A COMPARISON OF THE LACTATION PERFORMANCES BETWEEN ROMNEY, CORRIEDALE AND MERINO EWES UNDER HIGH COUNTRY CONDITIONS

A thesis
submitted in partial fulfilment
of the requirements for the Degree
of
Master of Agricultural Science with Honours
in the
University of Canterbury

by
G.H. Scales

Lincoln College

1966

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

I

INTRODUCTION

Factors which affect the growth of the lamb are of considerable economic importance in animal production. Most workers in this field have shown that growth rates are influenced to a large extent by milk production, especially in the early stages, hence the study of the yields, composition and persistency of lactation is of the utmost importance. In New Zealand, relatively little information is available on the yields of the various breeds, except for that of Barnicoat (1949, 1957), Hart (1961), Coop and Drew (1963) and indirectly by the weight gain of lambs (Coop, 1950).

Information was sought in this trial on the lactation performances of the Merino, Corriedale and Romney ewes grazing under High Country conditions. No records are available on the milk production of the Merino ewe in New Zealand, although Hart (1960) has investigated the yields of Corriedales under pen-feeding conditions, while Barnicoat (1949, 1957) made a comprehensive study of the milk production of Romneys in a North Island hill country environment.

This trial was designed to measure the relative milk yields and milk composition between three breeds run in this environment. Although the Merino is the predominant breed in the High Country, it is of interest to measure the milk yields and growth rates of Romneys on tussock grazing. It would be natural to assume that the yields of the Romney would be depressed by introducing them into the tussock environment, but the extent to which this may occur, if it does, is not known.

Similarly the persistency of lactation in relation to weaning dates is far from clarified. In this trial it is hoped that some of these questions can be answered so as to extend the knowledge on yields, growth rates and the suitability of a subsequent weaning date. Considerable work has been done in other environments by Clark (1954), Barnicoat (1957), Brown (1964) and Franklin (1964) who have investigated the possibility of weaning lambs earlier. Obviously further information on the relationship between milk yields and weaning weight would be desirable.

Numerous overseas workers have investigated the milking capacity of various breeds, thus Bonsma (1939), Wallace (1948), Thompson and Thompson (1953), Burris and Baugus (1955), Hunter (1957), Owen (1957), McCance (1959), Lloyd Davies (1963) have all emphasized the importance of milk yields as regards lamb growth rates. The literature related to the effects of birthweight on milk yields and growth rates and ewe live-weight on milk yields is variable. Similarly the relationship between milk composition and growth rates is not fully established.

In this experiment the mating was synchronised so that the ewes would lamb over a short period. This was done to ensure that the lambs were of comparable ages so that accurate relative yields could be measured. Although ample data is available on the hormonal synchronisation of mating with Merinos, the literature on the Romneys and Corriedales is small. Hence comparison of the suppression and synchronisation of oestrus cycles and subsequent fertility between breeds is worthy of investigation.

The oxytocin method of milk removal, a technique developed by McCance (1959) has proved extremely successful with Merinos. Whether this technique is equally effective with Corriedales and Romneys is not known, consequently this study provides an opportunity to investigate the method further. The majority of milk yield studies involve the use of the lamb suckling technique, however the oxytocin method was prefered in view of fewer associated errors.

In general it is hoped that this trial will increase the knowledge on some of the factors influencing growth rates both quantitatively and qualitatively in this somewhat different environment.

II

REVIEW OF LITERATURE

1. SYNCHRONISATION OF MATING

The objective in synchronisation is to increase the number of ewes exhibiting oestrus on any one day of the oestrus cycle. This has been achieved by progesterone and progesterone analogues administered as a subcutaneous injection, or by an impregnated sponge which is inserted in the vagina of the ewe. Similarly considerable use has been made of rams to synchronise ewes by converting a "silent" heat into an observed heat at the beginning of the breeding season (Radford and Watson, 1957; Edgar, 1963; Coop per. comm.).

The physiological basis for studies of synchronisation is well recognised. Progesterone produced by a corpus luteum (C.L.) in a normal cycle, inhibits maturation of the Graffian Follicles. Upon regression of the C. L., follicular maturation commences and an ovarian cycle consisting of follicle growth, oestrus and ovulation proceeds (Lamond, 1964). The C.L. of the ewe ceases to secrete significant amounts of progesterone 1-2 days before the onset of oestrus (Edgar and Ronaldson, 1958; Short and Moore, 1959; Short, 1961) and may be absent during oestrus (Short, 1963). Methods of detecting progesterone in the blood are not very sensitive (Edgar and Ronaldson, 1958) and as Brush (1962) points out, doses of 5-10mg. of progesterone per day are undetectable, yet it is known that 5-10mg. will suppress oestrus. Most of the physiological problems relating to the general field of synchronisation are to be found in the suppression of the oestrus cycles.

If this is satisfactory then up to 80-90% of the ewes will be synchronised within a period of 36-48 hours. However fertility after synchronisation has, in a lot of cases, been poor (Robinson, 1956, 1958; Davies and Dun, 1957; Hunter, 1954) the reasons remaining obscure.

