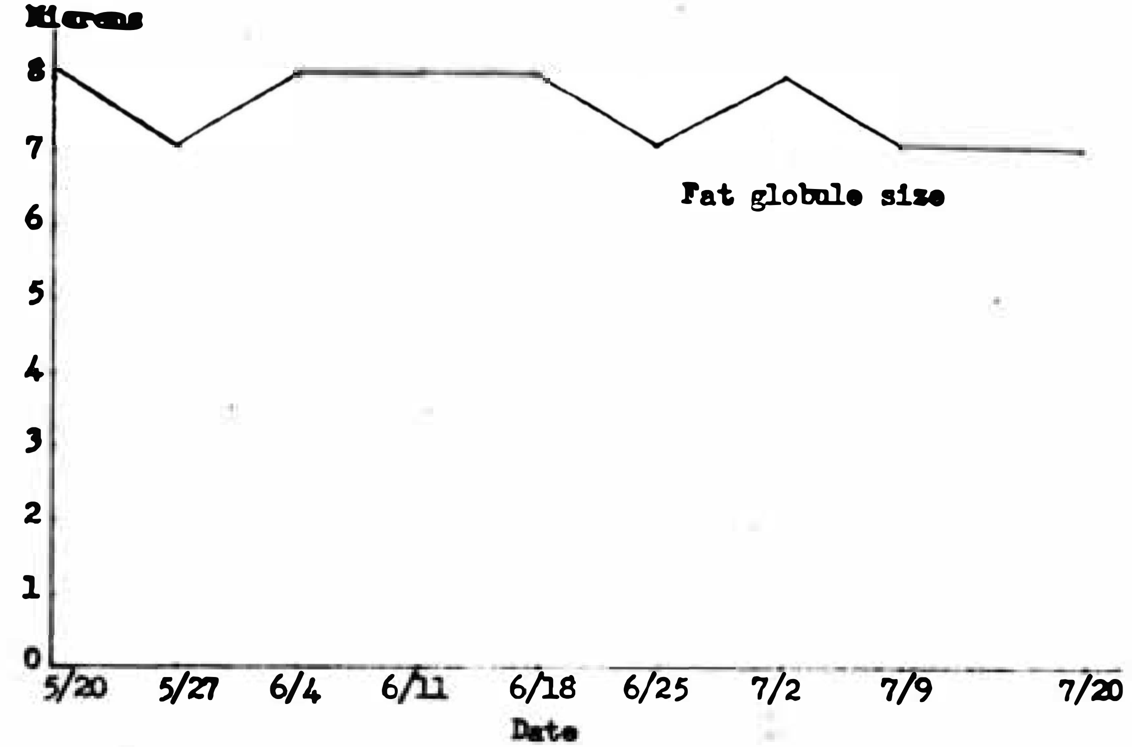
Ewe Number	date	fat%	solids-not-fat%	globule size (microns) predominant	globule size (microns) range	milk quantity (ml.) obtained	milk quantity (ml.) converted*
823	5/20	12.8	10.1	7	1-14	635	5080
	5/27	12.4	9.8	6	1-18	500	4000
	6/4	11.0	10.2	7	1-30	440	3520
(date	6/11	9.2	10.3	7	1-27	420	3360
lambed	6/18	10.0	10.4	7	1-54	390	2644
5/4)	6/25	9.6	10.6	9	1-27	440	2376
	7/2	9.2	11.5	8	1-20	410	2214
	7/9	8.8	11.2	8	1-54	495	2673
	7/20	11.0	11.6	7	1-27	285	1539
average		10.4	10.6	7		446	3045
51-11	5/20	7.4	11.3	9	1-27	250	2000
	5/27	7.2	11.0	9	1-27	285	2280
	6/4	6.0	10.8	8	1-30	300	2400
(date	6/11	7.0	10.5	9	1-27	305	2440
lambed	6/18	6.8	11.7	9	1-54	350	2373
5/8)	6/25	6.8	11.3	8	1-27	380	2052
	7/2	7.0	11.3	5	1-27	345	1863
	7/9	9.0	10.9	7	1-27	400	2160
	7/20	9.0	11.2	8	1-27	295	1593
average		7.4	11.1	8		323	2129
51-51	5/20	9.2	12.0	9	1-12	270	2160
	5/27	10.0	10.5	8	1-27	300	2400
	6/4	9.6	11.1	9	1-30	325	2600
(date	6/11	10.6	10.4	9	1-27	370	2960
lambed	6/18	11.6	11.1	9	1-27	340	2[illegible]5
5/7)	6/25	12.2	11.8	7	1-20	300	1620
	7/2	11.0	10.8	8	1-27	385	2079
	7/9	11.2	12.0	8	1-54	330	1742
	7/20	12.0	11.6	8	1-20	210	1134
average		10.8	11.3	8		314	2116
4952	5/20	7.6	11.8	6	1-54	195	1560
	5/27	9.0	11.0	8	1-20	300	1600
	6/4	9.6	11.5	8	1-54	210	1680
(date	6/11	8.6	11.1	8	1-18	185	1480
lambed	6/18	8.4	10.9	7	1-30	200	1356
5/7)	6/25	8.2	12.2	7	1-30	215	1161
	7/2	9.4	12.5	8	1-54	160	864
	7/9	9.0	12.3	10	1-54	140	756
	7/20	11.6	12.5	7	1-30	100	540
average		9.0	11.8	8		189	1192

