A STUDY OF THE EFFECTS OF PLANE OF NUTRITION ON MILK SECRETION AND LAMB GROWTH IN ROMNEY SHEEP; AND THE EFFECT OF WEANING DATE ON THE GROWTH OF ROMNEY LAMBS.

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INTRODUCTION

PART I - MILKING EXPERIMENT

The productivity of an animal depends on two factors, its potentiality, which is governed by its hereditary make-up, and the extent to which that potentiality is allowed to develop, this being regulated by the environment that characterises the habitat. The effects of genotype are obviously shown by the differences between breeds of stock in the amount and quality of meat, wool and milk they produce; but within breeds these effects are not so apparent though they have been conclusively demonstrated, e.g. yield and quality between flocks of Romney sheep.

Environmental influence on productivity is limited at the maximum level by the genotype, i.e. no matter how good the environment, the animal cannot produce more than the maximum ordained by the genes it possesses. Conversely, below the genotypic maximum, the environment can regulate the ceiling level of production. This interplay of factors is well illustrated by the adaptibility of different breeds of sheep to different habitats, e.g. the Romney is predominant in the North Island hill country while in the South the Merino and its crosses assume a greater importance.

Within a population with approximately common genotype, e.g. a single flock of uniform breed, the effects of environment below the threshold set by the genotype can be widely varied, e.g. the growth of lambs in a drought can be severely set back. It is with the effects of a particular factor of environment, i.e. nutrition, on the milk production and lamb growth of such a population that this investigation is concerned.

Owing to the small size and the varied topography of the country and the latitudes in which it is situated, the climate in which sheep farming is practiced in New Zealand varies greatly from province to province, from county to county and even from district to district. Soil and configuration changes are rapid and soil quality may differ widely in adjoining properties - these changes are naturally accompanied by differences in type and quality of vegetation and in the quantity and quality of the food available to stock.

The systems of sheep farming prevalent in New Zealand necessitate the moving of sheep from one type of country to another at different stages of their lives, so that they are called upon to produce in markedly differing environments within the space of a few years. The fat-lamb farmer depends on the hill-country man for his supply of ewes to be mated with Down rams; ewes for the hill-country breeding flocks move from the stud farms to the hills and the flocks on the poorer and higher hill-country obtain their replacements from those on the easier land. There is a constant flow of sheep from one farm to another, one district to another and from one environment to another. It is of interest and practical value to know what effect this variation in living conditions has on the milk of the ewe.

The importance of studies on the milk secretion of non-milking breeds of sheep has been stressed by other investigators viz. Bonsma (1939, 1944), Wallace (1948), Barnicoat, Logan and Grant (1949), Ritzman (1917), Fuller and Kleinhanz (1904) Niedig and Iddings (1919), and Pierce (1934, 1938).

The main justification of such studies would appear to lie in the dependence of the lamb on the milk yield of its mother for its early growth and development. Wool and meat are the major products of the sheep industry in this country and, of the meat, fat-lambs make up the greater portion (1949-50, sheep - 4,268,000: lambs - 12,719,000 slaughtered at Export Works (Census and Stats. Dept., N.Z., 1951)).

The research studies of Hammond (1952), McMeekan (1939) and Wallace (1948) have emphasised the importance of a high plane of nutrtion in early life to allow the young animal to grow to the fullest extent that its hereditary potentialities will permit; the rate of growth plays an important part in the final development of the animal, the fastest rate giving the best developed and balanced and the largest carcase.

A well grown animal is required both by the fat-lamb exporter and the breeder of flock replacements; the former looks for the lamb that will produce maximum meat of the best quality in the shortest time, which is achieved by producing lambs "fat off the mother". The breeder needs a young animal that will produce a good fleece, rear its lambs well, produce for a number of years and provide a profitable carcase at the end of its useful life. These standards will only be met by stock which have been themselves reared underoptimum conditions, which involves a high nutritional plane in early life, i.e. they must be the progeny of ewes with a plentiful milk supply.

The milking experiment laid down here was designed to furnish information on the milk supply of the Romney ewe and the growth of her lamb under different planes of nutrition, the sole feed of both groups being natural pasture. It commenced soon after tupping in the autumn and involved following the lactations of over thirty ewes through an average lactation of fourteen weeks.

Chemical analyses on milk samples were done throughout this time and the results compared between planes and between stages of lactation.

Liebig first pointed out that the differences in the composition of milk of various species is related, in a general way, to the shape and slope of the growth curve. Different species require different lengths of time to double their birth weight, the length of time being inversely proportional to the concentration of the various milk constituents, e.g. Espe (1941) summarised this in a table of which the following is an extract :-

TABLE I

RELATIONSHIP OF GROWTH RATE TO MILK COMPOSITION

Species	Days required to double Birth weight	Composition of milk percent			
		Proteins	Ash	Calcium	Phosphoric acid
Horse	60	2.0	0.3	0.124	0.131
Goat	22	3.7	0.8	0.197	0.284
Sheep	15	4.9	0.8	0.245	0.295
Cat	10	7.0	1.0	-	-
Rabbit	6	10.4	2.5	0.891	0.997

Little is known of the effect of the composition of the milk on the growth of the young within a breed but Gaines has obtained a high correlation between fat percentage and energy yield of milk. In this investigation an attempt has been made to compare the relationships between lamb growth : milk yield and lamb growth : milk energy.

PART II - WEANING EXPERIMENT

Since the production of lambs is of such importance any study which aims at increasing the efficiency of that production is worthwhile. In this investigation, in conjunction with the milking experiments above indicated, other experiments were laid down to determine the effects of early weaning and inoculation with rumen micro-flora on the growth of lambs.

Current practice is to wean lambs when they are in the vicinity of 70 pounds liveweight, i.e. when they are 14 - 16 weeks of age; it would be of considerable advantage if they could be separated from their dams (without harm to the carcase produced) some weeks earlier.

Firstly, management would be facilitated. The ewes would be removed from competition with their lambs for feed and could be removed to the poorer parts of the farm, leaving the better areas for the lambs and other more needy stock. If the ewes were to be sold off the place they could be quitted earlier when they would be in better condition - feed would be saved that could be used for the fattening of store stock thus resulting in a direct increase in the production per acre. If they were to be kept for mating again, the ewes would be very useful for controlling growth, for "cleaning up" and in general pasture management.

Secondly, the shorter lactation period involved would be beneficial to the ewes themselves. It would give them a better chance to recover from the effects of bearing and rearing the lamb which means they would sooner be fit for mating again. It would have a beneficial effect on the wool production, for Bosman (1937) has shown in South Africa that while pregnancy does not influence the fibre fineness of Merino wool significantly, lactation and the suckling of the lambs reduce the fibre fineness, the fleece density and the wool production appreciably.

Thirdly, it has been shown that the correlation between the yield of milk and the weight gains made by the lamb decreases rapidly towards the end of lactation (Wallace, 1948). This relation is also apparent from the curves for milk yield and lamb growth obtained by Bonsma (1939) and Barnicoat et al (1949) i.e. as lactation progresses the lamb relies less and less on the milk of the ewe and more and more on the other sources of feed available. The lamb may well be able to grow a high grade carcase without the long suckling period which common practice indicates that it needs.

PART III - INOCULATION EXPERIMENT

Much work in recent years has established the importance of rumen micro-organisms in the digestive processes of ruminant animals, (various authors) particularly in the breakdown of fibrous feeds into a form easily assimilated by the animal and in the elaboration of proteins, sugars and vitamins. When the young animal is born it lacks these organisms and must secure them from outside contamination.

The young ruminant has a digestive system suited for the readily available food, i.e. milk, that it is ingesting, a digestive system that resembles more the simple stomach of the mono-gastric animal than the complicated system of the ruminant animal. As its diet changes from milk only, to milk and forage and finally to all forage, the characteristic ruminant digestive system is developed. The animal with this digestive system is much more efficient in utilising fibrous feeds than the one with the simple stomach and therefore the sooner this system can be developed the greater will be the utilisation of fodder and the greater will be the weight gains made, leading to more efficient production.

Various studies have been made on the methods of observing, identifying and describing the micro-organisms of the alimentary tract of ruminants notably those of Smith and Baker (1938), Pearson and Smith (1943), Van der Wath and Mayburg (1941), Baker (1943, 1949), Moir (1951), William and Moir (1951) and Gall and Huhtanen (1951). In a series of papers commencing in 1947, Pounden and Hibbs, Conrad, Hibbs, Pounden and Sutton, Pounden, Ferguson and Hibbs, have described attempts to increase the speed of development of a typical rumen micro-flora and fauna in dairy calves by inoculating them with rumen contents or cuds taken from mature animals.

Cuds were taken from the mouths of mature cows and placed straightway in the posterior of the mouths of the calves; microscopic examinations of rumen contents were made and the stage of development of the mirco population judged by the identification of several species of bacteria believed to be associated with the normal population. Gram stained smears and direct observation were the methods used.

They found that the uninoculated calves took much longer to build up the normal population than the inoculated ones even when they were on pasture together and that when uninoculated calves were isolated from other animals the rate of build up was very slow indeed.

Inoculated calves suitably fed (the diet e.g. ratio of grain to hay, can markedly influence the numbers and types of organisms present in the rumen) maintained the most satisfactory level of ascorbic acid in the blood plasma during the first few weeks of age. They had smoother coats and a general more healthy appearance than similarly fed but uninoculated calves. The inability of calves on pasture to get the characteristic micro-organisms had no effect on gain in weight or general health and the explanation of this appears to be that substitute organisms can do a creditable job; however, the point is made that micro-organisms that have developed over a long period of time in the environment of the rumen can be expected to function most efficiently in this organ.

In a later experiment, Conrad et al (1950) found that when roughage constituted the entire dry feed, cud inoculations aided in providing micro-organisms which became established in uninoculated calves. The inoculations were observed to stimulate hay consumption at an earlier age than when no inoculations were given.

When calves were raised in segregation from other animals and without inoculations, no differences in weight gains was noticed but there were differences in appearance, the uninoculated calves being "pot-bellied" and rough coated.

A preliminary trial was therefore carried out to investigate the possibilities of a like procedure with lambs, the measure of effect being the comparative gains made by inoculated lambs and a control group over a specified period. If the results are satisfactory and a suitable practical technique can be devised, a further increase in the growth rate and the efficiency of production may be obtained.

OBJECTS OF THE INVESTIGATION

The experiments reported below find ample justification in the considerations set out in the foregoing paragraphs; the objects of the work may be briefly summarised thus :

1. A study of the effect of a lowered plane of nutrition on the Romney ewe with special reference to -
   (a) Milk yield.
   (b) Energy yield.
   (c) Composition.
   (d) Growth of the lamb in relation to (a), (b) and (c).

2. A study of the effect of early weaning of lambs on their subsequent weight gains and slaughter gradings.

3. A study of the possibilities of increasing the growth rate of lambs by inoculation at an early age with rumen micro-flora obtained from mature sheep.

PART I - MILKING EXPERIMENT

Experimental Methods and Materials

The experiments were carried out on the nutrition block of the Massey College farm, an area consisting of top-dressed and limed pastures of a high quality, predominantly perennial rye (Lolium perenne) and white clover (Trifolium repens). The soil is heavy clay and the district (Kairanga) is notorious for foot-rot.

(a) Ewes

The animals used were 36 Romney pure-bred ewes that had been previously milked in experiments conducted by Barnicoat et al over the last 4 years; at the beginning of 1951 they were in their fifth year of age. They were mated to Southdown rams.

The ewes were separated into high and low plane groups on the 18th May 1951, before which time they had all received the same treatment.as described for the high plane group below. From the previous records of milking performance each ewe had been given a "Performance Rating" (Barnicoat, 1949) and it was therefore possible to divide the 36 animals into those with high ratings - above the average - and those with low ratings - below the average. Equal numbers of these, i.e. highs and lows, were selected at random to go into the high plane and low plane nutrition groups.

The rating value was compiled from data on the number of lactations put up by the ewe, the number of lambs reared each time and in total, and the growth in weight of the lamb(s) from six to twelve weeks. The latter was taken as indicative of the amount of milk secreted by the ewe over this period. Barnicoat et al (1949) found a high correlation between lamb growth and milk yield over this period.

The high planes were rotated around the twenty, one-acre fields of the front portion of the nutrition block along with the other stock being carried and managed in accordance with good fat-lamb farm management. The low plane of nutrition was achieved by confining the group to a small area so that the feed to which they had access was insufficient to meet their needs and appetites. No actual measure of intake was possible and the only guide to the state of nutrition of the ewes was their appearance (as judged by the nutrition block manager) and the weights taken at approximately fortnightly intervals.

The aim of this method of rationing was to simulate, as far as possible, the plane of feeding that would be available to hill country sheep in a similar climate - how far this was achieved will be discussed in a later section. The live-weight growth curves of the ewes show that there was considerable difference in the changes of weight between the two groups over the experimental period and it is quite apparent that the two planes of nutrition were markedly different.

Low plane ewe with lambs (nearest ewe).

High plane ewe with lamb.

The paddocks in which the low plane group were kept were four that had been eaten out with wethers prior to the 18th May - one was on the top of a ridge that bounded a gully and the others contained portion of the gully. The growth of pasture in these paddocks was controlled by increasing or decreasing the stock in them by putting in or taking out wethers and/or other dry sheep. Great difficulty was experienced in keeping the feed low enough and yet not too greatly trampled and soiled by stock - full credit must go to the manager and farm staff for the way in which they controlled this difficult aspect of the investigation.

For the purpose of comparison, empirical calculations were made of the sheep carried on the high and low plane areas over the months of the experimental treatment. The high plane acreage was taken as the basic standard and the low plane area worked out to an equivalent acreage of pasture of similar value. The hilliness of the paddocks, the state of the pasture and the treatment the grass received were taken into account in determining that one acre of the low plane area was equivalent in feed value to three-quarters of an acre of the high plane area. The stock carried per acre in ewe equivalents was worked out for both blocks and the low plane ewe equivalent figure multiplied by 1.33 so that the relative carrying capacities could be compared. These are the values that appear in Table 2.

TABLE 2

EQUIVALENT CARRYING CAPACITIES OF THE HIGH AND LOW PLANE AREAS IN EWE EQUIVALENTS PER ACRE (CORRECTED)

Group	Month May	June	July	August	September	October
High Plane	6.8	5.3	5.2	5.7	7.8	7.0
Low Plane	11.6	9.6	8.8	8.4	9.9	8.1

During the months following October, cattle were run in all paddocks and the stock carrying figures became even more difficult to calculate and then in November the low plane group went on to feed that was very nearly as good as that which the high plane group had.

In the high plane group four ewes were dropped from the experiment for one reason or another, viz:

No.76 - Dry.

No.56 - Died early in September.

No.101- Killed in August because of sickness.

No.40 - The lamb, a single, was born dead and a foster from a set of triplets also died; a successful foster was made with another lamb but by the time the ewe was able to be included in the milking group it was over two weeks since she had lambed and, though she was milked right through the experiment, her record was discarded as being abnormal.

With these animals excluded the high plane group consisted of fourteen ewes, eleven with single lambs and three with twins.

Two ewes were dropped from the low plane group for similar reasons :

No.46 - Lamb died 2½ days and the ewe had no milk; since all other ewes in this group (except 319) produced and reared a lamb, the assumption that this lamb died from causes other than the treatment imposed is considered justifiable.

No.319 - Dry.

These omissions left, in the low plane group, sixteen ewes, twelve with single lambs and four with twins.

Very fortunately, two spare ewes that had received exactly the same treatment as the high plane group and which had come from the same original milking groups of the previous experiments were available - No. 89 which produced twins, and No.408 which produced a single. These, when included in the high plane group, brought the numbers up to those of the low plane, i.e. twelve singles and four twins, and also made even the "Performance Rating" distribution.

No.88 in the high plane group gave birth to twins but reared only one of them (Lamb No.423) and her record was included with the ewes rearing singles. This would appear to be justified from a comparison of her milk yield and the growth of her lamb with those of the other ewes and lambs in the experiment and also from the finding of Wallace (1948) that -

"lactation curves ... should be regarded as no less typical of the progeny reared than of the ewe herself."

Logan (1946) also found that it was the number of lambs reared and not the number suckled that determined the level of milk production.

(b) Lambs

All lambs were weighed within three days of birth and this weight is that referred to as "birth weight" throughout this report. Logan (1946), who quotes Hammond (1932) and Donald and McLean (1935), investigated the reliability of three-day weight as an estimate of birth weight and found that it is satisfactory - the same procedure was therefore adopted here.

For following the weight increases of the lambs, use was made of the weights recorded on milking days, the one taken being the first one after shutting away from the ewes. This "full weight" was chosen because of the great variability in the weight losses of the lambs over the 24 hour milking period (range of 0 - 1½ lbs).

A major difficulty in comparing the weight gains made by the different lambs was that the weights were all recorded on the same day and that on any particular weighing day the lambs were at different ages. Bonsma (1939) obtained more accurate records of the weights at regular time intervals by use of an age correction formula but since the lambs in this experiment were weighed at irregular intervals this method could not be used. The method employed was to plot the recorded weights on a graph and read off the weight at any given time by interpolating from it. While it was realised that the method was open to error, it was considered to be sufficiently accurate for constructing average growth curves and for obtaining changes in weight over a period of some weeks.

This same problem of irregular intervals between recordings of data was met throughout the whole investigation. It arose from the fact that the sheep were run as part of a large flock and the management of the experiment had to coincide with the management of the whole, resulting in considerable increase in the difficulty of analysis of the data.

(c) Milk Yields

Barnicoat et al (1949) explored the various methods of measuring the milk yields of non-milking breeds of sheep, e.g. hand milking, machine milking, pituitrin injections and the weighing of the offspring before and after suckling; this latter method proved by far the most efficient. Hand milking is, of course, applicable to ewes of milking breeds and many studies of performance and composition have been made: Weiser (1921), Muhlberg (1936), Maule (1937) Cardas and Nica (1947) Aritman (1946) and others. Fuller and Kleinhanz (1904) have shown that hand milking is unsatisfactory for the non-milking breeds and that lambs take more than double the amount obtained by hand milking. The method they used, that of weighing the lamb immediately before and after suckling, the difference in weight being the yield of milk, is reliable and has been widely employed: in sheep by Neidig and Iddings (1919), Pierce (1934) Bonsma (1939, 1944), Wallace (1948) Barnicoat et al (1949) and in pigs by Gohern (1865), Henry and Woll (1897), Carlyle (1903), Davies (1904), Ostertag and Zuntz (1908), Schmidt and Lauprecht (1926), Hempel (1928), Olofsson and Larsson, (1930) Hughes and Hart (1935), Bonsma and Oosthuizen (1935), Donald (1937) and Bell (1944).

The technique and procedure described by Barnicoat et al (1949) was essentially that followed in the present investigation. Milk yield recordings were made twelve times over a fourteen-week period and the total yields calculated from a lactation curve drawn from this data.

No ewe was milked until her lamb was at least three days old and since the early milkings were always done on a Friday or a Saturday, this meant that each ewe was milked before she reached the tenth day of lactation; the average figure was eight days. The first milking was done on the 17th August, 1951, and the last, the fourteenth, on the 13th December, 1951, the average number of records per ewe, excluding those in the low plane that went dry, being eleven.

The lambs were shut away from their dams at 11 a.m. on the morning that milking was to commence. The shed to which they were confined consisted of three lamb pens, each about twelve feet by ten, with a board floor, a central weighing pen and the ewe bails on the other side, five in number; a small race at the back of the ewe pens gave the ewes access and egress to and from the accompanying yards. The shed was partly roofed but as an additional precaution against bad weather the whole structure was thoroughly covered in with large stack tarpaulins, making a weather-proof and comfortable shed in which to work. The floors of the ewe pens and the large weighing pen were covered with sheep gratings and the lighting came from four large globes suspended from the rafters.

At milking time the ewes were brought from a nearby paddock, where they had been placed at the time of separation from the lambs, into the small yards adjacent to the ewe milking pens. To facilitate the identification of ewes and lambs the high and low plane groups were kept separate as it was easier to work with the smaller numbers. The low planes were always milked first, the other group meanwhile being left in a backyard until their turn came - it was considered better to bring this last group in at the same time as the low planes because they appeared to be less disturbed if they waited their turn in a small yard that abutted the lamb pens than if they waited some distance away in the paddock.

Identification of ewes and lambs was made by attaching a metal tag bearing the ewe's milking number on to the wool at the base of the neck and painting the same number on the back of the lamb; members of twin pairs had the additional identification of a large "T".

Identification of ewe.

Identification of twin lamb.

The ewes were let into the milking pens five at a time; working always from the same end to the other, the ewe would be identified, her lamb or lambs picked out from the appropriate pen, weighed, allowed to suckle, reweighed and put into the third lamb pen - with two groups of lambs and three pens there was always an empty pen awaiting the lambs of the group that was being milked. Twin lambs were weighed separately but were put in with the ewe together so that neither received an advantage.

Lambs were weighed to half ounces in a metal sling on a steel yard sensitive to 1/4 ounce, the difference in the two weighings, before and after suckling, being taken as the milk yield of the ewe. This procedure was carried out six times over a twenty-four hour period and the lambs' intakes summed to give the estimate of the daily milk yield of the ewes. Towards the end of lactation when the milk yield had dropped considerably the number of milkings was reduced to five and, finally, to four, as the ewes did not have enough milk to warrant more frequent sucklings.

The times of milking were 2., 5. and 9. p.m., 5., 7.30. and 10.30 a.m., the lambs being let out with the ewes again as near to the twenty-four hour period as possible. The milkings omitted later were those at 5 p.m. and 7.30 a.m.

It was observed that after the first few milkings the lambs required very little time to drink the milk available and when the technique was perfected, the whole operation of milking the thirty-three ewes could be completed in about forty minutes.

The same difficulty that was encountered with the lamb data arose when the lactation records of the different ewes were compared, i.e. that the animals were milked on the same day each week and not at the same time interval after parturition. Wallace's (1948) method of overcoming this difficulty could not be used with this data because of the irregular intervals between milkings, a fact that was mentioned earlier. The graphs drawn from the yield data were very irregular and smoothing was out of the question (Snedecor (1950) p. 398).

Therefore an attempt was made to sum the total yield by another method, viz. that of Bonsma (1939) who used Simpson's rule for the summation of the area bounded by three ordinates. The formula was modified for use with ordinates separated by unequal intervals and the yields for periods of approximately sixty-two days after the first milking evaluated for each ewe. The difficulty now was to correct these total yields to exactly the same time period so that they could be compared between ewes. Since no accurate method of making this correction could be found the Simpson's rule method was discarded in favour of the simpler and more convenient interpolation method.

This involved dividing the period covered by the curves, ten to eighty days, into ten seven-day intervals; the reading from the graph in the middle of an interval was taken as the average yield for that interval of seven days, i.e. readings were taken from the graph at 13.5, 20.5, 27.5, etc., days after lambing. The sum of these values multiplied by seven gave the estimated total yield. This figure, the yield for ten to eighty days of lactation, is that referred to as the "yield" hereinafter.

Ten days after lambing was the earliest time at which it was considered the records were reliable (the ewes had been milked for four seasons and soon settled into the milking routine) and eighty days after lambing the most convenient, latest reliable time. Since the same method and period were used for each of the animals, the yield thus calculated is suitable for purposes of comparison.

Though it was realised that the interpolation method described above was of doubtful value in the estimation of the yield of a single ewe accurately, it was considered to be useful for comparison of groups, and because it was the only method that would enable the present data to be analysed, it was employed in the consideration of the results of this experiment. The difficulties of fitting other methods of estimation were -

Length of the intervals between milkings,
Irregularity of these intervals,
Wide variation of the individual readings leading to dissimilarity between the graphed records of the individual ewes.

(d) Milk Composition

The methods of obtaining samples of milk from non-milking breeds of a sheep have varied between workers. There is little difficulty in getting representative samples from the milking breeds which are readily milked out by hand but this is not so easily achieved with meat and wool breeds as Fuller and Kleinhanz (1904) demonstrated. Niedig and Iddings (1919) milked one side of the udder, while the lamb suckled the other; Pierce (1934) milked just before the lamb was allowed to suckle and hoped to overcome the error of getting "fore-milk" by milking five or seven times per day; Bonsma (1939) milked by hand and does not report any special method; Barnicoat et al (1949) allowed the lamb to commence suckling just before the operator milked the other side of the udder.

The latter workers report that the fat percentage rises during milking in an irregular manner and that the fat content of milks from individual ewes vary considerably between milkings and between "quarters". Hence it was most important that the udder be well milked out and that strict standardisation of technique be maintained.

In this investigation the samples were taken at the 5 a.m. milking. This time was chosen because the long interval from the last milking at night to this one allowed sufficient milk to accumulate in the udder to give a sample large enough for analysis; also because small lambs might not be able to handle the overnight accumulation of milk. The lamb was allowed to suckle one side of the udder only, the right, while the milker gently milked the left side into a small container - the lamb was given about half a minute start so that the ewe let down her milk before sampling commenced. The milk sample was measured into a special container graduated in ounces and the weight added to that consumed by the lamb; it was thoroughly mixed and sufficient for analysis (about 50 - 100 ml.) corked up in a sampling bottle.

Twin lambs were put in one after the other, the change over being made when it was thought the first lamb had about half the milk - this was difficult to estimate in practice. A different member of the pair of twins went in with the ewe first at successive milkings.

Analysis of the samples was commenced on the day of sampling so as to avoid any of them going sour, a difficulty encountered by Logan (1946). Fat tests by the Gerber method were made on all the individual samples and composite samples made up from these were tested for fat (Gerber), total solids (by drying) ash, protein (Kjeldahl - conversion factor to protein 6.38), calcium (CaO) and phosphorus (P_2O_5).

Results and Discussion

1. Ewe Liveweights

The average lifeweight curves of the ewes are presented in Fig. I. Because tupping was spread over several weeks and because weights were recorded on the same days for all ewes it was not possible to compare the weights of the ewes at the same stage of pregnancy. The curves were drawn then by averaging the weights taken for each group on a particular day, this being regarded as the average weight of the group on that day. Most of the ewes lambed over a period of thirty-five days over which no weighings were done and though this staggering effect of the weights tends to smooth the average curves, they are considered to be representative of the different groups. The six ewes which lambed outside the thirty-five day period from 7th August, 1951 to 11th September, 1951 viz: numbers 9, 185, 67, 319, 217, 219, were excluded from the averages.

