A STUDY OF THE ROMNEY FAT LAMB EWE, WITH PARTICULAR REFERENCE TO MILK SECRETION AND ITS EFFECT ON FAT LAMB PRODUCTION.

Thesis submitted by " 392 " Alan Graham LOGAN

for the

M.Agr.Sc. Degree.

PREFACE.

The data obtained in the course of the investigation herin reported, were collected by the author , or under the supervision of Dr. C.R. Barnicoat or the author.

The writer is responsible for the analysis and interpretation of the material, and for the discussion of the results.

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GENERAL INTRODUCTION:

One of the distinguishing characteristics of mammals, is the dependance of the young, during early post-natal life, on nourishment secreted by the mammary gland of the mother. Hence milk secretion is of fundamental importance in all our farm animals with the exception of poultry. The essential attributes of milk (viz., high water content and liquid state, high digestibility, high protein content of excellent biological value, high calcium and phosphorus and the presence of most of the necessary vitamins) are specially suited to the needs of young rapidly growing animals.

In dairy cattle extensive study has been made of milk-producing ability and conscious effort made to improve this by breeding, and nutrition. Comparison of the characteristics of modern dairy cattle (highly developed milking qualities but inferior meat carcasses) and of beef cattle (early-maturing and good carcass quality but often poor milk yield) clearly indicate the extent of improvement from the wild form and the variation in productive efficiency of different types.

Valuable work on the milk-producing ability of other species, and its relationship to the welfare of the young has been carried out by Bonsma and Oosthuizen (1) and Donald (7) with Sows; and Ritzman (30), Fuller and Kleinhanz (10), Neidig and Iddings (24), Bonsma (2,3), 30a, Pierce (27,28) with ewes of non-milking breeds, and by several workers with specialised milking sheep, Scheingraber (31), Muhlberg (23), Maule (17).

These workers have shown that there is a close relationship between the mothering ability of the dam and the early post-natal expression of the hereditary potentialities of the young. Research with laboratory animals has strengthened this thesis (McDowell (18) and Enzmann (9)). McDowell has shown that the growth-curve of suckling mice is similar to the parabolic prenatal growth curve only when the milk supply is adequate. If this concept is fundamental, the indication is that the potential growth of the suckling is often not attained - a fact of some significance in live-stock production.

It is generally recognised that the relative rate of growth is more rapid in the early stages of the individual's life when "growth impulse" is strongest, and that the nutrition during this period may profoundly influence subsequent growth and development.

Hammond (15) and co-workers have suggested the permanency of the effects of periods of undernutrition, when they are applied during early life. Thus twins grow less rapidly than singles during the first month in consequence of having to share the milk supply, and although some of the difference is made up later when other food is consumed, the twin tends to be permanently retarded in its rate of growth. McMeekan (19) has demonstrated the influence of such periods of undernutrition on differential development of the growing pig.

Consequently, efficient live-stock production is largely dependant on rapid (and hence efficient) growth in the young animal, and this in turn is chiefly dependant on the milk production of the dam. This is of particular significance in fat-lamb raising, where feeding of concentrate supplements to lambs is not usually practised.

Analyses of milk of various species (and breeds within species) have shown considerable differences in composition.

Species.	Fat %.	SNF %.*
Sow	7.0	12.0
Ewe	5.0 - 7.0	11.0
Cow	4.0 - 5.0	9.0
Mare	1.0 - 1.5	8.0

It is also evident that these differences are related, in a general way, to the shape and slope of the growth curve of the suckling. Piglets double their birth weight in about one week, lambs in about three weeks and calves in about seven - eight weeks. A practical consideration arises when hand-rearing young animals on milk from other species, cow's milk being too rich for foals and too poor for piglets.

It is uncertain whether variations in milk composition within a breed are important. While some regard qualitative effects as unimportant, most authorities consider that composition has a certain limited influence on rate of growth of sucklings. Some workers (15) consider protein to be more significant biologically than fat, and others that total solids is the most important consideration. The general concensus of opinion, however, seems to point to the energy content of the milk as being the most vital concept (Gaines 11)), apart from yield.

More importance must, however, be attached to quantitative data, as an estimate of yield is more readily obtained than an estimate of any of the constituents, under practicalconditions.

* Morris, Morrison and various others.

Generalised observations in practice indicate considerable breed differences in milk yield. The Merino (improved for wool) and the Southdown (improved for carcass quality) are regarded as inferior in milking ability to intermediate or dual-purpose types (Romney and crossbred) (2).

In the New Zealand fat-lamb industry, during the war years 1939-44, between ten and twelve million lambs were killed annually, most of these being exported. Many of the fat lambs produced for export come from more or less specialised fat-lamb farms. The endeavour on this farm is to produce per acre, the maximum weight of fat lamb of the best quality, in the shortest time. In practice this objective involves the production of lambs fat from the mother.

The ability of the ewe is of vital economic importance on the specialist fat lamb farm as other sources of income are merely subsidiary. Our fat-lamb industry is essentially based on the use of crossbred ewes* culled from hill-country flocks, in which they have become less valuable for breeding flock replacements and growing wool than for selling as potential fat-lamb ewes. These five- and six-year old ewes are brought from

* In the North Island such ewes are virtually purebred Romneys having been graded up for many generations by Romney sires from a Merino-Lincoln base. In the South Island, crossbred ewes are mainly of the fine-woolled type, mostly Corriedales and half breds, although the Romney crossbreds are also employed.

comparaitvely hard grazing on to good quality pastures or arable farms and there mated with Southdown, or other early maturing "Down" rams. In this way the milking quality of the crossbred, (Bonsma (2)) is combined with the carcass quality of the Southdown.

The individual milk-producing ability of such ewes is unknown, but the fact that they have survived three or four lambings in a relatively poor environment, helps to insure reasonable performance in this respect. Experience has demonstrated that such ewes respond well to the improved nutrition and better management of intensive farming.

It is probable that under present conditions the maintenance of a high level of nutrition is the most vital concern of the specialist fat lamb farmer - particularly since milk yield is so intimately dependent on feed supply and since present knowledge does not permit the identification of good or poor milking strains of sheep.

Nevertheless the primary dependence of milking capacity upon inheritance makes the development of methods of improving this character in the sheep of great importance. A primary prerequisite is the investigation of methods of recording milk yield. While the present study is of the laboratory type in this regard, it is hoped that it may be of some assistance in an eventual solution of the problem.

To the stud breeder also, the milk-producing ability of his stock is of first rate importance as much success depends on producing well developed healthy animals for sale. It is generally recognised that much selection potential is expended on economically unimportant points, whereas little attention is paid to the milking ability of the ewes. In fact it is not unreasonable to suggest that the practice of supplementing the lamb from an early stage with concentrates or other specially nutritious foods may even tend to mask poor milking capacity and so lead to the perpetuation of low yielding strains. It is under the stimulating environmental conditions of the stud farm that the higher milking strains can be best located.

The fat-lamb raiser must also consider milk yield in relation to the carcass quality of his produce.

The general opinion among farmers and research workers is that rapid growth to slaughter produces the best fat-lamb carcass. Certainly the most rapid growth under normal commercial conditions is the most economical growth, but we know little about the effect of small differences in rate of growth on carcass quality at the varying ages at which export lambs are killed.

The differential growth gradient concept advanced by Hammond (15) in sheep, and McMeekan with pigs (19) is well expressed by the latter (21).

> "It is well established that the characters upon which the value of any meat animal depends are fundamentally the result of differential growth and development changes occurring within the body. Differences in rate, order and extent of development of particular parts and particular tissues are responsible for the differences in form in anatomical, histological and chemical composition, and in

structure of animals of different weights,
breeds and even of different species. Furthermore, hereditary and environmental influences
produce their effects upon the animal's body
by controlling and modifying differentially
the growth gradient mechanism."

It would appear, therefore, that there are good grounds for believing that studies of milking capacity in sheep are worthy of attention. Accordingly the experiments herein reported have been carried out. In particular they have been designed to provide information on the following points:

(1) Basic data on the milking ability of North Island Romney type ewes.

(2) The composition of their milk.

(3) The relationship between the milk yield of the ewe and the welfare of the lamb.

(4) The possibility of using the rate of growth of the lamb, as an index to the milking ability of the ewe, in breeding and selection work.

(5) The application of present techniques to more extensive field investigations and group comparisons.

II. MATERIAL AND METHODS.

(a) EWES:

The material available consisted of 42 mature ewes which were entering their fifth lambing season and 50 two-year old ewes purchased immediately prior to mating. These two groups were from the same flock originally and may be regarded as reasonably uniform samples from the same population, as the history of the flock showed consistent use of rams from the one stud for many years.

The area on which the ewes remained throughout, consisted of 20 one-acre paddocks, predominantly perennial rye (Lolium perenne) and white clover (Trifolium repens). Annual topdressing with superphosphate and lime had been carried out for several years previously. The soil is heavy clay which tends to be very wet in spring and the area (Kairanga) is notorious for footrot in sheep. The two age groups were divided equally into two mobs of mixed ages, one Southdown ram being employed in each. As each group was shifted daily a ten-day rotation was practised and the aim throughout was to keep the pastures 2-3 inches in height with the aid of cattle.

The rams were raddled frequently on the brisket, a different colour being used on each, and the colours changed fortnightly. As the ewes were moved between 8.0 - 9.0 a.m. each day, the rams were also alternated between mobs. This procedure enabled the date of tupping, the gestation period and the efficiency of the sire to be known.

One ram (No.62) proved of poor fertility and many of the ewes coloured by him returned to service. Tupping began on the 26th March and ram 62 was replaced on 26th April.

As the ewes were tupped, their eartag numbers (and also that of the ram concerned) were read and a raddle mark made on their sides. This facilitated the identification of ewes tupped each day, as it was only necessary to catch those ewes which were coloured on the rump but not marked on the side. Powdered raddle mixed with castor oil proved better than raddle alone for marking the rams.

Live weights of the ewes were recorded monthly for the first three months and thereafter fortnightly until the first ewes lambed. From then on all the ewes were weighed when milking took place.

The ewes lambing each day were separated from the mob and isolated for three days when the lambs were weighed and tagged. To simplify the experiment all ewes reared one lamb only, and consequently one member of each set of twins was either fostered or killed.

(b) LAMBS:

"Birth weight" throughout this paper refers to the weight at 3 days, as it is obviously impracticable under New Zealand farming conditions to be present when each ewe lambs - even with the small numbers dealt with in the present experiment. In order to investigate the relationship of three-day weight with "cleaned" birth weight, and to test its reliability as an estimate of weight at birth, newly dropped lambs were weighed whenever possible and these weights compared with the three-day weights. Donald and

McLean (6) and Hammond (15) both imply that a weight recorded at 2-3 days is useful and reasonably accurate.

The live weights used in plotting the growth curves were those obtained for the "empty" weighing at the early morning milking and thus compare with the final weight recorded immediately prior to slaughter.

Individual weights at 10-day intervals were obtained by plotting and smoothing the graphs of observed data. Periodical averages for each group were obtained - (a) by averaging the individual figures from the smoothed graph,and (b) by tabulating and averaging the observed data in 10-day periods. The resulting averages obtained by these two methods agreed very closely. The "smoothed average" figures are presented in the text.

(c) MILK YIELDS:

For convenience in determining the milk yields, temporary yards were erected. The lamb-holding pen, the three "milking" pens and the weighing pen were all covered by a canvas sheet, enabling work to be carried on despite rain.

The milk yields were determined over a 24-hour period, using the same technique as other workers (2). The young were weighed before and after suckling and the difference - or the milk consumed by the lamb - regarded as the yield of the ewe. The sum of the differences over a 24-hour period, using 4-5 weighings was taken as the daily milk production for the period. Thus, it is comparable with the New Zealand Group Herd Testing technique in measuring dairy cow yields, in that total periodical yields, and fat yields are estimated from one day's observations. Sampling errors are magnified according to the length of the period between sampling.

Bonsma (2), Pierce (27(28) and others have used this method with sheep of non-milk breeds, Donald (7), Bonsma and Oosthuizen (1) with sows and various workers with rabbits, mice and guinea-pigs. It is also recognised as a reliable method of estimating the milk yield of lactating women.

In the present experiment the ewes and lambs were separated about 11.0 a.m., the ewes returning to pasture. From 2.30 p.m. on the same day and 10.30 a.m. the following day, four or five weighings were carried out, one at 5.30 a.m. being utilised for milk sampling. This time was chosen because the ewes had accumulated sufficient milk overnight to allow an adequate sample to be taken, and because when still young the lambs often found it difficult to consume all the milk accumulated.

To facilitate identification a number was rubbed on the back of each lamb with dark raddle, and a tag with the corresponding number attached to the wool at the base of the neck of the ewe. For holding the lambs a reinforced canvas sling was found to be the most satisfactory. Steelyards weighing 100 lb. in ½ oz. proved rapid and accurate. As a routine measure for the first four or five weeks of each lactation, the udder of each ewe was handled and any milk remaining after the lamb had finished was withdrawn and measured.

Each ewe was brought in for the first determination following the tagging and weighing of the lamb. Thus in the main, the first observations were made on or between the third and tenth day of each lactation. Milk yield estimations were carried out at approximately weekly intervals from 1/9/44 to 6/10/44 and then at fourteen day intervals until 19/12/44. The yields of a small number of ewes still suckling lambs were recorded in mid-January, 1945. The majority of the records are fairly complete for 100 days. Where a record was incomplete, the gaps were filled in by interpolation of the graph and from average ratios between the missing period and the remainder of the total yield obtained from the complete records. Several records were discarded because lactation curves could not reasonably be interpolated from the data available. Lactations which were obviously abnormal because of disease were not included.

To determine the milk yield at any given stage of lactation, the observed yields were plotted on graph paper. The curve was then carefully smoothed and readings taken at ten-day intervals.

Two alternative methods were used for the analysis of the milk yield data, and the resulting figures compared with those obtained from the smoothed curves. In one method, the readings were taken from the plotted graphs at ten-day intervals before smoothing. In the other method, the observed data were tabulated in ten-day periods (the identity of the individual records thus being lost), and all observations falling within each period were averaged. This method cannot be used where the data is required for statistical analysis and is best used for larger numbers.

Readings were taken from carefully smoothed graphs, at the mid-point of each period, e.g. the readings in this case were taken at 5, 15, 25 days. By this means much of the error arising from the slope of the lactation curve is avoided. The somewhat arbitrary method of smoothing the plotted curves, is considered to be justified as:

(1) Any particular estimation may be higher or lower than the true milk yield of the ewe at the time -

(a) if she is nervous or upset, or

(b) if the lamb is unsettled

(c) day to day variation as observed in dairy cows,

may give a false estimation of the average daily yield for the period.

(2) The theoretical lactation curve is smooth rather than a series of straight lines joining a number of points.

(d) MILK COMPOSITION:

Most of the ewes in the yield determinations were also utilised for sampling - the few that were excluded being nervous or abnormal because of disease.

From the initiation of the experiment standardised technique was aimed at. The milk produced by each ewe was sampled at regular intervals and at a specified time during the 24-hour period. The time adopted was the early morning milking after the 12-hour night spell, the ewes then having sufficient milk accumulated to enable an adequate sample to be taken for analysis.

To obtain a representative sample of the whole of each ewe's milk was a problem. The difficulty in obtaining milk by hand is that the ewes of non-milking breeds, being unaccustomed to hand-milking, will not readily let down their milk when handled by humans. Apparently they require their own lambs to initiate the "letting down" processes.

Several ways of sampling were considered. One method is that of aliquot samples. From previous yields of the ewe the probable yield for the milking concerned is estimated and a specified proportion of this is taken from one quarter. This method appears unsuitable for large numbers of ewes, and may be erroneous in that the rise in fat percentage as milking proceeds may be rather variable (Whittleston (37)). In addition, the previously mentioned day to day variation would be likely to render any analysis obtained on this basis rather unreliable. Complete hand-milking, likewise, would be unreliable, as there is some variation in the proportion of their potential yields which the ewes will release with hand-milking (10).

It was thought that by allowing the lamb to suckle one quarter only, a representative sample could be obtained from the other quarter. This method was tried and provedsatisfactory once the operator became used to manipulating the small teats and holding the ewe still. In many cases the second quarter could be milked while the lamb was still suckling, the ewe then being quite contented. Most of the ewes soon became used to this handling and the quarter could often be emptied out in as little time as required by the lamb.

In view of the large variation in fat percentage in milk from individual ewes, and the uncertainty of the method of sampling from one quarter, detailed investigation of the qualitative aspects of the effect of milk on the lamb, were thought to be unwarranted.

The data available, however, (Fat % and S.N.F.%) were tabulated in ten-day periods and the figures falling within each period for the two age groups, were averaged and plotted as curves, on a similar basis to the milk yield curves.

(Note: The solids-not-fat analyses were corrected to a fat-free basis by the factor $\frac{S \times 100}{100 - F}$

Where S = Solids-not-fat %
F = Fat %

In the text "C/SNF" refers to this figure).

The rise in fat content during milking was investigated in a number of ewes, by milking into a two-ounce container, each consecutive sample being tested for fat. In these cases the lamb was allowed to suckle a second time and the second quarter was again stripped in case further milk had accumulated in the cistern.

In this investigation 400 samples were analysed for fat (Gerber) and for total solids over a period of 4 months, and at each milking, composites were made up of equal samples from all the ewes tested, the two age groups being kept separate. Further analyses were then carried out, viz. Protein, Ash, Calcium, (CaO), and Phosphorus (P_2O_5).

(e) CARCASS QUALITY:

All the lambs in this work were slaughtered on reaching marketable weights, that is between 63 and 70 lb. live-weight. In all cases the "empty" live weight (after a fast of 16-20 hours) is taken as the final weight on the growth curve.

Each carcass was subjected to a comprehensive study which included objective internal and external measurements of many parts, and eye judgments by an experienced grader of such items as finish, fullness of loin and shape of leg. In addition, a grading comparable to that used in the North Island industry, was carried out. A commonly used score or block-test was used to evaluate carcass suitability (The Cambridge Block Test), and various items such as cannon weight per unit length $\left(\frac{W}{L}\right)$ related to post natal variants.

III. RESULTS AND DISCUSSIONS.

(A) EWES:

(a) Milk Production:

(1) Milk Yield - The quantity of milk available to the lamb up to 10-12 weeks of age is thought to be important, not only because it is probably the most important single factor affecting the rate of growth for this period (Bonsma), but also because the welfare of the lamb subsequently is greatly conditioned by development attained prior to weaning (Verges (35)).

The foremost research on milking capacity of ewes of wool or mutton breeds, has been carried out in South Africa by Bonsma, whose technique has been largely used in this work. Information has been published also by Fuller and Kleinhanz, Niedig and Iddings, and Pierce.

In the experiment reported in this paper, 70 lactations were satisfactorily completed. The observed data from which the graphs were plotted ~~is~~ are shown in the appendix. The milk yield for each ewe was read off the smoothed graph to the nearest ounce at 10-day intervals, the mid-point of each period being used. The results obtained from the two alternative methods agreed very closely with the "smoothed graph" figures, so that only the latter have been presented.

The average lactation curves are shown in figure 1 and the periodical averages in Table I. Total yields (100 days) ranged from *2300 oz. to 5655 oz. in the young ewes, and from 3540 oz. to 6370 oz. in the old ewes.

*This ewe lambed late.

EFFECT OF AGE OF EWE ON MILK YIELD.

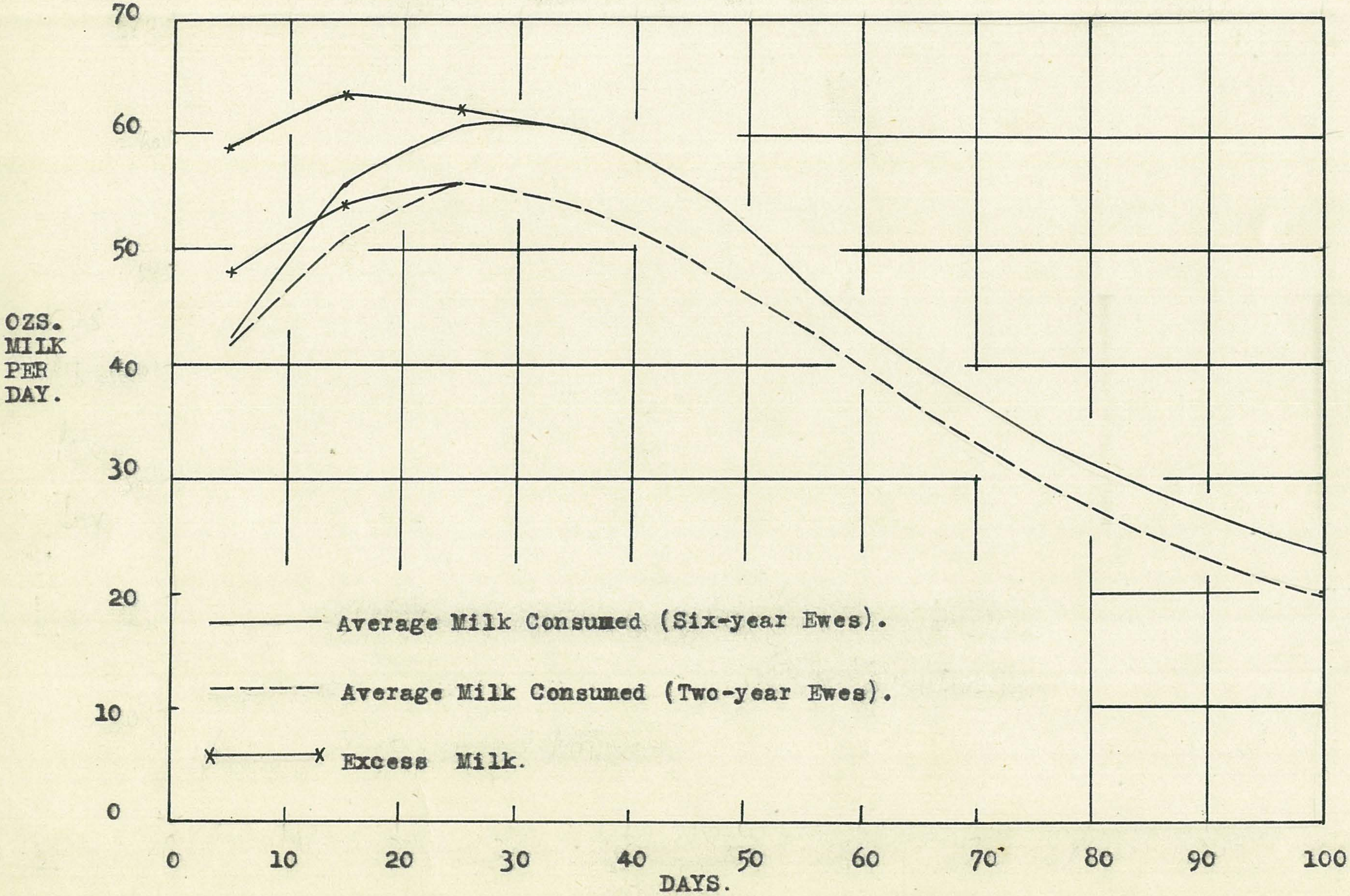


Figure 1.

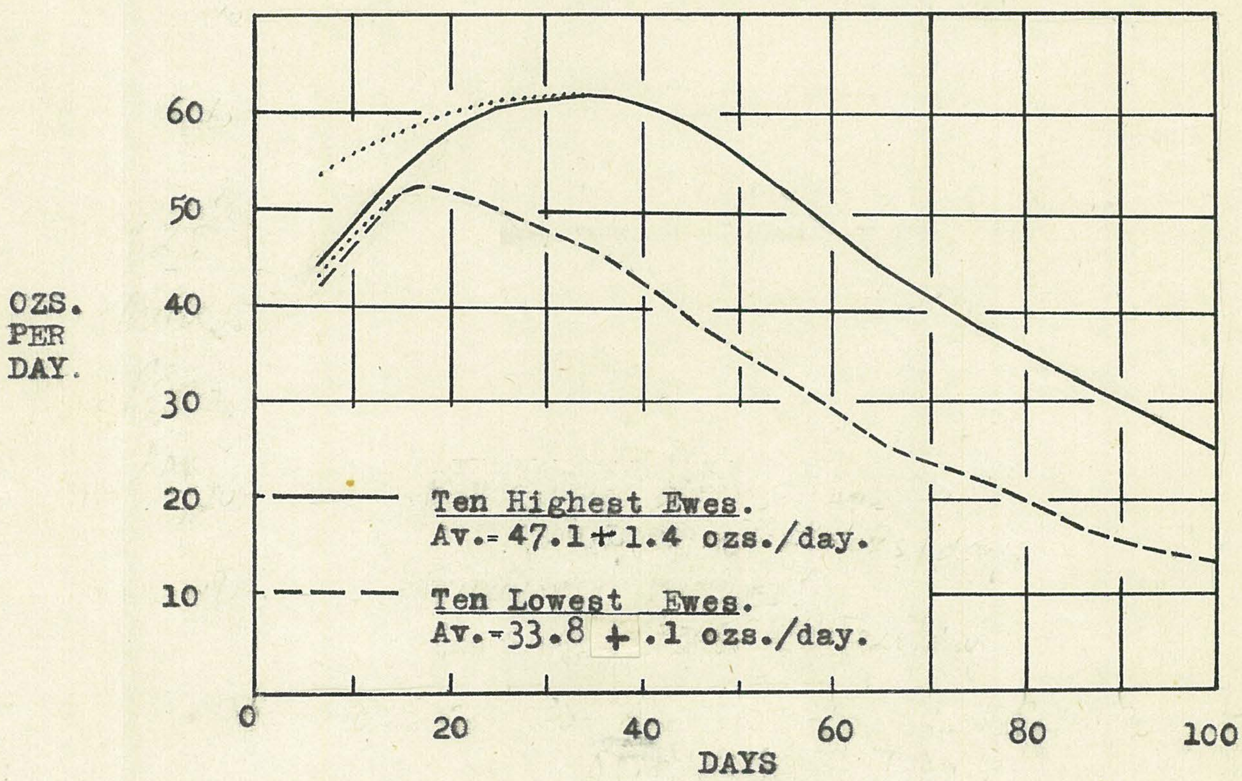
TABLE I.

Average Periodical Daily Milk Yields.

Period Days.	Two-Year Ewes. Consumed.	Two-Year Ewes. Excess.	Six-year Ewes. Consumed.	Six-year Ewes. Excess.
3-10	41.8 oz.	6.2 oz.	42.2 oz.	17.0 oz.
11-20	51.2	2.8	55.6	8.0
21-30	55.7	.4	60.9	1.4
31-40	53.7	-	60.4	-
41-50	49.0	-	55.6	-
51-60	43.1	-	47.2	-
61-70	36.2	-	39.9	-
71-80	30.2	-	33.8	-
81-90	25.2	-	28.9	-
91-100	21.3	-	25.1	-
Averages:	40.74	.94	44.96	2.64
Lactation Averages:	41.68		47.60	
100-day Lactation Total:	4168 ±	609 oz. (S.D.)	4760 ±	665oz. (S.D.)