* Converted to 24-hour basis for entire udder.

Table VI. Summary of the quantity and quality of ewe's milk of the No-tail breed for a 9-week period (May 20, to July 20, 1953).

Date	fat%	solids-not-fat%	predominant globule size (microns)	milk quantity (ml.) obtained	milk quantity (ml.) converted*	lambs removed (hours)
5/20	8.5	11.1	8	276	2208	6
5/27	8.3	11.3	7	284	2272	6
6/4	8.7	10.8	8	306	2448	6
6/11	8.6	10.8	8	291	2328	6
6/18	8.5	11.0	8	293	1986	8
6/25	8.4	11.7	7	323	1744	12
7/2	8.6	11.4	8	314	1695	12
7/9	9.2	11.8	7	320	1728	12
7/20	10.0	11.8	7	237	1280	12

* Converted to 24-hour basis for entire udder.



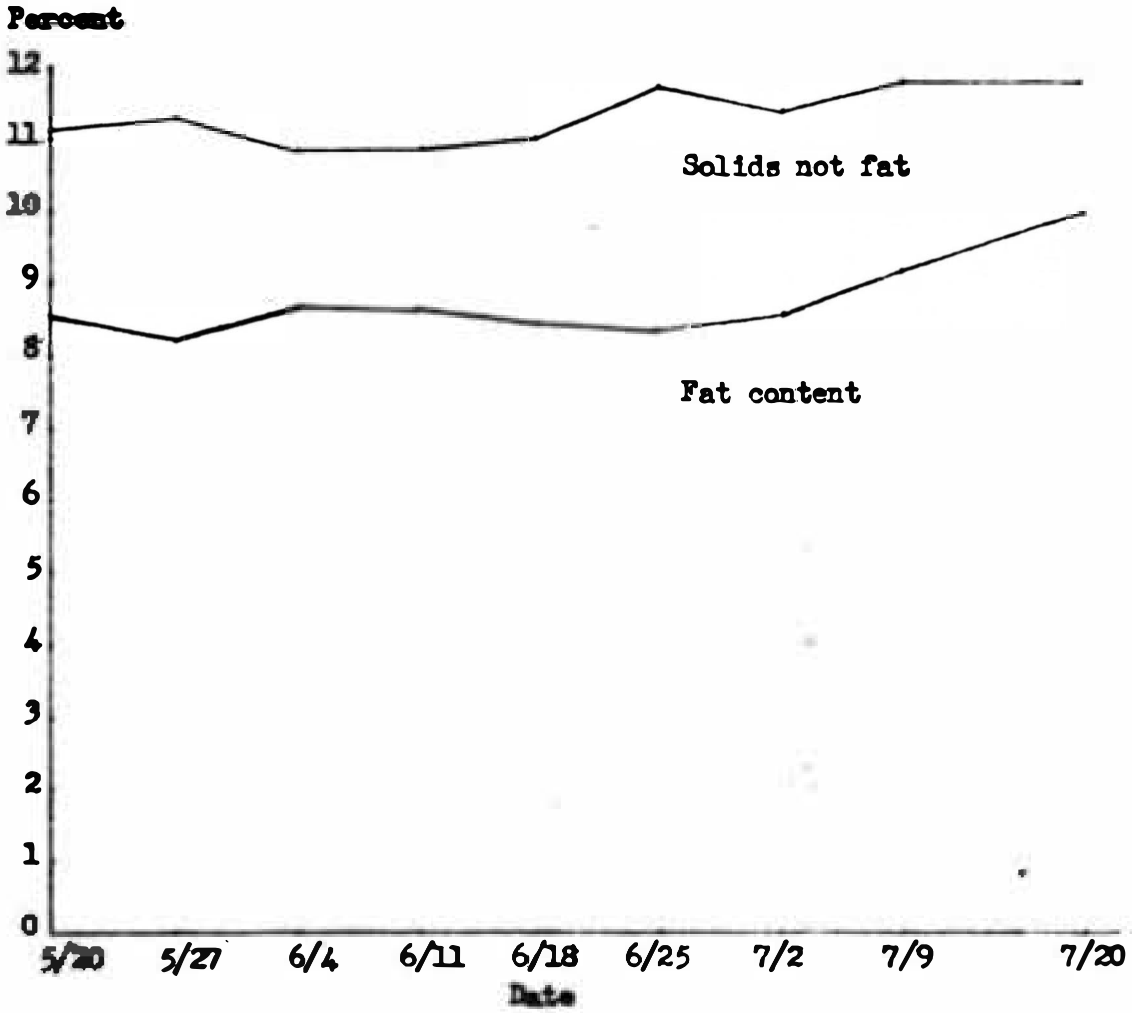


Fig. 2 Quality of milk from No-Tail ewes.

Table VII. Weights of lambs from No-tail ewes at various milking periods

Ewe Number	Milk Yield*	Date Born	Birth Weight	Weights at weekly milkings (pounds) 5/20	5/27	6/4	6/11	6/18	6/25	7/2	7/9	7/20	Total Gain**
823	3045	5/4	13.8	25.7	31.6	37.4	41.5	46.3	52.0	59.0	63.0	69.5	44.0
51-10	2406	5/11	10.5	15.2	19.9	26.2	31.0	35.6	42.1	42.5	48.0	54.5	38.3
51-53	2216	5/4	9.1	20.7	26.1	33.0	37.6	41.9	47.0	53.5	58.0	64.0	43.4
51-11	2129	5/8	9.8	14.0	19.7	26.0	30.2	34.3	39.8	42.0	47.0	54.0	37.0
51-51	2116	5/7	9.2	16.4	21.5	28.0	32.0	36.9	42.6	47.0	51.0	55.0	37.7