The weights at tupping, at commencement of treatment, immediately before parturition, immediately after the lambing interval, at end of treatment, and at the end of the experimental period are shown in Table 3.

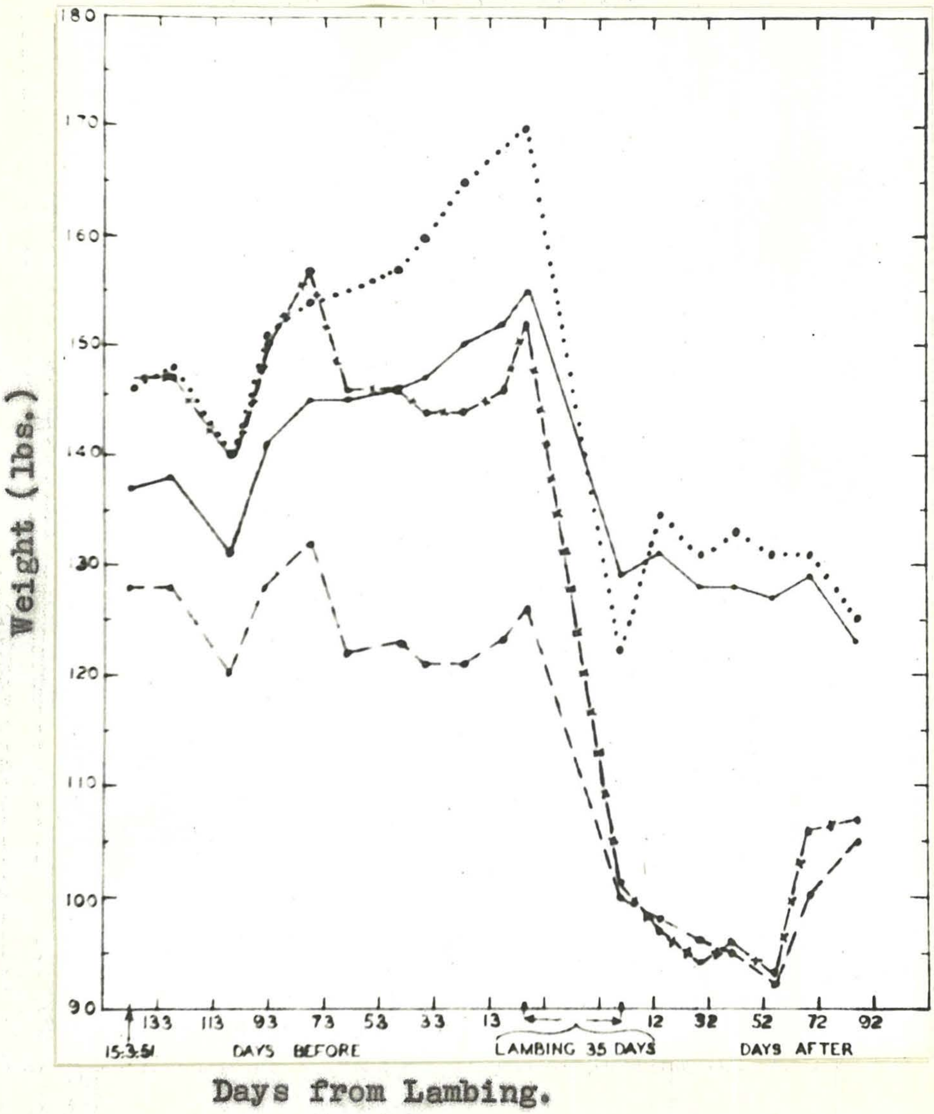


FIG. I.

MEAN LIVEWEIGHT CURVES OF EWES

High Plane Ewes with Singles (10 ewes) •————————•

-do- Twins (4 ewes) •···········•

Low Plane Ewes with Singles (10 ewes) •— — — — — —•

-do- Twins (3 ewes) •—x—x—x—x—•

TABLE - 3

AVERAGE LIVEWEIGHT CHANGES OF EWES

Stage	Date	High Plane		Low Plane	
		Singles	Twins	Singles	Twins
At tupping	15/3/51	137	146	128	147
Commencement of treatment	18/5/51	145	154	132	157
	Difference	8	8	4	10
Before parturition	7/8/51	155	170	126	152
	Difference	10	16	- 6	- 5
After parturition	11/9/51	129	122	100	101
	Difference	- 26	-48	-26	-51
End of treatment	5/11/51	127	131	92	93
	Difference	- 2	9	- 8	- 8
Total weight change	15/3/51 - 5/11/51	- 10	- 15	- 36	- 52
End of experiment	6/12/51	123	125	105	107
	Difference	- 4	- 6	13	14

High Plane - singles 10 ewes, twins 4.

Low Plane - singles 10, twins 3.

After the 5th November, 1951, the low plane ewes were put on to feed that was slightly better than what they had been getting up to this date, the reasons for this being -

(i) They were very poor and some appeared to be falling away in health

(ii) The spring flush of grass would naturally allow sheep on poor country to do a little better about this time than earlier in lactation.

The marked depression in the live weights of all the ewes at the end of March has no obvious cause. Examination of ewe data made available by Barton (1952) from records of sheep on the Massey College farm showed that a similar depression of live weight occurred about the middle of tupping time in several groups of ewes and in the same groups year after year. Roberts (1952) found that the same effect occurred in flocks of both Romney and Romney Cheviot cross ewes run on the College property. No satisfactory explanation has yet been put forward.

The initial differences in the mean weights of the groups at 15th March, 1951, are non-significant as shown by the analysis of variance.

TABLE - 4

ANALYSIS OF VARIANCE OF EWE LIVEWEIGHTS
AT 15th MARCH 1951

Source of variation	df.	SS.	M.S.	F	Result
Groups	3	1429.33	476.44	1.80	-
Error	24	6,369.35	265.39		
Total	27	7,798.68			

General Mean = 136.6 lbs.
Standard Deviation = 16.3
C = 11.9%

The difference figures in the table show that all groups gained in weight from tupping up till the 18th May, 1951, when the low plane treatment began; from then until lambing the high plane group continued to increase in weight while the low plane group lost. To lose weight over the period when the foetus is making most growth, i.e. the last six weeks of pregnancy (Wallace, 1948) these ewes must have been on very poor rations indeed and the loss in weight over this time is in marked contrast to the upward sweep of the curves for the high plane groups.

It was surprising that the high plane groups both showed overall losses between tupping and the first post-parturition weight; such a loss was to be expected in the low plane group but in the high planes it can only be accounted for by the good condition that the ewes were in at the commencement of tupping. Barton's data (1952) showed that the difference in live weight between tupping and immediately post-lambing tended to get less as the ewes increased in age. Since the ewes in this experiment were five years old, an age effect may be involved. This also accounts in part for the total weight change of - 10 and - 15 pounds observed for the high plane singles and twins respectively - the strain of lactation would cause the rest of the weight loss.

As expected, the low plane group steadily lost weight after lambing until their feed conditions were improved about seven weeks after the lambing interval. The greater part of the sudden rise in weight at the next weighing would be due to increased matter in the alimentary tract rather than to increase in condition, though doubtless the latter also played a part. The weight losses of - 36 and - 52 for the low plane group are much greater than those of the high plane over the same time interval.

The greater weight losses of twin bearing ewes as against singles was a marked parallel to the milk yields of the groups, the yield being directly proportional to weight loss.

There were no differences between the high and low plane groups with regard to lambing percentage, mortality etc. that could be put down to the nutritional treatment; the pertinent figures have been quoted under "Methods and Materials" and "Lambing Percentages".

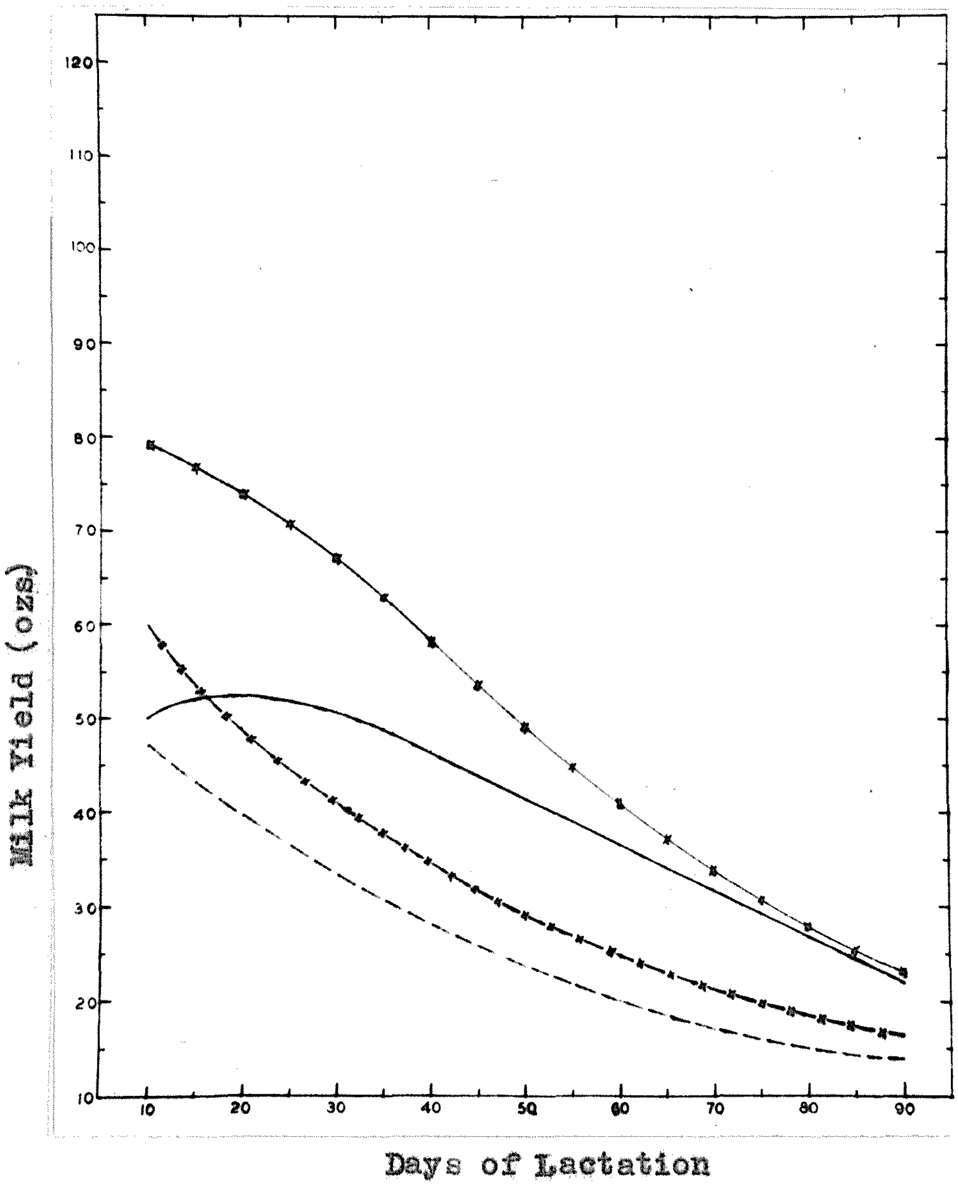


FIG. II

MEAN LACTATION CURVES OF EWES

High Plane Ewes with Singles ——————

-do- Twins ×—×—×—×—×—×—×

Low Plane Ewes with Singles — — — — —

-do- Twins —×—×—×—

2. Milk Yield of the Ewes

(a) Milk Yields

In order to study the total yields and the distribution of those yields over the lactation period, the mean lactation curves (Fig. II) and Table 5 have been constructed from the interpolated data.

TABLE - 5

MILK YIELDS OF EWES

	High Plane Group		Low Plane Group	
	Singles	Twins	Singles	Twins
Number of lactations	12	4	12	4
Period - Days	Average daily yield in ounces			
10 - 17	49.3	77.5	43.8	57.5
17 - 24	52.9	75.1	39.8	47.8
24 - 31	51.9	64.1	34.6	41.8
31 - 38	48.8	61.1	30.3	37.8
38 - 45	46.0	60.0	27.7	36.4
45 - 52	43.0	53.0	24.3	34.4
52 - 59	38.0	45.6	21.8	28.8
59 - 66	34.3	37.9	19.2	25.8
66 - 73	32.0	33.6	16.9	22.0
73 - 80	28.0	29.9	15.6	19.3
Average	42.3	53.9	27.4	35.1
	Average total yields in ounces			
10 - 80	2973.6	3774.5	1812.7	2459.8
Standard deviation	± 562	± 293	± 669	± 588

General mean total milk yield = 2574.1 ozs.
S.D. = ± 694.89 ozs.
C = 27.00 %

NOTE - Ewes which did not complete the lactation of 10 - 80 days, i.e. they dried off before the time was up, were not included in the average yield for the periods in which they gave no milk. They were, however, included in the total yield:growth correlation.

It can be clearly seen from the Table that the groups differed widely in their levels of milk production, the order from highest to lowest being high plane twins, high plane singles, low plane twins and low plane singles. The high plane group produced more than the low planes and within both groups the twins produced more than the singles. The analysis of varience (Table 6) shows the difference between planes to be H.S. and that between types to be S. The low F value for the interaction effect means that twins and singles did not differ in their reactions to the two planes of nutrition.

TABLE - 6

ANALYSIS of VARIANCE

Source of variation	SS	df	MS	F	Result
Planes	11,508,003.0	1	11,508,003.0	22.76	H.S.
Types	3,145,055.9	1	3,145,055.9	6.2	S.
Interaction	35,497.2	1	35,497.2	-	-
Error	14,155,718.4	28	505,561.4		
Total	28,844,274.5	31			

General Mean - 2574.12 ozs.
Standard deviation- ± 694.89 ozs.
C - 27.00%

NOTE "Type" refers to type of birth i.e. single or twin.

The differences in level of production may be due to differences in level over the early period when the ewe is producing most or to differences in persistency, i.e. the extent to which milk flow is maintained. It is apparent from Table 5 and Fig.II that the high plane ewes with twins had the highest initial production and the low plane ewes with singles the lowest, and that though the low plane ewes with twins were higher in the first period of seven days than the high plane ewes with singles, their production fell off very rapidly so that by the second period they were well below the latter group, i.e. the persistency of the low plane ewes was less than that of the high planes.

Table 7 shows the average yields for the successive periods expressed as percentages of the total average yield. The low plane group produced more of their total milk in the first two periods than did the high plane groups, less in the next four, and in the case of the singles only, less in the last four.

TABLE - 7

AVERAGE MILK YIELDS DURING SUCCESSIVE WEEKS AS PERCENTAGES OF THE AVERAGE TOTAL YIELD

	High Plane Group		Low Plane Group	
	Singles	Twins	Singles	Twins
Number of lactations	12	4	12	4
Period - Days	Percentage Daily Yields			
10 - 17	11.6%	14.4%	16.0%	16.4%
17 - 24	12.5	13.9	14.5	13.6
24 - 31	12.3	11.9	12.6	11.9
31 - 38	11.5	11.3	11.1	10.8
38 - 45	10.9	11.1	10.1	10.4
45 - 52	10.4	9.8	8.9	9.8
52 - 59	9.0	8.5	8.0	8.2
59 - 66	8.1	7.0	7.0	7.3
66 - 73	7.6	6.2	6.2	6.3
73 - 80	6.1	5.9	5.6	5.3

The figures are in agreement with the shape differences of the lactation curves of Fig.II, the curves of the high plane group being convex and those of the low plane group tending more to be concave, thus accounting for the comparative decline in production in the middle periods.

Table 7 also shows up the difference in persistency of the two groups - at 80 days of lactation the high plane groups gave a higher percentage of their total production than the low plane groups did of theirs. From Fig. II it is obvious that the high plane group produced at a higher level than the low plane throughout lactation. These results are in agreement with the findings of Barnicoat et al (1949) that (a) feeding during pregnancy was important for maintaining yield during the latter part of lactation, but had only moderate influence on total yield and (b) feeding during lactation was the primary factor influencing both initial and total yields.

The size of the standard deviations in Table 2 indicates the great variability of the individual records. Caution must be exercised in drawing conclusions from these data, particularly from the twin groups, because of the small size of the groups. Because of the large effect which the number of young suckled has on the milk yield as shown by Wallace (1948), Barnicoat et al (1949), in the analysis of the data in this investigation, twins and singles have been treated separately; this resulted of course in a reduction in the number of degrees of freedom in determining the significance of the results and some of the N.S. results obtained may well be due to this very small size of group.

In many of the investigations on milk secretion in sheep mentioned in the introduction, estimates of yield have been made and lactation curves drawn. Wallace (1948) reviewed the literature and the results quoted by him, converted from pounds of milk per week to ounces per day are shown in Tables 8 and 9 along with those of Barnicoat et al (1949) and the present investigator. It is quite apparent that the yields obtained in this experiment are comparable with the results of other workers.

TABLE - 8

SUMMARY OF FINDINGS ON THE MILK YIELDS OF EWES

Workers	Date	Period	No. of Sheep	Breed	Av. daily Yield oz.	Remarks
Fuller & Kleinhanz	1904	7th wk.	14	Various	44.8	
Wallace	1948	"	14	Suffolk	46.4	
Wallace	1948	"	22	B.L. x C.	56.0	
Murray	1952	"	12	Romney	46	High Plane Single.
Neidig & Iddings	1919	0-7 wk.	3	South-down	43.2	
"	1919	"	3	Hampsh.	76.8	
Wallace	1948	"	14	Suffolk	56.0	
Wallace	1948	"	22	B.L. x C.	73.6	
Pierce	1934	3rd wk.	6	Merino	43.2	
Wallace	1948	"	14	Suffolk	62.4	
Wallace	1948	"	22	B.L. x C.	88.0	
Murray	1952	"	12	Romney	49.3	H.P.S.
Pierce	1934	9th wk.	6	Merino	22.4	
Wallace	1948	"	14	Suffolk	38.4	
Wallace	1948	"	22	B.L. x C.	48.0	
Murray	1952	"	12	Romney	38.0	
Barnicoat et al	1943	-	-	South-down X	52.8	Max. daily yield
Murray	1952	-	12	Romney	52.9	-do- H.P.S.
Snell	1933	5th wk.	-	-	9.6	Very low plane of nutrition.
Snell	1933	"	-	-	3.2	
Murray	1952	"	12	Romney	51.9	H.P.S.
Murray	1952	"	12	Romney	34.6	L.P.S.
Bonsma	1939	1 - 12 wk.	-	Mer. x B.L.	40.0	
Bonsma	1939	"	-	Merino	25.6	
Wallace	1948	0 - 12 wk.	14	Suffolk	49.6	
Wallace	1948	0 - 12 wk.	22	B.L. x C.	64.0	
Barnicoat et al	1949	1 - 12 wk.	82	Romney	48.0	Average of different groups in different years.
Murray	1952	1 - 12 wk.	12	Romney	42.3	H.P.S.
Godden & Puddy	1935	-	-	-	-	Yields obtained by hand-milking; very variable.

TABLE - 9

MILK YIELDS OF SHEEP ON DIFFERENT PLANES OF NUTRITION

Worker	Date	Period	Breed	Average Daily Yield in Ozs.			
				H.P.S.	H.P.T.	L.P.S.	L.P.T.
Wallace	1948	0 - 16 wk.	B.L.xC.	44.0	64.0	-	41.7
Barnicoat et al	1949	12 wks.	Romney	45.0	60.0	22.0	31.0
Murray	1952	10 - 80 days	Romney	42.4	54.0	27.0	35.0

The shapes of the lactation curves obtained here are similar to those constructed from their data by Wallace (1948), by Bonsma (1949) and by Barnicoat et al (1949). Logan (1946) showed that a single lamb was unable to draw off all the milk produced by its dam in the early stages of lactation and that when the excess milk was plotted on the graph of the milk yield the curve did not show the peak to the same extent and in some cases tended to be without a peak. Therefore with twin lambs which are able to handle all the milk the ewe can supply, the curve will tend to be without the peak as is the case here with the high plane twins. This corresponds to the curves constructed by Barnicoat et al (1949).

The curves for the low plane ewes are also similar to those of Wallace and Barnicoat et al who have also studied the effect of plane of nutrition on the milk yield. This type of curve, i.e. one without a peak, is apparently produced also by breeds of sheep which are low producers, as well as by sheep which are low producers on account of a restricted diet. Bonsma (1939) showed that this is the case for Merino ewes.

As previously mentioned, a performance rating value had been assigned to each ewe on her records in other lactations and on the number of lambs she had borne in each season in which she conceived. An analysis of variance was carried out to determine whether, on this rating, there was any repeatibility of records, i.e. whether a high yielder in former seasons showed up as a high yielder in this.

TABLE - 10

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Planes	8,086,365.0	1	8,086,365.0	18.32	H.S.
Ratings	33,497.4	1	33,497.4	-	-
Interaction	7,381.1	1	7,381.1	-	-
Error	8,825,667.1	20	441,283.4		
Total	16,952,910.6	23			

The analysis showed that there was a H.S. difference in milk yield between planes, as was to be expected, but that there was no difference between ratings and no interaction effect, i.e. for example, a ewe with a high rating did not necessarily show up as a high producer in this season when compared to ewes with low ratings in the same plane or to ewes with high ratings between planes. It must be emphasised that the rating system employed is an empirical one and it may not therefore represent the true picture.

3. Energy Yield of Ewes

Pierce (1934) has shown that the energy of ewes' milk as determined by combustion in the bomb calorimeter approximates closely to that calculated from the formula drawn up by Overman and Sanman (1926) for computing the total energy of cows' milk from its composition. In the case of ewes' milk the calculated values in calories per U.S. quart were 1107 and 1211 respectively, at the two stages of lactation, whereas the values actually found were 1108 and 1196 calories. Gaines (1928) has used the figures of Stocking and Brew (1920) to derive a similar equation which approximates very closely to the one used by Pierce. This latter equation is readily transformed into the form

F.C.M. = M (.4 + .15f) where F.C.M. = 4% milk
F = fat per cent
M = milk weight.

Gaines found a correlation of 0.9882 between energy value of cows' milk and fat per cent and therefore the above formula in which all milk is reduced to milk of equal fat content and hence equal energy content supplies a readily calculable estimate of comparative energy content. Gaines considers this formula, though it contains a minor error, to be sufficiently accurate for ordinary work, and it has therefore been used in the calculation of the energy contents of the milks in the present instance.

The fat percentages of the milks of individual sheep had been determined at each milking. They were plotted on graphs for the purpose of estimating the percentage fat at a particular time stage in lactation by interpolation as had been done in the case of milk yield earlier. From the figures for individual ewes the average fat percentages for the seven-day periods between ten and eighty days of lactation were calculated for each of the four groups. From these figures and from the figures of milk yield over the same periods it was possible to calculate the energy yields and thence to construct average energy curves. These results are presented in Fig. III and Table 11.

The figures in this Table are higher than those of Table 5 because most of the fat percentages in the data were greater than 4% and each milk yield had therefore to be changed into a greater weight of milk at this lower test to be equivalent in energy content.

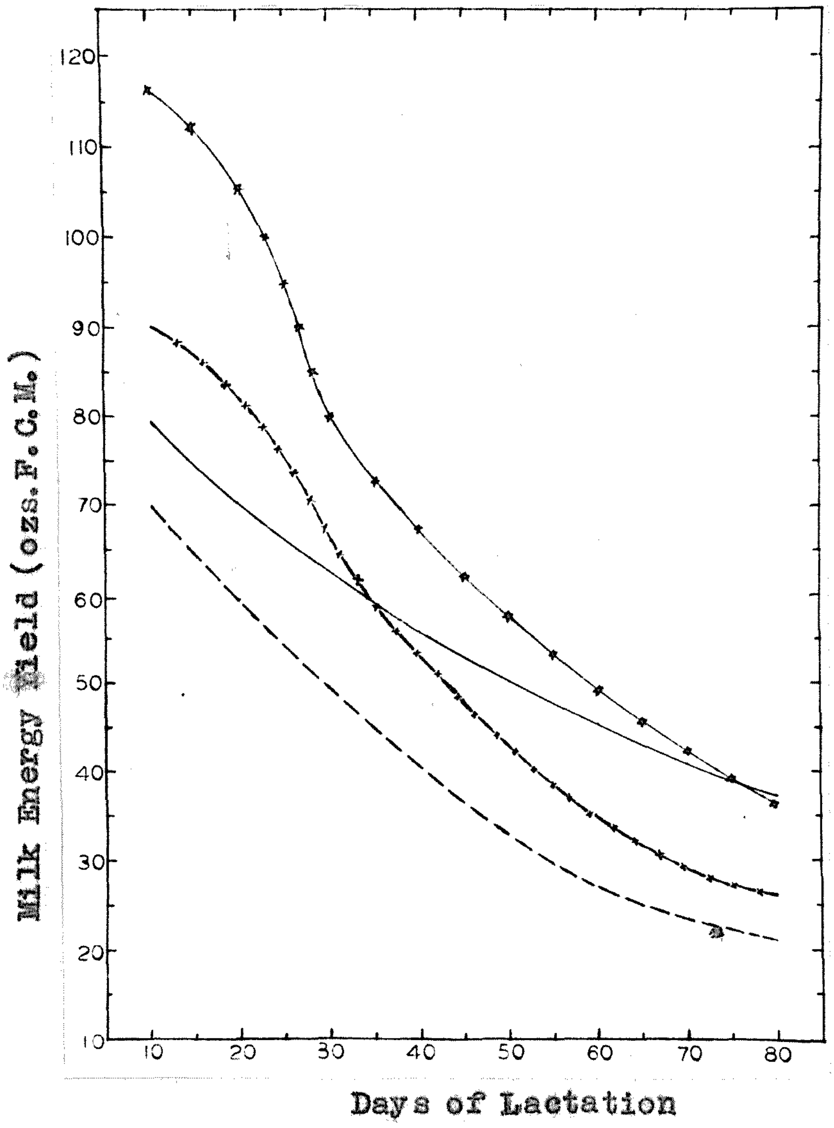


FIG. III

MEAN ENERGY LACTATION CURVES OF EWES

High Plane Ewes with Singles ————

-do- Twins ✕—✕—✕—✕

Low Plane Ewes with Singles — — — — -

-do- Twins —x—x—x—

TABLE - 11

ENERGY YIELDS OF EWES EXPRESSED AS OUNCES OF 4% F.C.M.