Study of the shape of the lactation curve is of some value, as the amount of milk produced in the first 4 - 6 weeks is probably almost as important in regard to lamb growth as the total yield. Persistency, no doubt, has some significance and appears to be influenced by genetical factors (Bonnier (3a)), (Gowen (14)). It is likely that those animals producing above average in the first half of lactation, tend to fall away in yield more rapidly than the "low maximum" types. To determine the differences in the shape of the curves of high and low yielders, the successive 10-day yields of the 10 best and 10 poorest milkers in each age group (excluding abnormal lactations), were plotted, along with

AVERAGE LACTATION CURVES (Two-year ewes).



AVERAGE DAILY GAIN (Lambs from two-year ewes).

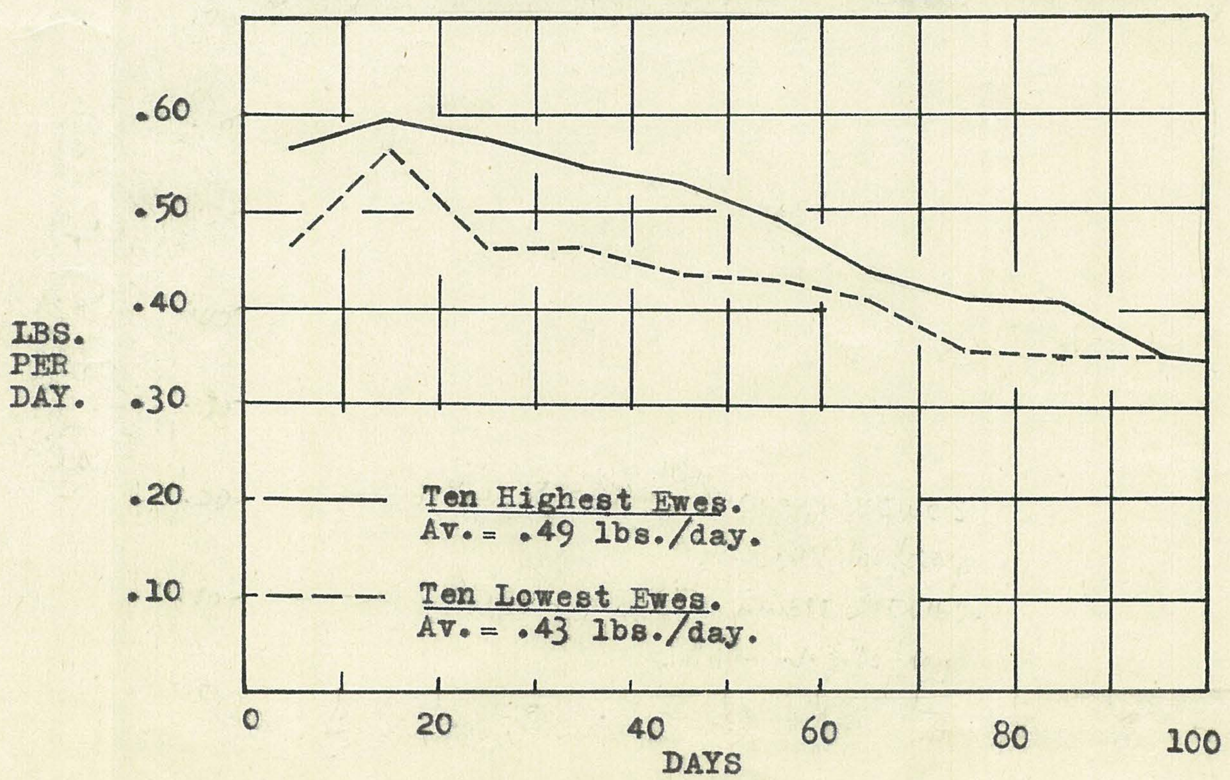
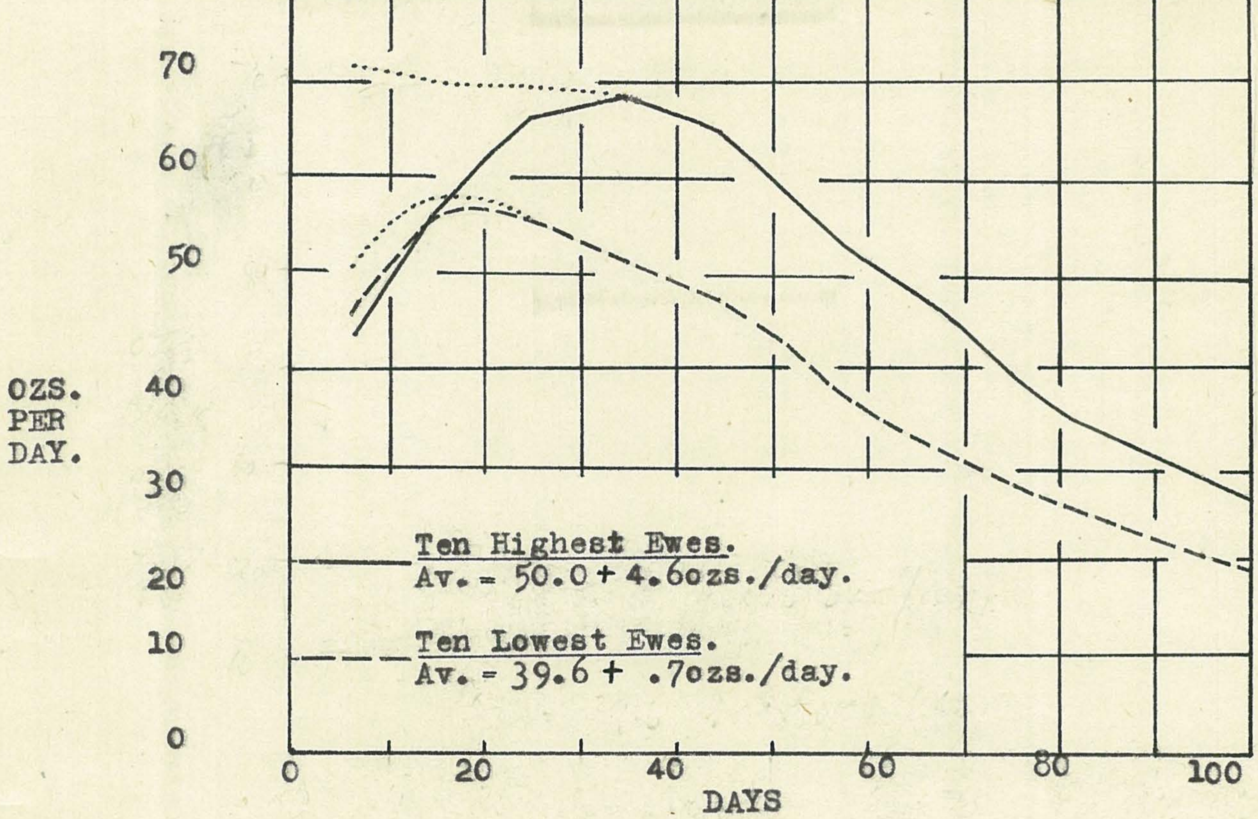


Figure 2a

AVERAGE LACTATION CURVES (Six-year ewes).



AVERAGE DAILY GAIN (Lambs from six-year ewes).

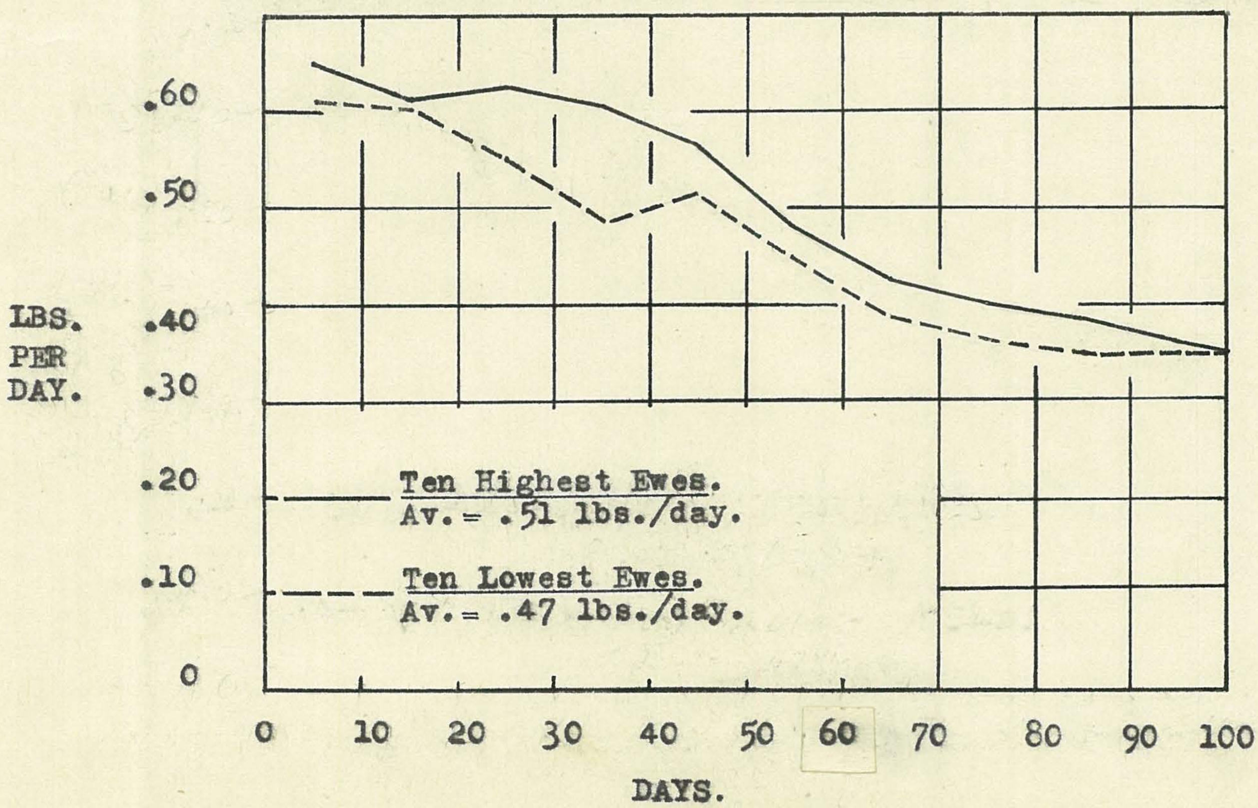


Figure 2b.

the average daily gain in live weight of the lambs (Figure 2). The differences in the average milk yield and rate of gain for these divisions was statistically highly significant.

Various types of curves including abnormal ones, are shown in Figure 3 also with the growth curves of the lambs.

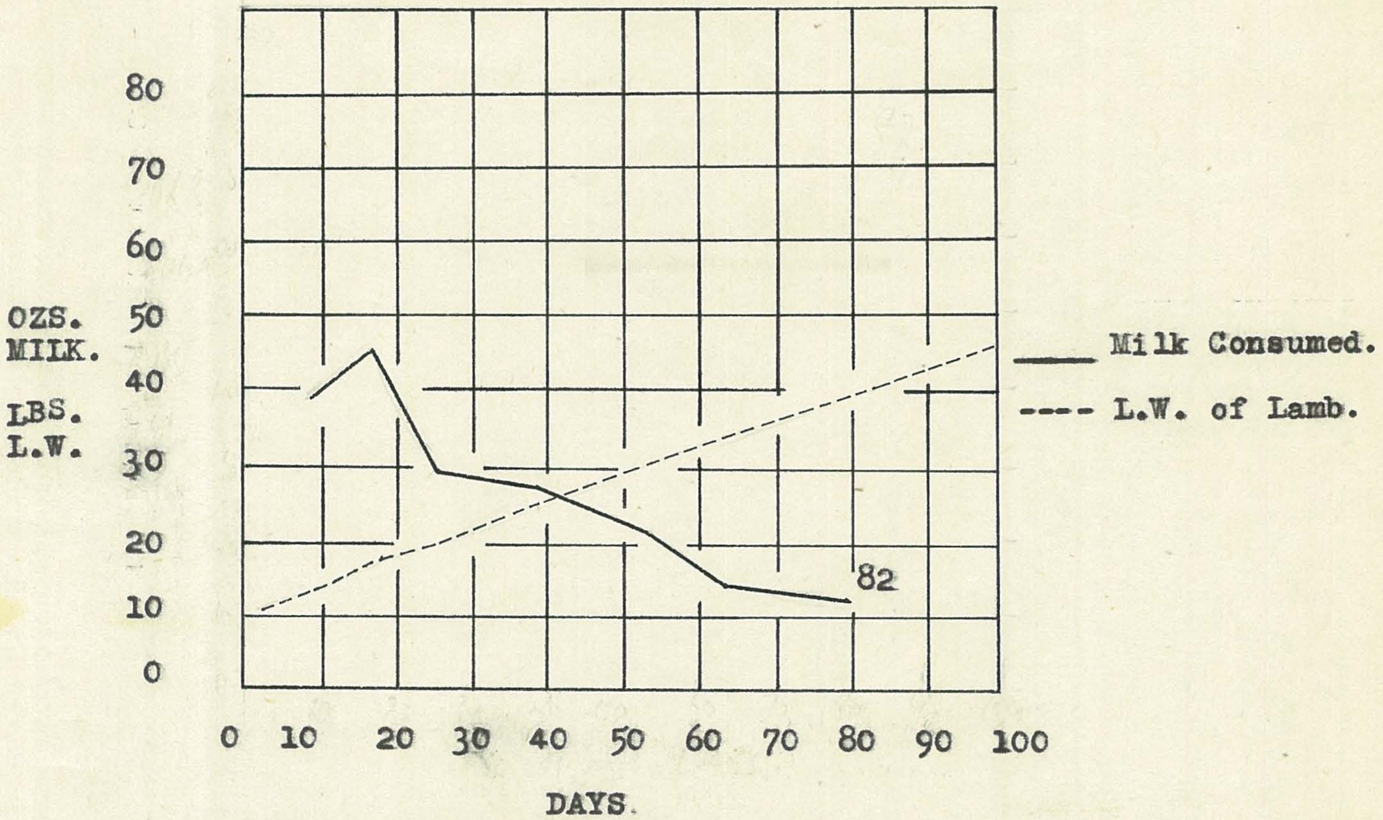
(i) Live Weight of Ewe and Milk Yield: In our data the correlation coefficient between milk yield and live weight of ewe was not significant. The weight used was the first following parturition. The non-significant correlation coefficient obtained, may be due to the varying degrees of fatness of the ewes, which were in excellent condition.

In dairy cows several workers have shown that heavier animals within a breed tend to be better milkers (though not necessarily more efficient milkers.)(11). This also holds in a general way between breeds.

Bonsma (2) obtained a highly significant correlation of + 0.512 within breeds, and attributes 25% of the variation in milk yield to variation in live weight of the ewe.

(ii) Age of Ewe and Milk Yield: The total milk yield of the six-year ewes was 11.4% greater than that of the two-year ewes. The two age groups in this investigation enable an analysis of variance of "age" and milk yield to be carried out. Variations in milk yield with age are probably mainly a result of increase in live weight. (Espe and other sources).

Lactation curves of individual ewes and the Growth curves of their lambs.



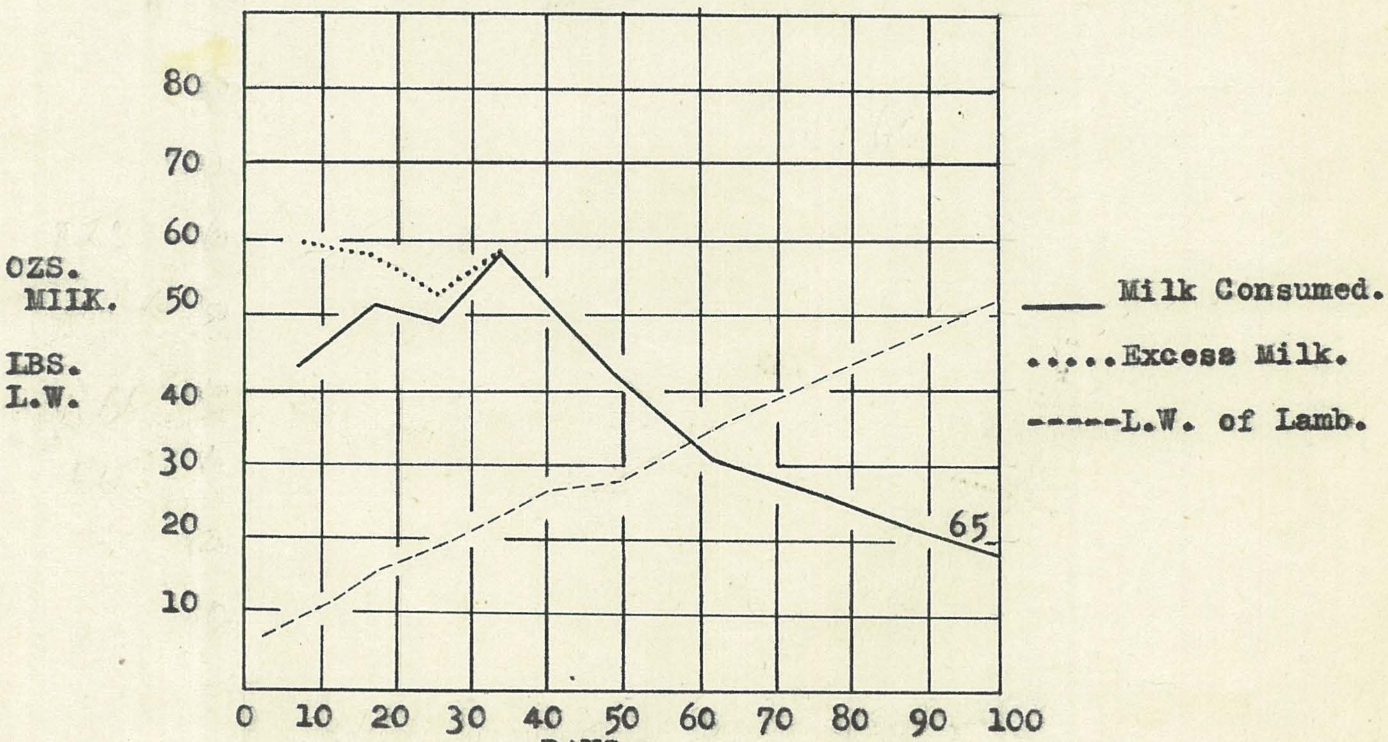
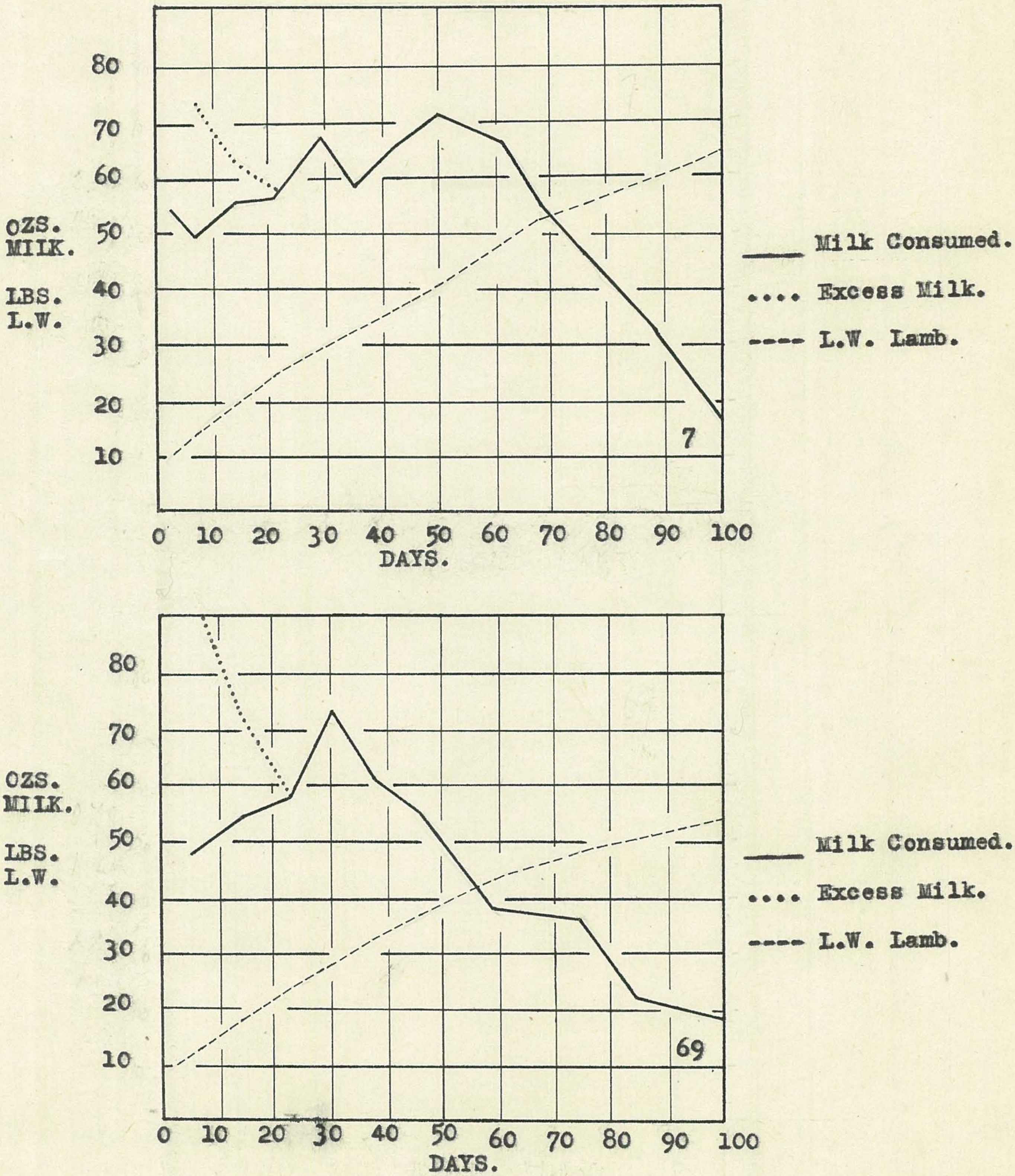


Figure 3a.


80
70
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20
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OZS. MILK.
LBS. L.W.
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DAYS.
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Milk Consumed.
.... Excess Milk.
---- L.W. Lamb.
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10
OZS. MILK.
LBS. L.W.
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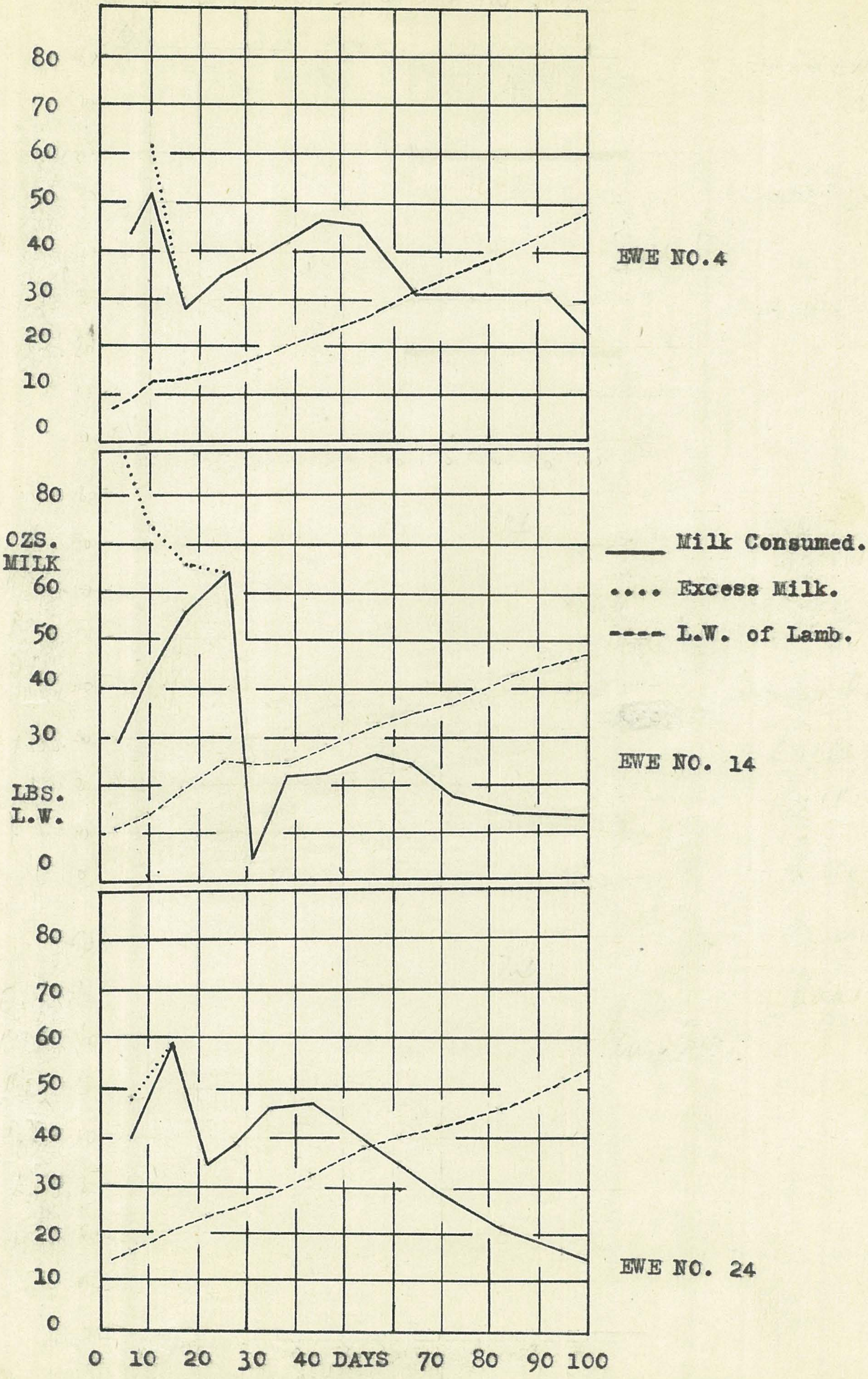
DAYS.
69
Milk Consumed.
.... Excess Milk.
---- L.W. Lamb.