4923	1843	5/11	11.0	15.9	18.6	24.4	29.0	33.2	39.0	39.5	40.0	46.0	30.5
841	1820	5/12	9.8	12.8	17.6	23.5	28.9	33.6	38.3	42.0	45.0	50.0	35.4
51-54	1808	5/8	11.8	16.0	18.8	23.0	26.3	29.7	35.2	39.0	40.0	46.0	28.6
50-27	1731	5/7	10.2	14.4	17.8	22.0	25.3	29.0	32.6	36.0	40.0	42.0	26.2
832	1673	5/11	11.0	14.4	17.8	21.5	25.4	28.7	35.0	39.0	42.5	47.5	31.7
50-7	1573	5/12	9.0	12.9	17.3	22.5	26.1	29.6	33.5	38.5	42.0	47.0	33.6
4952	1222	5/7	10.0	16.0	19.1	24.1	27.9	31.1	36.2	40.0	42.5	48.0	31.2

* Milk yield in milliliters converted to 24-hour basis for entire udder.
** Corrected to age of lamb.

Effect of Somatotropin on Lactation

Somatotropin was injected for a period of 6 days, commencing July 20, 1953, and terminating July 25, 1953. The results of these data are shown in tables VIII and IX, and figure 3. Table VIII shows that each individual ewe treated with somatotropin increased in milk yield on July 26, 1953, as compared to those ewes not treated with the hormone. Some showed a greater increase than others. Figure 3 shows graphically an abrupt increase in yield for the treated group while the control group decreased. An overall average increase of 47 percent was realized by the use of somatotropin.