	High Plane Group		Low Plane Group	
	Singles	Twins	Singles	Twins
Number of lactations	12	4	12	4
Period - Days	Average daily yield - ozs. 4% F.C.M.			
10 - 17	75.9	113.9	67.5	88.0
17 - 24	70.4	103.0	59.7	88.9
24 - 31	65.9	82.7	52.2	69.0
31 - 38	59.0	73.3	44.8	59.0
38 - 45	58.0	66.6	39.1	52.9
45 - 52	54.2	62.8	34.5	44.7
52 - 59	47.9	55.2	31.6	38.0
59 - 66	44.2	43.6	27.1	33.3
66 - 73	41.6	40.3	23.3	28.4
73 - 80	38.1	37.7	22.6	25.7
Averages	55.5	67.9	40.2	52.8
	Average Total Yields in Ounces			
Averages	3885	4753	2814	3696
S.D.	±857	±620	±933	±840

General mean energy yield = 3449.8 ozs.

S.D. = ±878.36 ozs.

C = 25.46%

The order of the groups from highest to lowest average energy yield was the same as for milk yield and as before the initial production of low plane ewes with twins was greater than that of the high plane ewes with singles but soon fell below the latter as lactation progressed. The size of the standard deviations for energy yield indicates that there was just as much variation between the milks on the energy basis as on the milk ounces basis - the energy calculation had no smoothing effect on the yields of the individual ewes within a group.

The noticeable difference in the two tables, however, is the lack of the peak in the curve of the high plane singles - this is clear in both the graph and the table and indicates that the milk produced in the first period had a much higher energy content per ounce, (due to a higher fat test) than the milk produced in subsequent periods; the fat per cent figures (see later) show this to be the case. This would appear to be a general effect because the curves for the high and low plane twins in Fig. III are noticeably steeper over the first few periods than they were in Fig. II.

Differences between groups in energy yield were due again to differences in level of initial production and to the fact that the high plane group produced throughout the lactation at a higher level than the low plane, except for the early period already mentioned when the low plane ewes with twins exceeded the high plane ewes with singles.

The analysis of variance of energy yield shows that there is a H.S. difference between planes and between singles and twins. The interaction effect is N.S. indicating that the single and twin groups did not differ in their reaction to the two planes of nutrition.

TABLE - 12

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Planes	10,839,168.5	1	10,839,168.5	14.05	H.S.
Type	7,076,373.3	1	7,076,373.3	9.17	H.S.
Interaction	8,739.9	1	8,739.9	-	-
Error	21,602,414.3	28	771,514.8		
Total	39,526,696.0	31			

General Mean Energy = 3449.8 ozs. F.C.M.
Standard Deviation = + 878.36 ozs. F.C.M.
C = - 25.46 %

4. Milk Yield and Ewe Weight

Bonsma (1939) reported a significant positive correlation between liveweight of ewe as recorded within a week after lambing and milk yield within the same breed. Wallace (1948) plotted the total milk yield against mean liveweight during lactation and claimed a relationship though data were scanty, the heavier ewes giving the greater yields. In dairy cattle, Gowen (1933), Edwards (1936) and McDowell (1930) have shown that within a particular breed milk yields tend to increase with increase in liveweight. Gaines, Davis and Morgan (1947) found a H.S. correlation between energy yield and liveweight over 231 lactations within the one breed.

On the other hand, Barnicoat et al (1949) obtained a N.S. correlation between milk yield and liveweight taken soon after parturition, but say that this may be due to the weight differences arising merely from differences in fatness of the ewes. Aritman (1946), working with Turkish breeds of sheep, reported no correlation between milk yield, liveweight or wool yield.

The correlation between milk yield and weight of ewe in this data was non-significant in all four groups.

		r	df.	
High plane	singles	0.39	11	N.S.
-do-	twins	0.59	3	N.S.
Low plane	singles	0.33	11	N.S.
-do-	twins	0.86	3	N.S.

This result may have been due to the smallness of the numbers; from the work cited above a positive significant correlation could have been expected. The weight taken was the first after lambing.

Bonsma (1939) has stressed the importance of the two factors that may cause liveweight differences between ewes, viz: size of frame and difference in condition, in affecting the yield of milk. The data to date are not sufficient to distinguish between the two but probably both are of importance.

5. Milk Yield and Time of Lambing

Barnicoat et al (1949) found a tendency for high milk yield to be associated with those ewes which lambed early and suggested that the effect was due to the quality of the early spring pasture being superior to the quality of later pasture.

The distribution of lambing was not normal in the experiment so no examination of the effect of lambing could be carried out.

6. Milk Yield and Wool Yield

Logan (1946) investigated the correlation between milk and wool yields for the purpose of determining whether high yield in the one was compatible with high yield in the other. He noted that a high positive correlation between milk and wool yield cannot be expected on genetical grounds except insofar as the general physiological level is common to both. However, evidence from various sources indicates that there is a positive correlation between liveweight and milk production and between liveweight and wool yield and therefore a correlation between wool and milk yields might reasonably be expected.

Logan's correlations, though N.S., were negative in both his six-year-old and his two-year-old ewes and were of a similar magnitude. Therefore, he suggests that the two products are possibly incompatible. Albibon et al (1951), working with Lacaune sheep in France, report positive correlations between the two products; sheep giving the most milk and butterfat were those with the heaviest fleeces; they were also the best fed.

Unfortunately, the fleece weights were not available for all the sheep in this investigation but sufficient were available for the correlation to be taken out. In the high plane group the value of r was 0.10 with 10 df and in the low plane it was 0.92 to 9 df. The first value is non-significant while the second is H. S. The mean yields are shown in Table 13.

The low plane fleeces were generally cotted, lacking in lustre or chalky and short; there was no lift.

These results would appear to be more in agreement with the findings of Albibon than those of Logan, viz: that high milk and wool weights are not incompatible. It is apparent that in the case of the low plane ewes threshold levels of malnutrition for both milk and wool production were passed and the treatment caused both to be so much effected that the high correlation found resulted.

TABLE - 13

AVERAGE MILK AND WOOL YIELDS

Group	Number of Sheep	Average Milk ozs.	Average Wool lbs.	r	Result
High Plane	11	2931.4	9.8	0.10	N.S.
Low Plane	10	1505.0	6.7	0.92	H.S.

7. Composition of the Milk

Logan in 1946 presented a convenient summary of the literature on the yield and composition of non-milking breeds of sheep up to that date in tabular form. This table is reproduced in Table 14 with additional results that have been published since 1946. Logan emphasises that much of the data in the Table is of little value because often no mention is made of the method of obtaining the milk samples, nor of the breed or stage of lactation in some instances.

TABLE - 14

SUMMARY OF YIELD AND COMPOSITION DATA
(After Logan, 1946)

Author	Yield ozs.	Total Solids	Protein	Fat	Sugar	Ash	Remarks
Konig	-	16.43	5.15	6.18	4.17	.93	
Richmond	-	20.54	6.68	8.63	4.28	.97	
Fuller & Kleinhanz	40.00	18.00	-	7.04	-	-	6 breeds
Neidig & Iddings	54.30	-	4.12	7.72	-	.83	6 breeds (10 - 15 days)
Schein-graber	90.67	15.76	4.55	5.05	-	.80	Mostly all milk ewes.
		25.94	9.33	10.16	-	.90	
Godden & Puddy	21.65	19.30	6.06	7.43	4.81	.97	Cheviots (various intervals between lactations)
	29.20	19.88	6.83	7.94	3.74	.93	
Gill	11.58	17.52	4.94	6.72	4.94	.91	9 yarded ewes
	23.63	16.17	4.93	5.10	5.19	.91	8 grazing ewes
	29.51	16.68	5.52	4.29	5.61	.98	3 ewes - lambs died.
Hopkirk	-	19.29	5.37	7.78	5.12	.92	4 ewes - lost twins.
	-	16.44	5.49	5.29	4.76	.90	16 ewes - lost singles.
	-	15.82	4.80	4.68	5.43	.87	14 ewes - normal
Pierce (1933)	42.43	17.66	4.29	7.41	4.83	.86	6 Merinos (3rd week)
	22.89	19.29	5.28	7.90	4.81	.90	6 Merinos (9th week)
Pierce (1935)	41.90	18.66	4.14	9.15	4.65	.89	5 Merinos (2nd week)
	33.80	18.45	4.47	7.61	4.79	.90	5 Merinos (4th week)
Pierce (1937)	38.73	18.13	4.67	7.83	-	-	12 Merinos
Bonsma		1623	5.25	4.76	-	.88	7 Merinos (8th week)
	26.21	18.76	5.59	6.81	-	1.12	(12th week)
		16.86	5.00	5.26	-	.83	5 B.L. (8th week)
	40.06	19.03	5.59	6.62	-	1.11	(12th ")
		16.05	4.85	5.36	-	.95	5 Ryeland (9th week)
	36.39	19.13	5.52	7.45	-	1.39	(12th week)
		16.95	5.86	4.91	-	.91	8 Romney (8th wk.)
	34.83	18.82	5.37	7.01	-	1.15	(12th ")
		16.71	5.13	5.05	-	.89	5 Dorset (8th wk.)
	34.35	18.96	5.47	6.92	-	1.23	Horn (12th wk.) (Yields are the averages of 12 wks. lactation).
Logan	41.68	15.99	5.47	5.10	4.67	.83	(Yields and composition averages of 100 day lactation). 2 & 6 year Romney respectively.
	47.60	16.91	5.49	6.06	4.53	.83	
*Drozdova & Nozdracev	36.8	-	-	7.06	-	-	Siberian Merinos 110 days lactation.
	31.8		-	7.16	-	-	Siberian Merinos 120 days lactation
*Murray	42.3	17.32	5.64	6.7	4.15	.85	12 Romneys, High Plane
	27.4	17.43	5.21	7.3	4.11	.83	12 Romneys Low Plane

* - Not quoted by Logan.

The method of obtaining samples that has been employed here was described earlier. Barnicoat et al (1949) examined the various methods closely and this one incorporates the observations and recommendations they have made. The salient features are: quiet and patient handling of the ewes and lambs, allowing the lamb to have a fairly good start over the operator when milking, milking the udder out as far as possible and as quickly as possible, strict standardisation of technique.

In one respect the method used in this investigation differs from that of Logan (1946) - he stated ....."The lambs appeared to favour the better yielding quarter first, leaving the poorer to the sampler", and derived a ratio of milk obtained by hand to that obtained by the lamb of about 0.5 to 1.0, average being 0.75. He allowed the lamb to suckle the half of the udder which it liked to choose and then he milked the remaining half, while here the operator always milked out the left-hand side and the lamb suckled the right. This point is of considerable importance in view of the variations in the composition of the milk from the different halves of the udder which have been reported by various workers. Barnicoat et al present the results of "between-half" comparisons from five pituitrin injected ewes yielding over 80% of their milk by hand. The solids-not-fat are relatively constant between halves but the fat percentage is particularly variable, e.g.

<u>Ewe 1</u> at the start yielded 5.8% fat from the left half and
5.9% from the right; at 7 - 10 days 7.7% and 6.8%;
and at 20 days 9.5% and 8.5%.

The other ewes show similar variability. Note that the percentage of both "quarters" rose with time.

Cardas and Nica (1947) compared the milk production of the right and left halves of the udder in Grey Turcana and Karakul sheep and found average difference in yield of 2.03 and 1.9 gms. respectively with variations of 0-20 and 0-20 gms. at different milkings, and 0 -18.6 and 0 - 9.2 gms. from different animals; the right halves yielded 2.66% and 3.91% less milk respectively.

On the other hand Drozdova and Nozdracev (1940), had ascertained that the milk yield and fat content from both teats were the same before comparing yields and composition.

No attempt was made in this investigation to compare the milk from the two halves of the udder but in Table 15 are shown the ratios of the milk obtained by the operator to that obtained by the lamb for the individual ewes. In the cases of Ewes 16 and 41, one record of each was excluded from the computation of the average ratio as they were considered to be abnormal owing, perhaps, to poor milking.

TABLE - 15

AVERAGE RATIO OF MILK OBTAINED BY HAND TO THAT OBTAINED BY THE SUCKLING LAMB.

Ewe No.	High Plane		Ewe No.	Low Plane	
	Ratio	No. of Records		Ratio	No. of Records
8	.95	11	1	.70	11
9	.53	8	10	.79	12
34	.81	12	16	.97	11
40	.87	10	28	1.11	8
65	.69	12	41	.63	10
86	.54	10	58	1.23	12
96	.75	11	85	.62	12
104	.67	12	87	.75	12
123	.93	10	106	.67	12
185	1.14	8	74	.92	12
408	.73	10	217	.60	7
88	.45	10	219	.83	7
319	1.09	13	48	.73	11
39	2.66	11	67	1.06	9
55	.60	13	117	1.00	12
140	.69	11	52	.66	12
89	.79	8			
Average	.87			.83	
S.D.	± .50			± .20	
	General Mean 0.85		S.D. 0.38		

The records of the ewes with ratios greater than unity were examined for abnormalities of yield, lamb birth weight, lamb weight gain and illness of ewe or lamb but none was found. In nearly all the ewes it was also observed that the ratio was fairly constant from milking to milking, (strikingly shown by Ewe No.39 which had the largest ratio of all) though it is obvious that the ratio varied considerably between ewes.

From these results it would appear that the halves of the udder differ in yield consistently - this conclusion is particularly supported by the fact that from seven of the ewes the operator obtained more milk than the lamb which surely indicates that the halves differed and the operator had the better half since the other conditions (size of lamb, illness, etc.) likely to affect the yield were quite normal.

The conclusion is, therefore, that the maximum yield obtainable by hand milking one side of the udder while the lamb suckles the other is not necessarily represented by ratio of 1:1 as assumed by Logan but that in many cases it may be more and in others less.

After considering the effects of the differences between halves and the change in composition from the commencement of milking to the finish, Logan concluded that an average ratio of 0.75 gave sufficiently accurate results provided the technique of obtaining the sample as described by him was adhered to. Since this technique has been followed in this experiment, since the average ratio was 0.85 and taking into account that the ideal ratio may well be something less than 1:1 the results of the analyses to be presented below are considered representative enough to give a true comparison between records and to allow comparisons of the yield between ewes on an energy basis to be made.

The individual fat analyses and the analyses of the composite samples will be found in the Appendix.

So as to avoid too great a distortion of the lactational trends in the composite samples, the number of sheep from whose milk these samples were made up was limited to those which lambed over the period from the 17th August, 1951, to the 9th September, 1951, all ewes lambing after this date being excluded. These later milk samples were analysed for fat only. In the comparison of the high and low plane groups the analyses on the 17th August, 1951, and the 13th December, 1951, were excluded as they were not common to both groups and contained only a relatively small number of ewes. The average data was graphed and analyses of variance done to detect differences between planes and lactational trends, the data being transformed to angles for this analysis (after Snedecor).

(a) <u>Fat</u>

Though the analysis of variance gives a N.S. result between planes, it is evident from the graph that the low plane group fat per cent was the higher throughout the greater part of the lactation period. The N.S. result would be caused by the last two average recordings; it will be remembered that after the 3rd November, 1951, the plane of nutrition of the low plane group was raised considerably and that their average yield in ounces appreciably increased. (See Fig.IV)

Apparently this increase in volume of yield caused the fat percentage to fall as is shown in the Figure.

The analysis of variance shows a significant difference in the fat per cent between dates which confirms the lactational trend shown in the figure. Unlike Barnicoat et al, who concluded that after the initial effects of colostrum disappear, the fat concentration increased during lactation, the Figure (IV) shows a decrease in concentration up to about 9 weeks and thereafter a steady increase. Work with dairy cows reveals a similar minimum of fat per cent about the 10th week.

TABLE - 16

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	25.023	11	2.275	3.39	S
Planes	2.864	1	2.864	4.26	-
Error	7.394	11	0.672		
Total	35.281	23			

(b) Total Solids

The figures show a drop in concentration at the beginning of lactation and a rise towards the end; the differences between dates are significant but there is no apparent difference between planes though this may be obscured, as before, by the decrease in percentage in the low plane samples towards the end of the lactation period. (Fig.V)

TABLE - 17

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	9.1814	11	0.8347	3.15	S
Planes	0.078	1	0.078	-	-
Error	2.9182	11	0.2653		
Total	12.1744	23			

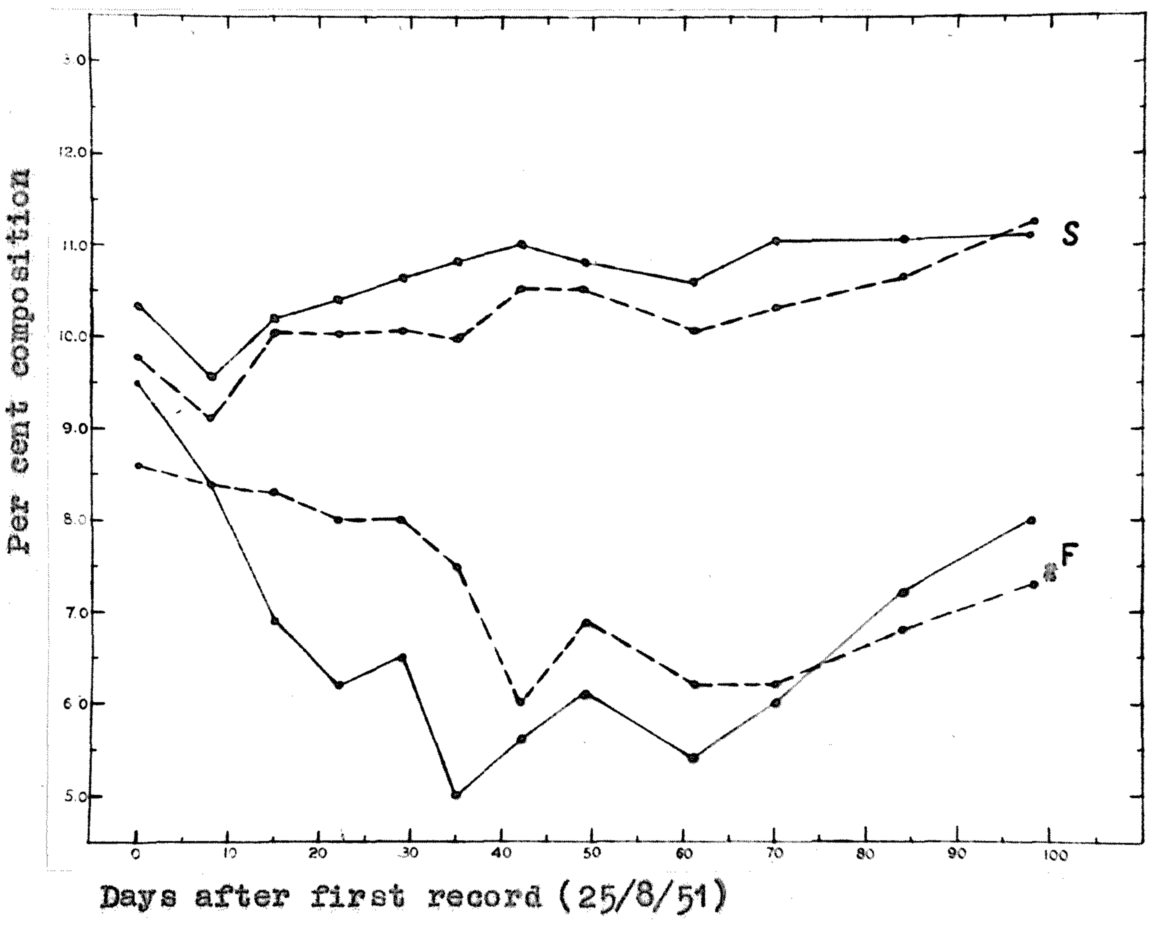


FIG. IV

CHANGES IN COMPOSITION DURING LACTATION

High Plane Ewes	●——●
Low " "	●— — —●
S	Solids-not-fat %
F	Fat %

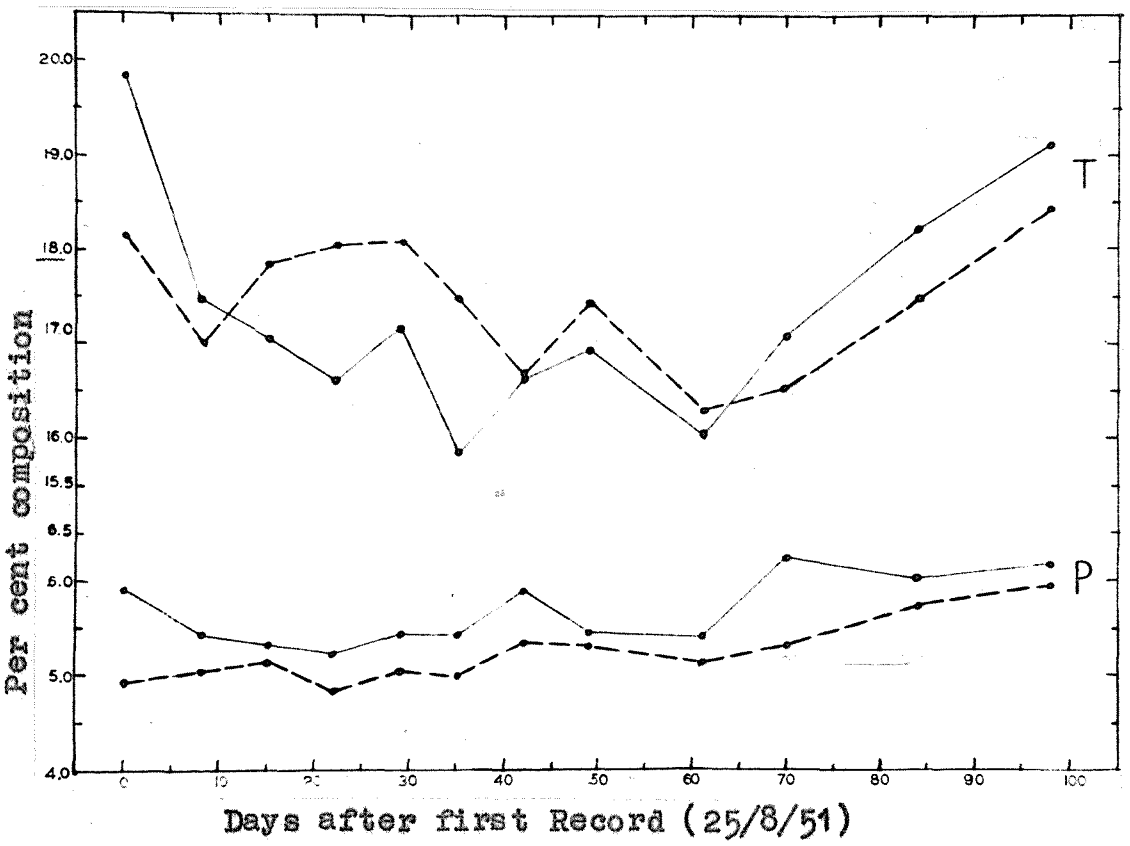


FIG. V.

CHANGES IN COMPOSITION DURING LACTATION

High Plane ewes ———

Low Plane ewes — — —

T Total Solids %

P Protein %

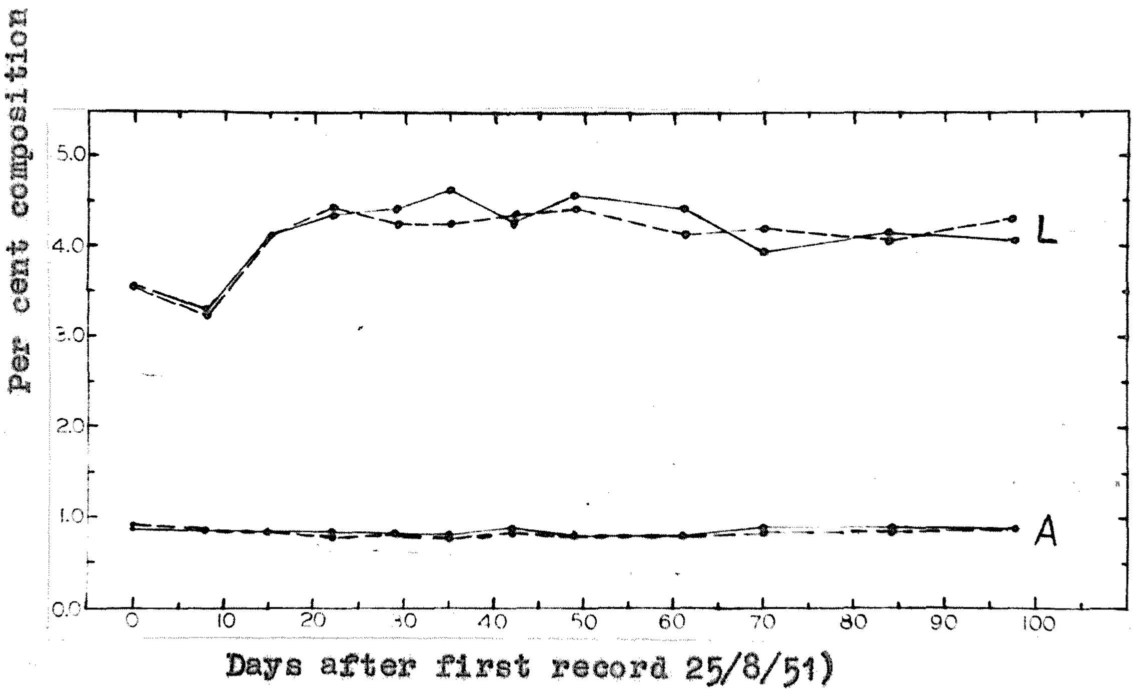


FIG. VI

CHANGES IN COMPOSITION DURING LACTATION

High Plane ewes	●————●
Low Plane ewes	●— — — —●
L	Lactose %
A	Ash %

(c) Solids-not-fat

There is a small but consistent rise in concentration from the beginning to the end of lactation and the high plane group is higher than the low plane group - both these effects are H.S. (Fig.IV)

TABLE - 18

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	4.1380	11	0.3762	16.79	H.S.
Planes	1.1094	1	1.1094	49.52	H.S.
Error	0.2481	11	0.0224		
Total	5.4955	23			

(d) Protein

Between planes and dates the differences in protein concentration are H.S., the high plane being the greater throughout and both groups showing a rise towards the termination of lactation.