Figure 3a.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OZS.
MILK
60
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LBS.
L.W.
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Milk Consumed.
.... Excess Milk.
---- L.W. of Lamb.
EWE NO. 14
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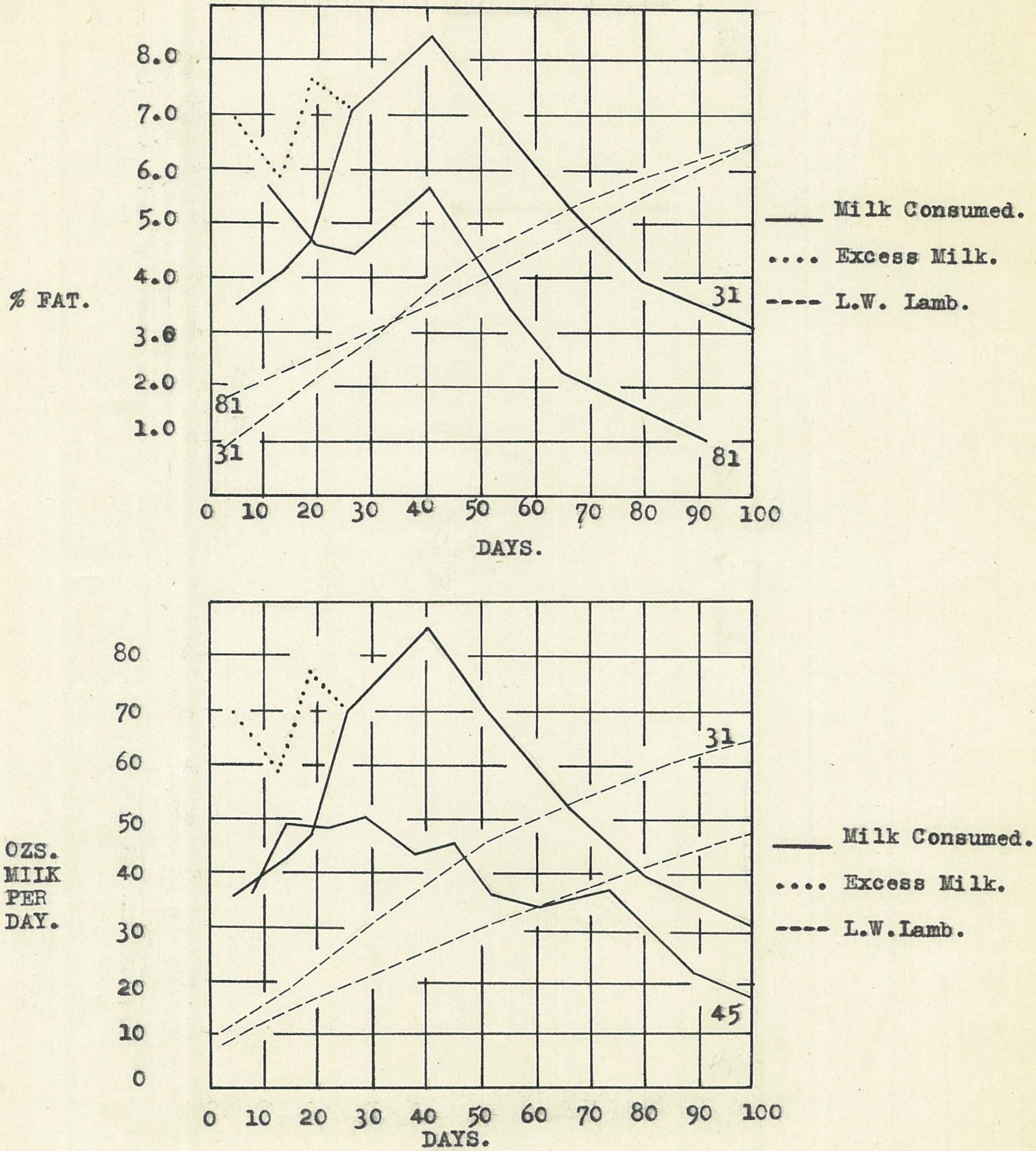
EWE NO. 24
0 10 20 30 40 DAYS 70 80 90 100

Figure 3b.



8.0
7.0
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0 10 20 30 40 50 60 70 80 90 100
DAYS.
Milk Consumed.
.... Excess Milk.
---- L.W. Lamb.
80
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OZS. MILK PER DAY.
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31
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0 10 20 30 40 50 60 70 80 90 100
DAYS.
Milk Consumed.
.... Excess Milk.
---- L.W.Lamb.

Figure 3c.

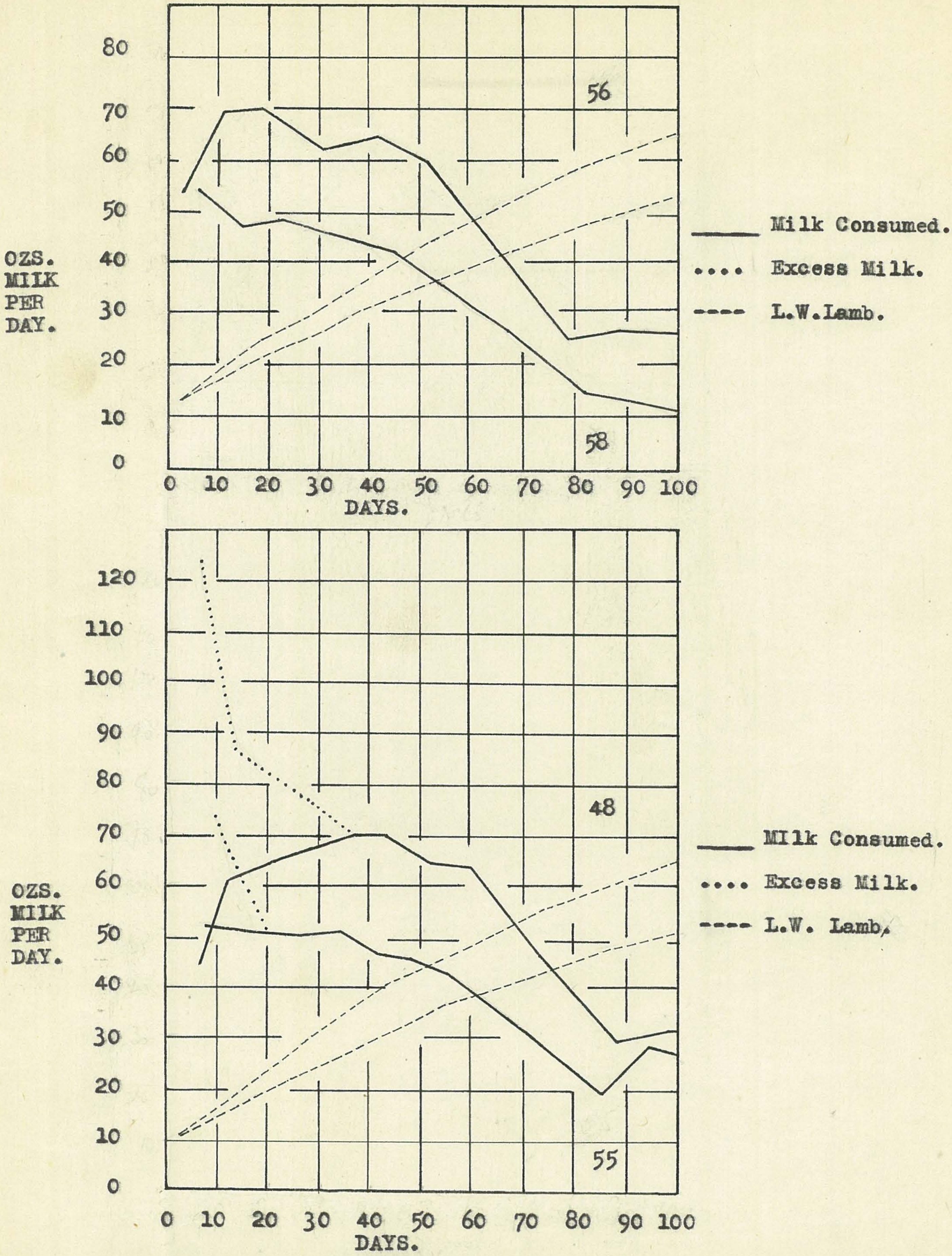

80
70
60
50
40
30
20
10
0
OZS. MILK PER DAY.
56
58
0 10 20 30 40 50 60 70 80 90 100
DAYS.
Milk Consumed.
.... Excess Milk.
---- L.W.Lamb.
120
110
100
90
80
70
60
50
40
30
20
10
0
OZS. MILK PER DAY.
48
55
0 10 20 30 40 50 60 70 80 90 100
DAYS.
MIlk Consumed.
.... Excess Milk.
---- L.W. Lamb.

Figure 3c.

ANALYSES OF VARIANCE.

Milk produced to 40 days and age of ewe.

Source.	d.f.	Mean Square.	F.
Between	1	22575.1	26.1 **
Within	68	864.5	
Total	69	1179.1	

** Significant at 1% level.

Milk produced 40-80 days and age of ewe.

Source.	d.f.	Mean Square.	F.
Between	1	139829.0	5.8 **
Within	68	24143.2	
Total	69	25964.7	

** Significant at 5% level.

The variation in milk yield associated with age is approximately 26% up to 40 days and 7% between 40-80 days in lactation.

The analysis of variance for the total 80 days period shows a highly significant age effect (F = 16.2)

Bonsma (2) gives the average yields of ewes from the first to fifth lactation and shows a 25% increase between first and third lactation. His data were based on insufficient ewes after this stage. Montanaro (22) working with large numbers of Sicilian milk ewes studied the effect of age on yield. All lactations used (553) commenced in October. The following are his results in the form of correction factors based on the highest lactation, which was the fifth.

No. of lactation	1	2	3	4	5	6	7	8
Factor	1.66	1.45	1.15	1.13	1.00	1.15	1.18	1.49

The number of lactations in each group vary from 32 to 121. It is likely that our earlier maturing breeds, would reach their maximum earlier than Sicilian ewes.

Of more significance than the total yield, is the production during the first 20-60 days, or the shape of the lactation curve. For instance, the difference between the average daily yields of the two age groups up to 50 days and from 50-100 days is 5.6 oz. per day and 3.8 oz. per day (115.4% and 112.1%) respectively, illustrating that the superiority of the six-year ewes declines with advance in lactation.

The shape differences in the lactation curves of the high and low producers are interesting. Comparison of these curves (Figure 2) shows that the peak of milk production is earlier in the low producers within an age group. The lower production of the young ewes is not associated with an earlier peak than the old ewes (Figure 1), in fact the curves are very similar in shape. Bonsma demonstrates a distinct breed effect on the shape of the lactation curve, and along with Bonnier and Gowen (in dairy cattle work) contends that the shape of the lactation curve is largely hereditary. The number of times lambs suckle the ewes during 24 hours may influence milk consumption.

It is not certain to what extent the limited number of feeds allowed the lambs during the experiment affected the capacity of the lamb.

It seems probable that the six-year old ewes would have produced more milk than was recorded if their lambs had been able to consume more during the first few weeks of lactation. This also applies to the young ewes but to a smaller extent. Occurring as it does, however, during an early stage of lactation when milk secretory activity is at its height, any drying off effect would tend to be offset as the lamb's capacity increased. No evidence is available to show whether ewes suckling twins are fully milked or not. Size of litter is known to have a considerable influence on the total milk yield in pigs and rodents, but it is not certain to what extent this applies to ewes.

It is interesting to observe that the appetites of the lambs, as measured by our technique, was of the same order in the two age groups during the first period. It is concluded that the significantly heavier birthweight and perhaps vigour of the lambs from the older ewes, was the cause of the more rapidly increasing appetite after this.

More detailed analysis of the records showed a marked difference in the total yields and in the shape of the curves (Figure 4 and Table II), when divided according to the success of the lamb in consuming the milk produced. Average daily live weight gain for the first three periods is also included.

AVERAGE MILK YIELD CURVES (Two-year ewes).
(a) Lambs consumed all milk produced.
(b) Lambs unable to consume all milk produced.

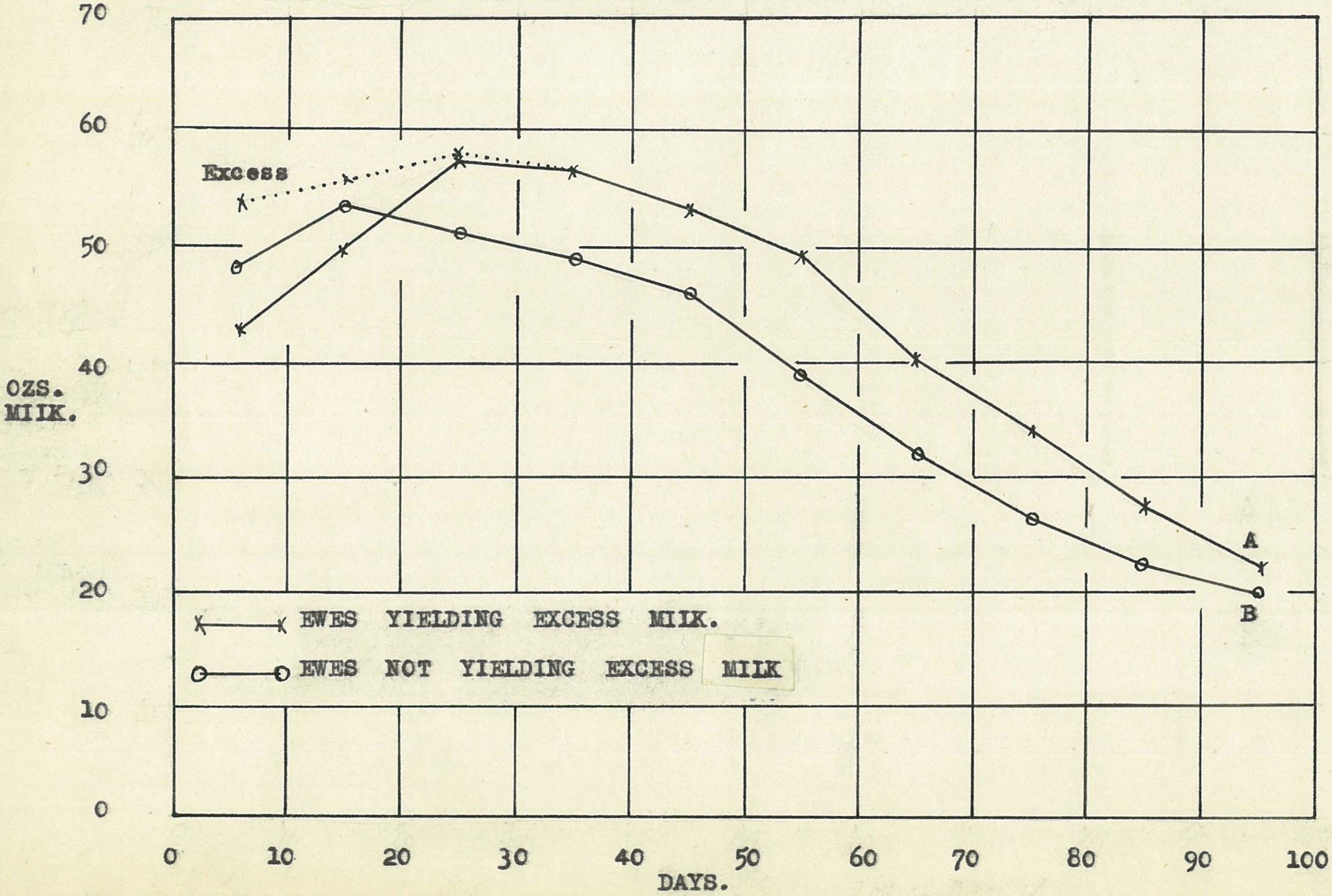


Figure 4a.

AVERAGE MILK YIELD CURVES (Six year ewes).
(a) Lambs consumed all milk produced.
(b) Lambs unable to consume all milk produced.

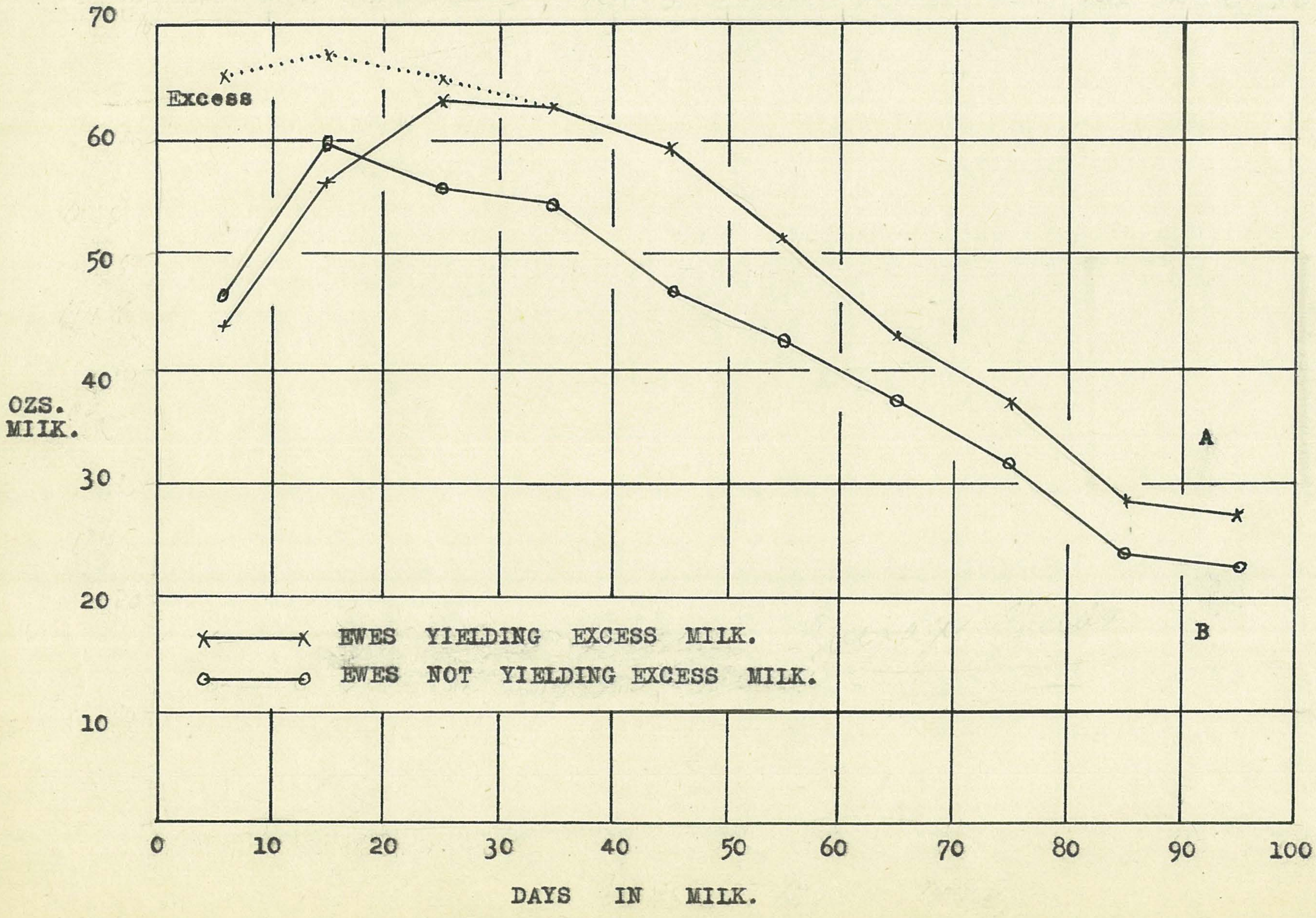


Figure 4b.

TABLE II.

Period. Days.	Two year Ewes. Excess. (oz)	Daily Gain. (lb)	No Excess. (oz)	Daily Gain. (lb)	Six year Ewes. Excess. (oz)	Daily Gain. (lb)	No Excess. (oz)	Daily Gain. (lb)
3-10	42.5 + 11.5	.63	48.3	.56	43.8 + 22.0	.69	46.6	.70
11-20	49.6 + 6.1	.55	53.6	.56	56.1 + 11.2	.60	59.5	.64
21-30	57.5 + 0.5	.53	51.4	.51	63.2 + 2.0	.60	55.8	.57
31-40	56.3		48.9		62.6		54.4	
41-50	53.2		45.8		59.1		46.8	
51-60	49.2		38.8		51.1		42.3	
61-70	40.1		31.9		42.6		37.0	
71-80	34.2		26.4		37.0		31.5	
81-90	27.4		22.3		28.1		23.8	
91-100	21.9		19.7		27.1		22.3	

In both young and old groups the "appetite" curve (A) is at a lower level for the first 20 days, then continuing an upward trend; while the yield of the other division (B) falls steadily from 20 days. It is noticed that the "produced" curves (A) and curves (B) are similar in shape and fall after 20 or 30 days. This evidence then demonstrates the normal shape of the Romney lactation curve, and that with high yielding ewes a false estimation of their milk-producing ability will be obtained unless the precaution is taken of handling the udder after the lamb has suckled. This result also substantiates the observation under practical farming conditions, that ewes sometimes produce too much milk for a single lamb.

In regard to the lower level of intake of division (A) during the first 20 days, a possible explanation of this, is that prior to the milking period, the lambs' appetites were continually satisfied and that they were not as hungry as lambs from division (B). A result of lambs not consuming all milk produced, is that a portion containing the higher percentage of fat is left in the udder. Whether this portion is obtained (and all the fat secreted with it) on the next suckling is uncertain. As demonstrated by consecutive fat analyses during milking, however, this effect is not likely to be important, particularly as S.N.F. are relatively constant.

When the experiment had been in progress some weeks, it became evident that some ewes were beginning the milking period with an accumulation of milk in their udders. It was not practicable to eliminate this source of error at that stage, but some correction was made in obvious cases, on the basis of subsequent estimates during the period. Normally the ewes begin the test period with an empty udder, as we have observed on handling the ewes. The lambs usually run to their mothers and suckle, when disturbed, thus helping to insure an empty vessel when the ewes and lambs are separated.

In order to determine if ewes bearing twins were better milkers than single bearing ewes - either inherently or in association with the endocrine system and general physiological level - the records were divided according to birth number. The average lactation curves are plotted in Figure 5. Evidently no difference exists in the case of the old ewes, but there seemed a possible difference in the young group. Analysis of variance of milk yield and birth number, however, showed that the single bearing and twin bearing ewes in the two-year group did not differ significantly. Even immediately after parturition, there appears to be little difference in either group.

As all ewes of both groups suckled one lamb only, any potential superiority in milk yield of the twin bearing ewes

MILK YIELD AND BIRTH NUMBER (TWO-YEAR OLD EWES).

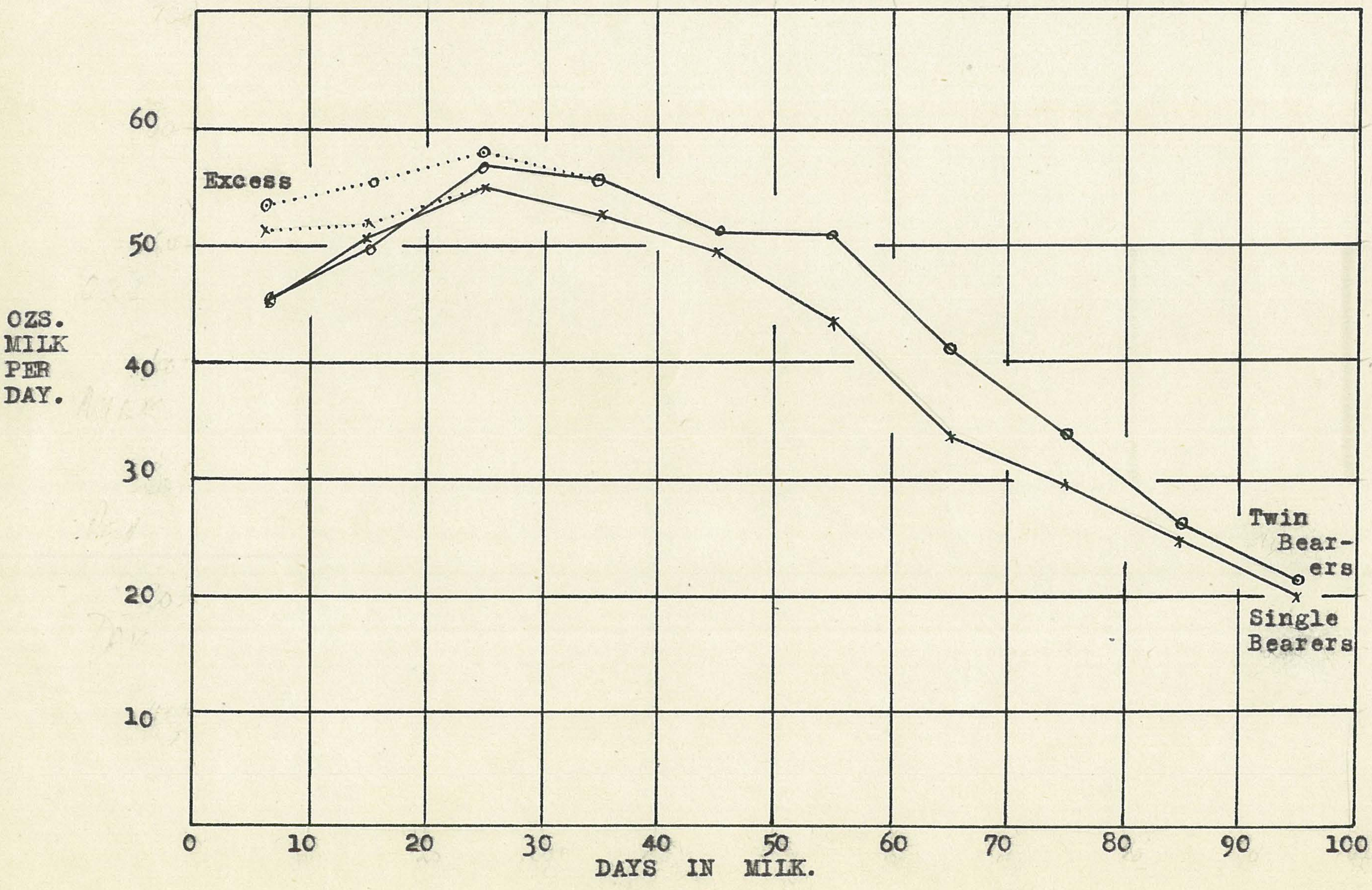


Figure 5a.

MILK YIELD AND BIRTH NUMBER (SIX-YEAR OLD EWES).