(a) Suppression of Oestrus Cycles

Dutt and Casida (1948), O'Mary, Pope and Casida (1950), Hunter (1954), Robinson (1956, 1958, 1960, 1961), Denny and Hunter (1958), Braden et al. (1960), Lamond (1960, 1964) have all shown that oestrus and ovulation can be suppressed during the breeding season by daily injections of 5-10mg. of progesterone and that ovulation accompanied by oestrus occurred within a few days of cessation of the treatment.

Dutt and Casida (1948) investigated various dose levels finding 10mg. per day was the optimum. Increasing the dose to 20mg. per day or 40mg. every 2 days gave no better suppression than 10mg. while doses of up to 80mg. every 4 days gave poor results. With 10mg., oestrus occurred 72 hours after progesterone withdrawal. Similarly O'Mary, Pope and Casida (1950), Hunter (1954), Robinson (1956, 1958, 1960) indicated that 10mg. per day for 16 days suppressed oestrus and ovulation satisfactorily and no great advantage could be obtained by giving doses greater than this. Twenty mg. every 2 days appears as good as 10mg. every day (Robinson, 1958; Braden et al., 1960; Lamond, 1963b) and simplifies the procedure.

Lamond and Lambourne (1961) examined in detail the dosage level of progesterone on the interval between the final injection of progesterone and the onset of oestrus. The dose was related to the rate of maturation of the follicles after cessation of injections. As the dose increased the interval increased, the interval being greater in the 2 day dose as compared with the daily dose.

Robinson (1960) recognised other factors which could influence the suppressive effects of progesterone besides the dose and frequency of injections. The progesterone treatment must have a sharp end-point, this being linked with the type of vehicle in which the progesterone is administered. He found that peanut oil or arachis oil was superior to a crystalline suspension the former having a sharper end-point with an associated higher fertility. The end-point is important in that if there is any residual progesterone carry-over at the time of fertilization, oestrus may be suppressed and a "silent" heat arise. Hence a continuous uptake followed by a sudden cessation in the progesterone level is required for efficient suppression and synchronisation. This is in line with the observations of Edgar and Ronaldson (1958) as regards progesterone levels during the oestrus cycle in the entire ewe. Other factors have an important bearing on the suppressive effects, hence Lamond (1962a) has indicated that in the early stages of the breeding season, more progesterone is required for suppression. Similarly the time of addition of rams in relation to the treatment can influence the number of ewes showing oestrus, for instance Lamond (1962d) cited ewes displaying oestrus one day after ram addition, the rams, in this case being added one day before the final injection. Normally oestrus would not occur until 48 hours after progesterone withdrawal.

(b) Synchronisation of Oestrus

On progesterone decline there is follicle maturation and oestrogen production with an associated heat 48-72 hours later. Dutt and Casida (1948), O'Mary, Pope and Casida (1950), Robinson (1956, 1958, 1960) found that oestrus was suppressed during treatment with 10mg. of progesterone per day and that about 70% of the ewes exhibited oestrus on the 3rd day after cessation of treatment. This can be compared to Hunter (1954) and Denny and Hunter (1958) who indicated 47% and 35% respectively of the ewes exhibiting oestrus.

It is apparent that gonadotrophin administration is not necessary for synchronisation and normal fertility (Lamond, 1964) although Robinson (1956) maintained it would reduce some of the animal to animal variation and in the time of onset of oestrus and ovulation. Robinson (1956) gave 500i.u. of Pregnant Mare Serum (P.M.S.) 24 hours after the final progesterone injection, with up to 90% of the ewes exhibiting oestrus 2 days later. Although Robinson (1956) claims that P.M.S. renders the onset of heat more predictable with better fertility results, Denny and Hunter (1958) claim that the difference is not significant.

Braden, Lamond and Radford (1960) indicated that Human Chorionic Gonadotrophin (H.C.G.) given 24 hours after P.M.S. further improved the oestrus - ovulation time relationship. Up to 80% of the ewes exhibited oestrus 24 hours after the H.C.G. injection, this being preceded by a 16 day treatment of 10mg. progesterone per day followed by P.M.S. given 24 hours after the final progesterone injection.

It appears that further work is required in the hormonal synchronisation field. For instance, Leathem (1961) has shown that nutrition can affect the pituitary - ovarian function, so nutrition may well affect the whole synchronising complex.

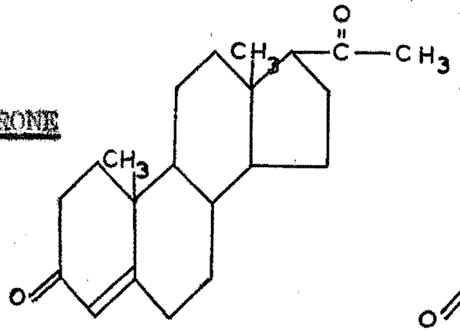
(c) <u>Fertility Following Synchronisation</u>