TABLE - 19

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	3.3563	11	0.3051	5.21	H.S.
Planes	1.8150	1	1.8150	30.97	H.S.
Error	0.6451	11	0.0586		
Total	5.8164	23			

(e) Lactose

Barnicoat et al report a decrease in this constituent as lactation advances but here there is a large increase over the first stages after which it is farily constant. The plane of nutrition had no obvious effect. (Fig.VI)

TABLE - 20

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	6.8064	11	0.6188	22.91	H.S.
Planes	0.0434	1	0.0434	1.6	-
Error	0.3170	11	0.0270		
Total	7.1668	23			

(f) Ash

The ash shows a similar trend to the protein and S-n-f, a steady rise in concentration during lactation and the low plane depressed by the poor nutritional conditions. The analysis of variance shows that the differences were H.S. (Fig.VI)

TABLE - 21

ANALYSIS of VARIANCE

Source of Variation	SS	df	MS	F	Result
Dates	0.2967	11	0.0270	9.31	H.S.
Planes	0.0235	1	0.0235	8.1	H.S.
Error	0.0319	11	0.0029		
Total	0.3521	23			

(g) Calcium and Phosphorus

The trends evident here are parallel to those of the ash as would be expected since the calcium and phosphorus are the major constituents of the ash.

Except for the difference in the behaviour of the lactose content the results recorded above are in complete agreement with those of Barnicoat et al. In dairy cattle, Riddet, Campbell, McDowell and Cox (1941) found that the milk of cows on reduced rations showed a fall in yield and S-n-f but no consistent change in fat. The fall in S-n-f was largely due to a fall in protein content.

The above results show strikingly the effects of lack of adequate nutrition on the composition of Romney ewes milk and emphasise the importance of optimum feeding to maintain the production of milk of normal composition.

(h) Effect of weather on composition and yield

Barnicoat et al observed that irregularities in the lactation curves and periodical variations in the fat contents of the milks of individual ewes suggest that weather might play directly or indirectly a part in influencing yield and quality of ewes' milk. Espe describes the effects of extremes of temperature on the yield of milk and fat in cows, high temperatures causing very considerable depression of fat yields.

Climatic variations are therefore worthy of notice when comparing the records of individual ewes. The data in this experiment were too widely variable to allow any particular variation to be ascribed to environmental changes so no attempt was made to evaluate the effects of weather on milk yield and/or composition.

8. Lambing Percentages and Sex Ratios

Tables 22 and 22A present the number of lambs born, the ratio of the sexes and the mean birth weights in each of groups. In Tables 23 and 23A are the same figures as they were modified in the milking groups.

TABLE - 22

LAMBING PERCENTAGES & SEX RATIOS AT BIRTH

Groups	Ewes to Ram	Singles		Twins		Total		Lambing %	Sex ratio ♂ : ♀
		m.	f.	m.	f.	m.	f.		
High Plane	20	8	4	6	6	14	10	120.0	1.4
Low Plane	18	6	7	6	2	12	9	116.7	1.3

m. = male f. = female.

TABLE - 22A

MEAN BIRTH WEIGHTS

	High Plane Group		Low Plane Group	
	Singles	Twins	Singles	Twins
Birth weight	13.7	9.4 lbs.	11.1	10.0 lbs.

TABLE - 23

LAMBING PERCENTAGE & SEX RATIOS IN MILKING GROUPS

Groups	Ewes to Ram	Singles		Twins		Total		Lambing %	Sex ratio ♂ : ♀
		m.	f.	m.	f.	m.	f.		
High plane	16	7	5	5	3	12	8	125	1.45
Low plane	16	6	6	6	2	12	8	125	1.45

TABLE - 23A

MEAN BIRTH WEIGHTS

	High Plane Group		Low Plane Group	
	Singles	Twins	Singles	Twins
Birth weight (lbs.)	12.9	9.6	11.1	10.0

The lack of marked differences between the birth weights of the two groups suggests that the plane of nutrition in the low group, while severe enough to affect the condition of the ewes, was not severe enough to affect the size of the lambs at birth. The milk supply which was markedly affected, influenced the rate of gain of the lambs so that differences in growth rate caused differences in weight at greater ages.

9. Lamb Growth

(a) Live Weight Gains of High and Low Plane Groups

The absolute weight gains over the three periods and the total time, 10 - 80 days, are presented in Table 24. The analysis of variance below, Table 25, shows that there were significant differences between the planes and between singles and twins. The lack of interaction means that singles and twins did not differ in their reactions to the planes of nutrition.

TABLE - 24

WEIGHT GAINS OF HIGH AND LOW PLANE LAMBS

Group	10 - 24 days	24 - 52 days	52 - 80 days	10 - 80 days	
High Plane					
Singles	8.0	14.7	11.8	34.4	lbs.
Twins	6.2	12.3	10.7	29.2	
Low Plane					
Singles	6.5	9.4	8.0	23.9	
Twins	3.5	7.7	7.0	18.2	

TABLE - 25

ANALYSIS OF VARIANCE OF LAMB GAINS 10 - 80 DAYS (TWINS SEPARATE)

Source	SS	df	MS	F	Result
Planes	936.05	1	936.05	49.03	H.S.
Types	263.54	1	263.54	13.81	H.S.
Interaction	8.26	1	8.26	0.43	-
Error	725.39	38	19.09		
Total	1933.24	39			

General Mean gain 27.11 lbs.
Standard deviation s ± 4.37
Coefficient of variation C 16.11%

The analysis of covariance by which the variation in the weight gains due to the effect of birth weight on growth was removed is shown below (Table 26).

TABLE - 26

ANALYSIS OF COVARIANCE AND TEST OF SIGNIFICANCE OF ADJUSTED GROUP MEANS

(X - birth weight in lbs. Y - gain in weight in lbs.10 - 80 days)

Source of variation	df	SSX	SPXY	SSY	Y'	df	MS	F	Result
Total	39	212.12	269.94	1933.24					
Planes (Pl)	1	8.10	87.08	936.05					
Types (T)	1	43.77	107.43	263.54					
Pl x T (I)	1	9.80	8.98	8.26					
Error (E)	36	150.45	66.45	725.39	696.04	35	19.89		
Pl + E	37	158.55	153.53	1661.44	1512.77	36			
Diff.Pl.					816.73	1	816.73	41.06	H.S.
T + E	37	194.22	173.88	988.93	833.26	36			
Diff.T.					137.22	1	137.22	6.95	S.
I + E	37	160.25	75.43	733.65	698.14	36			
Diff.I.					2.10	1	2.10	-	-

TABLE - 27

ADJUSTED MEAN GAIN

Group	Mean Birth weight X	Deviation from experiment mean x	Product bx	Mean gain y	Adjusted mean gain Y - bx.
H.P.S.	12.83	1.92	0.84	(4)34.42	(4)33.58
H.P.T.	9.69	- 1.22	- 0.54	(3)29.25	(3)29.79
L.P.S.	11.13	0.22	0.10	(2)24.00	(2)23.90
L.P.T.	10.00	- 0.91	- 0.40	(1)18.25	(1)18.65

Experiment mean birth weight = 10.91
b = 0.44

Unlike the examples quoted on P.60 where the analysis of covariance removed the significance of the difference between singles and twins, in this case the difference is still significant.

However, an examination of the adjusted means (Table 27) shows that the differences between singles and twins are less than they were in the unadjusted means. Therefore, the analysis of covariance has shown that the birth weight did have an effect on the weight gains made. But the amount of variance controlled by birth weight was not large enough to make the difference between types non-significant when the effect of birth weight on rate of gain was allowed for. The reason for this difference from the early weaning data is probably bigger differences between singles and twins in the milking experiment than in the weaning experiment. A comparison of the adjusted mean gains in the early weaning data (Table 47) with those here shows this to be the case. The number of animals in the milking experiment was not large enough for the effect of birth weight to show up statistically significant.

In the adjusted mean table the rank order is unchanged (figures in brackets) which indicates that the relation of the gains made by the groups to each other was not due to any difference in initial weight.

(b) Milk in Relation to Growth of Lambs

(i) Factors affecting the Rate of Gain

In this study it is important to evaluate the effects of all the factors likely to influence the growth of the lambs over the lactation period so that the variation in the weights of the lambs owing to the differences between ewes in milk yield may be accurately determined.

These factors have been examined and discussed in numerous works, some of particular importance to the present investigation being those of Donald and McLean (1935), Bonsma (1939, 1944), Wallace (1948), Barnicoat et al (1949), Phillips and Dawson (1940), with sheep, and Donald (1937), Bonsma and Oosthuizen (1935), with pigs. They have been examined particularly closely by Bonsma who stated the main ones to be - breed, sex, number of parturition, time of lambing, birth weight and number of young, milk yield of the dam, size of dam; other aspects of nutrition, season and parasites are additional ones that may well be taken into account.

By the very nature of the data in this experiment, several of these factors had no effect on the comparison of the growth rates of the different groups of lambs - the animals were all of the same breed and age (same number of parturition), the data were obtained within the one season - these are the obvious eliminations that can be made but the others require more searching scrutiny.

(1) Birth Weight

The fact that the weights of animals vary widely at birth is familiar to anyone who has worked with stock of one type or another. Chapman and Lush (1932) determined in sheep that about 25% of the variance in birth weight is due to genetic differences, 30 - 35% to tangible environmental factors and about 40 - 45% to intangible environment or accidents of development.

Bonsma found that the size of the ram had a H.S. effect on the weight of the lamb, sex differences have been noted by many workers, male lambs being significantly heavier (Bonsma (1939), McMeekan (1943)) - these are examples of the effect of genetic factors. The tangible environmental factors are best demonstrated by Huggett's (1941) concept of uterine nutrition - differences have been shown between twins and single lambs, between those of young and mature ewes, those of early and late lambers and those of ewes on low and high planes of nutrition (Bonsma, Wallace, Phillips and Dawson, McMeekan et al, Barnicoat et al); the differences due to these factors are all brought about through the channel of the nutrition of the foetus, the poorer nutrition producing the lighter weight lamb.

Workers differ in their findings on the effect of this difference in birth weight on the relative liveweight gains of the lambs from birth to some specified age. Bonsma concluded that the growth in the period soon after birth is correlated with the birth weight and quotes McMeekan (1936) - "Heavy litters being associated with heavy individual pigs not only are important in themselves, but have a definite relationship with the subsequent rate of growth of the animals, heavier weaners retaining their more rapid rate of growth right through to the market stage."

Wallace found a correlation of 0.7276 (0.526 required for significance at 1%) for birth weight and live weight increase but points out that similar correlations between birth weight and milk yield and milk yield and live weight increase indicate that the connection of birth weight with live weight increase is through the milk supply.

Barnicoat et al reported N.S. correlations when birth weight and rate of gain up to twelve weeks were considered within age or sex groups, but the numbers involved do not allow definite conclusions to be drawn.

Here a correlation (r = .495, 19 df) significant at the 5% level was found in the high plane group but a non-significant one in the low plane (r = .28, 19 df).

In the analysis of the weights of the three groups of lambs in the early weaning experiment (see later) the effect of the initial weight is again apparent. The analysis of variance on weight at 20 weeks and gain in weight from birth to 20 weeks showed a H.S. difference between size of family i.e. singles versus twins. But when the effect of birth weight is allowed for in the analysis of covariance this difference is changed to a N.S. one which means that almost all the differences in final weight and in liveweight gain are explained by birth weight alone. A similar reduction in the variance in the gains in weight was achieved in the milking group lamb data by covariancing birth weight. (Table 27)

Hence it is concluded that the birth weight does have an appreciable effect on the subsequent rate of gain, at least in the first few months of life.

(2) Sex

In that it affects the birth weight, sex can have an influence on the growth rate after birth. Bonsma showed that its influence was limited to this indirect action by eliminating the differences in weight between male and female lambs at twelve weeks due to birth weight; the analysis of residual variance showed that on the basis of equal birth weights the difference was non-significant.

A comparison of the gain made from six to twelve weeks in groups of male and female lambs from data made available by Barnicoat showed no difference between them, the mean gain for each being 22 pounds. These sheep were similar to and run under similar conditions as the stock used in this experiment.

(3) Time of Lambing

Bonsma (1939) reported that early lambs were heavier than late lambs at birth but Donald and McLean (1935) quote figures of Hammond (1932) showing that early lambs (singles) were about 2.2 pounds lighter at one week old than late lambs and find similarly in their own data. They show also, however, that the advantage of late lambs is due to improved condition of the ewe, there being a strong relationship between weight of ewe and birth weight of lamb. This being the case, the difference between Bonsma's result and those of these workers is readily explained by the very different nutritive conditions of the sheep examined.

On the other hand, Phillips and Dawson (1940) did not consider that the birth weight of lambs and the time of lambing were significantly correlated. On further analysis Bonsma finds that although there is a tendency for early lambs to have an advantage over late born lambs, the elimination of the effect of time of lambing as a separate cause for the variation in the growth of lambs is justified.

From the same data that was used to test the effect of sex on growth from 0 - 12 weeks, it was determined here that the date of birth did not influence the weight gains made; the average gains of two groups of single ram lambs being 57.8 pounds for each.

(4) Number of Young

The great difference in weight at birth between single and twin lambs is still apparent at twelve weeks of age but the results of many authors show that the ratio of the weights can be markedly altered. Hammond (1932) concludes that the changes in the ratios are due not only to differences in uterine nutrition but also to post-natal conditions of nutrition governed by the milk supply of the ewe. From his results it would appear that under favourable conditions of nutrition the ratio between the weights of singles and twins may narrow. Phillips and Dawson found that with maturity the weight differences due to type of birth tended to disappear.

The above considerations lead, therefore, to the result that the only two factors that would tend to obscure the effects of the levels of nutrition on groups of lambs in this investigation are the birth weight and the type of birth. The breed, age of ewe and season were common to both groups, the sex and time of lambing had no effect - only birth weight, size of family and nutrition are left of the factors that could cause variation in the relative weight gains. Therefore, allowance has been made for them in the consideration of the differences between the groups of lambs in this experiment.

(ii) Correlations of Yield and Weight Gains

The weight gains made by the lambs over the period 10 - 80 days after birth are shown in Table 28 together with the milk yields in ounces and energy yields in ounces of fat-corrected-milk for the same periods. In Figs.VII and VIII are graphed lamb growth and milk yields.

The gains in weight over the three periods were correlated with the milk yields and with the energy yields, the purpose being to see if the gain and energy were more closely connected than gain and milk yield. The method of determining the yields and the energy values has been described in a previous section, the correlations are tabulated in Table 29.

TABLE - 28

MILK YIELDS, ENERGY YIELDS AND LAMB GROWTH IN THE PERIOD 10 - 80 DAYS AFTER BIRTH

Group	10 - 24 days			24 - 52 days			52 - 80 days			10 - 80 days		
	Milk	Energy	Growth	Milk	Energy	Growth	Milk	Energy	Growth	Milk	Energy	Growth
H.P.S.	715	988	8.0	1328	1641	14.7	874	1205	11.8	2974	3751	34.4
H.P.T.	1073	1516	12.3	1671	2128	24.5	1029	1231	21.3	3774	4875	58.5
L.P.S.	583	866	6.5	818	1161	9.4	414	578	8.0	1813	2606	24.0
L.P.T.	734	1249	7.0	1053	1536	15.5	672	869	14.0	2460	3654	36.5

(Milk yield in ozs. - Energy yield in ozs.F.C.M.)

TABLE - 29

CORRELATIONS OF LAMB GAIN WITH MILK YIELD (OZS) AND MILK ENERGY (OZS. F.C.M.)

Period		High Plane Group		Low Plane Group	
		Singles	Twins	Singles	Twins
10 - 24 days	Milk	.88 (H.S.)	.85	.91 (H.S.)	.59
	Energy	.62 (S.)	.66	.91 (H.S.)	.36
24 - 52 days	Milk	.54	.86	.64 (S.)	.94 (S)
	Energy	.79 (H.S.)	.83	.62 (S.)	.75
52 - 80 days	Milk	.05	.62	.02	.16
	Energy	.14	-.23	.06	.19
10 -80 days	Milk	.60 (S.)	.15	.90 (H.S.)	.72
	Energy	.83 (H.S.)	.82	.88 (H.S.)	.47
Number in Group		12	4	12	4
Value of r for	H.S.	.684	.959	.684	.959
	S.	.553	.878	.553	.878

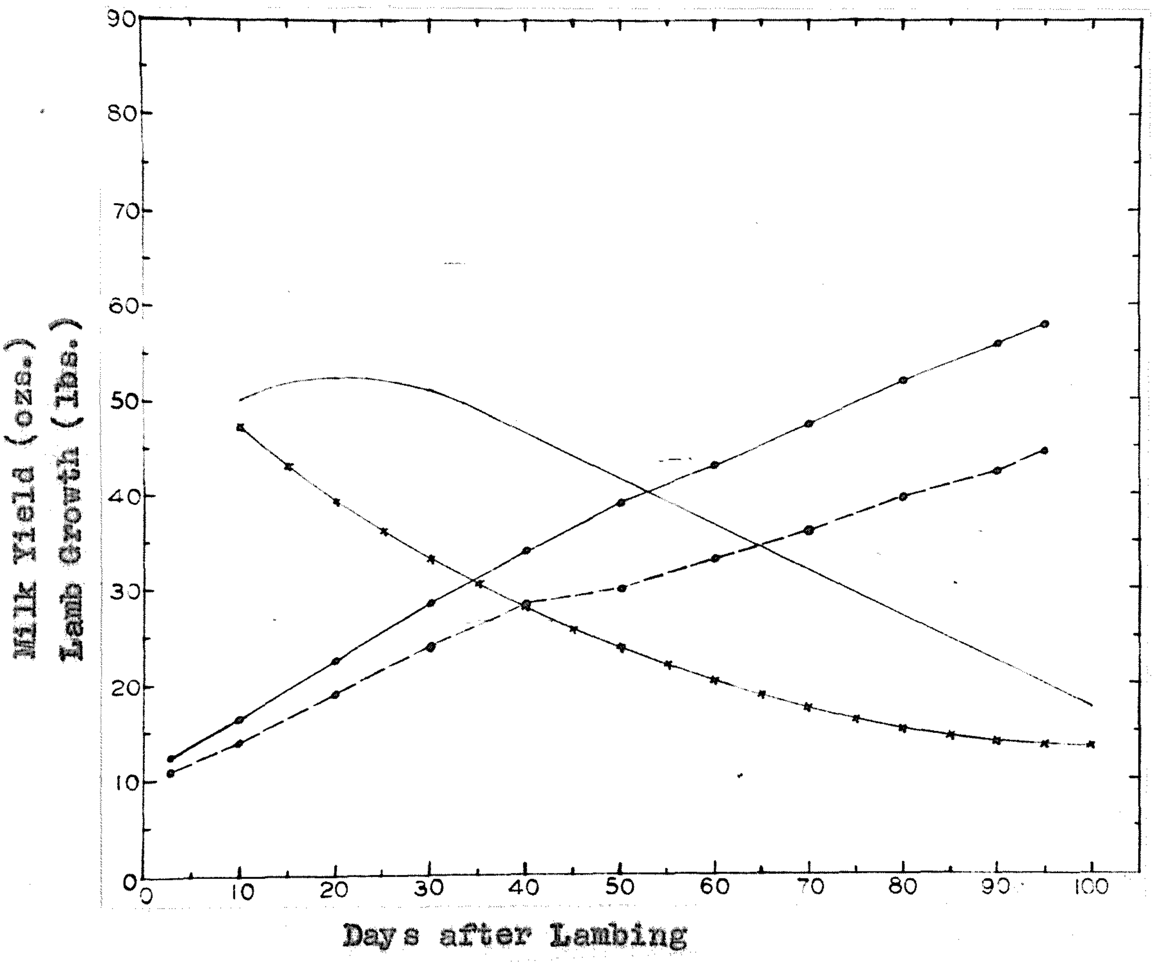


FIG. VII

RELATION OF MILK YIELD TO LAMB GROWTH

Single Lambs

Milk Yield, High Plane	———
Low Plane	×—×—×—×
Lamb Growth, High Plane	•———•
Low Plane	•— — —•

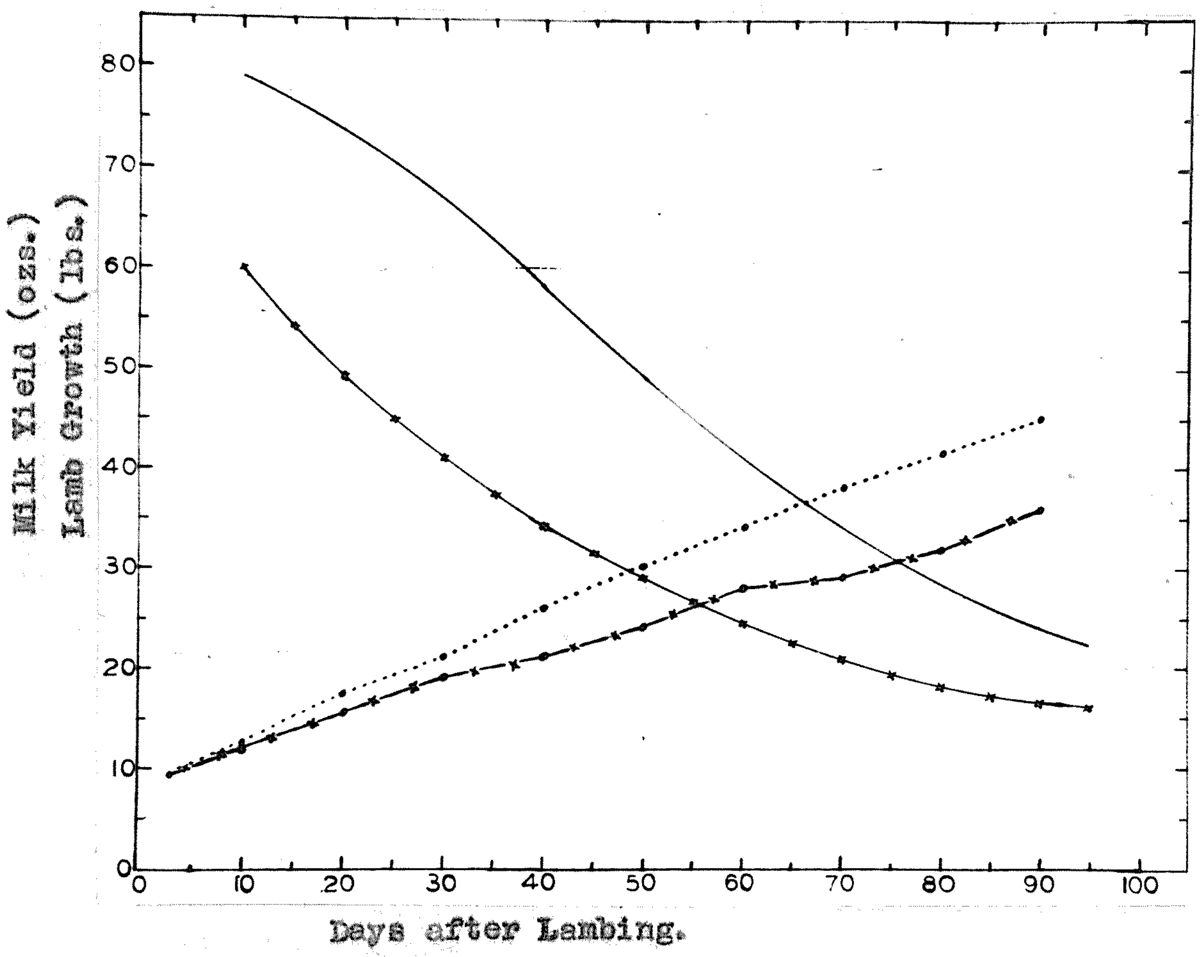


FIG. VIII

RELATION OF MILK YIELD TO LAMB GROWTH

TWIN LAMBS

Milk Yield	High Plane	————
	Low Plane	×—×—×—×—×—×
Lamb Growth	High Plane	• • • • • • • • •
	Low Plane	•—×—×—×—•

It is unfortunate that no estimate could be made of the amount of milk consumed by individual twins. The equal dividing of the total milk produced by a ewe between her twins was not considered valid in view of the finding of Donald (1937) and Bonsma and Oosthuizen (1935) on pigs - the largest pigs in a litter obtained the most milk - and the fact that there was considerable variation in the birth weights of the twin pairs. This meant that the correlations between gain and yield had to be considered within twins and within singles, resulting in a reduction in the degrees of freedom and therefore making it difficult to get significant correlations particularly in the twin groups.

The test for the difference between two correlation coefficients as set out in Snedecor (1950) shows that there is no difference between the two planes with respect to the size of the correlations of milk yield with lamb gain within the same period. In both groups of singles the correlation shows a gradation down from the first period through the second to the third which indicates that the lamb depended less on the milk supply of its dam in the latter stages. In the twin groups the correlations between the first and the second periods are not significantly different and the occurrence of the higher correlations in the second period is merely a chance effect. These groups also show the decrease in the size of the correlation from the first to the last period.

The relationship of energy and lamb gains is the same as for the milk yield and lamb gain and there is no difference in the strength of the correlations between gain and milk intake and gain and energy intake. Note however in the single groups in the first period, the low correlation of energy:growth in the high plane single group.

The relationship between yield and growth appears in the graphs in Fig. 7 and 8. also. The high plane group produced throughout lactation at a higher level than the low plane and the lambs showed a parallel relation between the groups. It is interesting to note in the graphs that the growth curves for the high and low plane groups diverge steadily up till about the fifth week after which the low planes lose relatively even more ground, the high plane curve continuing on up in almost a linear manner. Wallace observed that five weeks was about the average age at which the lambs began to eat pasture and, if these lambs were similar to his in this respect, the wider divergence of the curves at this time would indicate poorer utilisation of pasture by the low plane animals. The well grown young lamb is better able to make full use of its food than the poorly grown one and this, coupled with the dying off of the milk yield of the low plane ewes, resulted in much lower weight gains in the poorly fed group. Another factor was that the heavy stocking rate in the low plane paddocks resulted in a short, soiled pasture which did not compare with that in the high plane area.