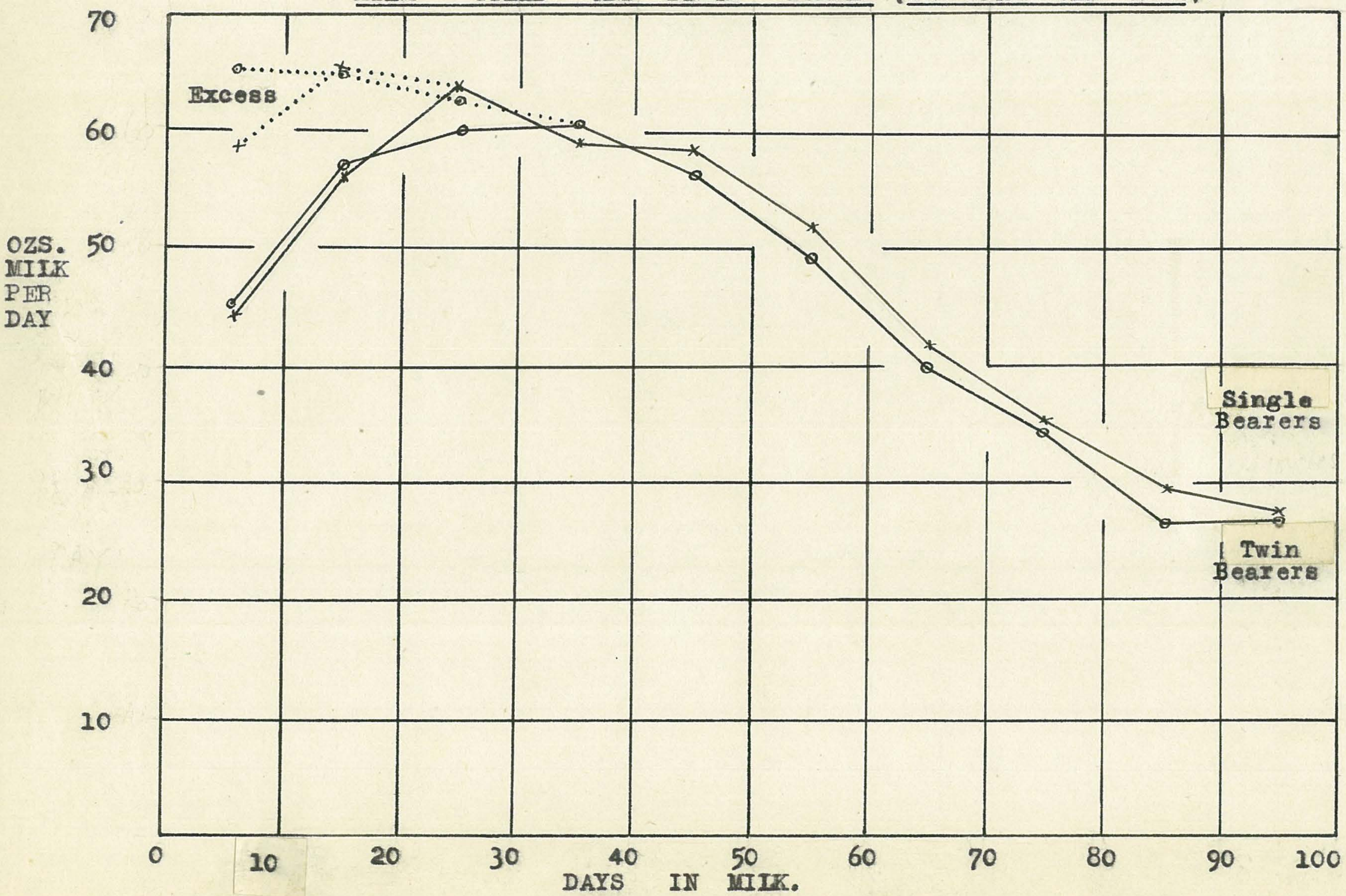


Figure 5b.

could not be adequately expressed. It is likely from work with rodents and pigs, that the cause of increase in milk yield with greater number of young is due to the greater mammary stimulation and more frequent milking out, rather than hormonal or other influences prior to parturition.

In view of the fact that many of the older ewes bearing singles produced milk in excess of the appetites of the lambs (in some cases up to 30 days after parturition), it seems that further improvement in milk yield should be accompanied by an increase in twinning rate, if optimum utilisation of the milk produced is to be obtained. This applies to ewes under a high plane of nutrition such as is found on most fat lamb farms in the North Island. A further reason why twinning is desirable under good grassland farming, is that the lambs have available, an excellent source of supplementary feed when milk yield begins to decline. In this way the aim of this type of farmer - to produce the maximum number of fat lambs off the mothers may be accomplished.

If this reasoning is valid, there are several courses open in any work designed to increase the fat lamb production of our Romney ewes, under North Island conditions.

(a) An improvement in the feeding and management of ewes, where this is not satisfactory. On all our hill country and second-class country in general, the immediate limiting factor in milk production is nutrition, rather than the hereditary potentialities of the ewes.

(b) It is only under the highest planes of nutrition that substantial improvement in inherent milking ability could give a worth while return. Breeding work, however, aimed at extending the peak of milk production in the ewe,(to such a stage in the lamb's development that it could deal with sufficient supplementary feed, to overcome the retarding effect of declining milk yield,)may prove possible. The considerable amount of variation in milk yield should allow a substantial and profitable increase in average milk yield of the flock through selection, though owing to low heritability this increase will be largely lost in the following generation.

(c) An increase in twinning rate to cope with high milk production under good nutrition.

The extreme variability in yield, throughout our flocks, is probably a more serious problem than the inherent level of milk producing ability of our best ewes.

Nutrition, both in its influence on twinning rate (flushing) and on milk secretion, is of far more vital importance to the fat-lamb farmer than is the genetical make-up of the ewes, especially as this is out of his control in most cases. Any improvement on the breeding side, must originate with the stud breeder, who supplies rams to the hill country breeders, who in turn sell their cull ewes to the fat-lamb farmer. Apart from the time required for the stud breeder to effect any improvement in his stock,(once he is convinced of the importance of the mothering qualities of his ewes) many years must elapse before the fat-lamb farmer receives any benefit from such breeding work.

Those farmers who are able to obtain two seasons' production from their fat-lamb ewes, however, may find it profitable to discard any ewes obviously not good mothers.

Comparison of milk yields obtained with North

Island Romney ewes, and those of Bonsma (6) using Merinos and various crosses, shows a considerably higher level for the former.

Merino	26.2 oz./day	(12 weeks)
Merino Crosses	36.2 " "	(")
Merino x Romney	34.8 " "	(")
N.Z. Romneys (2)	46.3 " "	(80 days)
" " (6)	53.0 " "	(")

In Figure 6 the lactation curves of New Zealand Romneys (the "consumed" estimate for two-year and six-year ewes) and South African Merino, Merino x Romney and Merino x Border Leicester crosses are plotted on a comparable basis. In view of the similarity of the curves for New Zealand Romney ewes and the South African Border Leicester x Merino ewes; and of the fact that the Border Leicester cross, the Ryeland cross (2) and the Romney cross curves begin at the same level, it is possible that the appetites of the lambs from the Border Leicester cross ewes were insufficient to cope with all the milk produced during the first week. Whether this was taken into consideration is not known.

It is evident that New Zealand Romneys not only produced more milk for the period, but declined in average daily yield less suddenly, after three weeks in milk, than did any of the South African groups of ewes. While the amount and kind of food available during pregnancy and lactation undoubtedly explains much of the difference between the New Zealand and South African results, the breeding of the ewes is obviously an influential factor. The absence of the characteristic peak of milk production between three and four weeks in lactation in the purebred Merinos, may explain some of the lack of persistency in the Merino

COMPARISON OF LACTATIONS OF N.Z. ROMNEYS AND S.AFRICAN MERINOS (BONSMA.)

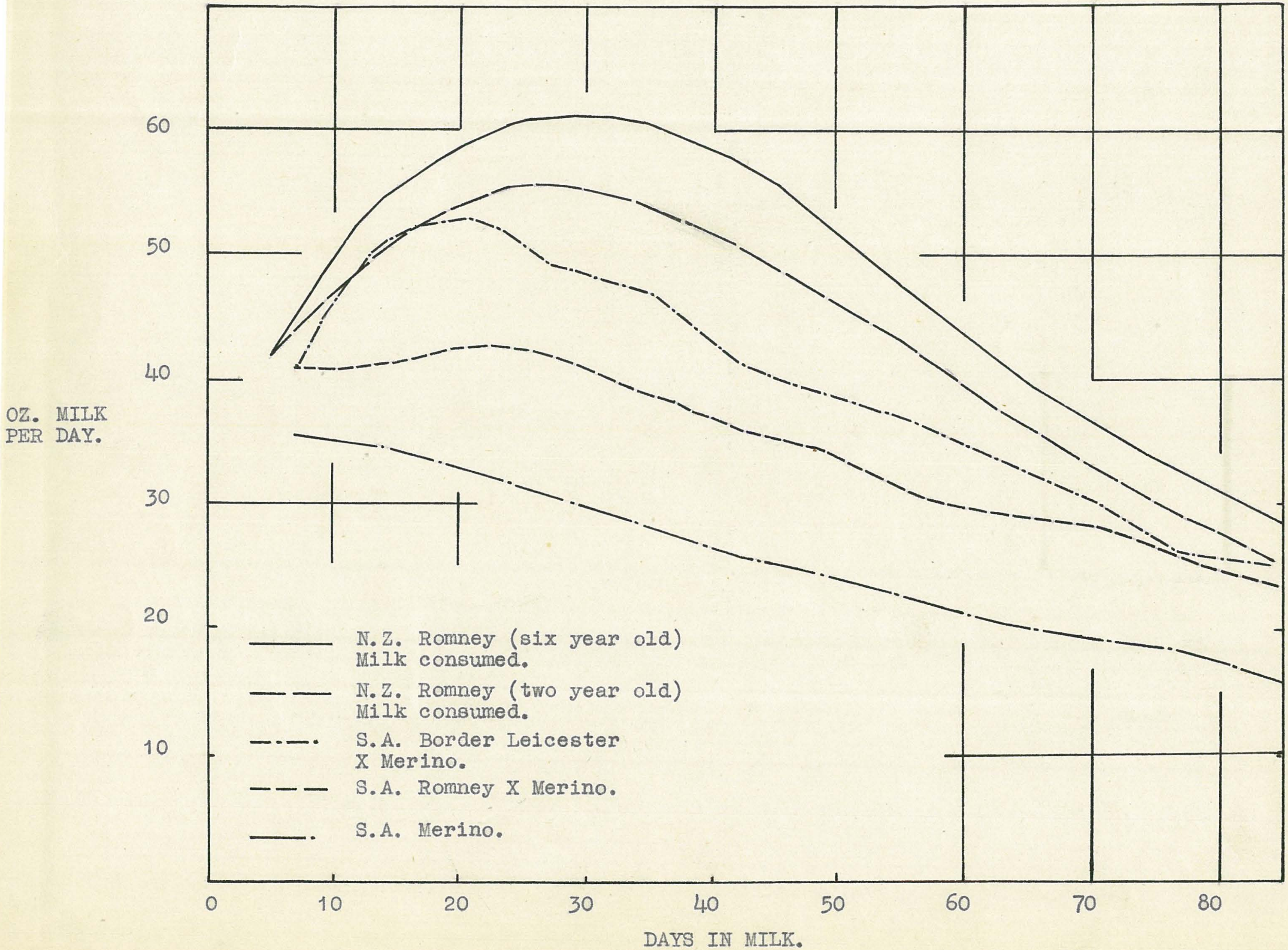


Figure 6.

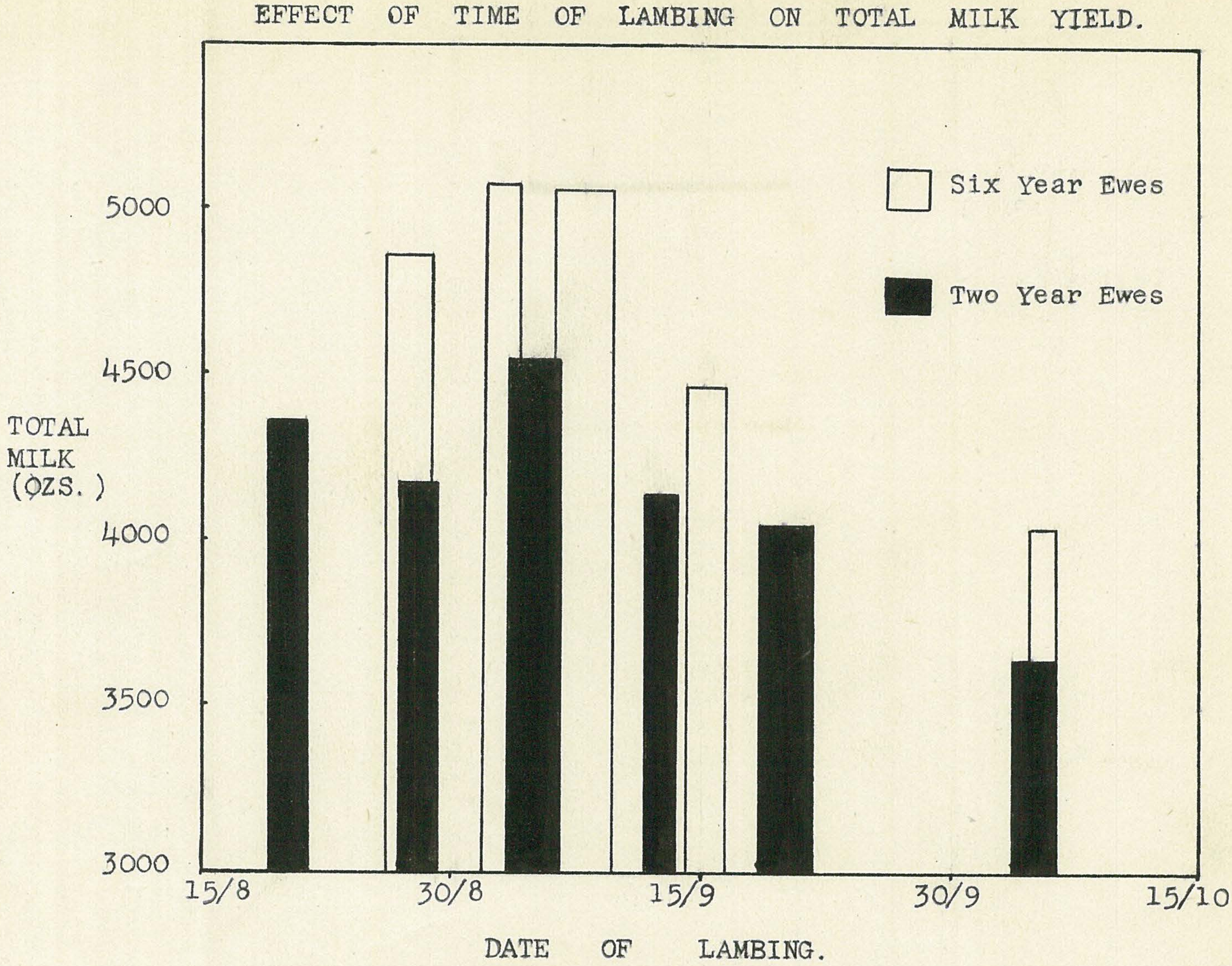
crosses. The effects of heterosis, breed, dominance and nutrition, however, are probably all concerned in these shape differences, and it is not possible on present evidence to separate and evaluate them.

(iii) Effect of Time of Lambing on Milk Yield: As lambing took place over a period of 2 months it was possible to study the effect of time of lambing on total milk yield. Figure 7a shows the milk yields grouped in convenient stages in order to include a sufficient number of records. In both age groups maximum milk yield appears to be in the first 7-10 days of September with a tendency to fall away considerably as the season advances.

Although the number of records contributing to each point on the graphs are necessarily small, support for the general conclusion previously mentioned, is given by the similarity of the two groups, which were presumably randomly distributed as regards time of lambing (see Figure 7b).

The reason for the lower yields of the early lambers is not clear, but is probably connected with the amount and quality of pasture immediately before and during lactation. No doubt the tendency for lower milk yield in the later lambing ewes is the result of changes in the quality of the feed rather than the quantity, as the length of the pasture throughout the experiment was adequate, to ensure ad. lib. conditions.

(iv) Other Factors influencing milk yield: Work with dairy cattle has given us some idea of the relative influence of environmental factors and of genetic factors on milk yield. The method of estimating the milk yield and the differential effects on the ewes of handling and being separated from their


EFFECT OF TIME OF LAMBING ON TOTAL MILK YIELD.
Six Year Ewes
Two Year Ewes
TOTAL MILK (OZS.)
5000
4500
4000
3500
3000
15/8
30/8
15/9
30/9
15/10
DATE OF LAMBING.

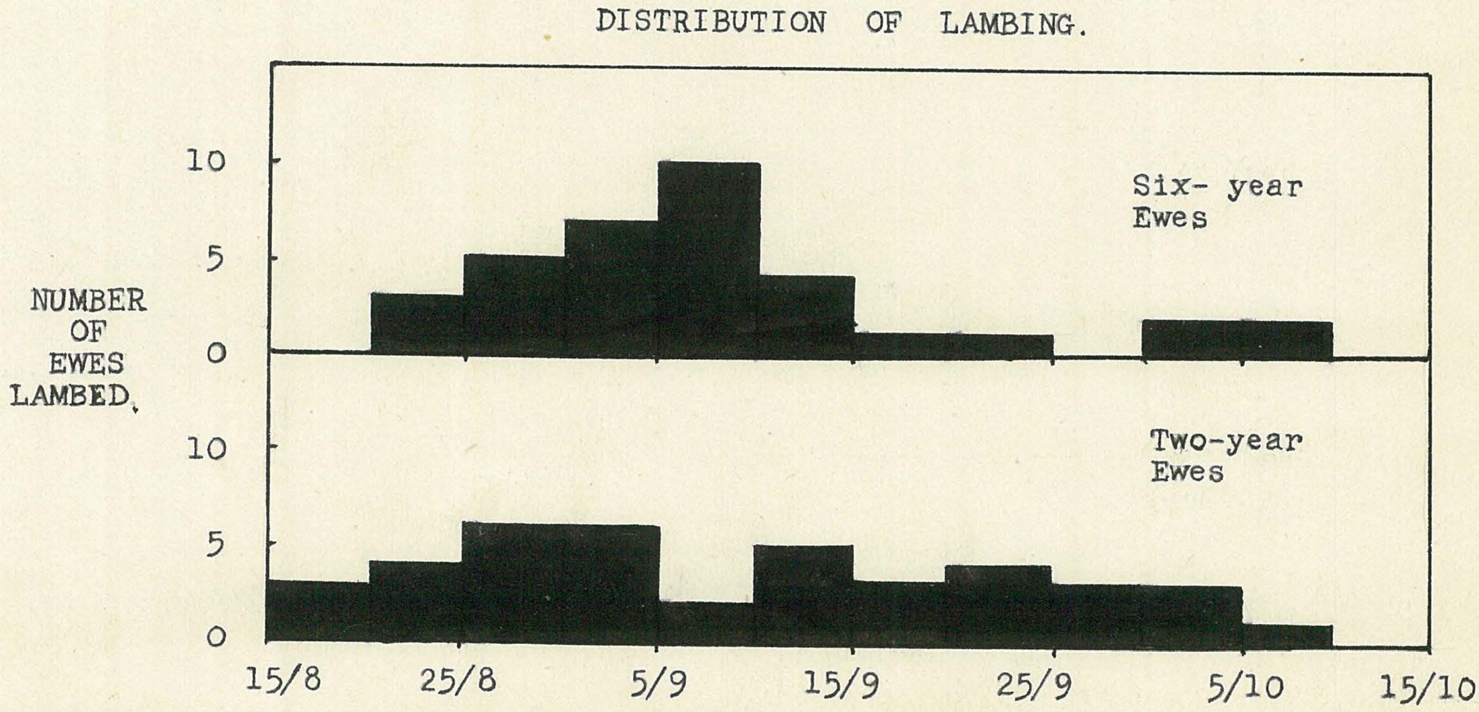

DISTRIBUTION OF LAMBING.
Six- year Ewes
Two-year Ewes
NUMBER OF EWES LAMBED.
10
5
0
10
5
0
15/8
25/8
5/9
15/9
25/9
5/10
15/10

Figure 7.

lambs, have no doubt contributed to the variation observed. Our data, however, does not permit more than reference to the possible other factors which may have been operating. Differential grazing capacity, the effects of parasites and of foot-rot, as well as genetic differences in the ewes have undoubtedly contributed. Since the general environmental factors, apart from foot-rot, were common, the greater part of the variance might be attributed to individuality and this indicates a commercial selection potential on a basis of milk yield.

(v) Comparison of efficiency of dairy cows and Romney ewes in lactation: Using the average recorded lactations for 100 days and the average fat percentages, viz. 4168 oz. with 5% fat, and 4760 oz. with 6% fat, the pounds of fat secreted per day for every 100 lb. live weight has been calculated. Assuming an average production for dairy cows of 230 lb. for 250 days and live weight of 850 lb. a comparable figure has been obtained.

2 year ewes	..	.100 lb.fat/day/100lb. L.W.
6 year ewes	..	.111 lb.fat/day/100lb. L.W.
Average Jersey Cow	..	.108 lb.fat/day/100lb. L.W.

To equal the efficiency of these Romney ewes the dairy cow needs to produce 224 lb. fat in a 250 day lactation.

Obviously such a comparison between species on a live weight basis is not a true one, but it is nevertheless interesting.

(2) Milk Composition - Data on the composition of milk from the more common British breeds used in New Zealand, such as the Romney, Leicester and Down breeds, are unfortunately rather sporadic and incomplete. Various workers give fat and solids-not-fat figures for a variety of breeds (Table III). Godden and Puddy (13) survey the literature on the subject of milk yield and composition in sheep up till 1935 and since then Bonsma (2) using South African Merinos and Merino crosses; and Pierce (27,28) using Australian Merinos have analysed the milk from a number of lines at various stages of lactation.

In many cases no mention is made of the method of obtaining the milk samples, nor in some instances of the breed or stage of lactation. As these points are of some importance in comparisons of breed or lactational differences in composition, some of the data presented in Table III are of little value, and are inserted merely as a convenient summary of the literature.

The analyses of 25 composite samples are presented in the appendix, and graphically in Figure 9. The ewes lambed over a period of 8 weeks and consequently the last ewe lambed when the first was already nearly two months in lactation, so that these analyses indicate seasonal as well as lactational effects. It is only in the case of fat % and S.N.F. % that unobscured lactational trends are available. As some of the composite samples had soured slightly before analysis, the periodical averages of fat % and corrected S.N.F. % were obtained by tabulating the individual data, and are shown in Table IV and in Figure 8. The analyses of the composite samples(appendix) shows S.N.F. uncorrected for fat percentage.

TABLE III

SUMMARY OF YIELD AND COMPOSITION DATA.

AUTHOR	YIELD (OZS)	TOTAL SOLIDS	PROTEIN	FAT	SUGAR	ASH	REMARKS
König	-	16.43	5.15	6.18	4.17	.93	
Richmond	-	20.54	6.68	8.63	4.28	.97	
Fuller & Kleinzhanz	40.00	18.00	-	7.04	-	-	6 breeds.
Neidig & Iddings	54.30	-	4.12	7.72	-	.83	6 breeds (10-15 days).
Scheingraber	90.67	15.76	4.55	5.05	-	.80	Mostly milk ewes.
		25.94	9.33	10.16	-	.90	
Godden & Puddy	21.65	19.30	6.06	7.43	4.81	.97	Cheviots (various inter-
	29.20	19.88	6.83	7.94	3.74	.93	vals during lactation).
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 " (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	" (4th.week)
	28.17	19.02	4.33	8.23	4.71	.92	" (6th.week)
Pierce (1937)	38.73	18.13	4.67	7.83	-	-	12 Merinos.
Bonsma	26.21	16.23	5.25	4.76	-	.88	7 Merinos (8th.week)
		18.76	5.59	6.81	-	1.12	(12th. ")
	40.06	16.86	5.00	5.26	-	.83	5 B.L. (8th. ")
		19.03	5.59	6.62	-	1.11	(12th. ")
	36.39	16.05	4.85	5.36	-	.95	5Ryeland (8th. ")
		19.13	5.52	7.45	-	1.39	(12th. ")
	34.83	16.95	5.86	4.91	-	.91	8 Romney (8th. ")
		18.82	5.37	7.01	-	1.15	(12th. ")
	34.35	16.71	5.13	5.05	-	.89	5 Dorset (8th. ")
		18.96	5.47	6.92	-	1.23	Horn (12th. ")
							(Yields are the averages of 12 weeks lactation).
Logan	41.68	15.99	5.47	5.10	4.67	.83	(Yields and composition averages of 100 day lactation).
	47.60	16.91	5.49	6.06	4.53	.83	2 & 6 yr.N.Z.Romney resp.

INFLUENCE OF STAGE OF LACTATION ON THE COMPOSITION OF ROMNEY EWES' MILK.