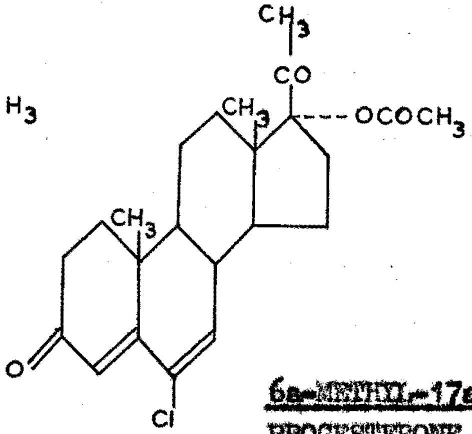
Although as has been indicated, 5-10mg. of progesterone per day is sufficient to suppress oestrus, subsequent fertility has not always been satisfactory (Robinson, 1956, 1958, 1961; Davies and Dunn, 1957; Davies, 1960; Lamond, 1960, 1962b). In general, fertility to natural service has been higher than artificial insemination (Hogue, 1962). Similarly as Robinson (1958) found, poor fertility results have been obtained with insemination on a time interval after the final progesterone injection. It seems as though the spread of ovulation is too great to use this method satisfactorily.

The same author presents possible reasons for the poor fertility following synchronisation. (1) Failure of fertilization due to an oestrus - ovulation imbalance. (2) The persisting effect of progesterone on the uterine and tubal environment causing an abnormal rate of ovum transport. This emphasises the necessity for a progestational agent whose activity ceases abruptly after the end of treatment. (3) Embryonic failure. This again is probably the repercussions of a hormone imbalance. However most workers have obtained satisfactory fertility to natural service following a course of either 10mg. progesterone daily for 16 days or 20mg. of progesterone every 2 days for 8 days.

1. Progesterone Analogues: Some of the progesterone derivatives are long acting when given intramuscularly but short acting when given orally. e.g. 6 methyl - 17 - acetoxyprogesterone. (M.A.P.).

PROGESTERONE





6a-METHYL-17a-HYDROXY PROGESTERONE ACETATE. (M.A.P.)

Southcott, Braden and Moule (1962), Evans et al. (1962), Roberts (1963), Hogue (1964) cited satisfactory synchronisation and fertility with 50-60mg. M.A.P. per day for 14 days, oestrus occurring in 70-75% of the ewes on the third day after treatment. Hogue (1964) states maximum synchronisation (100%) and fertility (82%) following a treatment of 750iu. P.M.S. before and after an 8 day treatment of 60mg. M.A.P. per day. Doses of 20mg. and 6.6mg. per day (Southcott et al., 1962) and 30mg. per day (Hogue, 1964) were too low, while 90mg. too high for efficient synchronisation, the interval between cessation of treatment and oestrus being longer with the higher dose.

Evans et al. (1962) and Roberts (1963) obtained satisfactory suppression, synchronisation and fertility following 100mg. M.A.P. every 2 days. Southcott et al. (1962) found a greater percentage of the M.A.P. treated ewes lambing, compared with the progesterone treated which could be a reflection on the sharper end point of the M.A.P. It is not known whether factors that influence the suppression of oestrus by progesterone (season, time of introduction of ram, nutrition, time of day of final dose) have similar effects with the action of oral progestagens. It is not possible to obtain satisfactory synchronisation with a single injection of a progestagen alone but Bindon and Roberts (1964) by injecting 10mg. of C.A.P. (6 - chloro Δ^6- dehydro 17a - acetoxyprogesterone) followed 2 weeks later by 10mg. of progesterone intramuscularly or 100mg. M.A.P. orally, obtained satisfactory synchronisation and fertility.

More work is required on the factors influencing an optimum suppressive progesterone dose e.g. location, season, nutrition, time of day. The gonadotrophic complex is not fully understood and the way whereby they act on the ovary is obscure. The present trends in research seem to indicate that many investigators expect to solve problems of synchronisation by field trials instead of a combination field and laboratory experiments. The fact that similar treatments give different results in different groups of animals especially in different locations, indicates the complexity of the problem. Further study on the physiology of suppression with progesterone with or without oestrogen is required.

Recent interest has been focused on the intravaginal and subcutaneous application of progestin impregnated sponges. Robinson (1964) used both progesterone and SC-9880, a progesterone derivative, (17a-acetoxy-9a fluoro-11B-hydroxypregn-4-en-3 20-dione) which were absorbed on to a polyurethane sponge. A string was attached and the sponge inserted into the vagina.

Oestrus and ovulation were completely suppressed and were effectively released 2-3 days after removal of the sponge. Fertility to natural service (75%) and artificial insemination (81%) was good. Subcutaneous sponges are also effective but not so practical. The sponge technique as well as inducing ewes to mate on a particular day can be used, together with gonadotrophin for inducing oestrus and ovulation in the anoestrus ewe.

(d) Synchronisation of Oestrus by the use of Rams

Evidence has been accumulated by Underwood et al. (1944), Thompson and Schinckel (1952), Riches and Watson (1954), Radford and Watson (1947) and Edgar (1963) that the introduction of rams among ewes just before the beginning of the breeding season has a stimulating influence on oestrus and ovulation. Radford and Watson (1957) using Merinos showed that if rams were added before the start of the "silent" heats, many of the ewes are stimulated to ovulate within 5-6 days and come on heat 17 days later i.e. 22 days after the joining of the rams, thus inducing a concentrated breeding activity. Once the ewes have commenced their own breeding cycles the presence of the rams cannot affect them in this way. Edgar (1963) investigated the optimum time of ram addition in Romney ewes using February 10th, February 20th and March 2nd as joining dates. The fertility of all groups were normal but the early addition gave an earlier and more concentrated tupping, the peak of which occurred 22 days later. For maximum stimulus the rams should be kept separate from the ewes before joining. In later trials Edgar found that joining rams in February 1st when ewes are just beginning to experience their "silent" heat gave the best results while January 10th appeared to be too early.