The treated ewes continued to produce more milk for one week following injections before returning to the yield produced prior to injection. The control group decreased in production more rapidly than the treated group. On August 4, 1953, which was 10 days post-injections, the treated group was still producing 306 milliliters more milk (converted basis) on the average than the control group, but the treated group had returned to the amount produced when the injection of somatotropin was started.

The fat percentage showed an increase as the result of somatotropin injections. For example, ewe 4923 increased 1.4 percent and ewe 51-53 increased 3.2 percent. The average increase for the 6 ewes was 1.5 percent. The average fat content for the control group remained constant. However, on an individual ewe basis milk samples from some control ewes increased while others decreased. The solids-not-fat decreased 0.7 percent for the treated group and were 1.1 percent lower than the control group. The solids-not-fat decreased in 5 of the 6 ewes in the treated group. The one exception increased the least in milk yield, and the fat content decreased and the solids-not-fat increased. The results strongly suggested that the administration of somatotropin caused the fat content to increase and the solids-not-fat to decrease slightly. On the average as the fat content increased 1 percent, the solids-not-fat decreased 0.5 percent. Donkers and Petersen (1951 and 1952) reported no change in fat content due to administration of somatotropin to dairy cows. Chung et al (1953) reported an increase of 50 percent in fat content with no reported change in fat globule size.

The value of somatotropin for commercial lamb production has not been determined. The 6 treated ewes certainly responded to this period of injections, but whether continued injections would cause a continued high increase in milk yield was not determined. Whether or not this increased production will require a correspondingly larger feed intake needs investigation.

Table VIII. Effect of somatotropin on lactation*

	Treated						Control						
Ewe number 832	7/9	7/20	7/26	7/28	7/30	8/4	841	7/9	7/20	7/26	7/28	7/30	8/4
Milk yield (ml.)	1539	1350	1701	1647	1647	1296		1944	1512	1512	1350	1269	1269
Fat percent	6.6	8.6	9.0	8.4	9.0	9.2		9.0	10.8	9.6	10.6	11.6	11.6
Solids-not-fat (%)	13.3	12.4	11.9	12.3	13.1	12.8		11.9	12.1	12.7	12.6	12.2	12.5
Ewe number 4923							51-54						
Milk yield (ml.)	1350	1107	1971	1539	1566	1296		1620	1404	1107	1242	1242	972
Fat percent	8.6	9.6	11.0	9.4	8.4	8.6		10.4	10.0	9.0	12.0	10.0	10.2
Solids-not-fat (%)	11.9	11.9	11.1	11.7	11.7	11.4		11.2	11.2	11.5	11.0	11.5	11.4
Ewe number 51-10							823						
Milk yield (ml.)	2214	1404	2511	2457	1944	1647		2673	1539	1647	2025	2079	1377
Fat percent	7.0	9.0	11.2	11.0	9.4	8.6		8.8	11.0	9.0	11.0	10.2	10.8
Solids-not-fat (%)	11.4	11.1	10.3	10.8	10.7	10.7		11.2	11.6	11.4	11.0	11.2	10.9
Ewe number 51-53							51-11						
Milk yield (ml.)	1566	1323	1836	1944	1782	1350		2160	1593	837	1485	1431	1188
Fat percent	11.2	10.0	13.2	13.0	13.0	12.2		9.0	9.0	11.6	10.4	9.6	10.0
Solids-not-fat (%)	12.0	12.8	11.0	11.9	11.9	11.8		10.9	11.2	13.2	11.0	11.2	11.6
Ewe number 50-7							51-51						
Milk yield (ml.)	1890	1404	1890	1431	1647	1188		1782	1134	1188	918	1188	864
Fat percent	9.2	9.6	9.2	9.2	9.2	9.6		11.2	12.0	12.6	10.0	12.2	14.0
Solids-not-fat (%)	12.0	11.6	12.1	11.7	11.3	11.8		12.0	11.6	11.9	12.6	12.7	12.1
Ewe number 50-27							4952						
Milk yield (ml.)	1269	1053	1296	1134	1404	864		756	540	270	135	108	135
Fat percent	10.0	9.4	12.0	11.4	10.0	9.4		9.0	11.6	12.4	12.0	10.2	11.0
Solids-not-fat (%)	11.5	11.5	10.7	11.0	11.6	11.6		12.3	12.5	12.9	12.6	12.0	11.1
Average:													
Milk yield	1638	1274	1868	1692	1665	1274		1823	1287	1094	1193	1220	968
Fat percent	8.8	9.4	10.9	10.4	9.8	9.6		9.6	10.7	10.7	11.0	10.6	11.3
Solids-not-fat	12.0	11.9	11.2	11.6	11.7	11.7		11.6	11.7	12.3	11.8	11.8	11.6