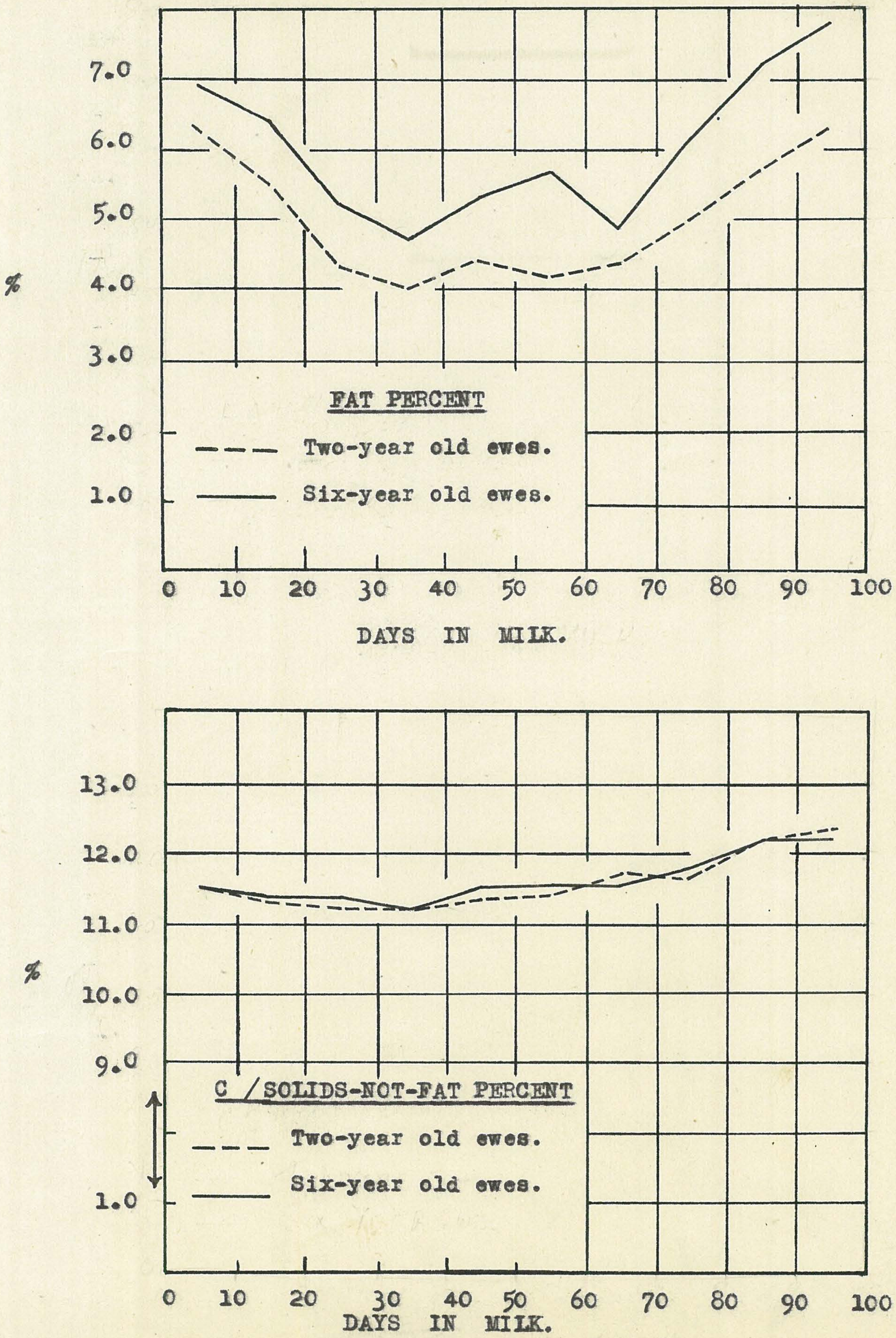
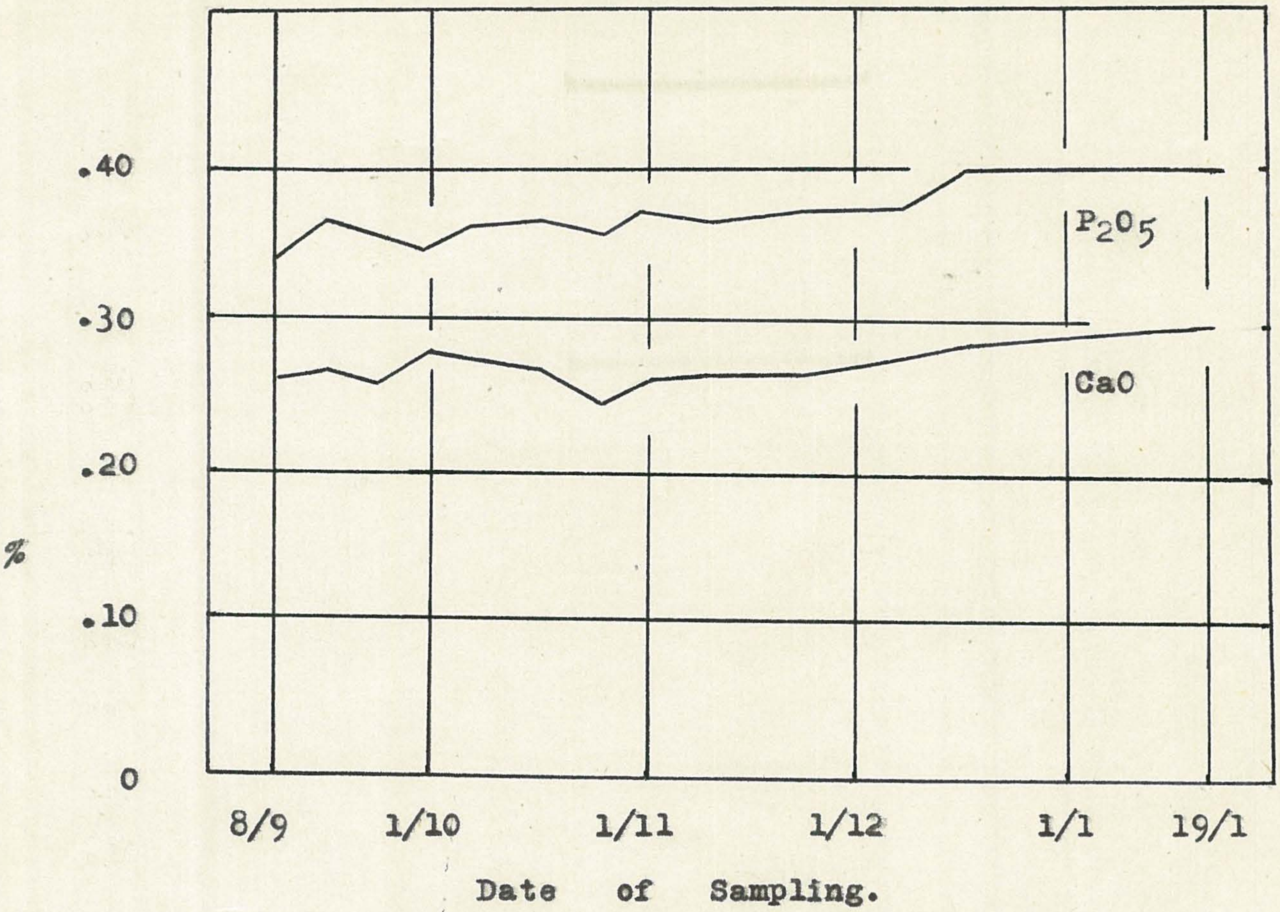


Figure 8.



AVERAGE PERCENTAGE OF CALCIUM AND PHOSPHORUS IN THE MILK OF TWO-YEAR OLD AND SIX-YEAR OLD ROMNEY EWES (Ages Combined).

Figure 9.

TABLE IV.

Two-year ewes.			Six-year ewes.	
Period. (days)	Fat %.	C/SNF %.	Fat %.	C/SNF %.
3-10	6.30	11.46	6.90	11.45
11-20	5.53	11.29	6.41	11.32
21-30	4.30	11.16	5.19	11.36
31-40	4.03	11.19	4.72	11.21
41-50	4.40	11.39 4	5.26	11.53
51-60	4.21	11.38	5.64	11.55
61-70	4.37	11.69	4.84	11.56
71-80	5.02	11.59	6.12	11.76
81-90	5.72	12.16	7.18	12.15
91-100	6.28	12.33	7.83	12.21

Age differences in milk composition are not evident except in the case of fat percentage. The six-year old ewes produced milk distinctly and consistently richer in fat than did the two-year ewes. This difference is highly significant but is difficult to explain, as it is generally accepted that a slight decline in fat test, occurs during the lifetime of a dairy cow, rather than the reverse.

Distinct lactational trends are evident in each constituent analysed, though in the case of protein and ash, the picture is obscured by seasonal influences, and by the fact that each composite sample included milk from ewes in varying stages of lactation.

The observation in cows, that fat tests vary as much within a breed as between breeds has been substantiated in ewes, as the range was from 2.0 - 20.0%. Weighted average tests varied from 3.0 - 9.0%; less variation was present in the C/SNF.%. Study of the graphs presented in Figure 8 shows an inverse relationship between fat percentage and milk yield. This also applies to C/SNF. %, but to a smaller degree. It is significant that no difference exists between the age groups for corrected SNF.%.

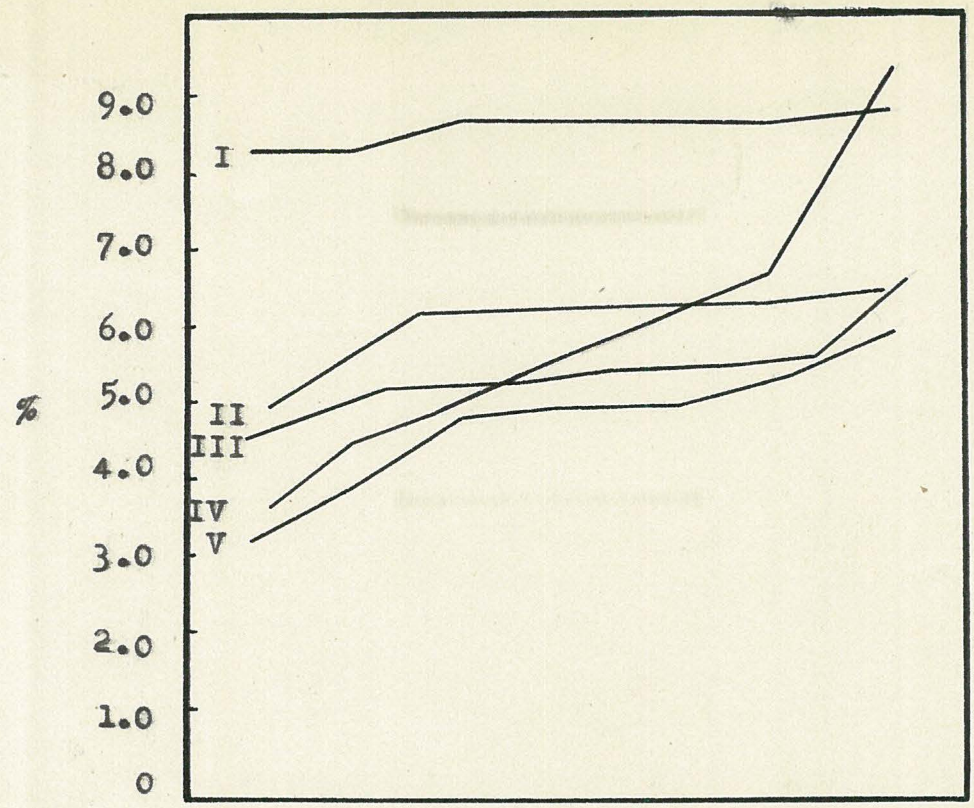
Because of the much greater variation observed in fat test, than in other solids, and because fat contains more than twice the energy of carbohydrates or proteins, it seems reasonable that fat test may be important in its influence on the calory intake of the suckling. Owing to the probable unreliability of single quarter sampling for individual comparisons, no attempt was made with the data from this investigation, to evaluate the role of the quality of ewes' milk, in the growth of the lamb.

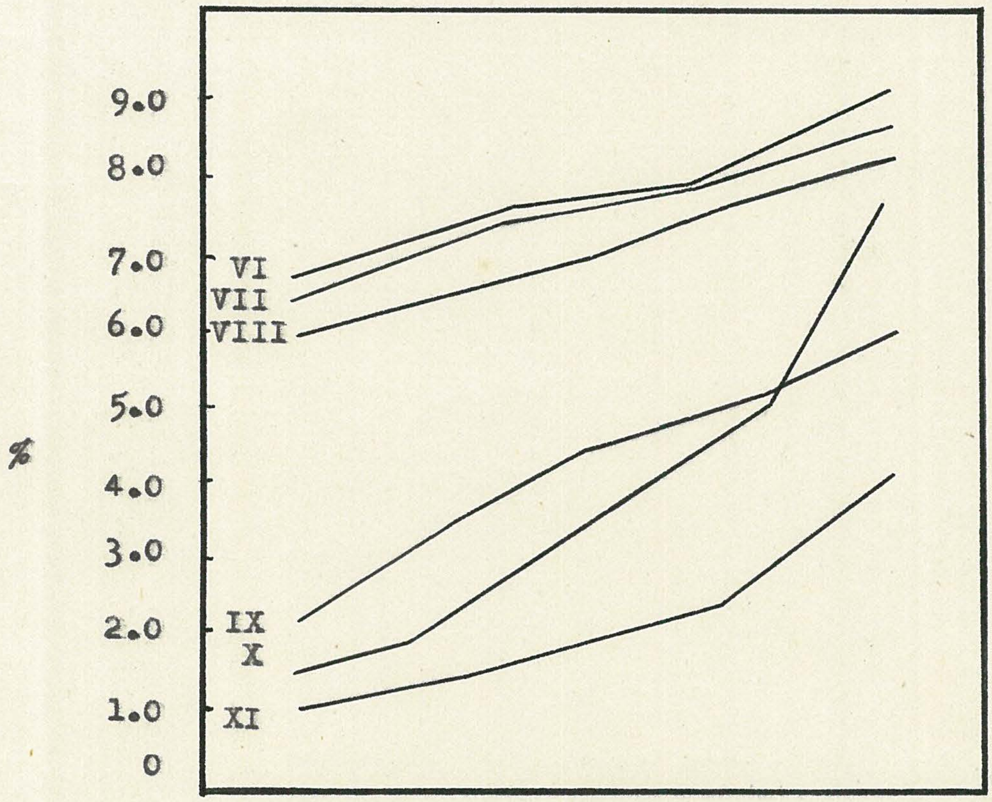
The consecutive sample analyses are presented in Figure 10 and Table V.

TABLE V.

Fat Analyses of Consecutive Samples taken during Milking.

Ewe No.	Reference No.	Date.	Fat Percentage. (Sample Number) 1	2	3	4	5	6	7	8	9
37	VII	15/9	6.8	7.8	8.2	9.2					
37	VI	22/9	7.1	8.0	8.3	9.6					
56	VIII	22/9	6.4	7.4	8.6						
48	I	29/9	8.2	8.3	8.6	8.7	8.7	8.7	8.8		
48	V	6/10	3.2	4.0	4.9	5.0	5.0	5.4	6.1		
44	X	6/10	1.5	2.1	3.2	4.3	5.3	8.2			
48	II	16/10	5.1	6.2	6.3	6.4	6.5				
72	XI	16/10	1.2	1.7	2.5	4.3					
48	IV	31/10	3.7	4.5	4.8	5.3	5.6	6.1	6.7	9.2	
70	IX	31/10	2.2	3.6	4.7	5.4	6.5				
48	III	8/11	4.5	4.9	5.2	5.3	5.3	5.4	5.5	5.7	6.8





RISE IN FAT PERCENTAGE DURING MIIKING.

Figure 10.

The quantity of milk produced seems to have had little effect on the slope of the curves, so that each curve is drawn on a percentage basis for easier comparison. The analyses presented are from only those milkings which seemed to represent a high proportion of the available yield, as compared with the amount obtained by the lamb.

These graphs do not show much variation in slope, except for Ewe 44 on 6/10/44 (X) and ewe 48 on 31/10/44 (IV). It was noted that in these two cases hand-milking was commenced as soon as the lamb settled down. In the remaining cases it is probable that the ewes had "let down" their milk, as the lamb had been on the ewe some time before sampling commenced. If this is the case Crowther's (5) findings are substantiated. He showed that in dairy cattle when one quarter is milked out first, the fat percentage rises regularly from the beginning to the end of the milking, but when the other quarters of this udder come to be milked out the fat percentage varies very little from the beginning to the end of milking.

Generally the more satisfactory method of obtaining samples of the milk, is to wait until the lamb has consumed most of the milk from the first quarter, before hand-milking the second quarter. The lamb should then be allowed to suckle the first quarter again and any further milk extracted from the second quarter. This procedure was always carried out when obtaining consecutive samples. If this latter portion was insufficient for separate analysis it was added to the previous sample. Whether this last milk was analysed separately or added to the previous sample has not been recorded. Experience with dairy cows has shown that the "strippings" or the last milk to be withdrawn (presumably from the small ducts and alveoli) is markedly higher in fat, than the average of the whole. The fact that portion of the available milk, including the strippings sometimes remains in the udder of the ewe, after hand-milking is not considered to detract greatly from the utility of the sampling procedure herein outlined.

In this investigation the average amount remaining in the udder after stripping is less than 25% of the estimated total of "available" milk. Many of the lambs were unable to consume all the milk available during the first month. Also the milk extracted by hand being a considerable proportion of the whole and being mixed in the udder by the lamb's suckling of the other quarter, should be a reasonably reliable and consistent index to the quality of the milk for comparative purposes.

However, this method undoubtedly gives an under-estimation of the true fat content of the milk, and the smaller the proportion of milk obtained by hand of the estimated total, the less reliable will the sample be. Conversely, however, Turner (32) has known that when the quarters of dairy cows are milked in rotation, milk from the first quarter, is richer than that from subsequent quarters. No observations on this point were made with our ewes.

In the application of this method of sampling to "spot-testing" techniques the slow rise in fat percentage is of distinct advantage. Provided care is taken to allow sufficient time for the lamb to initiate the "releasing" process, a reasonably reliable sample may be obtained. Previous workers who have attempted to hand-milk ewes, have had little success, in that only a small proportion of the potential yield was released. Fuller and Kleinhanz (10) found that the lamb obtained approximately 2½ times as much.

Considerable variation in the ratio of milk obtained by hand to that obtained by the lamb was found in this investigation. This ratio, when worked out for each ewe, as an average for all the samples taken, varied from .5 to 1.0, the average being .75. To a small extent the discrepancy can be accounted for by variation between quarters of the same ewe, as several ewes were observed to yield more from one quarter than from the other. The lambs appeared to favour the better yielding quarter first, leaving the poorer to the sampler. Considerable variation in both yield and test have been observed between quarters in dairy cows and this seems likely to be the case also with ewes. There is apparently no reason why milk secretion phenomena in cows and ewes should not be analagous.

It is evident, however, that hand-milking even under carefully controlled conditions does not extract the maximum amount from the udder. In view of the small rise in fat percentage observed in most of the ewes investigated it is unlikely that the fat percentage of a sample representing 75% of the available milk, would be greatly different from the true test.

According to the "pressure" theory of milk secretion (Hammond, Petersen)* it is probable that manhandling of the ewe, even after the lamb has suckled one quarter, will result in the relaxing of pressure in the ducts and it is likely that this involuntary action will cause the retention of milk that would have been obtained had the muscle fibres in the mammary tissue remained turgid. It is worth noting, however, that hand-milking without the

* Numerous publications.

assistance of the lamb, can only extract little more than the milk already in the cistern and larger ducts (40% - Fuller & Kleinhanz (10); Hammond (15a)) while the method herein outlined provides a sample containing milk impressed from the smaller ducts as well - about 75 per cent.

In several instances it was possible to milk out the second quarter while the lamb was still suckling, and these cases generally gave a ratio of 1.0. Unfortunately, it was not practicable to obtain consecutive samples in this way as the time taken was much greater.

The method of sampling used in this work is probably sufficiently reliable, although not as reliable as the New Zealand Herd Testing techniques where sampling does not upset the cows, nor cause any variation from the normal milking routine. In this regard, the necessity for quiet and patient handling of the ewes and lambs is emphasised, as they must both be contented before conditions are suitable for obtaining a high proportion of the total yield and a sample that is truly indicative of the composition of the milk.

(b) Live Weight Changes:

The live weights of the ewes recorded throughout pregnancy and lactation (adjusted to the initiation of both,) have been plotted as average curves in Figure 11. (Appendix)

The average weights at tupping, immediately prior to parturition, ten days in lactation, and when 100 days in lactation are shown in Table VI.

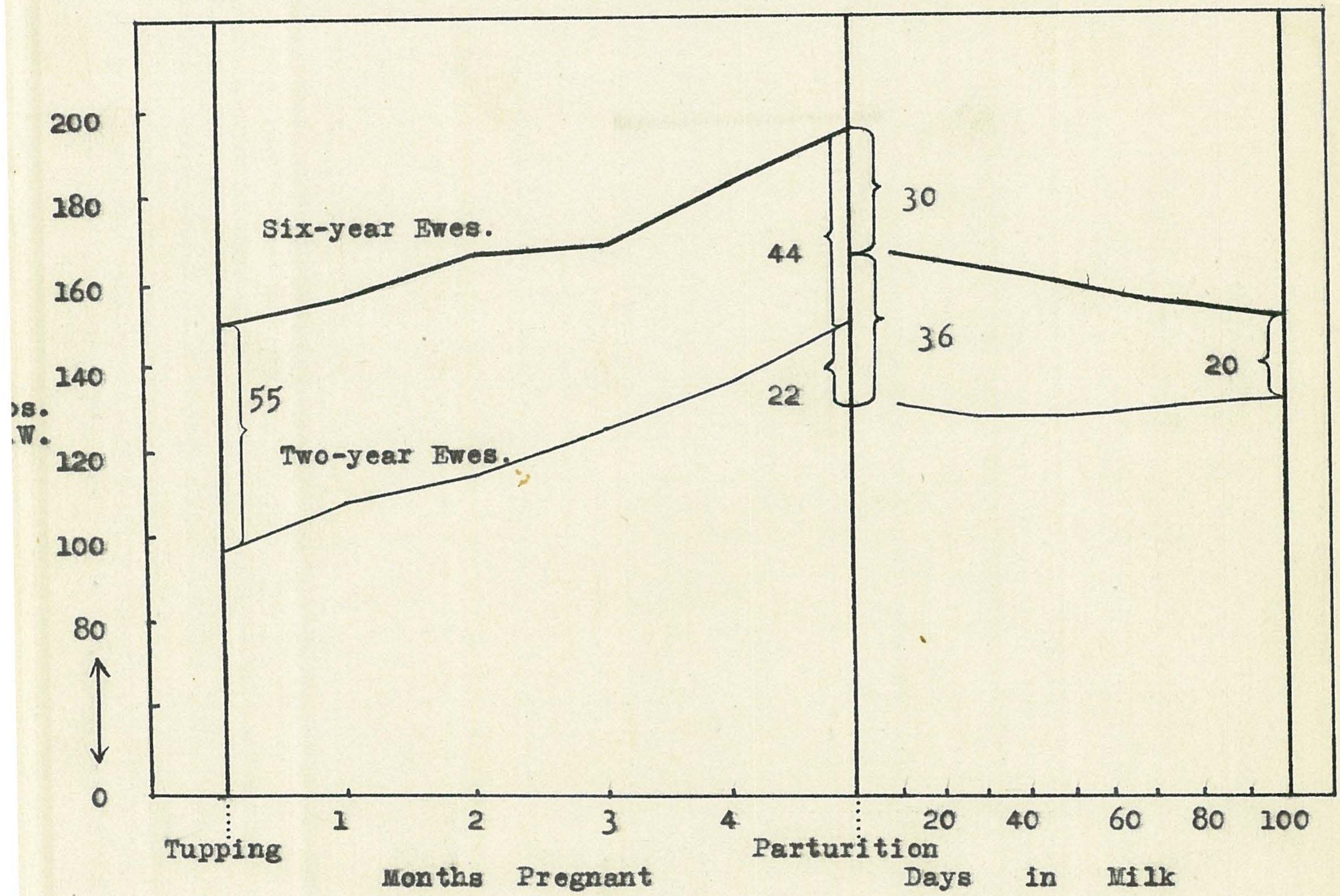
TABLE VI.

Absolute Live Weight Changes of Ewes.

Average Live weight:	Two Years.	Six Years.	Difference.
At tupping	96.8 lb.	151.9 lb.	55.1 lb.
Before Parturition	151.6	195.7	44.1
10 days in Lactation	129.5	165.7	36.2
100 days in Lactation	130.9	150.6	19.7

It will be noted that the difference between the weights of the two ages decreases consistently, indicating that:

(1) the young ewes increased in absolute weight more than the old ewes during pregnancy (despite the advantage of the latter in carrying a greater percentage of twins and lambs of heavier average weight.) When relative live weight is considered the differences are even more striking.



AVERAGE LIVEWEIGHT CURVES OF SIX-YEAR OLD AND TWO-YEAR OLD EWES THROUGH PREGNANCY AND LACTATION.

Figure 11.

T A B L E VII.

Relative Live Weight Changes of Ewes.

Average Live Weight:	Two Years.	Six Years.
At tupping	100.0	100.0
Before Parturition	157.0	130.8
10 days in Lactation	133.8	109.0
100 days in Lactation	134.3	98.9

(2) that the young ewes gained 1.4 lb. while the old ewes lost 15.1 lb. during 100 day's lactation.

The greater relative increase in live weight of the maiden ewes is in accord with the contention that pregnancy does not inhibit growth and that it may in fact be stimulating. * At parturition the mature ewes appeared in fat condition, and because their growth processes were no longer active, it is likely that much of their live weight increase was due to fat deposition.

During lactation the mature ewes decreased in live weight and appeared to lose condition while the young ewes were able to maintain their live weight. The reason for this situation is not clear but may be associated with growth in the younger ewes.

* Espe, who quotes Cole and Hart (1938)

(c) Lambing Results:

(1) Lambing Percentage: Of some practical importance is the fecundity of the ewe, a consideration that has not received due attention in New Zealand.

As expected the mature ewes were more prolific, though owing to the small numbers involved, the averages obtained serve merely as an indication. Table VIII sets out lambing and wastage in both groups.

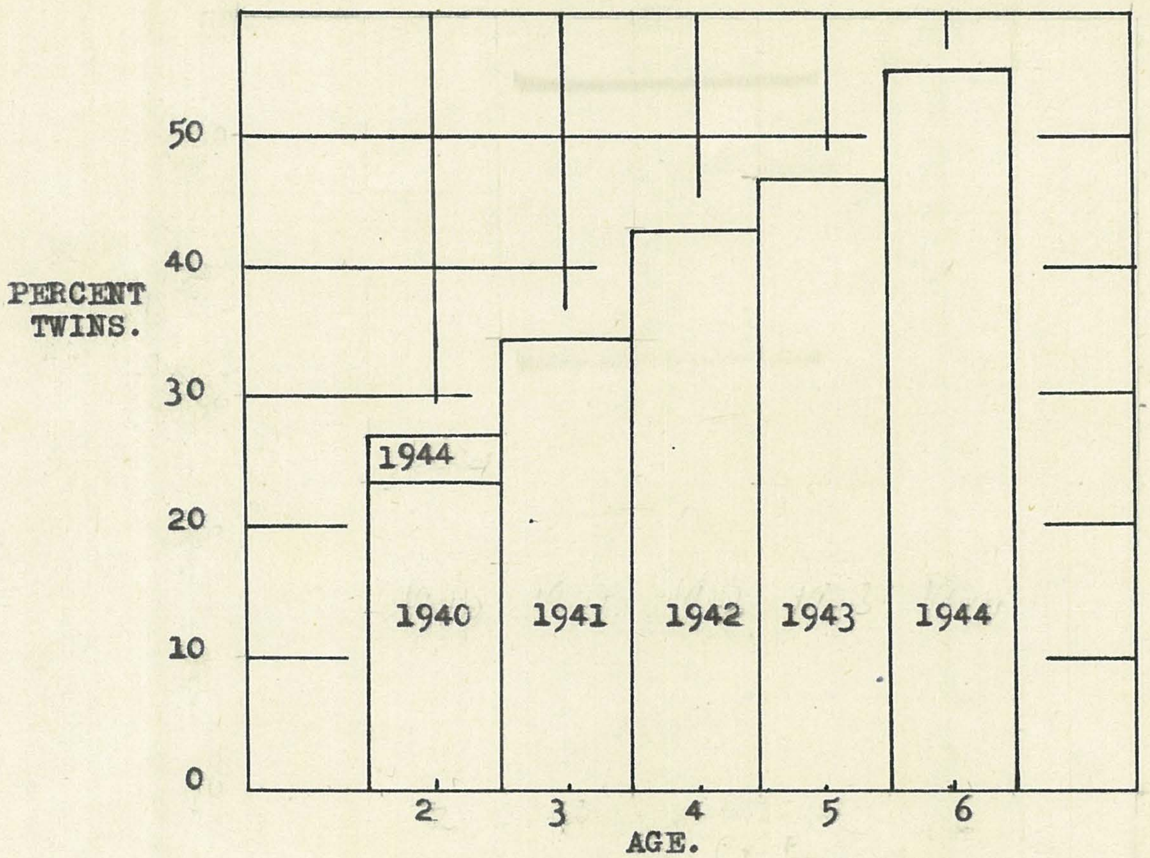
T A B L E VIII.