Both young and mature ewes are influenced by the ram but teasers are less effective and sometimes fail to stimulate susceptible ewes. It is possible that the scent of rams is the important factor influencing ovulation, the presence of the ram acting as a stress factor on the ewe. Braden and Moule (1964) observed that ovulation was induced in ewes 5-6 days after they had been trucked for a considerable distance while Lang (1964) found that the ovulation rate increased with increasing time from loading to slaughter. It appears then, that the presence of the ram can act as a stress factor on the susceptible female, the effect being transmitted from the adrenal gland via the pituitary to the ovary.

Coop (per. comm.) has recently investigated the optimum synchronising dates for Romney and Corriedale ewes. It appears as though the most suitable date is in late February - early March whereas with the Corriedales optimum synchronisation was obtained in the second half of January, the earlier date being expected, as the Corriedales have a longer breeding season. The peak of tupping occurred 22 days after ram entry when 75-80% of the ewes were tupped over a 6 day period. From 50-60% of the ewes lambed over a 6-8 day period in the first cycle and about 20% lambed in the second cycle. This method appears less accurate than hormonal synchronisation where it is possible to get 80-90% tupped within 48 hours, (Lamond, 1964) and also suffers from the defect that synchronisation has to be initiated before the ewes start cycling whereas the progesterone method can be applied at any stage of the breeding season.

2. MEASUREMENT OF MILK YIELDS

With sheep that are kept for dairy purposes, yields may be determined with little difficulty by hand milking (Weiser, 1921; Maule, 1937). However it is more difficult, as shown by Fuller (1904) in wool and mutton breeds, to withdraw all the milk by hand without oxytocin. Most workers in the lactation field have used the "plunket" method which entails the weighing of the lambs before and after suckling, this procedure being repeated 4-6 times during the 24 hours to give the daily yield. Some of the earlier workers who have used this method include Neidig and Iddings (1919), Pierce (1934), Bonsma (1939), Wallace (1948), Barnicoat (1949, 1957), Thompson and Thompson (1953), Guyer and Dyer (1954) and modified slightly by Owen (1957). Wallace (1948) used four determinations per 24 hours once a week for 16 weeks. This involved separating the lambs from the ewes for 4 six hour periods during the day. However the night interval of both Wallace (1948) and Barnicoat (1949) was as long as nine hours. This not only increases the stress between the ewe and lamb but means that the lamb(s) may not be able to cope with all the milk at the morning milking, hence the yield may be underestimated. Most recent workers have tried to decrease the interval between sucklings down to 4 hours, (Hunter, 1957; Hart, 1961; Coop and Drew 1963; Slen et al. 1963).

As the lactation proceeds the lambs are more able to consume all the milk consequently the determinations may be decreased down to 5 or 4, (Pierce, 1934; Bonsma, 1939). The "plunket" technique was modified by Barnicoat (1957) who used an electrically lit shed to speed up the night determinations. Between 30-40 ewes could be milked in one hour with 5 operators.

Owen (1957) introduced an udder cover which had the advantage of keeping the lamb with the ewe and so reduce the stress factor due to separation. Although Owen (1957) only made 4 determinations per day, none of the intervals were longer than 7 hours which was better than some of earlier workers. Owen (1957) and Hunter (1957) cited a strong correlation between the production in the first 2 sucklings and the production for the first day. Using a 12 hour measurement period would save considerable work especially with the night recording. Other methods of estimating milk production have included the milking machine (Barnicoat, 1949; Volcani, 1959; Whittlestone, 1951) the latter experimenting with pigs with some measure of success. Volcani (1959) observed that the machines only withdrew half the milk while Barnicoat (1949) had little more success.

More recently considerable use has been made of the "let down" hormone (oxytocin) in obtaining a measure of the milk produced. Although McCance (1959) was the first to make use of oxytocin for measurement purposes it has been known since the beginning of the century (Ott, 1911) that the Posterior Pituitary Extract (P.P.E.) would cause the ejection of milk from the udder. Milk ejection as shown by Gaines (1915), Turner and Slaughter (1930), Ely and Peterson (1941) is a neuro-hormonal reflex involving the oxytocic factor in the P.P.E. which is released from the neurohypophyses during suckling, to act on the myoepithelial cells of the alveoli and force the milk out into the ducts and milk cistern. The effects of oxytocin are offset by adrenalin which is produced in the case of fright or nervousness.