This result obviously supports the recommendations of Wallace, Bonsma, Barnicoat et al and Hammond that feeding during the last weeks of pregnancy and during lactation is of primary importance if the lamb is to make the early growth so essential to its later wellbeing and its ability to make use of the available food.

The regression equations of gain in weight on milk yield in the first weeks of life of the lamb, as presented in Table 30, show again the dependence of the lamb on the milk supply of its dam at this stage. The equations for both the high and the low plane groups are very similar showing that the relation is independent of level of nutrition; that it is also independent of breed of sheep is apparent from the similarity of the equations calculated by Wallace (1948) for different breeds. From the regression coefficients it can be seen that for each additional pound of milk consumed in the 10 - 24 days period a gain in weight of approximately 0.16 pounds resulted. Over the first month Wallace found from his regression of live weight on milk yield that each additional pound of milk consumed gave a gain in weight of approximately 0.17 pounds, a figure that agrees very well with the one calculated here.

TABLE - 30

REGRESSION OF LIVE WEIGHT GAIN 10 - 24 DAYS ON MILK AND ENERGY CONSUMPTION 10 - 24 DAYS

Group	Number of Animals	Correlation Coeff. r.	Regression Equation	t for Reg.
H.P.S. Yield	12	0.88	$y = .01x + 1$	5.98 H.S.
Energy	12	0.62	$y = .006x + 2.15$	2.48 S.
L.P.S. Yield	12	0.91	$y = .01x + .08$	6.84 H.S.
Energy	12	0.91	$y = .009x - 1.29$	7.17 H.S.

y (dependent variate) = gain in weight 10 - 24 days in lbs.
x (independent variate) = milk consumption 10 - 24 days in ozs.

Wallace observed that the strength of the correlation over the first month suggested that the growth made by the lamb over this period, which is a much more easily measured quantity than the actual milk yield, might be used to estimate the milk yield of the ewe up to this time. He calculated regression equations to express this relationship. Similarly, since strong correlations were found between gain and milk yield in these data, regressions of milk yield and energy yield on lamb gain were taken out. They appear in Table 31.

TABLE - 31

REGRESSION OF MILK AND ENERGY CONSUMPTION 10 - 24 DAYS ON LIVE WEIGHT GAIN 10 - 24 DAYS

Group		Number of Animals	Correlation Coefficient r	Regression Equation	t for regression	
H.P.S.	Yield	12	0.88	$y = 76.91x + 94.41$	6.15	H.S.
	Energy	12	0.62	$y = 60.29x + 500.91$	2.47	S.
L.P.S.	Yield	12	0.91	$y = 73.67x + 104.55$	6.95	H.S.
	Energy	12	0.91	$y = 95.05x + 248.35$	7.05	H.S.

y (dependent variate) = milk (or energy) intake 10 - 24 days in ozs.
x (independent variate) = gain in weight 10 - 24 days in lbs.

The difference between the yield and the energy regression coefficients in the two planes will be discussed in a later section.

Wallace found that the milk produced in the first month bore a definite relation to that produced over the whole of lactation (average of 38% in the first month) but when similar percentage figures were taken out of these data considerable variation was found both between singles and twins and between planes of nutrition; the same variability was evident in the milk and the energy figures (Table 32).

TABLE - 32

AVERAGE RELATION OF MILK AND ENERGY YIELDS IN 10 - 24 DAYS TO THAT IN 10 - 80 DAYS

Group	Number of Animals	Yield	Energy
H.P.S.	12	23.9%	26.8%
H.P.T.	4	28.4	30.9
L.P.S.	12	34.4	35.5
L.P.T.	4	30.3	34.2

The Table brings out again the effect of the level of nutrition on the milk yield of the ewes - the low plane ewes produced a much higher proportion of their total yield in the first few weeks resulting in a percentage noticeably greater than that of the high plane group.

The lack of a more constant percentage here seems to exclude the possibility of estimating the milk production over a period longer than the first few weeks of lactation from the gain in weights of the lambs.

The dependence of the lamb on the milk supply of the ewe for its optimum growth and development, which has been conclusively shown by a number of workers, mentioned in the above discussion, is an overwhelming inducement to sheep raisers to take the milk yield of the ewe into consideration at culling time. Logan showed that a high proportion of sheep were culled because of "poor Constitution" and pointed out that in many cases the so-called poor constitution resulted from the ewe milking well. The condition and size of the lamb should also be taken into account when the future value of the ewe is up for assessment.

As was shown above, the early nutrition of the lamb has a large influence on the growth that it makes later in life, i.e. the milk supply, which is the only source of food at the time, is of primary importance in the early stages. Therefore an estimation of a ewe's milking ability over the first three weeks may well be a valid basis on which to compare her rearing capabilities with those of other ewes.

The regressions in Table 31 indicate that the milk yield over this short period can be readily estimated from the weight gains of the lamb but before the scheme could be put into practice it would be necessary to determine whether the various factors that effect milk yield fit in with the equations e.g. would a different relationship be required for different breeds and types of sheep? (From Wallace's data this would not seem so but a wider breed range examination is necessary.)

The plane of nutrition does not seem to affect the regression as shown by the agreement between the equations for the high and low plane groups. Wallace emphasised that, in using a method of this kind, it must be remembered that the difference in yield between ewes rearing single and twin lambs may not truly reflect differences in their potential milk producing capacities. The means of obtaining the measure of the milk yield and the importance of using it have been amply demonstrated - what is needed now is a closer examination of the method with larger numbers of sheep, resulting in the evolvement of a practical scheme to be tried on full scale flocks under natural conditions.

Wallace found that the milk yield was more closely related to the live weight at 28 days than to the live weight increase between birth and 28 days. He explained this unexpected result by showing that very high correlations existed between birth weight and milk yield (0.7609), milk yield and live weight increase (0.9188), and birth weight and live weight increase (0.7276). In each case the correlation needed to have a value of only 0.526 for significance at the 1% level. He says -

" The strong correlations between the three "characters are not unexpected, for as has already been shown, "both the birth weight and the level of milk production are "similarly affected by the level of nutrition before lambing, "while the size of the lamb at birth largely determines its "ability to utilize to the full the milk available from its "mother; and, finally, the amount of milk received by the "lamb will clearly influence its rate of live-weight gain."

Here, however, there was no difference between the correlations of milk yield with live-weight at 24 days or with live-weight increase from birth to 24 days. Both correlations had values of 0.88 and were highly significant. This difference from the finding of Wallace is probably due to the low correlations between milk yield and birth weight and live weight increase and birth weight in these data. In Table 33 the low correlations, particularly in the low plane group, stand out.

TABLE - 33

CORRELATIONS BETWEEN MILK YIELD, BIRTH WEIGHT AND LIVE WEIGHT INCREASE 10 - 24 days

	High Plane Singles	Low Plane Singles
Milk Yield : Lamb Gain	0.88	0.91
Milk Yield : Birth Weight	0.63	0.45
Lamb Gain : Birth Weight	0.82	0.42

The reasons for the difference in the correlations of birth weight with milk yield and gain in the two planes are difficult to find. An examination of the mean birth weights in Table 23A shows that with a standard deviation of 2.1 the differences between singles and twins in the two groups were not very great. Apparently the low plane ewes, even though they lost a lot of condition prior to lambing, produced their lambs at the expense of their own body tissues. But their milk yield was disproportionately affected by the treatment in comparison to the effect on the birth weight thus giving rise to a different correlation to that obtained in the high plane group. With this disproportionately low milk yield and a near normal birth weight the lambs made live weight gains that were also out of proportion to the birth weight; this latter effect was due to the high correlation between milk yield and lamb gain. Thus the abberation in the correlations is explained in terms of the varied effect of the treatment imposed on the milk yield and the birth weights. (Barnicoat et al (1949) concluded that feeding during lactation was the primary factor influencing both initial and total milk yield.)

(c) Efficiency of Conversion of Milk to Live Weight Gains.

Brody, (1945) defines gross efficiency as output energy/input energy and net efficiency as output energy/(input energy less maintenance energy). Since lambs differ in their size at birth - this was particularly true of the high and low plane groups in this experiment (Table 23A)-their respective maintenance requirements will obviously differ also and therefore it was thought that the net efficiency of conversion of milk to live weight gains would supply a better perspective of the comparative efficiencies of the two groups of lambs than the gross energy estimation as used by Barnicoat et al (1949) and by Bonsma (1939)

The difficulty is in arriving at a reasonable value of the maintenance requirement of the animal over the period under consideration. Donald (1937) describes one method of achieving this, but in addition to the assumptions regarding the amount of milk required to produce unit live weight increase he made use of the relation maintenance : $W^{0.73}$ a relationship which does not hold for young growing animals. (Brody)

Woodman (1948) who gives tables of the maintenance requirement of sheep, says -

"No attempt is made in this table to state the requirements "of sheep below 60 lbs. live weight. Studies of energy "metabolism have shown that the "surface law" is not "applicable to lambs, and that it would therefore be incorrect "to attempt to deduce, on the basis of that law, the maintenanc "requirement of sheep below 60 lbs. live weight."

Another obstacle in the way of applying the net efficiency ratio was that apart from a short period early in lactation when it could be presumed that the lambs were eating no herbage (and for much of this period the milk intake was unknown) the exact intake was uncalculable owing to the fact that the lambs were grazing pasture with no measure of the amount eaten being taken.

The drawback of the gross efficiency as a measure of the efficiency of milk utilisation by the lamb is that no allowance is made for the maintenance requirement - a big lamb will be using a high proportion of the food intake for maintenance and only a small part for growth, i.e. there will be a low gross efficiency while a small lamb will use a larger proportion for weight gains and will show a higher gross efficiency. This, obviously, gives a biased comparison of the two efficiencies.

Weight gains are a poor measure of the use to which food is put because the different types of tissue laid down require different amounts of energy for the same weight increase, e.g. fat and muscle or bone. The animal laying down the higher energy requiring tissue would appear the least efficient, perhaps untrue.

However, since it was not possible for the above reasons to determine the net efficiency, the gross efficiency was calculated in the hope that the figures might have some value.

For each ewe the average ounces of milk and ounces of F.C.M. consumed per pound gain in live weight of the lamb were calculated in the three periods and an analysis of variance carried. These are shown in Tables 34 and 35.

TABLE - 34

ANALYSIS OF VARIANCE OF GROSS EFFICIENCY CALCULATED ON OUNCES OF MILK INTAKE PER POUND GAIN IN LIVEWEIGHT FOR H.P. AND L.P. (PLANES), SINGLES AND TWIN (TYPES) AND PERIODS 10 - 24, 24 - 52, 52 - 80 DAYS.

Source of Variation	df	SS	MS	F	Result
Total	89	71,383.95	802.07		
Periods (P)	2	11,182.32	5,591.16	10.30	H. S.
Planes (Pl)	1	231.89	231.89	0.43	-
Types (T)	1	2,903.60	2,903.60	5.35	S.
P x Pl	2	1,066.67	533.34	0.98	-
Pl x T	1	1,237.00	1,237.00	2.28	-
T x P	2	4,308.90	2,154.45	3.97	S.
P x PL x T	2	8,650.49	4,325.25	7.96	H. S.
Error	77	41,803.08	542.90		

S. D. = 23.30

General Mean = 82.25

(C = 28.33%)

TABLE - 35

ANALYSIS OF VARIANCE OF GROSS EFFICIENCY CALCULATED ON OUNCES OF F.C.M. INTAKE PER POUND GAIN IN LIVE WEIGHT FOR H.P. AND L.P. (PLANES), SINGLES AND TWINS (TYPES) AND PERIODS 10 - 24, 24 - 52 & 52 - 80 DAYS

Source of Variation	df	SS	MS	F	Result
Total	89	183,908.16			
Periods (P)	2	39,674.82	19,837.41	17.38	H. S.
Planes (Pl)	1	2,274.06	2,274.06	1.99	-
Types (T)	1	2,050.13	2,050.13	1.80	-
P x Pl	2	7,304.08	3,652.04	3.20	S.
Pl x T	1	3,777.94	3,777.94	3.31	-
T x P	2	12,962.34	6,481.17	5.68	H.S.
P x Pl x T	2	27,970.39	13,985.20	12.25	H. S.
Error	77	87,894.40	1,141.49		

S. D. = 33.75

General Mean = 113.30

C = 29.82%

The mean figures for these periods and for 10 - 80 days are shown in Table 36.

TABLE - 36

EFFICIENCY OF CONVERSION OF MILK YIELD AND ENERGY YIELD TO WEIGHT GAINS

Period		High Plane Group		Low Plane Group	
		Singles	Twins	Singles	Twins
10 - 24 days	Milk	91.9	87.6	88.55	111.2
	Energy	127.0	123.6	133.1	191.7
24 - 52 days	Milk	91.9	69.1	96.3	68.3
	Energy	111.3	87.1	137.0	102.5
52 - 80 days	Milk	84.9	48.4	60.6	52.3
	Energy	107.0	58.2	81.7	69.4
10 - 80 days	Milk	87.6	68.0	76.5	69.6
	Energy	108.9	87.8	110.2	105.3

Efficiency = ozs. milk or ozs. F.C.M. /lbs. gain.

The values in Table 36 represent the average amounts of milk consumed in ounces per pound of live weight gain and the average amounts of F.C.M. in ounces consumed per pound live weight gain. Bonsma and Barnicoat et al have also studied this relationship. Bonsma (1939) found an apparent increase in the average amount of milk consumed per pound gain in live weight as the level of total milk intake increased, indicating that the increase in live weight was not directly proportional to the increase in milk intake. Of the various factors which are probably associated with this apparent decrease in the efficiency of milk utilisation with increase in the total milk yield of the ewes he suggests the following :

"1. An increased level of milk intake would promote an increase in the rate of growth, leading to larger and heavier lambs, with a higher maintenance requirement at any given time than lambs on a lower level of milk intake.

2. Lambs reared on a higher level of milk intake would be in

a better position to promote fattening simultaneously with growth.

3. Lambs from low milk yielding ewes would naturally be more prone to consume other food than those reared by good mothers, whose milk supply would be more likely to satisfy their requirements.

A comparison of the milk consumption per pound gain in live weight, based on the first period only (i.e. 1 - 3 weeks), when the lambs were entirely dependent upon their dams' milk and little or no fat was as yet being produced, indicates no significant difference between the different levels of milk intake in the efficiency of milk utilisation. "

In 1944 he examined the efficiency of utilisation of milk by the lambs of different first and second cross ewes. The crosses were rams/mutton breeds by Merino and by Blackhead Persian ewes. No significant difference was found between Merino crosses or between Blackhead Persian crosses but the differences in utilisation between cross-bred Merino and Blackhead Persian ewes were highly significant particularly during the first 3 weeks. This breed difference was possibly due to inherent metabolic differences, closely associated with the adaptability of the Blackhead Persian to South African conditions.

Barnicoat et al (1949) found a change over in relative efficiency between the first few weeks of lactation and the later periods - in the early stages the lower milk intake groups were less efficient converters because a greater proportion of the energy from the milk was required for maintenance purposes, in the later periods the consumption of grass compensated for the lower milk intake and high efficiency resulted.

Thus it would appear that in considering the average figures in Table 36 three factors must be kept in mind, viz:

1. The relative maintenance requirements of the different groups, which depends on the body weight.
2. The levels of milk intake.
3. The amount of food other than milk which was consumed by the lambs.

Therefore in Table 37 the efficiency ratios are again presented but alongside each is the average milk and energy yield, the average body weight and the average gain for the period considered.

Note that in Tables 36 and 37, ewe No.28 was excluded owing to her abnormal efficiency ratio (231 in the first period against the average figure of 88) and to even the numbers in the high and low plane groups, No.8 was eliminated from the high plane group by random choice.

TABLE - 37

AVERAGE WEIGHTS, GAINS IN WEIGHT, YIELDS AND EFFICIENCIES IN THE PERIODS 10 - 24, 24 - 52, and 52 - 80 DAYS

Group	Average weight lbs.	Average yield ozs.	Average energy ozs. F.C.M.	Average Gain lbs.	Efficiency Ratio	
					Yield	Energy
10 - 24 days						
H.P.S.	21	706	967	8	(3) 91.9	(2) 127.0
H.P.T.	32	1073	1516	12	(1) 87.6	(1) 123.6
L.P.S.	18	583	833	7	(2) 88.6	(3) 133.1
L.P.T.	29	734	1249	7	(4) 111.2	(4) 191.7
24 - 52 days						
H.P.S.	33	1318	1641	15	(3) 91.9	(3) 111.3
H.P.T.	50	1671	2128	25	(2) 69.1	(1) 87.1
L.P.S.	28	818	1161	9	(4) 96.3	(4) 137.0
L.P.T.	42	1054	1536	15	(1) 68.3	(2) 102.5
52 - 80 days						
H.P.S.	45	855	1166	11	(4) 84.9	(4) 107.0
H.P.T.	72	1029	1231	21	(1) 48.4	(1) 58.2
L.P.S.	36	414	578	8	(3) 60.6	(3) 81.7
L.P.T.	55	672	868	14	(2) 52.3	(2) 69.4
10 - 80 days						
H.P.S.	35	2974	3885	34	(4) 87.6	(3) 108.9
H.P.T.	55	3774	4753	55	(1) 68.0	(1) 87.8
L.P.S.	30	1812	2814	25	(3) 76.5	(4) 110.2
L.P.T.	44	2459	3696	36	(2) 69.6	(2) 105.3

(NOTE: Figures in brackets in the last two columns refer to the rank order of efficiency of the groups within each period.)

Consider the analyses of variance, Tables 34 and 35. The difference in efficiency between periods is H.S. increasing progressively with the age of the lambs. This effect parallels the decrease in the correlation coefficients between lamb growth and milk intake. Both effects are due to increased intake of grass with increase in age.

No satisfactory explanation can be offered for the appearance of the significant difference between types in the yield analysis and not in the energy analysis or for the significance of the period x plane interaction in the energy analysis and not in the yield analysis. From an examination of the mean efficiencies for the 10 - 80 day periods it would seem that twins were more efficient on both the yield and the energy bases but the reason for the non-significance in the energy analysis is not obvious from this data.

It is necessary to point out that with coefficients of variation of the order that occur here (28 and 29 per cent) with groups of such small size, and with the complicating effects of the unknown pasture intake, a result significant at only the 5% level is not very reliable and not too much regard can be taken of it.

The interaction between period and type means that the singles and twins differed in the way in which their efficiencies changed from period to period. This is clearly seen in the Table of means, Table 38. In the high planes the efficiency figures (milk basis) for singles in the three periods are 91.9, 91.9, 84.9 respectively, and for twins 87.6, 69.1 and 48.4 respectively. In the low plane the greater rate of increase of efficiency for twins is even more marked, the corresponding figures being 88.6, 96.3 and 60.6, and 112, 68.3, 52.3. The difference in reaction to time change is obvious. The greater rate of increase of efficiency in the twin groups was due to the fact that the twin lambs, individually, were on a lower intake than single lambs. Grass began to play an important part in their diet at an earlier age than it did for singles and hence their gross efficiency of milk utilisation increased more rapidly with time. Other factors slowing down the change of efficiency of the singles were -

(a) The greater relative increase in weight up to this time (twice that of a twin lamb in the first period) owing to the better diet, resulting in a greater relative increase in maintenance requirement,

(b) the slower adaption to grass feeding, and

(c) the change in the nature of the weight gains made from muscle and skeletal tissue to fatty tissue with its higher energy demand per weight unit.

The same interaction is apparent in the mean efficiencies on the energy basis.

It is important to remember when comparing the periods that they were of different length, the second and third being twice as long as the first.

The triple interaction (highly significant in both analyses) provides more information on the relationship of types, planes and periods. It means that the singles and twins reacted differently in the planes in the different periods.

In the high plane single group the efficiency did not change from the 1 - 2 periods and it increased only a little from the 2 - 3 periods. The high plane twins' efficiency increased from the 1 - 2 period and increased greatly again from the 2 - 3. That is, twins changed differently to singles in the periods within the high plane. The efficiency of the L.P.S. decreased from the 1 - 2 period and increased from the 2 - 3 periods while the L.P.T. increased markedly from 1 - 2 and 2 - 3 periods. That is, the singles and twins changed differently from period to period within the low plane.

The increase in efficiency of the high plane singles from the 2 - 3 period was much less than that of the L.P.S., though the lack of marked change from 1 - 2 periods was common to both. The increase for H.P.T. for the 1 - 2 periods is smaller than that of the L.P.T. while in the 2 - 3 period the increase is greater in the H.P.T. That is, the planes differed in the changes made from period to period within the one type. Therefore singles changed differently to twins and the H.P. changed differently to the L.P. between periods.

This triple interaction is most strikingly shown by the comparison of the two extreme groups, the H.P.S. and the L.P.T. From the 1 - 2 period the former increased in efficiency from 91.9 to 84.9 while the latter increased from 111.2 to 52.3, a much greater change. This shows the difference in the change of type - planes to period.

The changes in the four groups from 1 - 3 periods were 7.0, 35.2, 28.0, and 58.9 for the H.P.S., H.P.T., L.P.S., and L.P.T. respectively. All twins were higher than all singles, L.P.T. were higher than all H.P. and L.P.S. were high than H.P.S. , i.e. the change was different over the period in all the groups, a triple interaction.

Consider the interaction in the energy analysis (Table 35); note the means (Table 37).

The effects noticeable were the same in form as in the yield means. Twins were greater than singles, low planes were greater than high planes, all groups differed.

The underlying reason for this interaction of plane, type and period was that the low plane lambs were on a lower milk and energy intake than the high planes and the twins, as individuals, not pairs, were on lower intakes than singles (see mean figures in Table 37). The lower the milk intake the sooner the lamb took to pasture with a consequent decrease in the amount of milk intake per pound of weight gain, i.e. an increase in gross efficiency.

The analyses show that overall there was no interaction between plane and type, i.e. singles and twins did not differ in their efficiency between high and low planes and that there was no difference between planes, i.e. that lambs on different levels of intake did not differ in efficiency.

These results show, therefore, that the importance of milk to the lamb is in the early weeks and that the age at which the lamb begains to consume grass in quantity varies according to the level of the milk intake, the higher the intake the older the lamb.

The very nature of the gross efficiency relationship makes it difficult to arrive at more precise conclusions on the efficiency of milk utilisation by lambs. The interplay of the various factors mentioned in the above discussion - the level of milk intake, the maintenance requirement, the amount of other food consumed and the nature of the weight gains made - obscures the relation of one lamb to another with respect to efficiency of milk utilisation. Until the net efficiency, which is a true measure of efficiency, is accurately determinable, this relation must remain unknown.

(d) The Value of the Estimation of the Energy of Ewes' Milk

The energy yield of milk is a much more fundamental concept than the milk yield. Milk varies widely in composition and contains a large percentage of water which has no more nutritional value than water from any other source. Moreover, it seems that the production of the water fraction of the milk requires no expenditure of energy by the animal. When the production of the animal is measured on a milk basis alone, the water of the milk is placed on an equal footing with the solids, which obviously gives inaccurate comparisons. For theoretical reasons, then, the energy measure of the production of ewes should provide a more accurate picture of the relationship between individual ewes, between groups of ewes and between ewes and their lambs.

The method of determining the energy yield of the milk used in this investigation was described in a previous section and throughout the text figures based on the energy evaluation have been included for comparison with the milk yield figures.

Considering the analyses of variance for milk and energy (Tables 6 and 12) and the mean values (Tables 5 and 11), it is apparent that there is no real difference between the results on the two bases or between the standard deviation for the two sets of data, i.e. the energy evaluation did not alter the relationship between planes or types or reduce the variability of the data. Gaines (1928) concluded that the milk yield is inversely proportional to the energy value per unit of milk, i.e. that the energy yield is not affected by the fat per cent of the milk. From this it followed that the variability in milk yield between animals due to difference in composition was eliminated when yield was measured on an energy basis. This was not the case in the data obtained here. (Note - That there was variability in composition in these data was shown in the section on composition, Table 14)

The growth of the lamb is dependent on the milk supply of the ewe in the early stages and it is the nutrients in the milk that affect the growth and not the absolute volume of milk. It could be expected, therefore, that if the energy estimation was a better measure of nutrient value of the milk than the milk yield a closer relationship would be evident between the lamb gains and energy than between lamb gains and milk yield over the first few weeks after birth.

In Table 29 are the correlation coefficients between milk and growth and between energy and growth. As mentioned below this table, there was no significant difference in these correlations(z test), but notice was drawn to the low value of the high plane singles' energy yield: lamb growth correlation.

The analyses of variance of efficiency of utilisation of milk yield and of efficiency of utilisation of energy yield show variation in the results with respect to types and the interaction between plane and period. It was pointed out, however, that the level of significance was not high enough for much reliance to be placed on these differences in result. In other respects, i.e. in the H.S. results obtained, the two analyses are similar. The means of the two lots of data show no notable difference in relative size or the way in which they alter with time, plane of nutrition or type of birth.

Apart from chemical analysis the only measure we have of the nutritive value of the milk is the growth made by the lamb. Therefore it was thought that if the amount of variance in the gains explained by milk intake and the amount explained by energy intake were compared, any differences in the relative accuracy of the two measures of yield as an estimation of nutritive value would be apparent.

Accordingly, lamb growth in the period 10 - 24 days was covarianced for milk yield and energy yield and the values of $(SPxy)^2/ SSx$ and SSy taken out of each analysis and compared. $(SPxy)^2/ SSx$ is a measure of the variance in the lamb gains that can be accounted for by the food intake and SSy is a measure of the total variance in the data. The relation $(SPxy)^2/ SSx / SSy$ expressed as a percentage provides a means of comparing the relative efficiencies of the two estimates of intake (milk and energy) in accounting for the variance in the lamb weights.

TABLE - 38

ANALYSIS OF COVARIANCE: X - MILK YIELD, Y - LAMB WEIGHT GAINS, 10 - 24 DAYS, SINGLES ONLY.