Lambing and Wastage.

Group.	Ewes put to Ram.	Ewes Lambing.	Ewes rearing Lambs.	Percent. Twins.
Two years	50	41	41	27
Six years	42	40	38	57

All ewes failing to rear lambs in the young group did so because they did not reproduce, while only two of the old ewes failed for this reason. The two old ewes lost after lambing died following difficult parturition.

From data collected at Massey College (4) on a similar population over 4 years (1940-3) the average percent twins is presented in Figure 12 and Table IX. No measure of the seasonal influence for these years is available, but 1944 was probably an unusually good season.



AGE OF EWE AND PERCENT TWINS.

Figure 12.

TABLE IX.

Percentage Twinning.

Year.	Age.	Percent.
1940	2	22.5
1941	3	34.8
1942	4	44.0
1943	5	48.2
1944	6	57.0
1944	2	27.0

(2) Birth Weight of Lamb: Bonsma (2) has found a highly significant correlation ($r = +0.492$) between live weight of ewe after lambing, and birth weight. He estimates that approximately 24% of the variation in birth weight is accounted for by the variation in weight of ewes. Similar results were reported by Donald and McLean (6) and others, but Australian workers have found only a weak or non-significant correlation, (though in this case live weights of ewes were those recorded during pregnancy.) Using the first live weight recorded after parturition, non-significant correlations were obtained for both groups, in this work. As the ewes were in fairly good condition, this result is not unexpected.

The birth weight averages of singles for the young and old ewes were 9.4 lb. and 11.4 lb. respectively. This result is that found in numerous investigations on large numbers of individuals, and these figures are inserted for comparison. From the analysis of variance of birth weight and age of ewe, it was found that approximately 19%* of the variation in birth weight is associated with age of ewe in these data.

* obtained from mean square.

ANALYSIS OF VARIANCE.

Birth Weight and Age of Ewe.

Source.	d.f.	Mean Square.	F.
Age group	1	94.49	18.82 (H.S.)
Error	75	5.02	
Total	76	6.02	

(F. at 1% level = 7.01)

(All birth weights recorded were used in this analysis)

The small numbers available do not allow further subdivision into sex groups.

(d) Wool Yield:

Many investigations in various wool-producing countries have established the fact that size within a breed is related to the amount of wool produced. Not only is the data collected during this experiment of little value for confirming such relationships, but the object of studying the wool yields of the ewes was merely to find out to what extent high milk yield and high wool yield are compatible (i.e. without any reference to quality or value of the fleece.) Unfortunately the wool yields were not available for all the ewes, thus further reducing the reliability of the results. Many of the fleeces from the old ewes were weak and others had lost some of the wool so that any correlation present would tend to be weakened.

A high positive correlation between milk and wool production cannot be expected on genetical grounds except insofar as the general physiological level is in part common to both. Again, the level of lactation could influence rate of wool growth only after parturition, representing about one third of the year. The ewes were shorn on 20th December when most of the ewes were well advanced in lactation. The effect of shearing on the ewes' milk supply is an interesting practical point and may be of some importance in regard to the time of ewe shearing, and the effect on the growth of the lamb. Table X sets out the mean milk yields up to 100 days and the mean fleece weight. Negative but non-significant correlation coefficients were obtained between wool yield and milk yield. According to conventional levels of statistical significance (Snedecor), the coefficients obtained (Table X) would be highly significant with approximately 70 degrees of freedom.

TABLE X.

Mean Milk and Wool Yields.

Age.	n.	Milk Yield.	Wool Yield.	r.
2 years	31	4165.0 ± 530.0 oz.	12.94 ± 1.78 lb.	-.314
6 years	26	4767.6 ± 624.0 oz.	10.95 ± 1.78 lb.	-.290

The degree of correlation between milk yield and wool yield is perhaps less interesting than the fact that high milk yield and high wool yield are possibly incompatible to some extent. Although the correlations are not significant they are both negative and of similar magnitude. Live weight of ewe and milk yield in these data, were not significantly correlated, but evidence from other sources indicates that there is a positive correlation between live weight and milk production and also between live weight and wool yield.

Unless these correlations, however, were rather higher than usually obtained between these characters, a negative correlation between the two dependant variables (milk yield and wool yield) is theoretically possible.

If the relationship between milk and wool production as suggested above, is a general one, it is likely that selection for wool yield would tend to reduce the milk production of the ewes. The ultimate effect of phenotypic selection for either or both of these characters, however, must depend on the relative effect of heredity and environment in determining the yields obtained.

(B) LAMBS:

(a) Live weight changes:

The average live weights of lambs from both age groups are presented in Table XI and Figure 13 from birth to 100 days. Up to 50 days the curves tend to diverge slightly but from then on the rate of live weight increase is similar.

T A B L E XI.

Period ending:	2 year Group. Live Weight.	2 year Group. Gain.	6 year Group. Live Weight.	6 year Group. Gain.
	9.09 lb. (Birth weight)		11.49 lb. (Birth Weight)	
10 days	13.19 lb.	4.10 lb.	16.30 lb.	4.81 lb.
20 "	18.85 "	5.66 "	22.54 "	6.24 "
30 "	24.06 "	5.21 "	28.42 "	5.88 "
40 "	29.03 "	4.97 "	34.08 "	5.66 "
50 "	33.58 "	4.55 "	39.31 "	5.23 "
60 "	38.42 "	4.84 "	43.93 "	4.62 "
70 "	42.66 "	4.24 "	48.10 "	4.17 "
80 "	46.59 "	3.93 "	51.99 "	3.89 "
90 "	50.24 "	3.65 "	55.69 "	3.70 "
100 "	53.86 "	3.63 "	59.24 "	3.55 "

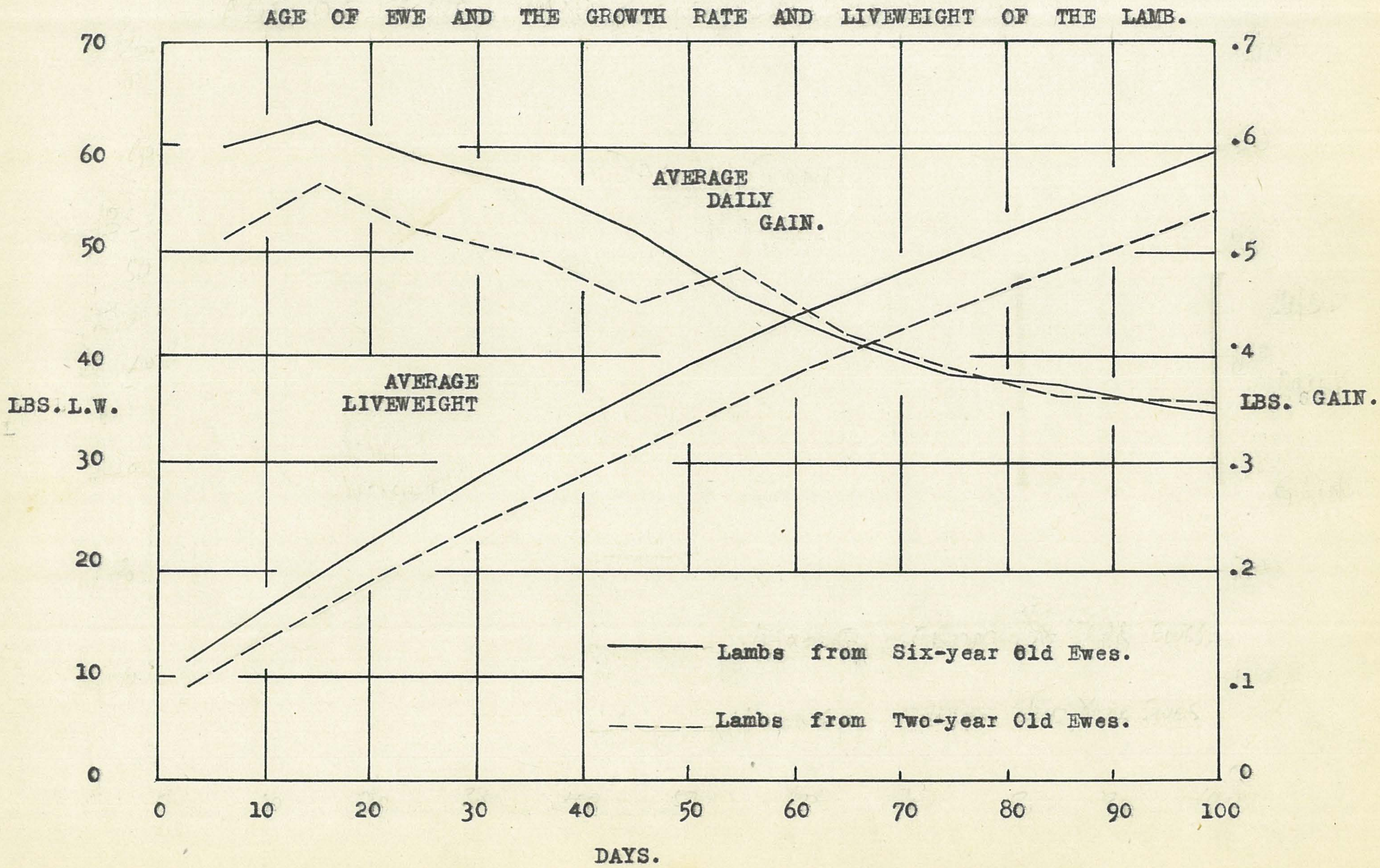
Analysis of variance of age of ewe and rate of gain (lb. per 10 days) of the lambs shows a highly significant difference up to 40 days and a non-significant difference between 40-80 days.

ANALYSIS OF VARIANCE.

Age of Ewe and Growth Rate of Lamb.

Source.	d.f.	Birth to 40 days. Mean Square.	Birth to 40 days. F.	40-80 days. Mean Square.	40-80 days. F.
Between	1	12413.0		191.0	
Within	68	554.6	22.4(H.S.)	325.7	1.7 (N.S.)
Total:	69				

Approximate apportioning of variance associated with age of ewe = 24% from B.-40 days.


AGE OF EWE AND THE GROWTH RATE AND LIVEWEIGHT OF THE LAMB.
LBS. L.W.
LBS. GAIN.
AVERAGE DAILY GAIN.
AVERAGE LIVEWEIGHT
Lambs from Six-year Old Ewes.
Lambs from Two-year Old Ewes.
DAYS.
0
10
20
30
40
50
60
70
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100
.1
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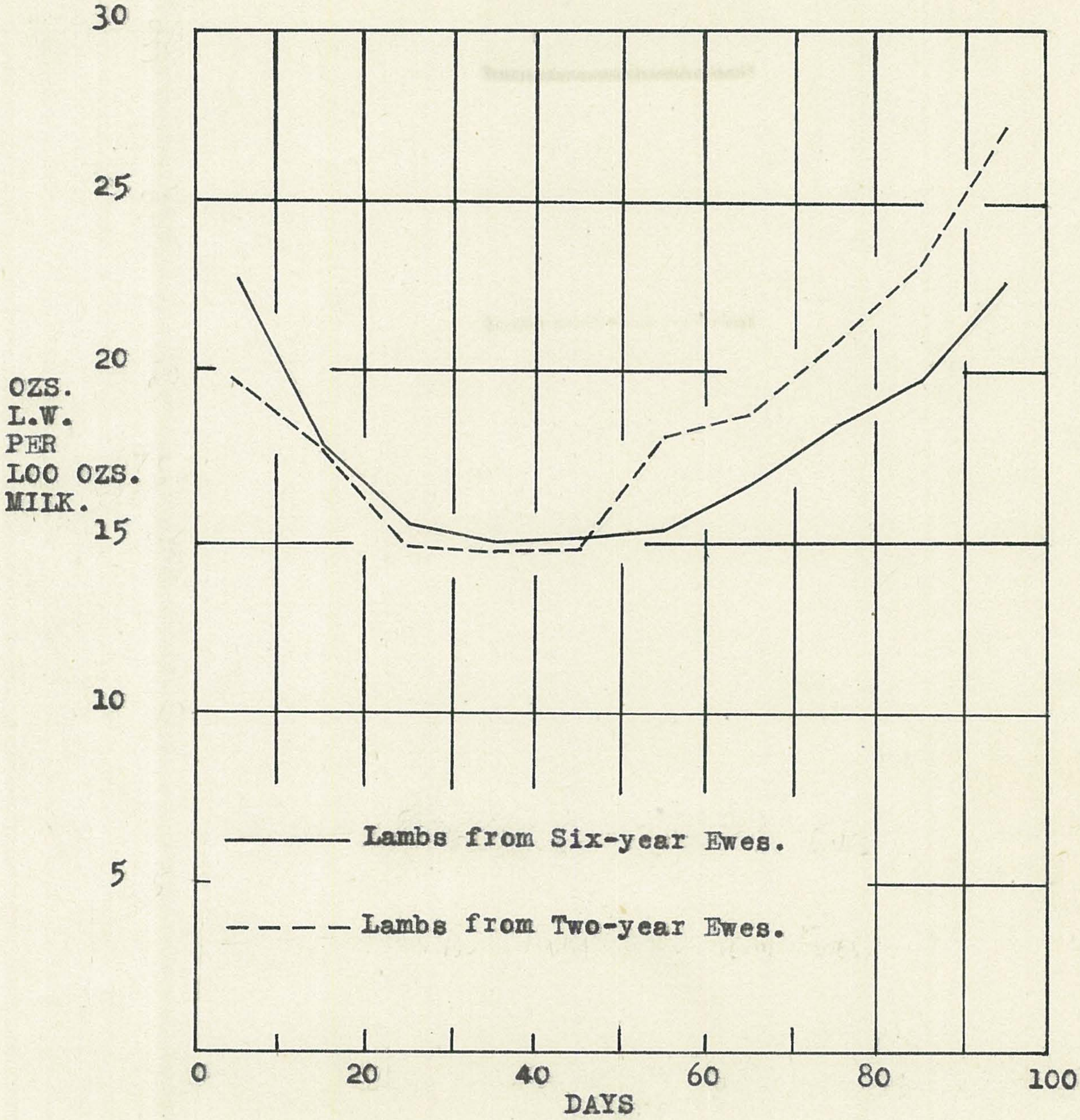
Figure 13.



AVERAGE GAIN IN LIVEWEIGHT (OZS) PER 100 OZS. MILK CONSUMED.

Figure 14.

(1) Effect of Milk Consumed: Both the fundamental and practical importance of milk to the young animal has been remarked on previously. In this section the results of initial statistical analysis are presented. In order to eliminate as far as possible any effects of birth weight on subsequent weights, "rate of gain" has been used in relation to milk consumed over various periods.

No attempt has been made to study the effect of milk composition on rate of gain, though in view of the extreme variation observed in fat content between ewes, it is possible that this constituent may have had some influence on rate of gain. Solids-not-fat variations between ewes were comparatively small.

Several lactation curves of particular interest are presented in Figure 3. Group A demonstrates shape variations; Group B the effects of udder troubles - the yield of milk and its effect on the welfare of the lamb; and Group C compares milk yield and live weight at various levels.

Table XII presents the mean milk yields and live weight gains for 20 day periods, milk consumption per pound gain, and the correlations between milk yield and daily gain. The average daily gain over 80 days:-

for lambs from 2 year ewes = .48 lb. per day

for lambs from 6 year ewes = .52 lb. per day

TABLE XII.

Period.	Age.	Mean Milk. (oz.)	Mean Gain. (lb.)	Oz. Milk per lb. L.W.Gain.	r for Milk and daily Gain.
Birth:-					
20 days	2	46.0	.54	86.0	.283 N.S.
	6	48.9	.61	79.9	.307 N.S.
20-40	2	54.7	.51	107.5	.660 H.S.
	6	60.6	.58	105.1	.620 H.S.
40-60	2	46.0	.47	94.8	.625 H.S.
	6	51.3	.49	104.2	.512 H.S.
60-80	2	33.2	.41	81.1	.142 N.S.
	6	36.8	.40	91.3	.303 N.S.
80-100	2	23.3	.36	63.9	-
	6	27.1	.36	75.8	

r = .610 (6)
r = .700 (2)

The non-significant correlation coefficients obtained between milk consumed and gain in live weight between 3 and 20 days in both age groups is interesting. Greater experimental errors are likely during the period immediately after parturition, because both ewes and lambs are in the process of settling down, and becoming accustomed to each other and to the imposed conditions of the experiment. Probably of greater significance than this, however, is the fact that the great majority of the lambs in this experiment were virtually full-fed for most of this period. It is possible from Table II that all lambs were able to gain equally, regardless of whether excess milk was produced or not during the first 20 days.* The less variable intake of milk and the leaving of excess milk, during the earlier stages are factors that would be likely to affect the interpretation of the results by statistical methods such as correlation.

*Although support for this is given by the growth of the lambs from the old ewes, it does not seem to be the case in the young group, and no conclusions can be drawn.

In the following two periods (21-40 days) and (41-60 days) the lambs were able to consume all the milk produced (except in a few cases). Consequently the greater variation in milk consumption resulted in the relationship between milk consumption and growth rate in the lambs becoming statistically significant.

Analysis of variance of age and milk consumed to 40 days shows a highly significant age effect. Between 40-80 days the difference between the two age groups was not significant, which again demonstrates clearly the marked influence of milk consumed during the first six or seven weeks of life.

It is difficult to determine the effect of differences in Birth Weight on early growth, as in this data no significant relationship was shown between the birth weights of lambs and their subsequent rate of gain. It is well to remember that the differential rates of development of the various tissues in the animal body, and the proportions of bone, muscle fat, liquid and offal at various stages of growth, profoundly effect any considerations of economy of gain or dry matter increase. The increased deposition of fat in the animal body, both subcutaneous and intermuscular, as growth and development proceeds would tend to give a lower figure for economy of gain in terms of milk consumed, In contrast to this, however, the increased consumption of herbage results in an apparently greater efficiency of milk utilisation.

After 10-20 days the larger difference in milk consumption of the lambs from the old ewes, accounts for most of the difference in rate of gain. From 40 or 50 days of age, the economy of gain in the young rises more rapidly than in the old group, indicating that the former are able to supplement their milk consumption to a large extent. Study of figures 13 and 14 illustrates the stage at which lambs are capable of consuming sufficient grass, or other suitable food, to overcome at least partially, the handicap of low or declining milk yield. Hammond (1932) found that the type of food consumed by the young lamb profoundly influenced the development of the rumen. Lambs fed milk alone had rumens averaging 327 ccs., whereas the rumens from lambs fed bulky fodders averaged 1832 ccs. capacity.

(2) Effect of Birth Weight: The birth weights of the lambs, along with the number of lambs born are the first objective measures obtainable regarding the reproducing qualities of ewes. Birth weight is only partly a result of the genetic make-up of the lamb, but seems to be a measure of vigour, and is an influential factor in determining live weight at subsequent periods - the relationship weakening with age. The birth weights of singles are less limited by the nutritional status and development of the uterus, than are the birth weights of twins. Hugget's (16) concept of uterine nutrition is expressed by the ratio of average birth weight of singles to average birth weight of twins - the wider the ratio the poorer the nutritional status. For instance, in this work the ratios were 1.13 and 1.01 for young and old ewes, respectively.

When utilising only one member of each set of twins, it has been assumed that singleshave no advantage over twins reared as singles on an equal birth weight basis.

A number of workers, including some quoted by Bonsma(2) have obtained highly significant correlations between birth weight and weight at subsequent periods. This seems logical, as the variation in birth weight is sufficient in itself to influence subsequent weights, quite apart from relative growth. When birth weight was correlated with weights at 40 and 80 days in this work, highly significant and significant correlations respectively were obtained.

TABLE XIII.

Correlation between Birth Weight and Live Weight of Lambs.

Age.	40 days.	80 days.
2 year old ewes	.450 (H.S.)	.338 (S)
6 year old ewes	.712 (H.S.)	.386 (S)

Correlations of similar order have been obtained by Clarke (4).

Birth weight and rate of gain up to 80 days were not found to be significantly correlated, whether the data were considered within age or within sex groups. The small numbers involved in this experiment, however, do not allow definite conclusions to be drawn.

Donald and McLean (6) working with substantial numbers of Canterbury sheep found that Birth Weight had a distinct influence on average daily live weight increase up to slaughter. Their data were grouped according to Birth Weight and the average daily gain of each group obtained.

By using the average daily gain from birth to slaughter weight, a misleading result could be obtained, because the lambs lighter at birth require longer to reach killing weights, in consequence of lower initial weight per se. The general decrease in relative growth rate with age proportionately exaggerates the time required to make up the deficit in initial weight.

Bonsma (2) has shown a correlation between size of ewe and productivity. This seems to be a general phenomenon in livestock. The fact that he obtained a significant correlation coefficient between birth weight of lamb, and milk yield of ewe, may partly explain the relationship between birth weight and subsequent gains demonstrated by Donald and McLean. The influence of size of ewe on production of milk and on birth weight of the lambs may be the connecting link.

On theoretical grounds the lambs lighter initially can be expected to increase in weight at a relatively greater rate, provided plane of nutrition is comparable, and the light lambs at birth are not genetically inferior. Growing animals subjected to a low plane of nutrition tend to accelerate in growth rate, when normal nutrition is again imposed. Twin lambs reared as singles tend to catch up on single lambs reared as such, (usually greater weight at birth) - but never quite do so. Similarly twin lambs reared as twins and hence having to share the milk yield of the ewe, attain maximum growth at about 11 weeks of age (2), and for a period thereafter grow faster than single lambs of the same age.

These considerations do not invalidate the hypothesis that birth weight directly influences subsequent rate of gain. They do, however, indicate that selection for high birth weight may have smaller advantage than expected, and that in the long term view, selection for twinning may be of more practical significance.

In order to investigate the relationship of weight at 3 days and "cleaned" weight at birth, newly born lambs were weighed whenever possible. The data include weights from another flock which was grazing on the same block as the ewes utilised for milk yield estimations. The correlation obtained between the two weighings, was highly significant (+.963 ; 20 d.f.), indicating the usefulness and accuracy of the 3-day weight. Weighing the lamb when 3 days old is not impracticable and in the present experiment proved simple and satisfactory. Undoubtedly some of the variation in weight at 3 days is due to the amount of milk consumed and whether the lamb had recently excreted or suckled. Lambs at this age suckle often and in small quantities and excretions of urine usually weigh no more than one or two ounces, so that unless faeces excretions are heavy, this variation is probably relatively small. Variation is also present in cleaned weights at birth. Unless the lamb is observed immediately following parturition, doubt may exist as to whether the lamb has suckled (though the quantity would be very small.) In addition the amount of fluid on the lamb, possibly varies considerably even when "cleaned."

It seems, therefore, that 3day lamb weights are almost as reliable as cleaned weights at birth, and possess the advantage of being more easily measured under New Zealand farming conditions.

(3) Other Factors influencing live weight changes: Numerous investigators have studied a number of factors known to

influence rate of growth, in particular sex, time of lambing, breed, season, parasites, and number of young, as well as aspects of nutrition other than the milk supply. It is not the purpose of this study to evaluate any of these factors, and in addition the material is unsuitable. Undoubtedly the sum of these factors is a tendency to reduce the closeness of the relationship between the milking ability of the ewe and the growth rate of the lamb. It is necessary to mention, however, that the lambs in this experiment suffered at various ages and to varying degrees of severity from "scald" and footrot. It was not possible to separate the lambs whose welfare was unfavourably affected and any attempt to allow for such effects would be spurious. Again, the effect, as a whole, is to reduce the correlation between milk obtained by the lamb from the ewe and rate of gain.

The higher correlation coefficients between milk yield of ewe and growth rate of lamb, obtained by Bonsma are explicable in view of the type of feed available during suckling. The lambs in the South African investigation were fed lucerne hay and concentrates as supplements to milk. Good quality pasture was always available to our lambs and this undoubtedly tended to obscure the advantage of lambs from high yielding ewes, as compared with those of Bonsma.

(b) Carcass Measurements:

The influence of variations in nutrition on the growing or fattening animal are well known, and several workers have studied the effects of extreme treatments for varying periods of time during life. In particular, McCay's (17a) work with rats is of fundamental interest, as is also that of Hammond (15) and McMeekan (19) with sheep and pigs. The latter have shown the effects of nutrition on carcass characteristics and have been able to modify markedly the growth and development of their animals, as evidenced by anatomical composition.

In this investigation nutritional variations were much less extreme, and consisted of effects incidental to age of ewe - in particular birth weight of lamb and milk supply. These two factors together account for a large part of the variation observed and have been considered in relation to carcass quality.

Sex of lamb, however, has an important effect on carcass characteristics (15 & 35) and in this work is taken into consideration as well as age of ewe. Consequently the various carcass gradings and measurements were analysed within sexes.

Of the various indices tried weight per unit length of fore cannon was found to be most closely correlated with rate of gain or milk yield.

TABLE XIV.

$\frac{W.}{L.}$ and rate of gain.

Wethers	r	=	.686 (H.S.)
Ewes	r	=	.383 (S.)

Milk consumed to 80 days was also positively correlated with W/L but was significant ($P < .05$) only in the wethers. Birth weight was not correlated with W/L so that combining the two age groups within sexes seems justifiable. Further subdivision would make the numbers too small. No correlation was established between any other carcass measurements taken (including total score or Cambridge block test, loin fat and eye muscle dimensions) and rate of gain.

Consideration of the average points scored by each sex in each age group as set out in the appendix shows that there is a consistent sex influence on some of these characteristics. It is evident on inspection that more variation is attributable to sex of lamb than to age of ewe. The male lambs averaged higher in W/L of fore cannon, but were inferior in regard to fatness both on the legs and over loin. The total points scored were apparently lower in the male lambs and in the lambs from young ewes.

As the sex differences in carcass characteristics were larger than "age group" effects, it seems likely that the latter are not of great importance. Before any definite conclusions can be reached, however, considerably larger numbers, and the use of statistical analysis is required.