Barnicoat (1949) failed to obtain satisfactory milk withdrawal with 10iu. pituitrin followed by hand milking. Although no reasons are given it is possible that too much time elapsed between injection and milking, since the action of P.P.E. is characteristically evanescent (Folley, 1952). The procedure as outlined by McCance (1959) was to milk the udder out by hand and after a given interval the ewe milked again. The milk produced at the second milking represents that produced for the given time interval. Immediately before each milking an initial dose of 5iu. of P.P.E. was injected into the jugular vein. Milk was withdrawn rapidly and when no more could be attained, a test dose of 5iu. was given and the ewe milked again. If greater than 10mls. was obtained then a further test dose was given.

McCance compared different dose rates finding 5iu. the most satisfactory. Doses of up to 10iu. were of no addedadvantage while doses lower than this, did not in many cases, give adequate withdrawal. McCance also compared different time intervals between milkings and found that the rate of secretion in the 2 hr interval was significantly higher than the 4 and 6 hr intervals. However the difference disappeared with advancing lactation. Lambs put with ewes after they had been hand milked following P.P.E. injection obtained little or no milk, indicating the complete withdrawal of milk from the udder. Yields were independent of the time of day and speed of milking.

McCance (1959) lists three requirements for a method of milk estimation.

1. The udder must be emptied to a comparable degree at the beginning and end of the period of observation.
2. That the technique itself does not affect the rate of milk production over this period.
3. That the rate of production during the period of estimation is the same as other periods to which the estimate is referred.

The oxytocin technique satisfies (1) whereas with the "plunket" method, complete emptying of the udder is not obtained unless twins are used. However the oxytocin technique may fall short of the second requirement in that estimates are to some extend dependent on the time interval between milkings. A four hour interval appears to be the best, the two hour interval giving higher yields which is probably due to supernormal emptying since Wallace (1948) and Munro and Inkson (1957) were unable to demonstrate any similar effect when using the lamb suckling technique. It would appear that a four hour interval in the "plunket" method would allow sufficient time for the ewe to settle down and conversely the maximum time so that the udder can be emptied completely at one milking.

In satisfying the third criterion it is necessary for the diurnal secretion to be constant, if the daily production is to be measured. McCance (1959), although using an unnatural physical environment found little difference (12%) in the diurnal production based on six 4 hour intervals.

Coombe, Wardrop and Tribe (1960) compared the "plunket" and oxytocin techniques, using 5 and 2 hour intervals respectively. On average the oxytocin technique gave 24.0% higher yields than the lamb suckling method, this being over a period of 0-10 weeks, although the difference was greater towards the end of lactation. However Coombe et al. were only using single lambs which would underestimate the yields as measured by the lamb suckling technique. Their results can be compared to Moore (1962) who, using a 4 hour for both, obtained a 6% difference over 10 weeks in favour of the oxytocin technique. It appears as though Coombe et al. (1960) have overestimated the oxytocin technique by using a 5 hour interval for the lamb suckling and only 2 for the oxytocin, instead of equal intervals for both. Moore (1962) feels that the reason for the differences in technique, can be explained by the fact that the ewes will not always stand for the lambs especially towards the end of lactation and hence the udder is not completely emptied. This means that the yields in the suckling technique will be under-estimated. If complete emptying of the udder is achieved the yields between the two techniques will be similar.

The oxytocin technique measures the "lactation potential" of the ewe uncomplicated by the appetite of the lamb. While the lamb suckling technique may be applicable to the growth of the lambs, the oxytocin technique is especially useful for comparative purposes and offers a simple and accurate measure of milk yields. As McCance (1959) points out, no training of the ewes is required, there being little stress imposes on the ewe. Up to 12 ewes per hour can be milked by 1-2 operators, which indicates the speed and simplicity of the method.

3. EWE LACTATION

(a) Milk Yields.

Although copious data is available on ewe milk yields throughout the world, there are only a few breed comparisons which have been made under identical environmental conditions. There are none where the lambing date has been precisely controlled so as to allow accurate comparisons to be made, although Lloyd Davies (1963) did make an attempt without any apparent success.

Yields obtained by various workers in different environments are given in the following table.

TABLE 1 - MILK YIELDS

SOURCE OF INFORMATION	BREED	LACTATION PERIOD	TOTAL YIELDS (lbs)
Bonsma 1939, S.Africa.	Merino	12	136
" " "	Merino x B.L.	12	189
" " "	Merino x Romney	12	183
Wallace 1948, Cambridge.	Suffolk	12	247
" " "	B.L. x Cheviot	12	336
Barnicoat 1949, N.Z.	Romney (twins)	12	330
" " "	Romney (singles)	12	257
Thompson & Thompson 1953, Aberdeen.	Cheviot (H.P.)	13	200
" " "	Cheviot (L.P.)	13	110
Burris & Baugus 1955, U.S.A.	Hampshire	12	166
Hunter 1957, S.Africa.	B.L. (2t)	12	259
" " "	W.Mt. (2t)	12	204
" " "	W.Mt (mature)	12	292
Owen 1957, Wales.	W.Mt	10	109
" " "	W.Mt (H.P.)	10	157
Coombe, Wardrop & Tribe 1960, Australia.	B.L. x Merino*	10	197
" " "	B.L. x Merino+	10	166
Hart 1961, N.Z.	Corriedale (twins)	12	259
" " (pers comm.)	Border-Leicester	12	400
Coop (pers comm.) N.Z.	B.L. x R (twins)	12	336
" " " "	B.L. x R (singles)	12	283
Lloyd Davies 1958, Aust.	Merino (singles)	10	153
" " 1963, "	Merino (singles)	10	147
" " " "	Merino (twins)	10	221