Source of Variation	df	SSX	SPXY	SSY	Y'	df	MS	F	Result
Total	21	838,320.00	9202.00	120.96	19.95	21			
Planes	1	103,228.17	1246.08	15.04					
Error	22	735,091.83	7955.92	105.92	19.81	22	0.90		
Diff.(P)					0.41	1	0.14	0.16	-

General mean gain = 7.29 lbs.

Standard deviation = ± 2.19

C = 30.04%

$$\frac{(SPxy)^2}{SSx} \div SSy \times 100 = 81.30\%$$

The figure 81.30% means that the intake of milk ounces accounted for this percentage of the variance in the weight gains made by the lambs in the single group.

As was to be expected when the variance due to intake was removed, the significant difference between the gains made by the high and low planes (see Table 25) disappeared. At this early stage milk formed practically the whole diet and the differences in yield of the ewes determined the different gains that the lambs made. The adjusted means in Table 39 are much closer together than the unadjusted ones.

TABLE - 39

MEANS & ADJUSTED MEANS: LAMB GAINS 0 - 24 DAYS ADJUSTED FOR MILK INTAKE

Group	Mean Yield X ozs.	Deviation from experiment mean x	Product bx	Mean Gain Y lbs.	Adjusted mean gain. Y-bx lbs.
H.P.S.	714.6	65.6	0.72	8.08	7.36
L.P.S.	583.4	- 65.6	-0.72	6.5	7.22

Experiment mean yield = 649 ozs.

b = 0.011

TABLE - 40

ANALYSIS OF COVARIANCE: X - ENERGY INTAKE, Y - LAMB WEIGHT GAINS, 10 - 24 DAYS, SINGLES ONLY

Source of Variation	df	SSX	SPSY	SSY	Y'	df	MS	F	Result
Total	23	1,182,579.96	9670.54	120.96	41.88	22			
Planes	1	89,426.04	1159.79	15.04					
Error	22	1,093,153.92	8510.75	105.92	39.66	21	1.89		
Diff.(P)					2.22	1	2.22	1.17	-
		C = 30.04%							

$$\frac{(SPXY)^2}{SSx} \div SSy \times 100 = 62.66\%$$

i.e. 62.66% of the variance in lamb gains was due to differences in the energy yields of the ewes.

TABLE - 41

MEANS AND ADJUSTED MEANS: LAMB GAINS 0 - 24 DAYS ADJUSTED FOR ENERGY (F.C.M.) INTAKE

Group	Mean Yield X ozs.	Deviation from experiment mean x	Product bx	Mean Gain Y lbs.	Adjusted mean gain Y -bx lbs.
H.P.S.	988.25	61.04	0.48	8.08	7.60
L.P.S.	866.17	- 61.04	- 0.48	6.50	6.98
		Experiment mean energy = 927.21 b = 0.008			

The percentage figures calculated seem to be very different. It is not possible to determine whether the difference is statistically significant or not. The adjusted means shows that the variation due to milk yield was greater than that due to energy. The difference between the mean gains corrected for milk yield is 0.14 lbs. while the difference between the same gains corrected for milk energy intake is 0.62.

From this data, then, the conclusion is reached that the measure of milk performance of Romney ewes as the amount of energy produced (calculated as fat-corrected-milk by the procedure described above) is certainly no better than the direct measure of yield of milk. Whether it is a poorer evaluation cannot be decided on this evidence alone.

This result is rather surprising considering the theoretical grounds on which the estimation is founded and the wide use that is made of the F.C.M. calculation in the dairying world. Three possible explanations can be put forward, viz:

(a) Perhaps the relationship of energy to fat in ewes milk is not the same as that in cows milk, i.e. the F.C.M. formula may not be valid. Its use in this investigation was based on the agreement between the energy of ewes milk determined in the bomb calorimeter and the energy calculated from the formula of Overman and Sanman (1926) as found by Pierce (1934). In view of the findings of this and other investigations quoted on the methods of obtaining milk samples for analysis, Pierce's samples may not have been truly representative.

(b) The growth of the lamb may not be directly related to the energy content of the milk, i.e. a lamb may be able to use a certain amount of energy in a dilute form better than it can use it in a more concentrated form. Thus there could conceivably be a more direct relation between milk yield and growth than there would be between energy and growth.

(c) Liebig was quoted in the Introduction to the effect that the rate of growth of an animal is determined by the amount of protein and mineral matter in the food. Table 1 shows the general relationship between these constituents of milk and the time required by the young of different species to double their birth weights.

During the lactation of dairy cows the fluctuations in fat concentration are greater than those of any other milk constituent; the protein shows a lesser, but still considerable, variation and the ash remains remarkably uniform (Heineman, 1921). From the tables of composition given by Barnicoat et al (1949) and from those of this investigation, it is evident that the milk of sheep has a similar relation between fat and protein plus ash.

The consequence of the more constant percentage of protein and ash is that the absolute amount of them in the milk is more closely related to milk yield than is the absolute amount fat. As the yield falls the fat percentage rises more than that of protein and ash and the amount of energy, calculated from the fat concentration and the yield, that the lamb receives does not fall the same relative amount as the other constituents. That is the lamb is getting very much less "growth materials" (protein andminerals) and only a little less energy. Hence the relationship of energy:growth is thrown out.

This could account, then, for a higher relationship between total milk yield and growth than between total energy yield and growth.

PART II - EARLY WEANING EXPERIMENT

Methods and Materials

Fifty 4-year old Romney ewes running in the same block as the high plane group above were set aside for this and Inoculation experiments (see later). The latter used four ewes with twin lambs and six others were lost for one reason or another, e.g. death of lamb and/or ewe. This left forty-one ewes after lambing in good health and condition in the experiment; they had all received the same treatment from tupping, being rotated around the one acre paddocks of the nutrition block in mobs of 20 - 30 and managed according to ordinary farm practice.

Of the forty-one ewes, nineteen had twin and twenty-two had single lambs and the sex ratios were as follows :

Twins	Ewe pairs	6
	Ram "	7
	Ram) Ewe) "	6
Singles	Ewes	6
	Rams	16

It was therefore possible to divide the sheep and lambs into three groups, each group having 2 ewe single lambs
5 ram single lambs
2 ram/ewe twin pairs of lambs
2 ram twin pairs of lambs
2 ewe twin pairs of lambs.

The extra ram-ram pair and the extra ram single were added to one group. This group was made the earliest group as it was the one in which was thought losses were most likely to occur, owing to the treatment.

Group 1 was weaned at nine weeks of age.
Group II -do- twelve -do-
Group III -do- sixteen -do-

As each lamb reached weaning age it was moved to a specially fenced paddock at the farthest possible distance from the paddocks in which its dam was running; the pasture in this paddock had been carefully eaten down some days previously and allowed to freshen-up before the weaned lambs were put into it. A few dry ewes were grazed with the lambs to keep them calm, and, to control the pasture growth, several young cattle beasts were included.

The weights of the lambs were recorded within three days of birth, similarly to the high and low plane groups, and thereafter they were weighed approximately every fortnight. All lambs, except one that was killed early in error, were kept and weighed until they were twenty weeks of age plus or minus a few days. This one lamb's weight record was eight days short of the twenty weeks but since the growth curve was practically a straight line the weight at 140 days was obtained by producing the curve on the required distance.

The recorded weights of each lamb were plotted on a graph and the weights at weekly intervals after birth read off by interpolation. These figures were those used in the comparison of the weight gains made by lambs from birth to 140 days of age.

Killing weights and carcase gradings at the Longburn Meat Works are included in the data.

Results and Discussion

The most extensive study so far on the early weaning of lambs is that by H.C. Bonsma and D.J. Engela (1941) with Merino ewes and cross bred lambs in South Africa. Their investigation consisted of two sections; in the first there were three groups of lambs weaned at eight, ten and twelve weeks, respectively, and a fourth group, the control, unweaned. These were fed dry feed consisting of lucerne hay and maize. The second contained one group of lambs which were all weaned at eight weeks and which ran on winter cereal pasture throughout the experiment. Comparative figures for this section came from the results of experiments conducted with similar cross bred lambs kept on winter cereal pasture from birth. The intakes of the lambs were carefully measured so that estimations of the costs of production between the various groups could be made. Slaughter results were included in the data to expose the effect of the treatment on the finish of the carcase.

They found that there was no significant difference between the weight gains made by the early weaned and the control groups of lambs. The carcases of the early groups also showed up favourably on comparison with the control groups. The difference in production costs was highly significant in favour of the early weaners, a saving of twenty per cent being estimated to be effected by weaning at eight weeks and at this stage returning the ewes to the veld.

Percival (1951), working with grade Jersey calves, was able to recommend the practice of early weaning particularly to town milk suppliers who did not have available the quantities of skim milk used by butterfat producers to rear their young stock. The early weaned calves had their milk ration reduced at six weeks and cut out altogether at eight weeks while the controls went on to skim milk between the sixth and eighth weeks. The growth rate of the early weaners was severely checked at six weeks, so much so in fact that at six weeks they were heavier than the controls while at eight weeks the controls were the heavier. At eight weeks no weaning check appeared in the early weaners and they made a good recovery from eight to eleven weeks. From eleven to eighteen weeks they grew at a satisfactory rate thoughnnot as fast as the controls. At eighteen weeks the difference in weight (28 lbs.) was about 13 per cent the weight of the controls, but body measurements indicated that this difference was due to condition rather than to any great difference in size. At thirty-five weeks the difference between the two groups had reduced to 9 lbs. and it was apparent that in a few more months early and late weaned animals would be indistinguishable.

Examination of the weights of the early weaned calves at weaning time showed that the practice of early weaning can be overdone and the results indicated that 100 lbs. is the minimum weight at which weaning should be undertaken. The recommendation was that weight is a better guide to the best early weaning stage than age.

The optimum age for weaning lambs was also investigated by Bosman and Bonsma (1944) in South Africa. They also recommended that weight rather than age may be the better index and that early weaning (eight weeks) is advantageous.

(a) Growth Rates

Table 42 contains a summary of the results of the weaning treatments, and curves showing comparative growth rates are graphed in Fig. IX.

TABLE - 42

SUMMARY OF RESULTS OF WEANING TREATMENTS; ABSOLUTE WEIGHTS

Weaning Group		Weight in pounds at -					Gain
	Birth	1 wk.	9 wks.	12 wks.	16 wks.	20 wks.	0 - 20 wks.
Singles							
9 weeks	12.4	15.5	49.0	57.1	64.7	76.3	63.9
12 weeks	12.2	16.8	46.7	56.4	66.1	76.5	64.3
16 weeks	13.8	19.2	53.1	63.8	75.0	85.9	72.1
Twins							
9 weeks	10.6	14.5	40.7	48.9	57.9	69.3	58.7
12 weeks	10.9	14.0	38.2	48.0	58.3	69.8	58.9
16 weeks	10.9	14.3	38.6	48.5	58.7	71.0	60.1

TABLE - 42A

SUMMARY OF RESULTS OF WEANING TREATMENTS; GAINS IN WEIGHT

Weaning Group	Weight gains in pounds from					
	Birth-1 wk.	1-9 wks.	9-12 wks.	12-16 wks.	16-20 wks.	0-20w
Singles						
9 weeks	3.1	33.5	8.1	7.6	11.6	63.9
12 weeks	4.0	30.5	9.7	9.7	10.4	64.3
16 weeks	5.4	33.9	10.7	11.2	10.9	72.1
Twins						
9 weeks	3.9	26.2	8.2	9.0	11.4	58.7
12 weeks	3.1	24.2	9.8	10.3	11.5	58.9
16 weeks	3.4	24.3	9.9	10.2	12.3	60.1

From this Table and from Fig. IX the sixteen week weaners seem to have made greater weight gains than the other groups. This apparent difference is analysed more fully in Tables 43 and 44.

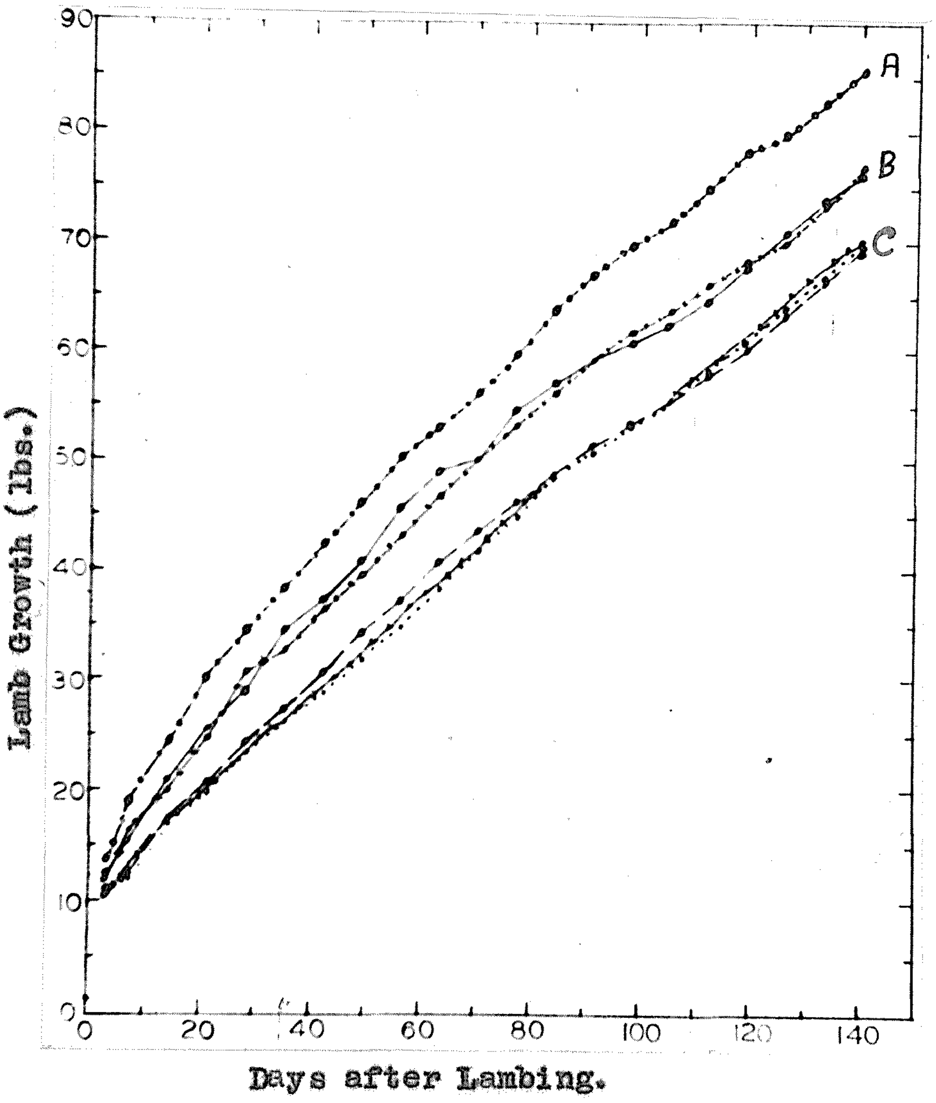


FIG. IX

GROWTH OF LAMBS WEANED AT DIFFERENT DATES

Singles weaned at	9	weeks	——	B
-do-	12	"	—×—×—	
Singles weaned at	16	"	—o—o—	A
Twins Weaned at	9	"	— — —	C
-do-	12	"	· · · · · ·	
-do-	16	"	—Δ—Δ—	

TABLE - 43

ANALYSIS OF VARIANCE IN GAIN IN WEIGHT
0 - 20 weeks

Source of Variation	df	SS	MS.	F	Result
Weaning dates	2	179.4824	89,7412	1.85	-
Type	1	726.8359	726.8359	14.95	H.S.
Interaction	2	126.3148	63.1574	1.30	-
Error	51	2479.1125	48.6100		
Total	56	3511.7456			

General Mean Gain = 62.12

Standard Deviation = ± 6.97 lbs.

C = 11.22%

The first analysis done was in gains of weight from birth to twenty weeks. One lamb from the first group was omitted (random choice) to even the numbers in the groups.

The analysis shows that (a) weaning at different dates had no significant effect on the gains in weight in the first twenty weeks; (b) single lambs gained significantly more weight in the period that did twins (see analysis of covariance for further analysis of this point); (c) the reaction of the lambs to altered weaning date was not significantly different in the two types.

A similar analysis was done in the final weights at twenty weeks. (Table 44).

TABLE - 44

ANALYSIS OF VARIANCE IN FINAL WEIGHTS AT 20 WEEKS

Source of Variance	df	SS	MS	F	Result
Weaning dates	2	248.0000	124.0000	2.01	-
Type	1	1,196.0002	1,196.0002	19.42	H.S.
Interaction	2	190.6270	95.3135	1.55	-
Error	51	3,140.5833	61,5801		
Total	56	4,775.2105			

General Mean weight = 73.46
Standard Deviation = ± 7.85 lbs.
C = 10.68%

The conclusions here are the same as for gain in weight.

Both of these analyses ignore the influence of the initial weights on the gains and on the final weights. To show how much of the above results are due to this effect alone, an analysis of covariance was required (Table 45).

TABLE - 45

ANALYSIS OF COVARIANCE; Y - GAINS IN WEIGHT, 0 - 20 WEEKS, X - BIRTH WEIGHT

Source of Variation	df	SSX	SPXY	SSY	
Total	56	193.4825	518.6700	3,511.7456	
Weaning dates	2	5.9035	36.0900	179.4824	
Type	1	54.4299	202.3900	726.8359	
Interaction	2	6.1342	21.9500	126.3148	
Error	51	127.0149	258.2400	2,479.1125	1,95
Date + E	53	132.9184	294.3300	2,658.5949	2,00
Diff. (D)					52
Type + E	52	181.4448	460.6300	3,205.9484	2,03
Diff. (T)					82
Int. + E	53	133.1491	280.1900	2,605.4273	2,015
Diff. (T)					61

In this analysis the tests of weaning dates, type and interaction all give N.S. results.

TABLE - 46

ANALYSIS OF COVARIANCE - Y WEIGHT AT 20 WEEKS
X - BIRTH WEIGHT

Source of Variation	df	SSX	SPXY	SSY	Y'
Total	56	193.4825	726.0263	4775.2105	
Weaning dates	2	5.9035	37.2631	248.0000	
Type	1	54.4299	255.1434	1196.0002	
Interaction	2	6.1342	33,0484	190.6270	
Error	51	127.0149	400.5714	3140.5833	1877.28
Date + E	53	132.9184	437.8345	3388.5833	1946.35
Diff.(D)					69.06
Size + E	52	181.4448	655.7148	4336.5835	1966.92
Diff.(S)					89.63
Int. + E	53	133.1491	433.6198	3331.2103	1919.06
Diff.(I)					41.77

Once again the tests of weaning date, type and interaction all give non-significant results.

Thus it has been shown that the **significant** differences in gain and in final weight are explained almost entirely by initial weight alone, and not by twinning as such. That is, if the twin lambs were born at the same weight as singles, their gains in weight up to twenty weeks would not be significantly different.

These conclusions are brought out also in the table of adjusted means, Table 47.

TABLE - 47

MEANS AND ADJUSTED MEANS FOR BIRTH WEIGHT - GAINS 0 - 20 weeks in Lbs.

Group	Mean Birth Weight lbs. X	Deviation from experiment mean x	Product bx	Mean gain Y	Adjusted mean gain Y - bx
9 weeks					
Singles	12.14	0.54	1.10	(4) 64.0	(4) 62.90
Twins	10.33	- 0.27	- 0.55	(1) 58.83	(1) 59.38
12 weeks					
Singles	12.14	0.54	1.10	(5) 64.29	(5) 63.19
Twins	10.58	- 1.02	-2.07	(2) 59.0	(2) 61.07
16 weeks					
Singles	13.57	1.97	4.00	(6) 72.29	(6) 68.29
Twins	10.83	- 0.77	- 1.56	(3) 60.08	(3) 61.64

Experiment mean birth weight = 11.60 lbs.

b = 2.03

The rank order of the means and the adjusted means (figures in the brackets) in the table was unchanged. The difference between the adjusted means is less than the difference between the unadjusted means, i.e. when the effect of birth weight on the gains is removed the difference between the different groups of animals come together as was shown by the non-significant result in the covariance analysis.

TABLE - 48

MEANS AND ADJUSTED MEANS FOR BIRTH WEIGHT, WEIGHT AT 20 WEEKS, in lbs.

Group	Mean birth weight lbs. X	Deviation from experiment mean x	Product bx	Mean weight Y	Adjusted mean wght. Y - bx
9 weeks					
Singles	12.14	0.54	1.70	(4)76.14	(4)74.44
Twins	10.33	- 1.27	-4.00	(1)69.17	(2)73.17
12 weeks					
Singles	12.14	0.54	1.70	(5)76.43	(5)74.73
Twins	10.58	- 1.02	-3.21	(2)69.75	(1)72.96
16 weeks					
Singles	13.57	1.97	6.21	(6)85.90	(6)79.69
Twins	10.83	- 0.77	-2.43	(3)70.92	(3)73.35

Experiment mean birth weight = 11.60 lbs.

b = 3.15

Unlike the case of adjusted means of gain in weight, the rank order altered in the adjusted means of weight at twenty weeks, the 9 week twins becoming heavier than the 12 week twins; but the differences are small in both mean columns (0.58 and 0.21 lbs. respectively).

It is noticeable from the rank order in both columns of adjusted means in Tables 47 and 48 that the twins are all below the singles and that the singles grade up from the 9 week group to the 16 week group. Within both singles and twins the 16 week groups are the highest and their advantage over all other groups in both final weight and weight gains is considerable. To examine this advantage more closely, an anlysis of variance was carried out on singles only for gain from birth to twenty weeks.

TABLE - 49

ANALYSIS OF VARIANCE OF WEIGHT GAINS, 0 - 20 WEEKS, SINGLES ONLY

Source of Variation	df	SS	MS	F	Result
Weaning dates	2	301.79	150.89	2.47	-
Error	18	1103.50	61.31		
Total	20	1405.29			

General mean gain = 66.86

Standard Deviation = ± 7.83

C = 8.54%

The means of the three groups of singles were 64.0, 64.3 and 72.1 lbs. for the 9, 12 and 16 week groups respectively. The difference in the gains made by the last group over the other two is not significant even when no account is taken of the initial weight in which the 16 week group had a considerable advantage (see Table 42). The size of this difference in gains made and the greater slope of the 16 week singles' growth curve in Fig.IX point to the importance of a further investigation with a larger number of animals to determine whether a difference in growth rate really exists.

Bonsma (1941) reached a conclusion similar to this. Though his earliest weaned group suffered an apparent set back at weaning time, no significant differences in gain showed up in the statistical analysis and he emphasises the essentiality of obtaining more data on a larger number of animals before "it can be conclusively proved that the rate of growth is actually affected to any appreciable extent." It is important to point out that Bonsma's control group was unweaned throughout and they therefore had an advantage over the other groups in that they suffered no weaning check over the period considered. This may not have made much difference (and what difference it did make was in favour of the late weaners) because the older the lambs at weaning the less severe the check.

The only group in this experiment in which a distinct check in growth rate at weaning is apparent was the 9 week singles. Their curve of weight gains is by far the most irregular of all over its whole length and the decrease in slope at the weaning age of 63 days may not be entirely due to the effect of the change in diet. The check does not appear to have been of a permanent nature.

In this investigation it was not possible to estimate the relative costs of production for the various weaning groups as Bonsma, with his careful records of daily intake, was able to do. The saving due to improved health and wool production of the ewe as well as the saving of feed, were also uncalculable. However, Bonsma and Percival both found that a considerable reduction in costs resulted from the practice of early weaning - the latter found this in spite of the lesser growth rate of the early weaners - and the suggestion is that a similar reduction would be found in this case.

Percival printed a table showing, in the earliest weaned group, the relationship of the weight at weaning to the weight at eighteen weeks. He found a definite relation, the lower weight animals at weaning showing the greater percentage underweight at eighteen weeks. In Table 50 are figures showing the differences in weight at twenty weeks, of lambs in the 9 weeks weaning group weaned at different weights. The numbers in brackets indicate the number of lambs from which the figures were obtained.

TABLE - 50

9 WEEK WEANERS: FINAL WEIGHT IN RELATION TO WEANING WEIGHT (LBS.)

Weight at Weaning	Weight at 18 weeks	Difference from mean of late weaners at 20 wks.	Per centage underweight
Singles		(86 lbs.)	(Under 86 lbs. at 20 weeks)
44.5 (2)	73	13	15.1%
49 (3)	77	9	10.5%
50.5 (2)	75	11	12.8%
Twins		(71 lbs.)	(Under 71 lbs. at 20 weeks)
28.0 (1)	61	10	14.1%
38.2 (4)	66	5	7.0%
42.0 (5)	70	1	1.4%
48.0 (2)	79	(8 lbs. over-weight)	-

There is general evidence of a relationship between weaning weight and final weight in this table but it is not as clear cut as that obtained by Percival. No recommendation can be made on this scanty evidence on the advisability of weaning at a set weight rather than at a set age or on the weight that would be most suitable if the former method proved the better of the two.

(b) Slaughter Results

This data were not available for all the lambs in all the groups so, by random choice, equal (17) numbers of singles and twins were chosen from each group and their slaughter results compared. These are shown in Table 51.

TABLE - 51

WEANING EXPERIMENT SLAUGHTER RESULTS

Weaning Group	Liveweight at Slaughter	Dressing per cent	Age (days)
9 week	76.8	43.6	155
12 "	77.4	43.6	155
16 "	79.4	44.0	154

Chi-square tests on the carcase grading in the three groups and in the 9 and 16 week groups were non-significant.

In Table 51 the early weaned groups compare very well with the older weaners and the agreement between the three groups here is much closer than that declared satisfactory by Bonsma in his data.