The results of Walker and McMeekan (35) show that ewe lambs are often too fat, but are slightly better in conformation than the wether lambs. As our lambs were all killed according to live weight, the ewe lambs may not have exceeded the optimum fatness whereas the wethers may have been insufficiently fat.

The W/L measurement is virtually an index of the maturity of the carcass, in that thickness growth occurs later than length growth of the cannon (Palsson). Consequently rate of gain (which was fairly well correlated with milk consumed) may be expected to show some relationship to W/L.

In conclusion it can be said that in this data the effects on carcass characteristics of differences in milk yield and birth weight between the two age groups were neither large nor consistent. The only significant individual relationship was that between rate of gain and thickness development of the cannon bone.

IV. PRACTICAL CONSIDERATIONS.

(A) Condition of Teeth and Milking Ability:

An examination of each mouth in the old group, during lactation, is summarised below in an arbitrary classification. * We know very little about the efficiency of various types of teeth, and no definite conclusions can be arrived at until classification is on a more scientific basis.

TABLE XV.

Condition of Teeth.	Number.	Average Milk Yield (100 days)
Excellent	3	4553 oz.
Good	3	4502
Fair	14	4870
Poor or Bad	5	4620
"Gummy"	6	4972

This result is unexpected, but two observations are of interest:

(1) The grass throughout the experiment was kept in excellent condition, and at about 2-3 inches in height. It is likely that poorly mouthed ewes would be less at a disadvantage under these good grazing conditions than they would under hard or short grazing. The practical value of this observation is that where pastures are suitable even gummy ewes are quite useful for fat lamb raising.

* Thanks are due to Dr. C.R. Barnicoat, who examined the teeth and permitted me to make use of his material.

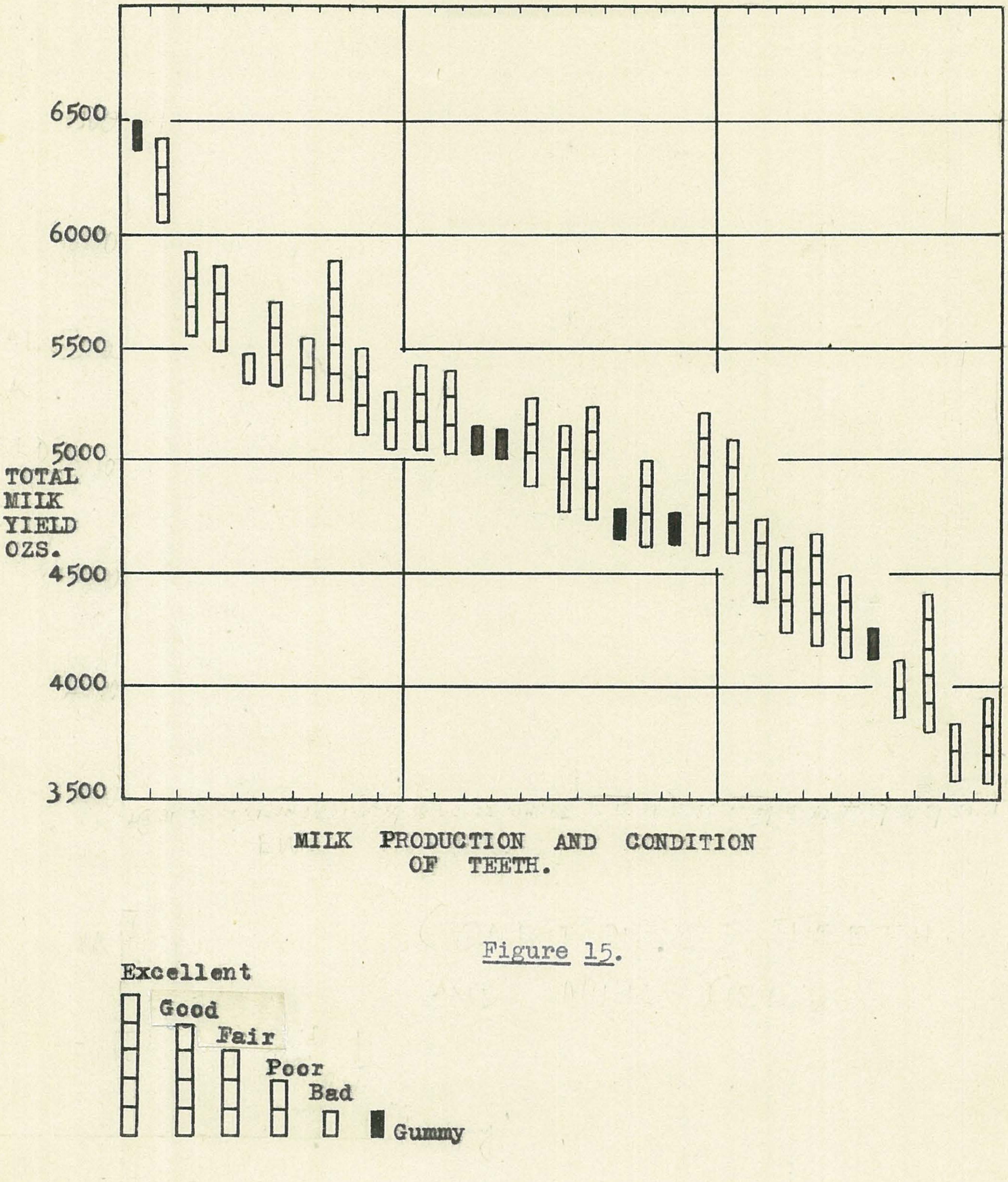

6500
6000
5500
5000
TOTAL
MILK
YIELD
OZS.
4500
4000
3500
MILK PRODUCTION AND CONDITION
OF TEETH.
Excellent
Good
Fair
Poor
Bad
Gummy

Figure 15.

(2) It is possible that ewes which have milked well during their lifetime have poorer teeth because of the greater drain of calcium and phosphorus from the body, but are inherently better milkers than lower yielding ewes which still have sound teeth at 6 years of age.

The results are graphically presented in Figure 15.

(B) Culling of Ewes and Milking Capacity:

In order to determine the effectiveness of the farmer's conception of a "good" and "poor" type of fat-lamb ewe, an experienced shepherd carried out a normal culling of the ewes about weaning time. The ewes are classed below under the reasons for their being culled.

T A B L E XVI.

	Reason for Culling.	Average Daily Yield.	Difference from average of all Ewes.
Two Year Ewes	Lameness (2)	44.0 oz.	+ 2.4 oz.
	Poor Constitution (8)	42.4 oz.	+ 0.7 oz.
Six Year Ewes	Lameness (3)	44.9 oz.	- 2.8 oz.
	Poor Constitution (8)	49.7 oz.	+ 2.0 oz.

No doubt some of those culled for "poor constitution" were in this condition as a result of milking well. This result emphasises the necessity of considering the welfare of the lamb when culling ewes after weaning, and indicates that the average culling is probably almost ineffective in differentiating the poorer milk producers. More information is needed before such a conclusion can be established.

V. GENERAL DISCUSSION.

In studying the sheep industry in New Zealand, the considerable variation in types of farming, in the breeds and crosses of sheep utilised, and in the kinds of product, is of great importance. The reasons for this versatility and stratification are found in the differences in soil fertility, topography and climate, and in the influence of these factors on the amount and quality of feed available during the year.

The Merino is used for specialised fine-wool production on high altitudes, low fertility and difficult country, mainly in the Southern Alps and higher foothills. The half-bred and crossbred types, including the Corriedale, are found on easier country and under better conditions generally. In addition to wool, store sheep and cull ewes are sold. This stratum in the South Island corresponds to the hill country in the North Island where the Romney crossbred type and a few Corriedales are run.

It is from this type of farm that the fat-lamb producer obtains his ewes for crossing with fat-lamb sires, and it is safe to say that the New Zealand fat-lamb industry is largely dependant on a supply of cheap ewes of a crossbred type.

The Romney in the North Island is the premier breed and like the Jersey breed of dairy cattle, is particularly suited and adapted to North Island conditions. Very little information is available in regard to the relative milking ability of the Romney. Bonsma (2) provides a comparison of various breeds crossed with the Merino and places the Border Leicester and the Ryeland crosses as superior to the Romney x Merino, with the Dorset Horn cross slightly inferior. While these estimations of milk yield are of crossbred ewes, they probably indicate the relative milking ability of the purebreds. There is no other information sufficiently reliable, and a complete absence of data on breeds used in New Zealand and under New Zealand conditions.

The importance of considering milking ability in sheep production has been amply emphasised. From experience with Romney sheep in New Zealand, and the fact that this breed has remained the most popular after considerable trial and error, it is reasonable to conclude that the breed is inherently satisfactory in regard to milk yield.

The present investigation has clearly shown that the best of our Romney ewes under good conditions are excellent milkers. It is also evident that the poorest milkers are far below the best, and even under a high plane of nutrition are unsatisfactory.

While this variation facilitates phenotypic selection, the probably low heritability of milk yield precludes any substantial improvement by this method. Given a method of locating and culling poor milk producers at an early age, however, the better milk producers in the flock will be proportionately more numerous for the remainder of their productive lives.

Before undertaking any work aimed at increasing production, whether it be for fat-lamb, mutton or wool, it is essential to decide the most useful and effective method of evaluating productivity. Of fundamental importance is the relation between the size and efficiency of the individual between size and environment and whether production per unit or per acre or net financial return per individual or per acre is to be considered.

Under poor nutrition conditions, large size is a disadvantage, and a highly improved animal may not even survive. Conversely, under the conditions found in fat-lamb areas in general in New Zealand, large ewes, when producing a high percentage of twin lambs, may be more productive per acre than a greater number of small ewes, especially under "flying flock" management.

One of the most useful indices (of the efficiency of his stock) to the specialised fat-lamb farmer is,no doubt, the return per acre. Owing to the fluctuating nature of prices, however, production of fat-lamb per acre is a better index. Return per unit of labour while of paramount significance in the primary industry, is not so useful as an index applicable to the animal efficiency aspect of production.

It is not improbable that under a given set of environmental conditions, an optimum size for efficiency of farm animals exists. (Gaines (11); Brody : numerous publications from Missouri Agric. Exp. Station.) If this is the case productivity per 100 lb. live weight would decline above this size, and smaller animals would be less productive or incapable of reproducing to required standards.

While little evidence of a relationship between "size" (live weight) and milk yield (within ages) is obtainable from our data for reasons previously stated, the general concept is so universally accepted and fundamental that its consideration is essential. In selecting for greater fleece weight, fat-lamb per ewe or milk yield the implications of individual size should not be forgotten.

The gain to be obtained by careful selection for milk yield in our ewe flocks is likely to be profitable for several generations. The amount of improvement per generation, will tend to decrease, however, and continued selection may be required to maintain uniformity and average merit.

Owing to the dual nature of the Romney sheep, it is unlikely that selection and breeding for milk yield will ever attain first rank priority, as in the dairy cow. Milk yield in ewes, should always be considered along with fertility, wool yield and quality, carcass conformation and longevity, as the main criteria of efficient and productive animals. While mass selection for any one of these characteristics is fairly simple and effective in a given generation, the low heritability, and the greatly weakened selection potential when considering several factors, make the possible overall improvement in genetical constitution per generation very meagre indeed.

High productivity in each of two or more characters may not be possible on physiological grounds but there are undoubtedly odd individuals that are good meat, milk and/or wool producers and this indicates that such a population is possible. The competition of the various processes concerned, however, in the animal body, especially under limited calory intake, and the possible incompatability of the relevant endocrine mechanisms makes the breeding of a population uniformly high producing in several characters an unpromising proposition.

The conclusion reached by many breeders and research workers in regard to genetic improvement in polygenic characters is that mass selection or phenotypic selection is inefficient, and some form of progeny testing is necessary. Whatever the method of selection utilised, it is self-evident that reliable and practicable means of evaluating production are required.

The underlying objectives of this investigation, besides that of obtaining data on the milk yield and composition of Romney ewes, were to determine the usefulness of the "Plunket" system for estimating milk yield in ewes of a wool and mutton breed, and whether the techniques utilised could be adapted to broader fields. Supplementary to these problems was whether growth rate of the lamb during part or all of the suckling period is a reliable index to the ewe's milk-producing ability.

In mammals the dependance of the young during early post-natal existence on the milk supply of the mother, does not require further reiteration. This factor, however, is the major one in the growth of the lamb for about two months. It is of some practical significance that the relationship between milk yield and growth rate is sufficiently close to make the direct measurement of milk yield unnecessary.

Several factors must be taken into consideration if accurate selection for milk yield is to be made on the basis of the growth rate of the offspring.

(a) Number of lambs suckled by the ewe, There is some suggestive evidence that ewes suckling twins are stimulated to greater milk production than ewes suckling singles. In multiparous mammals such as rodents and pigs, a greater number of sucklings has been found to be associated with increased milk yield and it is reasonable to assume that this phenomenon applies to ewes also. No evidence was obtainable in this regard in the present experiment, but it has been shown that ewes producing milk in excess of the single lamb's appetite are quite common. Although no factual data is available it seems probable that the relationship between gains made by singles and twins and the milk yield of the dams is not a simple one. Comparisons made only amongst ewes suckling singles and amongst ewes suckling twins would be more discriminating.

(b) Factors associated with age of ewe, as demonstrated in this investigation, and also by Bonsma (2) and Montanaro (22) have an important influence on milk yield. Analogy with dairy cattle, about which our knowledge is more complete, lends support to this contention. The age at which merit is recognisable, has an obvious bearing on the rate of progress in improvement. In characters which can be evaluated in the lamb, culling can be made early (often when individual value is considerable) and the cost of keeping the breeding stock to productive age is then borne only by the superior portion of the population. Except in the case of the debatable policy of selection on pedigree, the individual's milking ability is normally not demonstrated until 26 or 27 months of age. The mating of lambs in New Zealand is not a common procedure but could conceivably be practised in research institutions or on a small scale under stud flock conditions - (provided a sufficient proportion of the lambs can be induced to breed.)

Does the production of young animals indicate their lifetime production? Data concerning wool yields and characteristics in sheep (Bohle, Rasmussen and others) and milk and butterfat production in dairy cows (various workers) have given reasonable repeatability estimates in most cases (McMahon). It is safe to say that the low producers and high producers can be identified but that the demarcation line is not very precise when a proportion of the flock or herd is to be culled on the basis of their first season's production.

For the most efficient culling, the lowest milk producers could be located during their first lactation, but borderline ewes should be allowed to remain in the flock until their second lactation confirms or disputes the first result. Comparisons should be made only after due allowance for age.

(c) Differences in weight at birth must be accounted for when considering any subsequent weight in the estimation of milk yield. It is obvious that a range of birth weights from approximately 7-15 pounds as frequently encountered could seriously affect live weight at any later age. To obtain a better index to milk yield in the ewe, the live weight gains of the lamb made over a given period must be considered rather than live weight at a given age.

(d) The time of the year of lambing influences total yield and persistency. Comparisons should be made among ewes lambing at definite phases of the season, unless the distribution of lambing dates is comparable. The effect of season precludes any comparisons of groups between years, though statistical adjustments can be made with suitable data.

(e) Many investigators have shown that sex is a factor in rate of growth. The difference between castrated males and normal females, however, is not important, and differences in live weights at weaning age, can largely be explained by the higher birth weights of the male lambs.

In view of the foregoing, a reliable estimate of milk-producing capacity, can only be obtained if the number of young, the age of the ewe, time of lambing and initial live weight of the lamb or lambs, are taken into account.

The period of growth during suckling which is most closely related to the milk supply, the amount of other food consumed, and the availability and reliability of weights at various ages, determine the data required in work of this nature. From the results presented earlier in this paper, it is evident that the lamb is still very dependent on milk for growth up to six or seven weeks of age. In the case of poor milkers the lambs may attain independence at an earlier age.

During the first ten days of life, the lamb is perhaps more subject to environmental influences than at any other time. This is a period of settling down and adaptation for both ewes and lambs. The birth weights of lambs are of considerable value in research work and as an index to the lamb's vigour, and perhaps to the ewe's physiological level. Weight at birth, however, is not always easy to obtain under field conditions and perennial uncertainty is associated with it. By using a weight at a known age as the initial one, in calculating rate of gain, weighing at birth can be avoided.

Most ewes seem to produce sufficient milk for a single lamb during the first ten days. Accordingly the period between 10 days and 40 or 50 days of age is probably the most accurate for estimating the milk yield of the ewe from the gain in live weight of the lamb. The relationship is unreliable in very early life and weakens with age.

It is contended that "live weight at weaning" is of limited value in this respect because:

(1) Initial weight is an important consideration.

(2) The entire suckling period contains several distinct phases. In particular growth in the period immediately before weaning bears little relationship to milk supply.

(3) Age at weaning, being rather variable, must also be considered in relation to the lactation curve of the ewe, and the growth curve of the lamb.

The facilities available largely determine whether live weights at various ages are obtainable under practical conditions. Docking when occurring in the first two weeks of life may be a convenient opportunity for the initial weighing, but is often left too late for this purpose. Provided the dates of birth are known, some variation in ages at first weighing is not a disadvantage. Weighing the lambs at six or seven weeks is fairly simple, and often shearing coincides with this age for many of the lambs.

Any attempt to establish an equation for the estimation of milk yield, from live weight gain would be vitiated by the large variation in environmental circumstances, influencing the nutrition of the flock.

Direct estimation of milk yield by weighing the lambs before and after suckling is also likely to be practicable in field investigations. Identification of the individual lambs would be an advantage. The milk consumption can then be related to the growth of the lamb, though the ewes need not be handled during the milking period. Where the average milk yield of various groups is required at particular stages in lactation, or particular times of the season, individual identification of either ewes or lambs is unnecessary.

In either case the ewes and lambs in each group are drafted at the chosen commencing time, and kept separated for 24 hours during which period three or four weighings are carried out. The lambs are run over the scales or weighed with steel yards and sling, and joined with the ewes. When most of them appear to have completed suckling they are drafted off or picked out, and re-weighed as quickly as possible. From the total of the differences in weight thus obtained (whether individual or massed) the daily yield is calculated. It would be advisable to limit the numbers in each group so that the lambs do not spend too long locating their mothers. A random section of a flock is usually readily available, by taking a cut out when the flock is well distributed.

With the minimum of handling that ewes and lambs receive with this procedure reliable information in regard to the level of milk yield should be obtainable.

While this investigation was primarily concerned with fat-lamb production, it has implications of a broader nature, further study of which is thought to be desirable. Useful data of this kind from a wide range of environmental conditions and at various stages of lactation are essential in the solution of many problems of sheep husbandry.

Individual evaluation of milk-producing ability in ewes is useful in sorting out the environmental and genetic factors affecting growth in lambs. This knowledge is needed in research work in formulating breeding policies and in the better understanding of flock management.

The ultimate objective of the farmer is concerned with the weight and quality of lamb produced in relation to time, and to costs of production. Of the various factors involved, the milk production of the ewe has been shown to be of considerable importance, but in practice it should be regarded in its true perspective along with fertility, birth weight of lambs, hardiness and conformation. The summation of these factors is the number, weight and quality of lambs weaned during a lifetime. Age at slaughter weight is more especially important to the fat-lamb producer.

VI. SUMMARY.

In this study of milk secretion in New Zealand Romney ewes, information has been secured concerning:

(a) The level and variability of milk yield and composition.

(b) The effect of age, and of stage of lactation on milk yield and composition.

(c) Live weight growth and carcass conformation of the lambs in relation to their milk consumption.

Attention has been directed to the possibilities of extending or modifying the technique of Bonsma and others to field or survey investigations of a nature likely to be of assistance in sheep breeding.

EWES:

(a) Six-year ewes yielded more milk than the two-year ewes. Variation in yield associated with these ages was an important fraction of the total variance.

Time of lambing affected the total milk yielded, presumably because of seasonal changes in quantity and /or quality of pasture.

Under the conditions of the experiment many of the ewes, especially in the old group, apparently produced milk in excess of the appetite of the lamb, in the initial stages of lactation.

(b) Considerable variation in the fat content of the milk was found.

The old ewes produced milk richer in fat throughout lactation than the young ewes.

Fat and solids-not-fat content of ewe's milk showed lactational trends very like those of dairy cows. Less pronounced trends existed in the case of calcium and phosphorus.

Limited data have been obtained concerning the rise in fat percentage during the milking process.

(c) Young ewes showed greater relative increase in live weight during pregnancy and smaller relative decrease during lactation than the old ewes. This is attributed to growth processes and differences in the degree of fatness. The live weights of the ewes and their milk yields were not significantly correlated, probably because of variation in degree of fatness.

(d) Six-year ewes produced more twins and lambs of heavier weight at birth, than the two-year ewes.

(e) With the small numbers of ewes involved in this experiment no significant relationship could be established between milk and wool yields of the ewes.

(f) The amount of milk produced by the old ewes was apparently unrelated to the condition of the ewes' teeth.

Subsequent culling on customary standards was also found to be unrelated to milk yield.

LAMBS:

(a) Rate of gain of the lambs during the first 80 days and milk consumed during this period were significantly correlated. ($r = 0.693$ for 2 year ewes; $r = 0.636$ for 6 year ewes.)

Subdivision of this period into 20-day intervals showed only the 20-60 day periods to yield significant correlations in this respect.

(b) Weight at three days and weight at ages up to 80 days were significantly correlated (r was 0.450 and 0.338 in the young ewes, and 0.712 and 0.386 in the old ewes at 40 and 80 days respectively.)

Weight at three days and gain over any period up to 80 days were not significantly correlated.

(c) The detrimental effect of foot infections on the welfare of young lambs, was a disturbing and uncontrollable factor.

(d) No definite relationship of milk consumption or rate of growth with carcass characteristics was found except in the case of the quality index $\frac{\text{weight}}{\text{length}}$ of fore-cannon bone, which was positively correlated with rate of growth in both wether and ewe lambs. $\frac{\text{Weight}}{\text{length}}$ was positively correlated also with milk consumed, but r was significant (5%) only in the wether lambs.

VII ACKNOWLEDGEMENTS.

It is with pleasure that I acknowledge the advice and assistance willingly given.

From the late Mr. E. Gould I received invaluable help, and it was he who bore the burden of managing the ewes throughout the experiment. With his wide experience of sheep, he helped to solve several practical problems.

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In particular I am sincerely gratefull to Dr. C.R.Barnicoat for his advice and assistance and for the ash and protein analyses.

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Appendix IA

MILK YIELDS IN OUNCES.

Two Year Ewes.

Ewe No.	Date Lamb.	28/8	1/9	8/9	15/9	23/9	29/9	6/10	14/10	25/10	1/11	9/11	22/11	5/12	16/12	19/1
1	15/8		6 44	59	61	49	47	44	39	28	27	25	18	15		
2	16/8		35	76	58	45	49	42	44	28	33	22	17	14		
3	17/8		11 40	46	56	48	44	50	46	37	37	30	29	16		
4	22/8	44	10 52	3 27	35	39	42	47	45	31	31	31	31	16		
5	23/8	38	2 42	53	59	44	43	34	36	35	36	22	17	14		
6	25/8		5 39	48	59	62	51	62	55	41	54	32	24	21		
7	25/8	10 54	24 49	8 55	2 56	67	58	65	71	66	55	46	32	14		
11	26/8		41	58	53	39	48	39	42	31	26	14	20	15		
12	27/8		13 25	6 37	4 49	49	53	50	47	48	36	34	35	27		
13	28/8		3 47	53	62	52	51	41	35	38	25	23	18	13		
16	29/8			53	59	61	53	52	52	44	41	38	31	26		
19	31/8			37	47	38	53	54	49	53	47	30	34	29		
20	31/8			14 44	7 45	54	58	61	65	57	49	39	38	30		
22	1/9			12 35	58	67	58	60	49	45	39	35	32	20		
25	2/9			11 40	5 56	56	61	56	63	39	41	37	25	14		
27	2/9			57	65	60	57	57	49	46	43	31	22	24		
28	2/9			2 53	61	61	64	58	66	47	48	34	35	24		
34	5/9				8 49	58	53	51	58	58	50	38	26	28		
35	5/9				14 40	5 42	53	67	57	50	44	43	42	34		
40	8/9				10 50	3 65	67	65	72	61	56	39	40	31		
44	8/9				10 55	3 57	49	59	53	57	43	30	31	23	14	
51	11/9				11 33	11 47	14 45	3 48	50	54	48	54	42	28	19	7
52	11/9					2 47	53	55	54	51	42	46	36	21	18	
53	12/9					10 43	2 43	53	51	53	43	37	31	19	15	11
57	15/9					8 38	7 40	6 48	48	68	66	62	28	33	35	
58	15/9					54	47	48	46	41	42	36	27	15	13	4

MILK YIELDS IN OUNCES.

Two Year Ewes. (Contd.)

Ewe No.	Date Lamb.	28/8	1/9	8/9	15/9	23/9	29/9	6/10	14/10	25/10	1/11	9/11	22/11	5/12	16/12	19/1
63	17/9					8 55	47	54	58	54	47	34	24	13	15	
64	18/9						7 45	5 50	2 57	57	48	45	36	28	21	12
65	20/9						13 46	7 51	3 49	58	52	42	31	26	22	12
66	22/9						13 29	65	60	66	52	29	41	31	26	
67	22/9						50	56	59	59	50	40	30	25	17	
68	23/9						9 45	20 47	66	63	60	56	55	38	32	
70	23/9						11 54	2 66	53	62	46	40	42	26	17	13
71	30/9								50	44	40	42	29	25	23	
72	30/9								63	60	75	57	42	37	31	
73	23/9							45	51	57	52	42	37	22	21	
75	4/10								53	58	53	56	59	34	30	
76	5/10								7 37	44	55	54	51	29	31	
78	3/10								40	52	43	43	40	27	25	
82	13/10									39	45	29	27	21	14	

(Note:) The experimental animals were run together in respect to age, but were divided into two mobs for convenience in handling. Ewe numbers 1-40 & 41-82 were the two mobs during most of the season. The dates above refer to the time at which the first mob was milked - the second mob being milked the following day or the second day.)

Appendix IB.

MILK YIELDS IN OUNCES.

Six Year Ewes.