SOURCE OF INFORMATION	BREED		LACTATION PERIOD	TOTAL YIELDS (lbs)
Slen et al. 1963, Canada.	Suffolk	(singles)	8	196
" " " " "	Hampshire	"	8	179
" " " " "	Rambouillet	"	8	173
" " " " "	Corriedale	"	8	156
" " " " "	Romnelet	"	8	179

* Oxytocin
\+ Lamb suckling

It can be seen that the yields of a given breed are influenced by the location and also the method used to measure milk production, as indicated by Coombe, Wardrop and Tribe (1960). The only true comparative work published, is that of Fuller and Kleinheinz (1904), Neidig and Iddings (1919), Bonsma (1939), Wallace (1948), Hunter (1957) and Slen et al. (1963).

Different authors have used varying planes of nutrition, lactation lengths and number of lambs suckled, which makes any comparison difficult. The effect of location is illustrated by the differences in yields between Bonsma (1939) and Lloyd Davies (1959) who used similar breeds of comparable ages. Hence it is difficult to ascribe any value to a breed unless all the modifying factors are taken into account.

Barnicoat (1949) and Owen (1957) have found large individual variation in yields, some ewes secreting over three times as much as the lowest yielders, this being confirmed by most workers.

Coombe, Wardrop and Tribe (1960) compared Merino x Border-Leicester ewes with Merino x Romney Marsh ewes using both the oxytocin and lamb suckling methods and found no significant breed difference with either method, although higher yields were obtained with the oxytocin technique. Fuller and Kleinheinz (1904) determined yields of 14 breeds in the seventh week of lactation while Neidig and Iddings (1919) compared several breeds (Hampshire, Cotswold, Shropshire, Rambouillet, Lincoln) at 10 day intervals for 50 days, the Hampshires giving the highest yields and associated growth rates.

The East Friesland sheep, one of the highest yielding, produces up to 1600lb in 259 days which is approximately 520lb for a 12 week lactation. Hence breeds incorporating some East Friesland blood are likely to be of high milking potential. An example of this can be seen in the Colbred sheep. Lloyd Davies (1963) recorded low yields associated with high stocking rates and native grazing. Higher milk production was recorded in ewes (a) rearing twins as compared with singles (b) rearing single Merino x B.L. cross lambs as compared with single Merino lambs. Barnicoat (1949) using single lambs indicated yields varying from 233 - 278lb for a 12 week lactation. Slen et al. (1963) compared five breeds (Suffolk, Hampshire, Rambouillet, Canadian Corriedale and Romnelet) and showed that amongst ewes nursing singles, the Suffolk ewes were the highest yielders, while with twins the Canadian Corriedales were the highest.

(b) <u>Lactation Curves</u>

Evidence from dairy cows indicate that yields reach a peak 4-6 weeks after parturition and subsequently decline (Sanders, 1930; Esp, 1941; Riddet and Campbell, 1943; Brody, 1945). The literature concerning lactation curves in sheep is conflicting in that some workers have found curves typical of the dairy cow, while others have obtained a uniformly declining curve with no peak.

The shape of the curve as reported by Neidig and Iddings (1919), Pierce (1934), Bonsma (1939), Wallace (1948), Barnicoat (1949), Thompson and Thompson (1953) and Burris and Baugus (1955) is characterised by an increase to an early peak depending on the breed and level of yield, with a subsequent gradual decline. Bonsma (1939) reported the typical dairy type curve with its associated peak in all breeds, except in the Merino and low yielders, while Barnicoat (1949) obtained variable types of curves, depending on the level of production and the number of lambs suckled. With high yielders there were peaks at about three weeks, whereas with low yielders and in the case of twins there were little or no peaks at all, as was the case with Lloyd Davies (1963) and Slen et al. (1963). Hart (1961) using Corriedales fed on a maintenance ration, obtained similar curves, while Slen et al. (1963) indicated little inter-breed differences in the shape of the curves or between single and twin bearing ewes, the curves being flat in all cases. The rate of decline of yields did not appear to be as rapid as other workers, which was especially noticeable with single bearing ewes. Lloyd Davies (1963) did not find any pronounced peaks although it was obvious that nutrition had a considerable modifying influence on the shape of the curve. On improved pasture with light stocking, yields were generally characterised by a peak in early lactation, but if poor pasture and heavy grazing then there were little or no peaks, the yield declining more rapidly with advancing lactation.

From the authors mentioned it appears that when ewes are suckling twins, or are low yielders associated with a low plane of nutrition, the peaks are likely to be small or nonexistant. As Barnicoat (1949) points out, this type of curve could be associated with younger ewes which have lower yields, but unfortunately the literature is too variable to draw any definite conclusions. For instance, Wallace (1948) cites lower yields and flatter lactation curves in ewes suckling singles as compared with twins. Although the Border-Leicester x Cheviot ewes had higher yields than the Suffolk, both breeds had the same generalized form, the maximum yields being recorded in the second and third weeks.