* Treated ewes received 25 mg. of somatotropin suspended in 5 cc. physiological saline per ewe daily for 6 days. Control ewes received 5 cc. of physiological saline per ewe daily for 6 days.

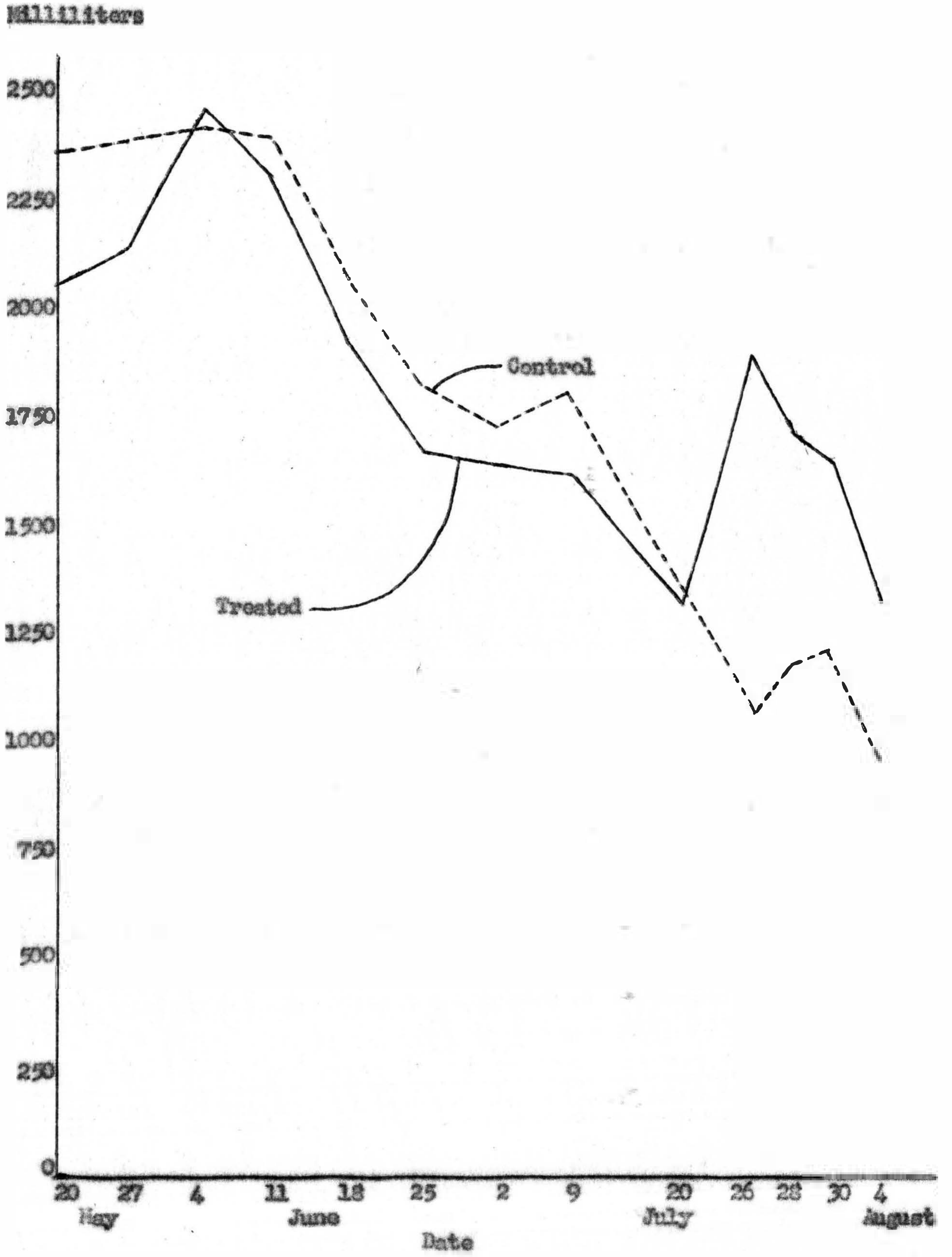


Fig. 3 Effect of somatotropin on milk yield.