Ewe No.	Date Lamb.	28/8.	1/9.	8/9.	15/9.	23/9.	29/9.	6/10.	14/10.	25/10.	1/11.	9/11.	22/11.	5/12.	16/12.	19/1.
8	25/8	15 34	19 39	8 55	67	59	51	54	49	35	38	30	36	29		
9	25/8	7 51	5 55	14 48	57	60	49	46	46	30	39	25	20	12		
10	26/8		15 36	10 56	70	65	59	56	57	46	45	44	31	25		
14	29/8		66 22	31 43	17 40	2 62	4	22	22	27	24	18	14	14		
15	29/8		54 43	17 46	17 49	68	69	56	52	61	46	41	30	29		
17	29/8			50	58	54	51	54	45	52	47	40	35	32		
18	30/8			10 38	56	59	63	61	56	49	49	39	29	28		
21	31/8			28 48	11 55	63	67	61	62	54	54	43	42	34		
23	1/9			13 39	7 52	64	73	69	67	55	44	40	31	30		
24	1/9			8 40	58	35	39	46	47	40	35	30	21	17		
29	3/9			6 25	77	59	65	56	58	53	37	33	33	23		
30	3/9			18 34	69	61	69	63	58	57	60	46	39	35		
31	3/9			35 35	28 31	30 47	70	77	85	71	65	52	40	34		
33	4/9			11 38	5 61	62	63	70	65	47	42	36	31	28		
37	7/9				41 46	26 57	12 51	6 63	67	61	48	45	28	23		
38	8/9				22 52	6 74	76	69	74	43	63	44	41	32		
39	7/9				35	64	59	57	52	43	48	38	39	22		
41	8/9				26 46	12 48	10 45	60	76	73	43	43	45	32		
42	8/9				5 61	18 39	47	48	44	51	40	23	28	31		
43	8/9				11 43	14 60	69	63	61	64	54	44	46	26	24	
45	8/9				37	49	49	51	44	46	37	34	38	23	19	17
46	9/9				16 54	18 54	65	65	61	60	50	44	29	22	24	
47	9/9				10 51	72	67	74	59	60	53	46	43	22	29	
48	9/9				80 44	21 66	21 60	9 68	70	70	65	64	47	30	32	
50	11/9					60	53	53	47	40	40	23	20	13	11	8
54	13/9						18 21	30	31	31	28	31	25	16	17	11

MILK YIELDS IN OUNCES.

Six Year Ewes.
(Contd.)

Ewe No.	Date Lamb.	28/8.	1/9.	8/9.	15/9.	23/9.	29/9.	6/10.	14/10.	25/10.	1/11.	9/11.	22/11.	5/12.	16/12.	19/1.
55	13/9					16 57	10 51	50	51	47	46	43	32	20	29	9
56	18/9					3 51	70	71	63	73	66	61	44	26	28	
59	15/9					47	44	58	51	41	44	36	36	20	24	
62	17/9					8 45	23 33	9 48	63	69	61	43	44	33	29	
69	23/9						39 53	15 58	58	73	61	55	38	36	22	13
77	5/10								19 43	69	63	53	51	26	24	
79	3/10								55	67	69	62	54	37	34	
80	6/10								47	59	55	50	42	34	30	
81	12/10									57	46	44	56	34	23	

ANALYSES OF COMPOSITE SAMPLES.

	2 year old Ewes.							6 year old Ewes.						
Date.	Fat.	S.N.F.	Protein Nx6.38	Lactose (Diff.)	Ash.	CaO.	P_2O_5	Fat.	S.N.F.	Protein Nx6.38	Lactose (Diff.)	Ash.	CaO.	P_2O_5
8/9/44	4.50	10.96	5.30	4.77	0.89	0.26	0.36	5.50	10.70	5.20	4.61	0.89	0.26	0.32
15/9/44	5.25	10.90	5.45	4.56	0.89	0.27	0.37	6.25	10.67	5.45	4.31	0.91	0.26	0.36
22/9/44	4.80	11.10	5.10	5.11	0.89	0.25	0.35	5.75	10.63	5.30	4.43	0.90	0.26	0.36
29/9/44	5.65	10.67	5.30	4.50	0.87	0.27	0.34	6.90	10.81	5.40	4.52	0.89	0.28	0.35
6/10/44	4.35	10.77	5.05	4.87	0.85	0.27	0.36	5.60	10.71	5.25	4.61	0.85	0.27	0.36
16/10/44	4.90	10.68	5.00	4.83	0.85	0.26	0.36	5.63	10.84	5.05	4.91	0.88	0.27	0.37
25/10/44	4.45	10.67	5.20	4.60	0.87	0.24	0.36	4.65	10.56	5.15	4.55	0.86	0.25	0.35
1/11/44	4.25	10.76	4.95	4.94	0.87	0.25	0.36	5.45	10.89	5.15	4.89	0.85	0.27	0.38
9/11/44	3.90	11.20	5.45	4.87	0.88	0.27	0.37	5.05	10.95	5.10	5.03	0.82	0.26	0.36
22/11/44	5.30	11.10	5.50	4.66	0.94	0.27	0.38	6.75	10.92	5.40	4.60	0.92	0.26	0.36
6/12/44	5.20	11.66	6.10	4.56	1.00	0.28	0.29	6.75	11.17	6.20	4.03	0.94	0.27	0.36
16/12/44	5.80	11.12	6.10	4.05	0.97	0.28	0.40	6.85	11.16	6.10	4.07	0.99	0.29	0.40
19/1/45*	7.70	11.02	6.65	4.37	1.00	0.30	0.40							
Average	5.1	10.89	5.5	4.67	.83	.267	.360	6.06	10.85	5.5	4.53	.825	.270	.364

(* 19 samples analysed irrespective of age of ewe)

Appendix II.

Appendix IIIA.

LIVE WEIGHTS OF 2 YR. OLD EWES.

Ewe No.	Tupping	Months Pregnant 1	2	3	4	5	Days Lactation 10	20	30	40	50	60	70	80	90	100
1	80	97	107	111	121	135	120	126	124	124	123	123	123	124	125	126
2	88	100	110	116	123	135	120	123	122	123	123	123	123	123	124	125
3	90	110	120	126	142	158	140	140	138	137	134	132	131	133	135	137
4	90	110	120	125	133	145	132	133	133	131	131	133	134	135	136	138
5	116	129	137	146	164	178	150	150	143	135	140	143	145	147	152	155
6	90	110	118	120	132	147	131	131	132	133	133	134	136	138	140	142
7	97	119	128	133	152	167	138	137	137	136	135	134	136	138	140	142
11	86	100	113	115	134	142	130	130	131	131	132	132	132	133	133	134
12	85	94	47	109	128	137	130	130	131	131	132	132	132	133	133	134
13	92	108	119	120	135	142	138	138	138	138	139	139	139	139	140	140
16	94	107	115	118	135	150	145	145	146	147	148	149	150	151	152	152
19	102	113	120	126	135	145	120	121	122	123	124	127	128	130	131	132
20	89	107	113	121	132	143	120	119	117	116	117	118	119	120	120	120
22	87	101	105	110	123	133	115	113	112	110	110	110	111	112	114	115
25	91	101	102	104	119	137	118	118	119	119	120	120	121	122	123	123
27	102	118	120	123	129	154	128	128	129	139	130	130	131	131	132	132
28	84	95	106	115	130	148	125	125	126	126	127	128	128	129	129	130
34	102	115	122	128	136	160	135	135	136	136	137	138	138	139	139	140
35	108	122	129	137	151	167	140	135	130	131	131	131	131	133	134	136
40	102	112	116	128	140	155	130	127	125	123	121	120	120	122	125	127
44	91	105	112	120	135	155	135	134	133	132	130	130	131	133	134	135
51	73	84	88	94	107	125	108	100	95	95	96	97	100	102	104	105
52	91	105	112	120	132	152	122	122	122	121	121	121	121	120	120	120
53	93	101	105	112	130	150	123	123	122	121	120	120	119	118	118	117
57	118	127	131	142	160	177	142	140	139	138	136	135	134	132	131	131
58	112	120	122	133	146	164	133	134	134	135	136	137	138	138	139	140
64	120	125	127	133	146	163	138	138	139	139	140	140	140	141	141	142
63	108	111	110	115	127	147	115	115	115	115	115	115	115	115	115	115
65	100	107	109	118	130	154	129	128	127	126	126	125	124	123	122	120
66	98	103	103	112	127	148	136	136	135	134	134	133	132	132	131	130
67	99	99	102	111	122	146	110	110	110	111	111	111	112	112	112	112
68	120	125	130	138	158	187	149	148	148	147	146	145	144	144	143	143

70 - 71, 72, 73, 75, 76, 78, 82 omitted.

LIVE WEIGHTS OF 6 YR. OLD EWES.

Ewe No.	Tupping	Months Pregnant 1	2	3	4	5	Days Lactation 10	20	30	40	50	60	70	80	90	100
8	130	143	150	156	171	184	165	164	163	162	160	159	157	155	153	154
9	130	143	154	153	152	184	145	143	140	138	136	134	132	128	122	115
10	148	164	165	165	177	188	163	165	164	161	158	155	153	152	152	151
14	180	196	199	104	222	232	197	198	198	197	196	195	195	197	199	202
15	165	180	184	188	200	220	181	183	184	184	183	184	184	184	187	189
17	158	170	173	177	188	197	168	167	167	166	165	165	164	163	162	160
18	143	157	163	164	172	184	161	155	150	145	141	137	133	130	130	130
21	142	157	166	170	184	202	175	170	167	164	160	157	153	150	150	148
23	143	157	162	167	160	183	153	150	147	145	144	143	143	142	141	140
24	126	136	139	144	153	168	135	134	134	133	132	131	130	120	110	100
29	150	164	169	170	180	198	180	179	178	177	176	175	174	172	170	170
30	182	198	203	211	228	248	205	204	203	201	200	199	198	197	196	196
31	156	165	170	176	189	207	160	158	156	154	152	151	150	149	148	148
33	164	175	182	187	197	208	170	169	167	166	164	163	162	161	160	160
37	142	154	157	165	172	185	158	148	146	146	145	145	145	146	147	148
38	143	154	157	161	168	190	140	143	140	140	140	140	141	142	143	144
39	132	143	150	157	170	187	157	155	152	150	149	148	147	147	146	146
41	161	168	169	179	187	195	162	160	159	157	157	156	155	154	153	153
42	174	185	190	196	202	218	192	192	192	191	191	170	173	175	177	178
43	158	172	178	185	196	205	180	179	177	175	174	172	171	170	167	165
45	144	153	154	159	165	175	151	150	149	148	146	145	144	143	141	140
46	157	165	165	170	182	193	168	166	164	162	160	158	155	153	150	148
47	149	158	161	165	176	196	168	166	164	162	160	158	155	153	150	148
48	160	169	173	182	190	210	167	163	160	157	154	150	147	145	143	146
50	121	133	139	148	160	180	142	140	138	136	134	130	128	125	123	120
54	160	169	170	182	194	204	167	163	160	157	154	151	148	146	143	140
55	160	169	169	175	186	203	167	163	159	155	151	149	147	144	140	137
56	188	190	194	204	215	226	198	197	196	195	194	193	190	188	185	183
59	140	152	152	157	167	193	142	148	148	142	140	137	134	130	128	126
62	155	161	163	177	186	199	155	155	155	153	150	145	140	135	130	126
69	156	161	164	178	189	206	165	165	165	165	165	165	165	165	165	165

77, 79, 80, 81 omitted

Appendix IV A.

LIVEWEIGHT OF LAMBS IN POUNDS.

Lambs from Two Year Ewes.

Lamb Number.	Birth Weight.	1/9	8/9	15/9	23/9	29/9	6/10	14/10	25/10	1/11	9/11	22/11	5/12	16/12
1	8.0	17.9	21.8	26.7	30.1	33.5	37.1	40.6	46.3	49.0	51.1	54.8	60.4	
2	7.0	17.8	21.8	26.1	30.1	32.5	36.1	39.2	43.3	45.8	48.3	53.4	56.8	
3	7.0	13.5	17.4	21.5	24.1	26.3	30.0	33.9	39.8	42.5	45.6	50.4	54.8	
4	7.5	12.1	13.7	15.1	17.6	20.3	22.7	26.6	32.2	35.0	38.0	44.0	50.0	
5	7.9	11.5	15.1	19.6	23.1	25.4	29.1	33.0	38.3	41.6	44.4	48.5	54.3	
6	8.8	11.5	16.0	20.7	25.3	29.2	33.4	38.0	44.6	46.8	50.6	56.8	63.0	
7	10.2	13.8	19.5	24.6	29.2	32.1	35.9	40.6	47.8	52.0	54.7	59.9	65.3	
11	9.2	11.7	14.8	18.4	21.9	25.2	27.6	31.5	36.4	39.3	41.7	46.9	51.5	
12	7.5	8.0	11.8	15.9	19.0	21.9	25.7	29.2	34.6	37.2	40.0	45.6	51.4	
13	11.1	10.6	14.8	19.3	22.8	25.8	28.2	32.2	38.0	40.8	43.6	49.7	55.6	
16	8.0		10.4	16.0	20.5	23.4	26.4	30.0	35.0	37.9	40.3	46.1	49.4	
19	7.0		9.5	13.3	15.7	19.0	22.4	26.9	32.2	35.6	38.4	43.5	48.6	
20	12.3		15.8	19.8	23.8	27.7	32.1	36.5	43.3	45.8	48.3	53.6	57.9	
22	9.5		11.9	15.3	19.1	21.7	25.6	29.4	35.0	37.9	40.0	44.4	48.4	
25	9.5		11.6	16.6	20.6	23.8	27.8	32.3	38.1	41.2	44.3	50.4	56.0	
27	12.0		13.2	18.0	21.8	24.6	28.4	32.6	38.7	41.5	43.9	49.6	55.2	
28	9.5		11.1	15.3	19.0	22.4	26.1	30.3	35.0	38.0	41.8	46.6	50.8	
34	7.0			13.1	16.4	20.9	23.4	27.5	33.3	36.6	39.8	45.8	51.9	
35	9.0			12.5	14.7	18.0	21.5	25.4	31.6	34.0	37.8	44.1	50.2	
40	10.0			14.1	18.0	22.8	27.7	33.2	41.2	44.9	47.6	53.5	58.6	
44	10.8			14.7	18.1	21.6	25.3	30.8	35.0	38.7	42.1	47.8	51.4	53.0
51	9.0			9.6	13.0	15.7	17.8	21.8	25.5	28.1	31.6	37.6	42.4	44.7
52	9.0				12.9	17.5	22.1	26.8	30.6	35.3	40.0	45.8	53.0	54.9
53	8.0				12.0	16.2	20.0	24.8	28.0	31.3	34.3	38.8	43.8	45.1
57	7.5				10.5	15.4	18.9	25.4	29.8	33.7	38.2	43.9	51.2	53.6
58	12.6				14.8	19.4	22.4	26.7	30.4	33.2	36.5	41.8	47.4	49.2
63	11.0				12.2	18.2	23.1	26.7	30.3	34.2	37.3	43.4	50.0	51.2
64	9.3					15.8	18.6	23.1	27.0	30.6	34.4	40.2	46.2	48.9
65	7.2					11.0	15.4	19.0	22.6	26.3	27.6	34.7	41.9	45.2
66	6.5					9.2	13.5	18.7	22.0	25.7	29.7	35.8	42.7	46.1
67	11.5					14.5	19.6	26.4	31.0	35.3	39.1	44.4	50.0	52.7
68	8.5					10.6	15.5	21.3	25.5	29.8	33.3	40.2	47.1	49.9
70	9.0					10.4	15.9	19.8	23.9	27.5	29.8	35.4	42.0	43.9
71	11.5							18.3	21.6	24.7	28.5	35.4	42.0	45.4
72	6.1							14.2	17.7	21.0	25.1	31.6	38.1	40.2
73	9.0							18.8	22.8	26.1	29.6	35.8	43.0	45.5
75	11.0							15.6	19.8	23.7	26.8	33.9	41.9	44.7
76	8.5							12.5	16.5	20.7	24.4	31.6	38.7	42.4
78	7.5							12.9	16.0	19.7	22.3	28.6	34.6	36.9
82	10.3								13.6	16.9	19.4	24.4	30.0	33.3

LIVEWEIGHT OF LAMBS IN POUNDS.

Lambs from Six Year Ewes.

Lamb Number.	Birth Weight.	1/9	8/9	15/9	23/9	29/9	6/10	14/10	25/10	1/11	9/11	22/11	5/12	16/12
8	15.0	17.2	21.2	25.4	29.5	32.8	36.3	40.8	45.9	48.9	52.0	58.6	63.8	
9	13.6	16.2	20.7	27.0	31.7	35.2	38.7	42.3	48.6	51.8	54.5	58.8	63.4	
10	12.5	14.0	18.5	23.1	28.1	32.0	35.6	40.6	46.9	48.5	52.6	58.8	63.3	
14	11.0	10.6	14.8	19.4	24.5	23.9	25.5	28.0	32.7	35.3	37.3	42.8	47.3	
15	11.0	11.0	16.4	21.1	25.0	28.3	32.2	37.0	43.5	46.2	49.1	54.7	59.8	
17	9.5		14.7	19.1	23.2	26.6	30.4	34.2	41.0	44.1	47.4	52.5	57.1	
18	9.5		14.0	18.8	23.7	27.1	31.4	36.5	42.6	45.8	49.0	55.3	60.7	
21	13.5		15.7	19.2	23.6	26.7	30.8	35.1	39.8	43.2	45.6	48.4	52.8	
23	9.5		12.0	17.1	21.7	25.1	29.3	33.6	39.6	43.0	46.1	51.3	56.1	
24	14.0		15.7	20.0	23.5	25.3	29.3	32.8	37.9	39.9	41.4	46.3	51.6	
29	10.4		11.0	16.7	20.7	24.0	29.0	34.2	40.0	43.0	46.9	50.0	54.7	
30	12.5		14.3	20.2	25.7	29.2	32.8	37.2	43.3	46.2	48.6	54.2	59.9	
31	10.0		11.2	17.0	21.5	26.6	31.9	38.1	45.6	49.6	53.0	58.4	62.9	
33	12.5		13.0	19.0	22.6	26.3	30.6	35.2	40.8	43.1	45.8	51.4	56.6	
37	12.1			15.7	19.7	23.2	27.8	33.4	40.6	44.6	47.4	53.3	57.8	
38	13.0			18.3	23.2	27.2	31.5	37.2	43.7	46.2	50.1	56.1	60.8	
39	10.4			14.4	18.3	23.1	27.8	32.3	38.0	41.0	44.1	48.7	52.6	
41	10.2			13.9	17.9	21.6	26.1	31.1	35.7	39.9	43.1	49.3	54.6	
42	10.0			13.6	16.1	19.7	24.0	28.3	32.8	37.0	39.8	44.7	49.3	
43	10.0			13.7	18.0	22.4	26.6	32.0	35.4	39.4	43.3	50.0	55.1	59.6
45	7.5			11.1	13.7	17.3	20.7	24.4	28.0	31.1	34.8	39.4	44.8	47.1
46	12.0			15.1	19.0	24.0	28.4	33.1	36.7	39.7	42.4	46.0	49.6	51.5
47	11.0			13.7	17.7	22.0	26.4	31.3	35.3	38.8	43.0	48.2	55.2	56.9
48	11.5			14.2	18.6	24.2	30.1	36.4	40.4	44.5	48.9	55.6	61.0	63.1
50	10.0				16.4	21.2	24.6	28.1	30.0	32.0	36.8	40.1	45.1	47.4
54	9.5					12.1	14.5	17.9	20.9	24.3	27.2	32.6	38.4	40.8
55	10.5				14.0	18.6	21.7	26.1	29.9	33.0	37.1	41.8	47.7	49.8
56	10.4				14.0	20.4	25.7	30.1	35.3	39.6	44.6	51.7	58.8	60.4
59	11.6				13.3	18.7	22.2	27.9	31.9	35.4	38.8	43.8	50.1	52.9
62	8.7				9.3	14.1	17.3	22.6	27.5	32.3	36.3	42.1	49.0	51.8
69	10.3					12.7	17.5	23.4	27.4	32.0	36.3	42.8	47.8	49.1
77	11.5							17.0	21.3	26.3	30.0	37.5	45.3	47.5
79	15.0							19.6	25.1	29.1	33.2	39.1	46.8	50.3
80	14.6							18.0	22.7	26.1	30.3	38.2	45.5	48.4
81	13.0								21.6	24.3	28.5	34.1	42.9	46.5

Appendix V A.

CARCASS DATA.

Lambs from Two Year Old Ewes.

(A) Ewe Lambs:-

Lamb Number.	Cannon. Length (cms.)	Cannon. Weight (gms.)	Cannon. W/L.	(1) Legs.	(2) Fat Cover.	(3) Loin.	(4) Loin Fat.	(5) Eye.	(6) Ribs.	(7) Colour.	Total.
1	10.0	27.5	2.75	26	9	8	17	10	10	4	84
2	10.1	28.2	2.79	23	9	9	19	10	9	4	83
5	9.8	25.5	2.60	21	8	8	17	12	8	5	79
12	10.4	30.5	2.93	20	7	7	12	11	9	4	70
13	9.7	24.8	2.56	23	9	9	20	9	10	4	84
19	9.1	25.3	2.78	23	9	10	20	12	9	4	87
22	9.7	26.0	2.68	23	8	8	17	15	8	4	83
25	9.7	26.3	2.71	24	9	9	19	13	10	4	88
27	10.0	27.4	2.74	20	7	9	19	14	10	4	83
28	9.8	25.6	2.61	21	7	8	19	11	7	4	77
51	10.0	25.0	2.50	22	8	8	17	10	6	4	75
53	9.6	25.5	2.66	24	9	8	17	9	9	5	81
57	9.8	25.5	2.60	27	9	9	18	10	10	4	87
58	10.6	30.0	2.83	22	7	8	5	10	6	4	62
64	9.8	27.7	2.83	24	9	8	17	11	8	4	81
66	10.9	29.4	2.70	14	7	7	19	12	8	4	71
67	9.9	26.5	2.68	23	8	8	19	10	10	4	82
68	10.2	27.6	2.71	27	7	9	19	6	10	4	82
70	10.2	24.6	2.41	21	8	8	17	12	8	5	79
71	10.3	26.7	2.59	20	7	7	17	7	8	4	70
72	10.3	26.1	2.53	25	8	8	17	8	10	4	80
73	10.6	28.9	2.73	20	7	8	19	9	8	4	75
76	10.1	28.3	2.80	26	9	8	20	10	7	4	84
78	9.9	24.0	2.42	23	8	9	20	8	8	4	80
Average:	10.02	26.79	2.67	22.58	8.04	8.25	17.50	10.38	8.58	4.13	79.46

(B) Wether Lambs:-

Lamb Number.	Cannon. Length (cms.)	Cannon. Weight (gms.)	Cannon. W/L.	(1) Legs.	(2) Fat Cover.	(3) Loin.	(4) Loin Fat.	(5) Eye.	(6) Ribs.	(7) Colour.	Total.
3	9.8	25.6	2.61	24	8	9	19	10	9	4	83
6	10.4	29.9	2.88	22	8	8	20	8	9	4	79
7	10.0	32.4	3.24	23	8	7	12	13	4	4	71
11	10.7	26.7	2.50	24	8	8	12	9	8	4	73
16	10.2	27.9	2.74	24	7	8	12	13	8	4	76
20	10.5	31.7	3.02	24	8	8	12	11	5	4	72
34	9.4	26.5	2.82	30	8	9	20	10	10	4	91
35	9.9	24.8	2.51	24	8	8	19	12	8	4	83
40	10.3	36.5	3.54	25	8	8	18	12	10	4	85
44	10.6	31.5	2.97	21	7	8	17	9	5	4	71
52	9.2	26.8	2.91	29	7	6	19	12	6	4	83
63	10.3	28.9	2.81	20	8	7	17	10	9	4	75
65	10.4	26.2	2.52	24	8	8	17	11	8	4	80
75	10.5	29.9	2.85	24	8	9	19	10	9	4	83
82	10.7	28.5	2.66	21	8	8	19	10	8	4	78
Average:	10.19	28.92	2.84	23.93	7.80	7.93	16.80	10.67	7.73	4.00	78.87

Appendix V B.

CARCASS DATA.

Lambs from Six Year Old Ewes.

(A) Ewe Lambs: -

Lamb Number.	Cannon.			Cambridge Block Test Points.							
	Length (cms.)	Weight (gms.)	W/L.	(1) Legs.	(2) Fat Cover.	(3) Loin.	(4) Loin Fat.	(5) Eye.	(6) Ribs.	(7) Colour.	Total.
10	10.0	27.1	2.71	26	9	9	20	8	10	4	86
15	10.4	31.1	2.99	18	8	8	17	12	7	4	74
17	10.1	28.5	2.82	24	9	9	19	12	10	4	87
21	10.1	25.8	2.55	22	8	8	19	13	9	4	83
23	10.7	27.5	2.57	20	9	9	19	10	10	4	81
29	10.5	29.2	2.78	23	8	8	19	9	9	4	80
30	10.5	29.8	2.84	17	9	9	20	9	7	4	75
46	9.7	26.3	2.71	26	8	10	20	15	9	4	92
48	9.9	28.4	2.87	26	9	10	14	10	10	4	83
50	10.5	26.3	2.50	18	8	8	17	10	8	5	74
55	10.0	24.0	2.40	27	10	9	19	13	10	5	93
62	10.4	27.5	2.64	17	8	7	17	13	8	4	74
69	11.4	29.9	2.62	14	9	8	17	10	10	5	73
77	10.9	29.7	2.72	17	6	7	17	10	10	4	71
79	10.3	29.0	2.82	24	7	7	12	12	8	4	74
Average:	10.36	28.01	2.70	21.27	8.33	8.40	17.73	11.07	9.00	4.20	80.00

(b) Wether Lambs: -

Lamb Number.	Length (cms.)	Weight (gms.)	W/L.	Legs.	Fat Cover.	Loin.	Loin Fat.	Eye.	Ribs.	Colour.	Total.
8	10.3	30.5	2.96	21	7	7	12	12	8	4	71
9	10.9	36.4	3.34	13	6	6	12	8	6	4	55
18	10.3	29.9	2.90	26	8	9	14	8	9	4	78
31	9.6	26.9	2.80	30	8	8	17	12	10	4	89
33	10.1	26.9	2.66	24	8	8	18	11	9	4	82
37	10.8	32.2	2.98	22	7	7	12	8	9	4	69
38	10.2	32.4	3.18	24	8	7	15	12	9	4	79
39	9.9	26.1	2.64	28	10	9	20	8	9	4	88
41	10.3	28.2	2.74	23	8	9	8	11	8	4	71
42	10.4	30.0	2.88	21	8	8	19	11	9	4	80
43	10.3	29.4	2.85	24	8	9	19	7	10	4	81
47	10.2	27.6	2.71	27	8	9	19	13	10	4	90
56	11.5	38.9	3.38	12	8	7	12	14	8	4	65
59	10.7	30.3	2.83	17	6	7	12	10	10	4	66
80	10.3	28.3	2.75	19	8	8	17	8	8	4	72
81	10.7	32.5	3.04	19	8	9	17	7	9	4	73
Average:	10.41	30.41	2.92	21.88	7.75	7.94	15.19	10.00	8.81	4.00	75.56