According to Wallace (1948) and Owen (1957) approximately 38% of a total 4 month yield is secreted in the first month whereas in the last month only about 11% is secreted. Although the B.L. x C ewes had a more pronounced peak in Wallace's trial this does not indicate a breed difference. This is because (1) The mean ages of each breed differed. (2) There were more twins suckled in the B.L. x C ewes, which influences the shape of the curves profoundly. Twins reached a maximum production about a week earlier than singles, although this could possibly be explained by the fact that singles were not able to draw off all the available milk, especially in the early stages. There was no peak in the low yielding Suffolks, the lambs being apparently able to withdraw all the milk from the beginning.

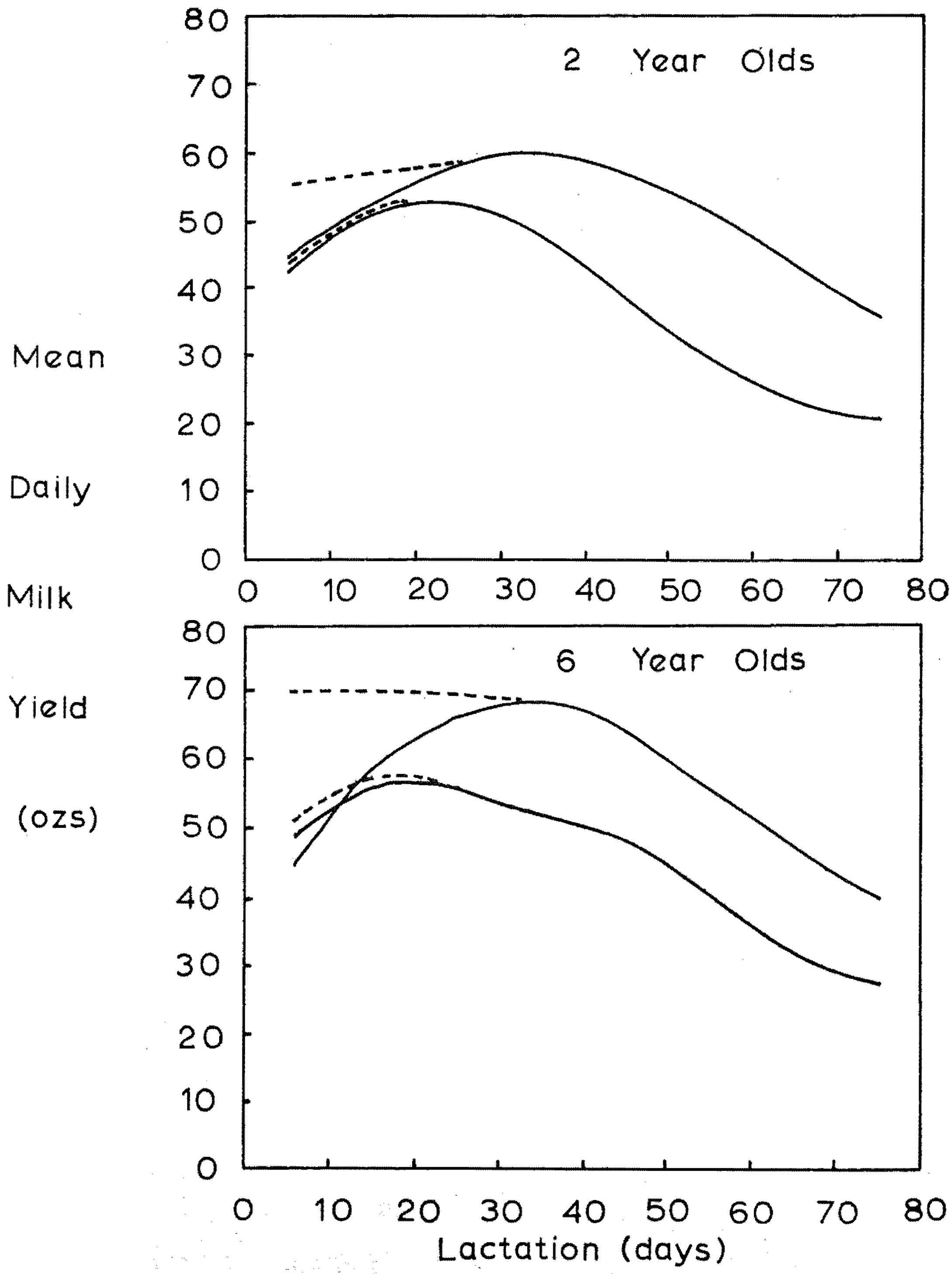
Barnicoat (1949) attempted to explain the reasons for the differing shapes in lactation curves. As pointed out above there is copious milk in early lactation. Barnicoat stresses the necessity of twins to measure the potential yield, which is what the ewe is capable of yielding. This can be compared to the actual yields, as obtained by the "ad lib" consumption by the lamb. The derived "potential" and "appetite" curves differ in shapes, as can be seen in figure 1 which indicates the desirability of twins when measurements on milk yields are to be made. This is especially so with high yielding and older ewes. A less pronounced peak is evident in the 2 year old ewes while low yielders are characterised by earlier peaks. The broken line indicates the type of graph that would be produced if all milk is removed in the early stages of lactation. Twins tend to flatten out the peak, thus approaching the characteristic curves obtained by Bonsma (1939), Hart (1961), Lloyd Davies (1963) and

Figure 1 Effect Of Milk Yield On The Shape Of The Lactation Curve. Average Yields Of The Highest And Lowest Yielders.