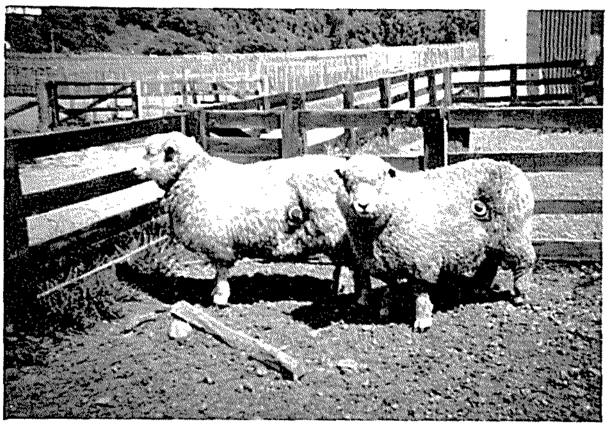
The conclusion is that the groups of weaners in this experiment showed no differences in dressing percentages, age at slaughter or quality of carcase as juded by the commercial grading system.

From the results of this experiment and those of Bonsma and Percival it is concluded that the practice of early weaning has much to recommend it. Lambs on good country weaned at nine weeks of age make satisfactory growth in comparison to lambs weaned at greater ages. The conditions under which these lambs and ewes were run were first class North Island fat lamb conditions and whether the same results would be obtained on poorer country is a matter of conjecture until further experimentation is carried out.

PART III - INOCULATION EXPERIMENT

Methods and Materials

The rumen material used in this experiment was obtained from two wethers with rumen fistulas belonging to the Grasslands Division of the Department of Scientific and Industrial Research, which at the time of sampling were on a diet of fairly coarse, stemmy grass.



Sheep with rumen fistula.

Rumen contents were collected at 8.30 a.m. by means of a metal spatula and placed immediately into a thermos flask heated to approximately 37°C. (Woodman and Evans (1938) have shown that the temperature of the sheep rumen is about 37°C) There were about 150 ml. of rumen contents, fairly solid, with much coarse fibre and little free liquid; they were diluted by shaking vigourously in 400 ml. of fresh cow's milk and strained through coarse muslin. Milk was chosen because it was thought to be a suitable incubation medium of the required pH and containing nutrients suitable for micro-organic-life. The result was a dull green liquid of the consistency of milk and this is what is referred to as "the liquor" hereafter.

A sample of the liquor was examined under the microscope, hanging-drop and Gram stain preparations being employed. An examination was made one hour after collection from the rumen and again two and a half hours after. Large numbers of bacteria (mostly Gram positive) and Protozoa were observed to be present and actively motile and no change in the micro-population could be noticed between the two examinations, either in number of organisms present or in their motility. Since Baker (quoted by Pearson and Smith (1943)) has shown that no significant change takes place in rumen ingesta prepared similarly to the above in the first two to four hours of incubation, this was considered sufficient evidence that the liquor being inoculated into the lambs was representative of the flora and fauna of the sheep from which it was taken. In this experiment the time interval between collection and inoculation did not exceed two hours.

After dilution, the liquor was quickly replaced in the thermos flask and transported to the nutrition block. The lambs, eight in all, were drenched with the standard drenching gun with one ounce of the liquor per lamb, care being taken to see that it went down the oesophagus and liberally coated the inside of the mouth and lips.

An attempt was made to get the lambs to take the solid unstrained rumen content - if small lumps were used the lambs could be made to swallow it by pushing it well into the throat and holding the mouth closed; otherwise they ejected it. However, the drenching method was much simpler and since Pearson and Smith (1943) found that the strained liquor was rich in Protozoa and bacteria, this latter method was the one finally adopted. Also, since the lambs were weaned and wholly dependent on pasture for their needs, it was thought that they would soon fill their bellies with fibrous matter and therefore it would not be of any great advantage to introduce fibrous matter with inoculation.

The lambs used were four sets of twins that had originally been included in the early weaning experiment and which, up to the time of weaning, had received treatment identical with those in it. They were weaned at nine weeks of age and were so chosen that they would all be taken from their mothers within the shortest space of time possible viz. three days. The first pair were weaned on the 17th October and the last pair on the 19th. Inoculations were done on the 20th, 21st and 23rd October.

Liveweights were recorded as for the other groups of lambs and the data handled similarly. Control animals for this investigation were those in the nine weeks weaning group of the early weaning experiment.

Dung analysis was made to try and detect whether the treatment had had any effect on the digestive powers of the animals. The two groups of lambs, treated and controls, were shut in a shed with a wooden floor in separate pens, left for about four hours and the total excrement collected; this was done on the 29th October, the 6th November and the 14th November.

The samples were dried in the water oven and stored in labelled bottles till the collection period was over; they were dried in the electric oven, finely ground and allowed to take up moisture again before being analysed for moisture, ash, protein and crude fibre.

Results and Discussion

(a) Lamb Growth

In Table 52 and Fig. X the weight gains made by the two groups are compared.

TABLE - 52A

AVERAGE WEIGHTS OF INOCULATED & CONTROL LAMBS (lbs.)

Group	Birth Weight	Weight at			Gain in Weight
		1 week	9 weeks	20 weeks	
Inoculated	10.3	13.6	37.7	61.1	50.8
Control	10.6	14.5	40.7	69.3	59.5

TABLE - 52B

AVERAGE WEIGHT GAINS OF INOCULATED & CONTROL LAMBS (lbs.)

Group	Birth -1 week	1 - 9 weeks	9 - 20 weeks
Inoculated	3.3	24.1	23.4
Control	3.9	26.2	28.6

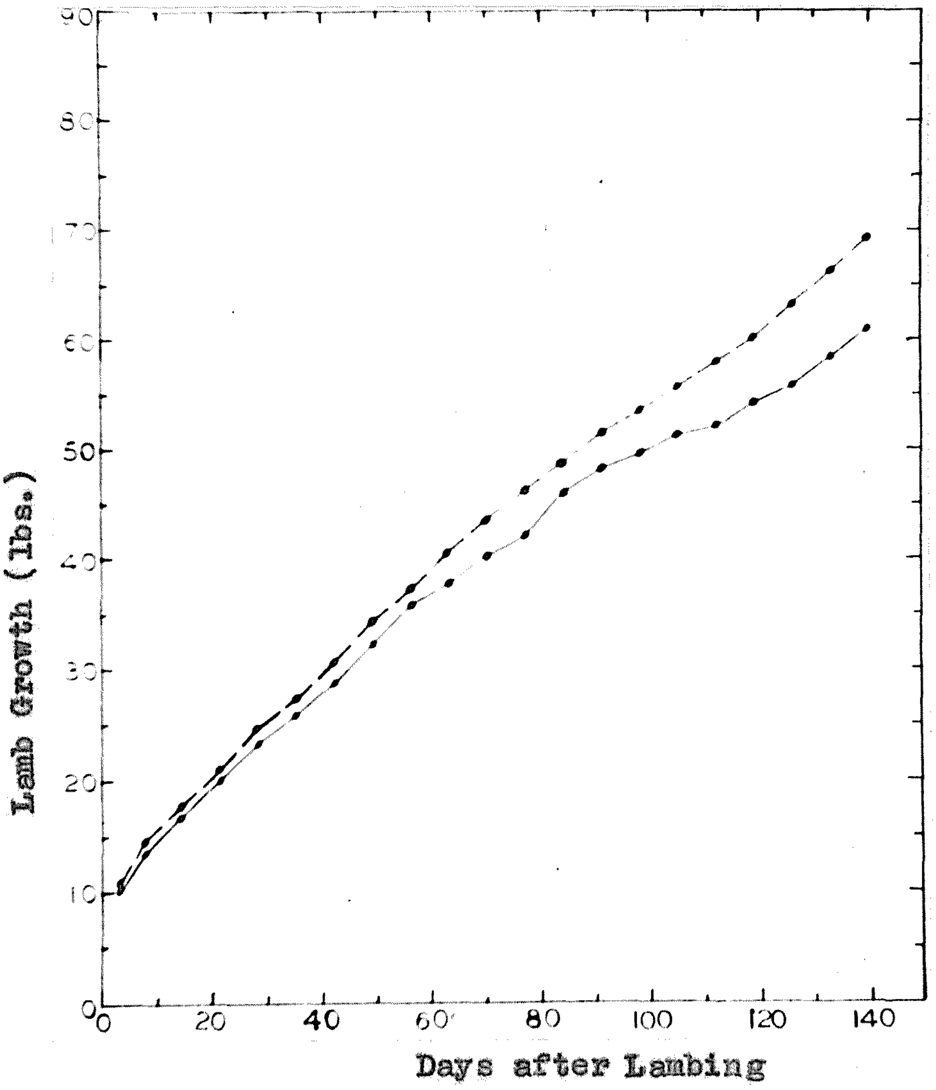


FIG X

GROWTH OF INOCULATED AND CONTROL LAMBS

Inoculated ●————●

Control —●— —●— —●—

The Figure shows very clearly that the inoculated lambs grew at a slower rate than the control group the difference in gain over the twenty weeks being 8.7 lbs. The significance of the variation between the groups is evident in the analysis of covariance.

TABLE - 53

ANALYSIS OF COVARIANCE: X- BIRTH WEIGHT
Y GAIN, 0 - 20 WEEKS

Source of Variation	df	SSX	SPXY	SSY	Y'	df	MS	F	Result
Total	19	55.49	103.97	1245.95	1051.15	18	61.83		
Groups	1	0.30	10.34	357.07					
Error	18	55.19	93.63	888.88	730.04	17	42.94		
Diff.(G)					321.11	1	321.11	7.48	S

General Mean gain = 56.05

Standard deviation = ± 6.84

C = 12.20%

The adjusted mean gains are tabulated in Table 54.

TABLE - 54

ADJUSTED MEAN GAINS OF INOCULATED AND
CONTROL LAMBS FROM 0 - 20 WEEKS

Group	Mean birth weight X lbs.	Deviation from experiment mean x	Product bx	Mean gain Y lbs.	Adjusted mean gains Y - bx
Inoculated	10.38	- 0.12	- 0.22	50.88	51.10
Control	10.63	0.13	0.24	59.50	59.26

Experiment mean = 10.50

b = 1.87

The difference between the adjusted mean gains is significant, i.e. the slower rate of growth of the inoculated group is a real difference. Figure X shows that the inoculated lambs lost weight with respect to the controls from birth and in order to see if the gains made after the treatment were significantly different between the two groups, the gain from nine to twenty weeks was covarianced for weight at nine weeks. (Table 55).

TABLE - 55

ANALYSIS OF COVARIANCE: X - WEIGHT AT NINE WEEKS, Y - GAINS IN WEIGHT, 9 - 20 WEEKS.

Source of Variation	df	SSX	SPXY	SSY	Y'	df	MS	F	Result
Total	19	436.50	104.50	792.00	766.98	18			
Groups	1	43.80	73.51	125.05					
Error	18	392.70	30.99	666.95	664.50	17	39.09		
Diff.(G)					102.48	1	102.48	2.62	N.S.

General mean gain = 26.5

Standard deviation = 6.09

C = 23.0%

TABLE - 56

ADJUSTED MEAN GAINS OF INOCULATED AND CONTROL LAMBS FROM 9 - 20 WEEKS

Group	Mean weight at 9 wks. X lbs.	Deviation from experiment mean x	Product bx	Mean gain Y lbs.	Adjusted mean gain Y-bx
Inoculated	37.7	- 1.8	- 0.144	23.44	23.30
Control	40.7	1.2	0.096	28.55	28.46

Experiment mean/9 weeks weight = 39.5 lbs.

b = 0.079

The small reduction in the difference between the mean gains when the adjusted means were calculated and the non-significant result in the analysis of covariance indicates that no effect on the growth rate of the inoculated lambs by the treatment can be inferred from these data. The significant difference in the weight gains made between birth and twenty weeks may be due in part to the treatment but this can not be determined from the evidence in hand. Part or all of the difference in gains was most certainly due to some other factor which operated from birth.

(b) Slaughter Results

The Chi-square test applied to the carcase gradings given at the Longburn Freezing Works gave a non-significant result. That is, no difference in the gradings of the two groups could be stated with certainty to exist.

In Table 57 are the average liveweights at slaughter, the dressing percentages and the ages of the two groups of lambs. The only difference appears to be in age. The inoculated group, because of their slower growth rate, took a longer time to reach killing weight than did the control group.

TABLE - 57

INOCULATION EXPERIMENT SLAUGHTER RESULTS

Group	Liveweight at slaughter (lbs.)	Dressing per cent	Age (Days)	Number of Animals
Inoculated	75.2	42.5	178	7
Control	77.0	43.0	160	12

(NOTE: Carcase weights were frozen weights, i.e. hot carcase weight less 4½%.)

(c) Dung Analyses

A summary of results is presented in Table 58.

TABLE - 58

INOCULATION EXPERIMENT DUNG ANALYSES (DRY MATTER BASIS, PER CENT)

Date sampled	30/10/51		6/11/51		14/11/51	
Group	Control	Inoculation	Control	Inoculation	Control	Inoculation
Protein %	24.3	24.4	17.1	21.1	23.1	23.8
Ash %	22.4	21.3	40.4	32.2	24.3	22.8
N.F.E. and ether Extract % (by difference)	35.7	32.1	30.0	29.5	35.9	36.2
Fibre %	17.6	22.2	12.5	17.2	16.7	17.2
Totals %	100.0	100.0	100.0	100.0	100.0	100.0
Protein/O.M.%	31.3	31.0	28.7	31.1	30.5	30.8
N.F.E./O.M.%	46.0	40.8	50.3	43.5	47.4	46.9
Fibre/O.M.%	22.7	28.2	21.0	25.4	22.1	22.3

No consistent differences between the two groups can be observed over the Table. It is noticeable, however, that the percentage of crude fibre is greater in the inoculated group in the first two samplings which again is the reverse of what would be expected. The differences between the groups are also much less in the third sampling than in the other two.

It must be realised that the number of sheep from which these samples were taken was small and that the samplings were few. For any concrete result to emerge, the differences between samples would need to be large and consistent, requirements which are not fulfilled in the figures in Table 58.

This preliminary trial shows, therefore, that no advantage can be gained by carrying out rumen inoculations of lambs by the procedure described above. The weight gains made by the two groups, the comparative slaughter results, and the dung analyses, reveal no superiority of the inoculated lambs over the other group which is the result that was sought after.

There are two facts which may partly account for the anomalous results, viz:

(a) The season was a poor one for lambs, being exceptionally wet - over twice the average rainfall was recorded in Manawatu for the months October and November.

(b) The inoculation group of lambs was so chosen that they all reached nine weeks of age within a few days of each other. It so happened that to accomplish this the group of lambs chosen were all early lambs and were among the first ten lambs to be weaned in the whole flock running on the nutrition block. The control group was weaned at the same age but the spread of their lambing dates was much wider and they were weaned over a long period. Some occurrence adversely affecting lamb growth may have taken place early in the season and affected the inoculation groups more severely than the control.

SUMMARY and CONCLUSIONS

PART I - MILKING EXPERIMENT

Considerable discussion of results having taken place in the various sections above, only the major issues with which the investigation was concerned will be dealt with here.

The great variation in environment to which sheep in New Zealand are subjected in their life time was stressed in the Introduction and the importance of knowing the effects of this variation on the ewes pointed out. This investigation was designed primarily to examine the effects of plane of nutrition on the yield and composition of the milk of the Romney ewe and on the growth of her lambs over the suckling period.

Differences in milk yield of the ewes on high and low planes of nutrition are shown by the average figures for the period 10 - 80 days. The high plane singles and twins produced 2973 and 3774 ounces respectively and the low plane singles and twins 1812 and 2459 ounces. The differences in total milk yield were due to differences in level of production throughout lactation and in persistency of milk flow, the low plane groups being less in both respects.

The composition of the milk showed lactational trends for fat, total solids, solids-not-fat, protein, lactose and ash. The low plane of nutrition caused the fat to rise and the solids-not-fat, the protein and the ash to fall, but there was no change in the total solids or lactose.

An analysis of variance on performance in previous seasons and in this one showed that there was no evidence of repeatability of milking ability in these data.

An estimate was also made of the energy of the milk and the energy yields of the ewes were compared over the same periods as for milk yield. The high plane single and twin groups yielded 3885 and 4753 ounces of fat-corrected-milk (4 per cent) respectively and the low plane singles and twins 2814 and 3696 ounces. The four groups are in the same order here as they were for yield of milk. The energy calculation had no "smoothing effect" on the data, there being just as much variation in the yields of the individual ewes within a group on the energy basis as on the milk basis.

The results show, therefore, that ewes need to be adequately fed if they are to yield milk of normal composition to the fullest extent of which they are capable.

A detailed study of the growth of the lambs in the milking groups and of the relation of their weight gains to the milk yield of the ewes was also made. Of the factors affecting lamb growth at this early stage (10 - 80 days), besides the effect of the plane of nutrition imposed, only birth weight and type of birth (i.e. single or twin) were important under the conditions of this experiment.

Significant differences in growth were found between the high and low plane lambs and between singles and twins, some of the latter being due to differences in birth weight.

Correlations between milk yield and lamb growth over successive periods of the lactation show the almost complete dependence of the lamb on the milk supply of the dam over the first weeks of life and the decrease in dependence as the lamb ages, e.g. in the high plane single group the correlations ran 0.88, 0.54 and 0.05 for the three successive periods of two, four and four weeks.

In view of this result the need of breeding ewes capable of yielding a plentiful supply of milk, particularly while the lamb is young, hardly needs emphasis. A poorly grown lamb will not be able to make full use of the food available to it in later life; the most critical stage therefore is the early period after birth.

Highly significant regressions were

found for lamb weight gain on milk yield in the early stages and for milk yield on lamb gain over the same period. These equations give further support to the suggestion of developing a method for estimating the comparative milking ability of ewes from the growth of the lambs.

Efficiency of conversion of milk into weight gains by the lambs was determined for all groups. The gross efficiency increased as the lambs neared weaning age due to the increased consumption of food other than the milk of the ewes. Interaction effects between planes, periods and types in the analysis of variance were explained in terms of differences in the level of milk intake and in the ages of the lambs when they first began to eat pasture in quantity. The importance of the milk supply in the early stages was emphasised again by these figures.

Throughout the study correlations between intake and lamb growth rate were compared on the basis of both milk energy (expressed as 4% fat-corrected-milk) and actual milk yield. The results show that the weight of milk yielded is a better measure of the value of the milk to the lamb than the total milk energy when the latter is determined from the percentage of fat in the milk and the weight of milk yielded. The main reason for this appeared to be that the growth of the lambs was more dependent on the amounts of protein and ash in the milk ingested than on the energy intake. The protein and ash followed the absolute yield of milk more closely than did the energy content and thus the relationship between milk yield and lamb growth was closer than that between energy yield and lamb growth.

The most important result emerging from this experiment is the dependence of the lamb on the milk supply of its dam for maintaining maximum growth. The yield of milk is therefore a most important characteristic of ewes. This is particularly so in New Zealand where the fat lamb industry relies greatly on the production of quickly fattening lambs, which requires rapid growth in the early post-natal stages, the period when milk yield is all-important.

Taking the milk yield of the ewe into consideration in a breeding plan would present practical and theoretical difficulties. As has already been pointed out the problem of measurement of yield could be overcome by using the weight gains of the lamb over the first few weeks as an index of milking ability. This would not be practicable except in a very general way under any but stud conditions. In a commercial grade flock where the individual ewes and lambs are not identified it would be well nigh impossible to use the lamb as an index of the ewe's value except for between mob or between flock comparisons.

The addition of another item to the selection index would greatly reduce the selection potential and this may be the most serious disadvantage to the inclusion of milk yield in the estimation of a ewe's worth. Whether or not the yield of milk is taken into consideration will depend on its relative economic value and, though this value is difficult to determine, it may well be higher than the relative economic values of some of the criteria at present regarded by stud masters as being of importance.

The principal aim of this experiment was to study the effects of overstocking on the milk yield of grazing ewes. At the same time it was hoped to gain some insight into the effect on the yield and composition of the milk of the transfer of sheep from one type of country to another, viz: from fat lamb conditions to hill country conditions and vice versa. Under the system of fat lamb raising in New Zealand such a transfer is common practice - the flock ewes from the stud breeders (lowland country) go on to the hills early in life and later, as cast-for-age ewes, are sold to the fat lamb farmers on the rich flats where they are used for one or two seasons longer.

It would be most difficult to carry out this milking technique with ewes on the harder hill country. It was considered that by imposing a low plane of feeding on grazing ewes, the results would at least give some indication of the performances of hill country ewes.

The validity of any conclusions drawn from this parallel would depend on how nearly the conditions of the low plane group approached those of sheep grazing on hill country. The pastures that these low plane sheep were grazing were typical high grade fat lamb pastures except that, in this instance, the grass was grazed down short and consisted mostly of the fibrous lower portions of the plants. It was considerably soiled also for a great deal of the time, particularly in the wet weather. The pasture species were mainly perennial ryegrass (Lolium perenne) and white clover (T. repens). The area to which the sheep were confined was restricted so that the carrying capacity was very high - average of about nine ewe equivalents per acre in comparison to the normal stocking of about six ewe equivalents per acre.

In contrast, ewes on hill country, though getting equivalent amounts of bulk food, are under very different conditions. The stocking rate is much less (2 - 3 ewes) - the sheep have more scope and get the pick of the tops of the grasses at most times. The pastures are rarely composed of ryegrass and white clover alone but contain in addition quantities of brown-top (A. tenuis), crested dogstail (C. cristatus), sweet vernal (A. ororatum), yorkshire fog (H. lanatus), danthonia (D. pilosa), suckling clover (T. dubium), and perhaps subterranean clover (T. subterraneum). The bigger area and the more rugged topography that the hill country ewe covers also result in much higher energy requirements for movement.

Therefore, in comparison to normal hill country, the conditions under which the low plane ewes in this experiment ran must be regarded as artificial. Nevertheless, despite this, the experiment can be interpreted broadly from the point of view of differences in nutritional planes of grazing animals, in contrast to previous results obtained with penned animals fed concentrates.

The results certainly emphasise the disadvantageous effects of overstocking on milk yields and suggest that the milk yields of hill country ewes are of a distinctly lower order than those of similar animals under better conditions.

PART II - WEANING EXPERIMENT

The purpose of this investigation was to compare the effects of different weaning dates, viz: nine, twelve and sixteen weeks, on groups of similar lambs. The results show that, at least under good conditions, lambs weaned at nine weeks of age compare favourably with later weaned lambs. There were no significant differences between the weight gains made or in the slaughter results of the three groups of lambs.

A considerable saving in costs of production could be expected from early weaning due to saving of pastures and protection of the health and condition of the ewes, the earlier the weaning the greater the saving. The results indicate that weight rather than age may be the better indicator of weaning date.

PART III - INOCULATION EXPERIMENT

A small group of lambs nine weeks of age and just weaned was inoculated with rumen ingesta from mature sheep. The object of the experiment was to determine whether an improvement in growth would result from the early establishment of a mature microflora in young sheep.

The results were inconclusive but indicate that under the excellent conditions of nutrition prevailing in New Zealand the practice would not have much value. There is the possibility, however, that under harder conditions some small assistance to the lamb such as this, may prove to be of practical importance and the results do not suggest that further experiments in this line would be unwarranted.

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APPENDIX TABLE I

MILKING GROUP EWE WEIGHTS (lbs.)

Ewe No.	15/3	29/3	19/4	2/5	18/5	1/6	19/6	29/6	13/7	30/7	7/8	11/9	25/9	10/10	23/10	5/11	19/11	6/12
8	148	147	139	150	152	152	150	150	155	161	163	147	148	143	146	143	149	146
9	117	118	113	120	123	122	122	122	128	129	131	155	-	130	125	131	133	128
34	139	144	138	144	152	151	151	154	156	158	161	124	126	126	126	127	126	104
40	139	140	138	147	158	158	162	166	174	179	182	149	135	153	153	154	156	149
65	105	106	100	108	116	117	123	126	131	130	130	100	102	98	103	101	103	99
86	135	136	133	140	142	142	143	146	152	152	152	-	143	138	134	133	133	131
88	131	133	131	144	143	143	150	151	153	152	148	111	110	107	108	107	108	104
96	150	151	137	150	156	157	158	162	171	176	183	156	155	149	145	144	146	139
104	118	117	106	118	121	115	110	106	110	117	125	120	123	119	114	116	117	113
123	150	147	144	151	155	152	151	149	144	142	144	117	118	116	124	121	124	120
185	130	131	128	133	138	138	141	142	144	144	143	150	155	135	137	135	130	125
391	135	137	124	143	149	150	155	156	161	169	170	141	149	145	142	145	147	144
408	154	157	150	159	165	166	166	168	171	169	172	142	137	136	140	137	140	130
39	134	131	126	141	146	146	151	152	155	158	161	122	115	115	114	114	117	111
55	127	127	116	131	137	135	138	144	151	157	162	110	110	111	112	112	112	104
140	142	145	138	146	152	153	154	156	161	162	162	133	127	126	134	128	125	119
89	182	190	178	184	180	186	185	187	194	191	195	-	182	170	170	169	169	167

APPENDIX TABLE 1 (Contd.)