Table IX. Weekly milk yields of ewes (milliliters)

Ewe Number	5/20	5/27	6/4	6/11	6/18	6/25	Date 7/2	7/9	7/20	7/26	7/28	7/30	8/4
							Treated						
51-10	2720	2640	3600	2840	2237	2052	1944	2214	1404	2511	2457	1944	1647
51-53	2080	3120	3000	2840	2237	1674	2106	1566	1323	1836	1944	1782	1350
50-7	1280	1720	1960	1600	1492	1458	1350	1890	1404	1890	1431	1647	1188
50-27	1920	2120	2240	2320	1797	1620	1242	1269	1053	1296	1134	1404	864
632	1520	1840	1920	1800	1763	1620	1701	1539	1350	1701	1647	1647	1296
4923	2880	1640	2160	2360	1797	1701	1593	1350	1107	1971	1539	1566	1296
Average	2067	2180	2480	2293	1887	1688	1656	1638	1274	1868	1692	1665	1274
							Control						
641	1440	1760	2040	2080	1932	1890	1782	1944	1512	1512	1350	1269	1269
51-54	1840	2120	2240	1880	1898	1674	1593	1620	1404	1107	1242	1242	972
823	5080	4000	3520	3360	2644	2376	2214	2673	1539	1647	2025	2079	1377
51-11	2000	2280	2400	2440	2573	2052	1863	2160	1593	837	1485	1431	1188
51-51	2160	2400	2600	2960	2305	1620	2079	1782	1134	1188	918	1188	864
4952	1560	1600	1680	1480	1356	1161	864	756	540	270	135	108	135
Average	2347	2360	2413	2367	2085	1796	1733	1823	1287	1094	1193	1220	968

SUMMARY AND CONCLUSIONS

Eighty-six ewes representing 4 breeds; Columbia, Hampshire, Southdown, and No-tail, were hand-milked to determine the effect of breed, stage of lactation, and somatotropin on milk composition and yield.

The method of obtaining a representative sample of milk proved to be important if reliable results were to be obtained. This study showed that in order to obtain a representative sample, milk must be allowed to accumulate in the gland and oxytocin can be used to cause complete milk let-down in order to completely evacuate the gland. Milk samples obtained without removing the lambs prior to milking and without the aid of oxytocin contained an average of 8.4 percent fat for the Columbias, Hampshires, and Southdowns at one week post-partum, and 9.1 percent fat at 10 weeks post-partum. Milk obtained after a 12-hour accumulation (lambs removed), without the use of oxytocin, contained an average of 2.8 percent fat for the same 3 breeds at 8 weeks post-partum. When the lambs were not removed prior to milking, they kept the milk gland emptied to the extent that only strippings, high in fat, were obtained.

Samples of milk were obtained at 16 and 20 weeks post-partum with the aid of oxytocin and lambs removed 12 hours prior to milking. The fat content for the Columbias averaged 8.9 percent, Hampshires 9.1 percent, and Southdowns 7.6 percent at 16 weeks post-partum. At 20 weeks post-partum, the Columbias averaged 9.7 percent, Hampshires 9.0 percent, and the Southdowns 8.9 percent fat.

Milk from the No-tail ewes was obtained by using oxytocin and the lambs were removed for 6 to 12 hours prior to milking. There was no erratic change in fat content during the 9-week period. The average fat percentage ranged from 8.3 percent to 10.0 percent for the 12 ewes with a tendency for the fat content to increase as lactation advanced.