Ewe No.	15/3	29/3	19/4	2/5	18/5	1/6	19/6	29/6	13/7	30/7	7/8	11/9	25/9	10/10	23/10	5/11	19/11	6/12
1	129	134	120	136	141	125	129	127	129	136	137	114	114	106	103	99	111	103
10	149	150	141	149	148	142	143	142	143	146	149	122	118	116	110	106	116	111
16	144	137	134	140	145	131	130	128	127	126	131	100	91	91	95	93	105	109
28	100	109	92	102	104	97	93	92	92	95	95	69	67	71	76	70	72	-
41	123	116	109	109	109	101	104	103	102	103	108	86	91	90	93	91	100	105
58	129	133	128	137	140	138	140	136	133	133	133	97	99	92	84	83	93	94
85	136	137	129	139	146	130	126	125	124	127	130	95	93	91	90	89	96	100
87	137	135	125	129	135	125	126	125	124	124	127	120	124	122	118	119	125	125
106	134	133	130	142	146	134	132	131	132	136	140	109	102	98	98	93	102	106
74	106	105	94	102	109	101	102	101	103	100	103	84	82	78	79	80	84	88
319	149	149	140	149	151	145	141	141	140	137	141	146	149	150	160	-	169	171
217	110	111	109	120	126	110	111	108	106	101	100	106	83	85	82	82	81	88
219	143	143	139	148	155	142	137	134	135	132	136	149	130	125	130	115	120	-
48	135	136	133	140	148	139	137	136	134	134	137	83	81	79	80	78	94	94
67	148	143	140	153	158	146	145	144	144	141	142	151	-	105	106	102	106	106
117	112	153	143	154	157	146	147	146	145	151	158	112	102	98	99	97	108	112
52	152	153	143	157	165	153	152	151	152	154	161	108	109	106	108	103	115	115

APPENDIX TABLE II

RECORDED MILK YIELDS

Ewe No.	Date 17/8	25/8	2/9	9/9	16/9	23/9	29/9	6/10	13/10	25/10	3/11	17/11	1/12	13/12
Time Interval in Days		8	8	7	7	7	6	7	7	12	9	14	14	12
							High Plane							
8	–	–	55½	54	62	58½	63½	57½	43½	39½	40	30	19½	–
9	–	–	–	–	–	–	72½	55½	60	58½	46	44½	40½	22½
34	–	16½	21½	31	32	32	31	22	21½	19	14½	13½	9	–
40	4/9 –	–	–	–	49	44	44½	41	41	40	28½	30	28½	14
65	–	41	46½	45½	53	48½	45	45½	38	40½	35	29	19½	–
86	–	–	–	–	66½	56½	58	53½	48½	42½	25½	26½	15	14
88	–	32	36	41	33	35½	31½	34	33	26	19½	15	13	–
96	–	–	77½	69½	59	66	53	59½	57	41½	35½	27½	18	–
104	–	44½	58½	65	65½	61½	48	41½	38½	32	26½	22½	10½	–
123	–	–	–	50½	48½	58½	51	50½	53	44½	38½	26	22	12
185	–	–	–	–	–	–	62½	36	55½	49½	38	45½	33	27½
391	50	55½	54	56	51	61	54	43	49	39	29	27½	19½	–
408	–	–	–	40	58	45½	47½	40	37½	43	27	33½	23	–
<u>Twins</u>														
39	–	–	70½	71½	69	58	62½	54½	49	36	25	24	23	–
55	80	81½	81½	65½	68½	62	52½	46	34	40	27	22½	27½	–
140	–	–	73	71	65½	56½	58½	61	50½	29½	26	31½	19½	–
89	–	–	–	–	–	93	86	82½	58	63½	52	47½	29½	–

APPENDIX TABLE II (Contd.)

	17/8	25/8	2/9	9/9	16/9	23/9	29/9	6/10	13/10	25/10	3/11	17/11	1/12	13/12
							Low Plane							
1	-	-	-	46½	41	41	45½	34	30	21	16½	17½	13½	8½
10	-	-	41	42	36	39½	33½	33½	30	24	28	19	17½	2
16	-	36	36	26½	21	19½	17	17	13½	11½	6½	13	3½	-
28	-	29	20	13½	15	8	5½	7	5	-	-	-	-	-
41	-	-	47	51	42½	38	26	33	26	19½	13½	12½	10½	-
58	-	-	41½	41	40½	36	36	35	31	20	17½	17½	16	12½
85	-	50½	55	45½	31½	33	32½	32	19½	15	12	17½	17	-
87	-	-	42	66	57½	43	43½	42½	38	28½	18½	18½	13½	13½
106	-	48½	58	53½	42	37½	31½	34½	31½	28	24	25½	18½	-
74	-	-	34	40	32½	28½	23½	20	14	11	6½	11	10½	8½
217	-	-	-	-	25½	25½	21½	16	14	6½	6	-	-	-
219	-	-	-	-	-	66½	54	67½	56½	47	35	30½	-	-
Twins														
48	-	-	53	37	21½	23	28	20½	22	19	13½	14½	11½	-
67	-	-	-	-	-	53	33½	64½	47½	37	35½	26	13½	12
117	-	-	68½	80	56	49	40	30½	32½	27½	20½	24	13½	19
52	-	72	71	42½	52½	50	40½	52	36	35	26½	27	23½	-

APPENDIX TABLE III

RECORDED FAT PERCENTAGES

Time Interval in Days		8	8	7	7	7	6	7	7	12	9	14	14	12
Ewe No. / **Date**	**17/8**	**25/8**	**2/9**	**9/9**	**16/9**	**23/9**	**29/9**	**6/10**	**13/10**	**25/10**	**3/11**	**17/11**	**1/12**	**13/12**
							High Plane							
8			8.6	7.6	6.5	8.0	6.8	5.9	8.0	5.9	7.8	9.2	10.4	
9							3.6	4.0	4.0	4.0	4.0	4.0	5.6	6.6
34		18	9.9	5.4	5.7	7.0	6.0	5.8	6.5	6.5	6.4	8.8	9.4	
40					3.8	9.2	7.0	6.6	6.9	5.2	6.0	6.4	7.4	8.8
65		10.7	10.1	6.8	6.8	6.0	5.4	4.5	5.8	5.9	6.8	6.7	8.2	
86					2.9	4.2	6.4	8.1	7.1	7.5	7.2	10.0	7.6	13.2
88		14.4	7.7	6.9	7.7	7.0	5.0	6.8	6.1	4.7	5.8	7.2	8.2	
96			8.4	6.0	5.8	6.6	3.4	6.8	6.0	5.5	4.8	7.7	7.4	
104		5.5	3.5	2.0	2.2	2.0	3.2	3.3	4.4	4.3	3.0	6.7	6.0	
123				10.1	7.3		4.6	4.7	5.2	5.2	5.4	4.9	6.6	9.6
185							9.0	10.0	6.1	3.3	5.2	4.7	6.0	8.2
391	9.6	6.4	7.9	6.5	6.8	5.2	5.2	6.4	6.5	5.7	7.3	8.0	9.4	
408				9.2	7.4	5.8	7.0	5.2	6.2	6.8	5.3	6.1	7.0	
Twins														
39			8.0	6.4	6.4	4.2	3.6	5.0	4.2	3.6	3.8	6.1	7.6	
55	12.9	9.0	8.6	7.2	7.3	5.6	6.4	7.4	6.3	6.3	7.9	7.8	8.6	
140			7.5	5.4	5.4	5.6	4.8	5.5	6.5	5.7	7.6	6.9	6.4	
89						6.2	5.0	5.4	6.2	3.2	3.8	4.4	4.0	

APPENDIX TABLE III (Contd.)

	17/8	25/8	2/9	9/9	16/9	23/9	29/9	6/10	13/10	25/10	3/11	17/11	1/12	13/12
								Low Plane						
1				10.8	9.3	8.2	8.0	7.4	7.7	7.6	7.2	7.5	10.6	8.9
10			6.0	5.4	7.6	6.0	5.1	4.6	4.0	5.6	4.8	6.0	8.0	10.6
16		9.3	7.7	10.4	9.7	10.2	9.0	8.3	8.3	7.2	8.1	8.0	8.0	
28		7.0	7.4	8.5	8.3	9.6	9.0	7.4	8.8					
41			6.0	4.8	6.8	6.2	10.2	5.8	8.8	10.6	7.6	8.8	6.6	
58			9.4	8.9	9.8	8.0	6.4	6.4	7.7	6.4	7.0	7.1	6.0	11.2
85		9.0	8.4	7.2	8.4	8.6	7.2	5.6	6.4	5.6	5.5	6.2	5.6	
87			10.5	5.1	6.0	6.8	5.6	4.8	6.0	5.8	6.6	6.7	8.2	7.8
106		7.1	7.8	4.0	6.6	6.2	5.0	3.2	4.4	4.0	5.7	4.5	5.6	
74			6.5	7.9	7.0	6.0	5.6	5.8	7.2	5.2	6.0	6.3	6.6	11.6
217					6.5	9.8	7.7	8.0	8.4	-	5.6			
219						7.6	7.0	5.4	8.3	6.0	8.4	6.8		
Twins														
48			4.3	10.6	10.2	11.4	8.4	7.2	8.2	6.7	6.7	9.2	7.6	
67						9.1	6.8	7.0	6.8	4.6	5.8	6.2	6.0	8.2
117			8.6	7.2	10.1	9.1	8.0	6.4	5.5	4.8	5.2	5.4	7.4	9.0
52		10.9	8.7	11.6	7.2	6.8	10.2	5.2	5.6	5.6	6.0	5.6	6.7	

APPENDIX TABLE - IV

ANALYSIS OF COMPOSITE MILK SAMPLES (per cent)

Date	Fat (Gerber)	Total Solids	S.N.F.	Protein (Nx6.38)	Lactose (by diff.)	Ash	CaO.	P_2O_5.	Number of Sheep
					High Plane				
		%							
*17/ 8/51	11.1	20.82	9.77	5.34	3.59	0.84	-	-	2
25/ 8/51	9.5	19.83	10.33	5.89	3.55	0.89	.31	.37	7
2/ 9/51	7.9	17.46	9.56	5.42	3.28	0.86	.29	.34	10
9/ 9/51	6.8	17.05	10.25	5.3	4.11	0.84		.35	12
16/ 9/51	6.2	16.6	10.4	5.21	4.35	0.84	.27	.35	12
23/ 9/51	6.5	17.16	10.66	5.42	4.42	0.82	.26	.35	12
29/ 9/51	5.0	15.82	10.82	5.4	4.62	0.80	.27	.34	12
6/10/51	5.6	16.62	11.02	5.87	4.27	0.88	.27	.35	12
13/10/51	6.1	16.92	10.82	5.43	4.58	0.81	.27	.35	12
25/10/51	5.4	16.01	10.61	5.38	4.42	0.81	.26	.35	12
3/11/51	6.0	17.06	11.06	6.22	3.95	0.89	.30	.35	12
17/11/51	7.2	18.21	11.06	6.0	4.18	0.88	.28	.34	12
1/12/51	8.0	19.12	11.12	6.16	4.07	0.89	-	-	12
12 week average	6.7	17.32	10.64	5.64	4.15	0.85	.28	.35	

APPENDIX TABLE IV (Contd.)

Date	Fat (Gerber)	Total Solids	S.N.F.	Protein (Nx6.38)	Lactose (by diff.)	Ash	CaO.	P_2O_5.	Number of Sheep
					Low Plane				
25/ 8/51	8.6	18.15	9.78	4.92	3.53	0.91	.31	.36	5
2/ 9/51	7.9	17.00	9.10	5.01	3.23	0.86	.23	.33	12
9/ 9/51	7.8	17.85	10.05	5.11	4.11	0.79		.34	13
16/ 9/51	8.0	18.04	10.04	4.82	4.43	0.79	.25	.32	13
23/ 9/51	8.0	18.07	10.07	5.02	4.25	0.80	.25	.31	13
29/ 9/51	7.5	17.48	9.98	4.96	4.25	0.77	.25	.31	13
6/10/51	6.0	16.51	10.51	5.32	4.35	0.84	.25	.34	13
13/10/51	6.9	17.41	10.51	5.29	4.42	0.80	.27	.34	13
25/10/51	6.2	16.27	10.07	5.11	4.14	0.82	.24	.33	12
3/11/51	6.2	16.52	10.32	5.28	4.20	0.84	.27	.33	12
17/11/51	6.8	17.46	10.66	5.7	4.09	0.87	.26	.35	12
1/12/51	7.3	18.43	11.13	5.93	4.31	0.88	-	-	12
* 13/12/51	9.8	-	-	-	-	-	-	-	6
12 week average									
	7.3	17.43	10.18	5.21	4.11	0.83	0.26	.33	

* - omitted from average.

APPENDIX TABLE V

WOOL WEIGHT OF MILKING EWES

High Plane		Low Plane	
Ewe No.	Wool Weight	Ewe No.	Wool Weight
Singles	lbs.	**Singles**	lbs.
8	-	1	8.1
9	11.2	10	7.5
34	11.3	16	6.9
40	14.7	28	5.4
65	7.2	41	7.0
86	11.2	58	7.2
88	9.5	85	8.5
96	11.1	87	8.6
104	9.0	106	9.6
123	8.1	74	8.1
185	6.7	319	-
391	14.3	217	5.1
408	8.2	219	-
Twins		**Twins**	
39	10.3	48	-
55	10.4	67	-
140	9.2	117	-
89	13.3	52	

APPENDIX TABLE VI

MILKING GROUP LAMB LIVEWEIGHTS (Lbs.)

Ewe No.	Lamb No.	Date of Birth	Birth Weight	17/8	25/8	2/9	9/9	16/9	23/9	29/9	6/10	13/10	25/10	3/11	17/11	1/12	13/12
8	485	26/5 ?	15½	-	-	17	21½	27	33	37	42	47½	52½	57	64	70	
9	574	22/9	14	-	-	-	-	-	-	16	20	24	30	35½	41	50	55½
34	413	14/8	9½	-	11½	13½	16½	19	22	24½	27½	30½	35	40	44½	49	
40	549	4/9	8	-	-	-	-	12	16½	19	22	25½	32	37	43½	49	54
65	422	15/8	12	-	15	19	22	26	29½	32	36	36	41	46	53	59	
86	555	9/9	14½	-	-	-	-	17	23½	28	32½	37	42½	48½	55	61	66½
88	523	15/8	8½	-	11	14½	17½	20½	24	26	28½	31	35½	39½	37	43	
96	474	25/8	17	-	-	20	25	31	36	39	43	46½	51½	57	62	68	
104	451	21/8	13	-	13	19	24	28½	33	35½	38½	41½	46	50	56	61	
123	542	2/9	13	-	-	-	15	20	24½	27	31	34½	39½	44	49	54½	57
185	575	25/9	13	-	-	-	-	-	-	12½	17½	21½	29½	35	44	51	55½
391	406	10/8	10½	13	17½	22½	26½	30½	34½	37½	41½	44½	48½	51	56½	61½	
408	513	13/8	14	-	-	-	16½	21	26	29½	33	36½	42	45½	50	56	
39	472	24/8	10	-	-	12½	16	19	21½	24	27	29	34½	37½	41½	45½	
	473	24/8	10½	-	-	13	16	18½	21	23	26	28½	34	38½	43½	48	
55	411	13/8	12	13	17	21½	24½	28	32	33	37½	39½	45	47½	51	56	
	412	13/8	11	11½	15	19½	22½	25½	29	31	34	36	40½	42	48	50	
140	460	22/8	10½	-	-	13½	16½	20	23½	25½	28	31	35½	39½	43	48½	
	461	22/8	6	-	-	8½	11	13½	17	19	22	25½	30	33½	38	44	
89	562	13/9	9½	-	-	-	-	-	12½	15½	19	22	26½	30	37	43	
	563	13/9	8	-	-	-	-	-	11½	14½	17½	20½	26	30	35	40½	

APPENDIX TABLE VI (Contd.)

Ewe No.	Lamb No.	Date of Birth	Birth Weight	17/8	25/8	2/9	9/9	16/9	23/9	29/9	6/10	13/10	25/10	3/11	17/11	1/12	13/12
1	530	31/8	13	–	–	–	16	20	24½	27½	31½	35	35½	39	45	51	54
10	492	28/8	12	–	–	12½	15½	18½	22	24	27	30	35	44½	44	47½	49½
16	426	16/8	11½	–	13½	18	20½	23	26	27½	30	32½	34	36	41½	45	
28	445	19/8	10	–	11	12½	12½	13	14½	16	17½	19½	–	20	36	–	36
41	477	25/8	15½	–	–	18	22	25½	29½	32	36½	38½	42	45	50	54	
58	487	27/8	10	–	–	10½	14½	18	21½	24½	28	31	34½	37	43½	47½	52½
85	435	17/8	11	–	13½	19	22½	26½	30	32½	35½	38½	40½	41½	45	49	
87	493	28/8	10	–	–	10	15½	20½	24½	28	32	35	38	40½	47	49½	53½
106	444	19/8	10½	–	11½	15½	20	23	25½	28	30	32½	36	39	45	48	
74	486	27/8	8	–	–	8½	11½	14½	17½	19½	22	23½	26	27½	33	35½	39
217	557	11/9	8½	–	–	–	–	9	11½	13	14½	15½	16½	18	20	28	28
219	572	17/9	13½	–	–	–	–	–	14½	18½	22½	32½	35½	41	41	45	49
48	457	22/8	10	–	–	12	13½	15	15½	16½	18	18½	20	21½	27	32½	
	458	22/8	8½	–	–	11	12½	13½	14½	16½	18½	19½	21	23½	28	32	
67	569	16/8	10½	–	–	–	–	–	11½	12½	14	16	19½	22½	28	32½	37
	568	16/8	10½	–	–	–	–	–	12	14½	17	19½	22½	25½	31	34	39
117	494	28/8	11½	–	–	11½	15½	19	22½	26½	27	29½	32½	36½	39½	45½	51
	495	28/8	9½	–	–	9½	11½	13	15	16½	18	19½	23	24	31	35½	40½
52	446	20/8	9½	–	9½	13	14½	15½	18	20	22	24½	28½	30	33½	36½	
	447	20/8	10	–	10½	14½	17	19	22	24½	26½	29	33	34½	41	44	

APPENDIX TABLE VII

WEANING EXPERIMENT LAMB WEIGHTS (Lbs.)

Lamb No.	Date of Birth	Birth Weight	4/9	11/9	25/9	10/10	23/10	5/11	19/11	4/12	17/12	31/12	11/1	14/1	29/1
9 weeks group - Singles															
508	30/8	12	16	20	30	41	48	53	59	63	65	71		74	80
570	16/9	10	-	-	14	25	33	39	45	52	56	62		68	71
496	29/8	13	19	22	31	38	46	52	56	61	57	65		74	74
565	14/9	13½	-	-	21	32	43	49	57	62	65	70		75	80
561	12/9	13	-	-	22	32	40	46	51	55	57	64		71	75
476	25/8	13½	22	22	31	39	47	53	61	65	68	75	80		
532	1/9	11½	⌿	15	24	34	41	46	52	56	58	66		73	78
466	23/8	12½	23	25	33	42	49	54	59	63	65	72	75		
Twins															
402	10/8	10½	26	26	32	42	46	52	55	58	60	70	75		
403	10/8	9	22	23	28	36	41	49	53	57	60	67	72		
517	31/8	9½	-	13	20	27	34	41	45	50	53	59	71	68	
518	31/8	9½	⊖	14	20	28	33	40	46	52	57	64	74	70	
540	2/9	12	-	17	26	33	38	42	47	50	52	56		64	66
541	2/9	12	-	16	27	34	41	49	54	60	62	69		75	79
452	21/8	11	21	21	30	36	43	47	51	56	58	63		75	69
453	21/8	10½	18	19	27	33	39	46	49	52	54	58		63	65
509	31/8	11½	14	19	23	31	38	43	49	54	58	63		72	78
510	31/8	7	⊖	11	17	22	25	29	34	42	45	52		60	63
497	29/8	12	17	18	27	36	44	50	56	63	68	75		82	85
498	29/8	11½	16	17	23	32	38	44	51	57	62	68		76	82
483	26/8	11½	-	20	28	39	47	53	59	63	65	72		79	80
484	26/8	10½	-	19	26	34	41	48	54	59	63	69		76	80

APPENDIX TABLE VII (Contd.)

Lamb No.	Date of Birth	Birth Weight	4/9	11/9	25/9	10/10	23/10	5/11	19/11	4/12	17/12	31/12	11/1	14/1	29/1
12 weeks groups - singles															
478	26/8	13	18	23	33	42	50	56		69	72	78			
538	1/9	14	-	-	27	35	41	48	53	59	62	68		72	79
531	1/9	8	-	11	17	22	22	24	30	36	41	45		52	54
566	16/9	13	-	-	18	29	38	43	52	58	64	70		76	80
504	28/8	14½	21	22	33	37	44	51	59	64	66	71		75	82
411	18/8	12	25	26	37	46	54	60	67	72	78	84	90		
463	23/8	11	14	24	33	43	51	59	64	67	69	74	80		
		twins													
404	10/8	8½	21	21	25	32	38	45	50	54	58	62		69	75
405	10/8	8	19	23	23	31	37	44	48	51	54	59		66	68
523	31/8	13	-	17	25	33	36	41	50	56	61	66	-	72	78
524	31/8	11½	-	16	23	29	35	42	50	56	58	66	-	72	73
547	4/9	12	-	14	18	24	29	32	38	46	47	54		61	64
548	4/9	12	-	14	20	24	28	33	40	46	47	54		61	64
431	17/8	9½	21	22	26	32	39	45	51	58	62	69	72		
432	17/8	10½	22	23	29	37	44	47	51	53	53	56		62	62
511	31/8	11½	14	14	21	28	36	41	49	55	60	65		72	78
512	31/8	11	14	14	21	28	35	42	49	54	57	65		72	78
551	9/9	11½	-	-	21	30	38	44	52	58	64	68		71	77
552	9/9	11½	-	-	20	26	32	38	46	53	57	64	70		

APPENDIX TABLE NO. VII (Contd.)

Lamb No.	Date of Birth	Birth Weight	4/9	11/9	25/9	10/10	23/10	5/11	19/11	4/12	17/12	31/12	11/1	14/1	29/1
16 week group - singles															
475	25/8	13½	22	23	33	42	48	54	62	64	68	73	76		
440	18/8	11	25	26	34	42	47	51	58	63	66	69	74		
500	29/8	14½	-	23	37	46	55	59	68	76	80	84		93	95
550	8/9	15½	-	-	27	38	47	53	63	71	77	84		91	95
514	31/8	13	-	19	29	36	43	48	57	62	71	73		79	85
490	27/8	16	24	-	38	48	56	62	71	77	82	90		99	101
436	18/8	13	29	32	42	-	58	64	72	76	78	84			
		twins													
467	24/8	13½	23	25	33	42	52	56	65	72	79	84	88		
468	24/8	9½	18	20	28	36	43	48	57	61	63	71	75		
535	1/9	10	-	14	20	26	31	35	43	46	46	54		62	66
546	1/9	9	-	12	19	23	31	36	42	45	52	58		65	68
488	27/8	11	18	19	26	32	37	41	47	54	60	67		74	76
489	27/8	10	12	19	25	32	39	45	53	58	62	68		74	76
515	31/8	12	15	16	23	30	36	42	48	51	58	59		68	76
516	31/8	12	-	16	24	31	36	42	49	53	61	57		67	71
521	31/8	11	-	16	22	30	36	42	49	55	60	64		73	78
522	31/8	12	-	17	22	31	38	41	52	58	65	71		79	83
519	31/8	9	-	13	14	16	21	26	32	39	43	48		57	61
520	31/8	11	16	16	18	24	29	33	40	43	48	54		61	64

APPENDIX TABLE - VIII

SLAUGHTER RESULTS - WEANING EXPERIMENT

Lamb No.	Live weight at slaughter lbs.	Age (Days)	Carcase weight lbs.	Grade *
9 weeks groups				
508 (Singles)	80	155	37	D8
570	72	138	32	P2
496	74	156	33	P2
565	80	140	36	Y
561	75	142	34	P2
476	80	139	35	D2
532	78	153	35	D2
466	75	141	30	P2
402 (Twins)	75	154	35	D2
403	72	154	32	P2
517	71	154	31	P2
518	74	154	31	P2
540	73	179	33	P2
541	79	152	35	P2
452	75	191	31	Y
453	-	-	-	-
509	78	154	30	Y
510	-	-	-	-
497	85	156	37	P8
498	82	156	34	P2
483	80	159	33	Y
484	80	159	35	P2
12 weeks group				
478 (Singles)	80	138	37	D2
538	78	153	35	P2
566	82	138	38	D8
504	82	156	38	P8
411	90	146	37	D8
463	80	141	32	P2
531	-	-	-	-
404 (Twins)	75	175	33	D2
405	73	202	32	D2
524	75	154	33	P2
523	78	154	34	D2
547	75	177	32	P2
548	72	177	31	D2
431	73	147	31	Y

APPENDIX TABLE VIII (Contd.)

Lamb No.	Live weight at slaughter	Age (days)	Carcase weight	Grade *
	lbs.		lbs.	
12 weeks group (Contd.)				
432 (Twins)	-	-	-	-
511	78	154	33	P2
512	78	154	34	P2
551	77	145	33	P2
552	70	124	31	P2
16 weeks group				
475 (singles)	76	139	34	P2
440	74	146	36	D2
500	95	156	32	D2
550	95	146	46	D4
514	85		39	D8
490	101	158	48	D4
436	84	146	42	D8
467 (twins)	88	140	31	P2
468	75	140	34	D2
535	75	180	34	P2
536	79	180	36	Y
488	78	158	35	P2
489	76	158	36	P2
515	71	154	31	P2
516	71	154	29	Y
521	78	154	37	D8
522	83	154	36	P2
519	72	154	30	P2
520	73	154	33	D2

(NOTE - Carcase weights were frozen weights, i.e. hot carcase weight less 4½%)

* - See Barton R.A., 1947, Proc.10th Ann.Meeting of Sheep Farmers, Massey Agric.College.

APPENDIX TABLE - IX

SLAUGHTER RESULTS - INOCULATION EXPERIMENT

Lamb No.	Live weight at Slaughter lbs.	Age (days)	Carcase weight lbs.	Grade
418	75	197	32	P2
419	70	149	31	Y
420	-	-	-	-
421	76	197	34	D2
429	81	147	34	Y
430	75	168	31	P2
438	75	194	32	D2
439	75	194	31	P2

(NOTE: Carcase weights were frozen weights, i.e. carcase weight less $4\frac{1}{2}\%$)

APPENDIX TABLE - X.

INOCULATION EXPERIMENT - LAMB LIVEWEIGHTS (lbs.)

Lamb No.	Date of Birth	Birth Weight	11/9	25/9	10/10	23/10	5/11	19/11	4/12	17/12	31/12	11/1	14/1	29/1
418	15/8/	11	26	27	35	40	48	48	52	53	57	-	67	72
419	15/8/	10	22	33	41	45	51	55	58	61	64	70	-	-
420	15/8/	9	30	26	34	35	33	34	36	35	40	-	46	50
421	15/8/	9½	18	25	32	37	44	48	52	54	60	-	67	68
429	14/8/	15½	24	33	41	46	55	60	65	69	75	81	-	-
430	14/8/	9½	21	28	35	38	47	49	53	56	64	68	70	75
438	18/8/	9½	21	28	35	39	45	51	55	57	61	-	66	68
439	18/8/	9½	18	25	32	37	44	50	51	52	55	-	65	67