The solids-not-fat of the milk from the 3 breeds were quite similar and were not affected by the method used in obtaining the sample. At one week post-partum, (lambs with ewes) the average solids-not-fat for the Columbias, Hampshires, and Southdowns was 13.0 percent. The average solids-not-fat content for the 3 breeds at 8 weeks post-partum (lambs removed for 12 hours) was 12.5 percent. Milk obtained at the third sampling (lambs with ewes) taken at 10 weeks post-partum, contained an average for the 3 breeds of 12.5 percent. The fourth and fifth samples (16 and 20 weeks post-partum) were collected with the use of oxytocin and lambs removed for 12 hours, and contained an average of 12.3 and 12.0 percents, respectively. The average solids-not-fat of the milk from the No-tail ewes ranged from 10.8 percent to 11.8 percent for the 12 ewes during the 9-week period. The percentage of solids-not-fat was not affected by the fat test. In other words, regardless of an increase or decrease in fat percentage, the solids-not-fat remained quite static.

Milk yields were collected from the Columbias, Hampshires, and Southdowns at 16 and 20 weeks post-partum. All milk samples were taken from one-half of the udder by hand-milking and milked completely dry. The lambs were removed 12 hours prior to milking and oxytocin was injected 1 to 2 minutes prior to milking. Differences in yield existed among the 3 breeds. The Columbias averaged 339 milliliters, Hampshires 400 milliliters, and the Southdowns 238 milliliters of milk at 16 weeks post-partum. At 20 weeks post-partum, the Columbias yielded an average of 237 milliliters, Hampshires 235 milliliters, and the Southdowns 124 milliliters of milk. These are average figures and some individual ewes gave considerably more milk than others.

The average milk yield of the No-tail ewes for the 9-week period ranged from 276 milliliters for the first week of sampling to 237 milliliters for the ninth week. Some of the ewes of this group outyielded individual ewes of the other groups, (Columbia, Hampshire, and Southdown) but no comparison can be made because of different stages of lactation.

Little variation existed among the 4 breeds studied relative to fat globule size but there was a tendency for larger globules to be secreted as lactation advanced. A predominant size was noted in each sampling. During the 5 sampling periods, the Columbias, Hampshires, and Southdowns ranged from 5 to 8 microns. No definite relationship existed between globule size and fat content. The predominant fat globule size for the No-tail ewes averaged 7 to 8 microns.

The average total yield of the 6 heaviest producing ewes and the 6 lowest producing ewes was 2293 and 1638 milliliters, respectively. The 6 lambs from the highest producing ewes gained an average of 38.5 pounds for the 9-week period compared to an average of 31.1 pounds for the lambs from the 6 lowest producing ewes.

Somatotropin (Armour and Company) suspended in 5cc of physiological saline, was injected into 6 ewes at the rate of 25 milligrams per ewe daily for 6 days and the ewes were milked on the seventh day. Six ewes served as the controls and received 5cc physiological saline daily. The ewes receiving somatotropin yielded 47 percent more milk than the controls during the experimental period. The fat content of the milk from the treated ewes increased on the average 1.5 percent and the solids-not-fat decreased 0.7 percent during the same period. The ewes were milked on the second, fourth, and eighth day post-injections to determine the lasting effect of the hormone. On the eighth day the treated ewes had returned to the amount produced at the beginning of injections.

On the basis of the animals used and under the conditions existing in this experiment, the following conclusions were drawn:

1. The method of obtaining a sample of ewe's milk was important if a representative sample was to be obtained for yield and fat content determination.

2. The method of sampling made little difference in determining the solids-not-fat of ewe's milk.

3. Oxytocin administered at the rate of 10 I. U. injected intravenously caused milk let-down in 1 to 2 minutes and furnished a representative sample as shown by the uniform fat test and also by physical examination of the gland which showed complete evacuation.

4. There was tendency for the fat content of ewe's milk to increase with advanced lactation.

5. Little variation in fat globule size existed among the 4 breeds with a tendency for larger fat globules in all breeds to be secreted as lactation advanced.

6. The solids-not-fat of ewe's milk of all breeds studied seemed to be the least variable and remained quite static regardless of stage of lactation or fat content.

7. Oxytocin apparently had no adverse effect upon the udder.

8. Ewes injected with 25 milligrams of somatotropin per ewe daily

for 6 days increased in milk yield 47 percent as compared to the control group.

9. The fat content of milk from ewes treated with somatotropin increased 1.5 percent while the solids-not-fat decreased an average of 0.7 percent as compared to the pre-treatment period.

10. The lambs from the 6 highest producing ewes gained an average of 7.4 pounds more than the lambs from the 6 lowest producing ewes.

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