—— Appetite Curves

----- Potential Curves

Reproduced From Barnicoat et al (1949)



Slen et al. (1963). The disadvantage of using single lambs for milk yield measurements is illustrated by Barnicoat (1949) where up to 40% of the milk was left in the udder of mature ewes in the first 20 days. However over the whole lactation period it was only 5%.

Both Hunter (1957) and Owen (1957) observed lactation curves similar to that of dairy cows. Hunter reported no differences in the shape of lactation curves between Border Leicester or Welsh Mountain ewes or between singles and twins in spite of considerable yield differences. Peaks were sharp, reaching a maximum in the second week, the Border Leicester ewes falling slightly faster towards the end of lactation.

It is possible that the peak in the lactation curve may occur within the first week after parturition and hence will not be recorded by workers who are recording weekly. This could account for why in many cases, curves without peaks have been obtained.

Coombe, Wardrop and Tribe (1960) obtained definite peaks at about two weeks with Merino cross ewes rearing single lambs. They used both the lamb suckling and oxytocin techniques, there being a slightly earlier peak with the oxytocin. The variable shapes of lactation curves that have been obtained by workers in this field are difficult to explain, but appear to depend on the number of lambs suckled, level of nutrition, level of production (which is a reflection on nutrition), age of the ewe, technique of measurement and possibly location, providing all other factors are held constant.

(c) Milk Composition

As milk composition varies with the stage of milking (Hammond, 1932; Espe, 1941) it is important that a representative sample be obtained from the ewe. Complete emptying of the udder is necessary, as the milk increases in fat content towards the end of milking. When oxytocin is being used for milk withdrawal, sampling presents no problems. However when the lamb suckling method is used, one quarter is milked out by hand, while the lamb suckles the other as indicated by Barnicoat (1949) and Hart (1961). This is necessary so that the maximum "let down" stimulus is obtained in both quarters, which ensures the complete removal of milk by the lamb. The quarters are milked alternately at each sampling time. Higher fat contents are likely to be obtained using oxytocin, due to the more complete withdrawal of milk.

Although fat percentages are variable, the solids-not-fat (S.N.F.) are relatively constant. Barnicoat (1949) experienced difficulty in obtaining a relationship between fat percentages and growth rates, due to the large variations in fat percentage.

There is not a great deal of information available on the composition of ewes milk in New Zealand other than Barnicoat (1949, 1957), and Hart (1961). Overseas workers include Pierce (1934), Godden and Puddy (1935), Bonsma (1939), Wallace (1948), Slen et al. (1963) and Gardner and Hogue (1964). In general, the average composition values are within the following range.

	RANGE %
Total solids	15.8 - 25.9
Fat	4.7 - 10.6
Protein	4.1 - 9.3
Lactose	3.7 - 5.6
Ash	0.80 - 1.23

With the exception of Neidig and Iddings (1919), most workers have shown that the fat, protein and ash contents are high in the beginning of lactation but decline to a minimum 2-4 weeks later, remaining constant for a time and then rising with successive weeks of lactation. Lactose values usually decline or remain relatively constant. Barnicoat (1949) states that fat could rise by 4%, protein 2% and ash 0.15%, while lactose could decrease 0.7%, this being over a 12 week period.

There are considerable interbreed and intrabreed differences in the composition of milk. The most variable factor appears to be the fat, this varying according to Ritaman (1917) and Neidig and Iddings (1919), from 2.4% - 12.1%. Wallace (1948) suggests that the fall in efficiency of milk production is due to the increase in energy content associated with the fat content of the milk. Unfortunately Wallace's data is limited in that only two ewes were used for measurement purposes, this being for a period of 18 days after lambing. However he did show that on the first day after lambing the fat percentage was 25% whereas after 18 days it was down to 8.5%.

Values obtained by prominent investigators are given in the following table.

TABLE 2 - MILK COMPOSITION

AUTHOR	TOTAL SOLIDS	FAT%	PROTEIN%	LACTOSE%	ASH%	BREED	WEEKS LACTATION
Godden & Puddy (1935)	19.30	7.43	6.09	4.81	0.97	Scottish	-
Bonsma (1939)	16.23	4.76	5.25	5.34	0.88	Merino	8
" "	16.95	4.91	5.86	5.27	0.91	Romney	8
Pierce (1934)	19.29	7.90	5.28	4.81	0.90	Merino	9
Wallace (1948)	18.10	7.45	4.58	4.86	1.21	Romney	2
Barni- (1949)	16.25	5.30	5.45	4.60	0.90	Romney	12
coat (1957)	16.30	5.50	5.50	4.40	0.87	Romney	12
Hart (1961)	17.88	6.68	-	-	-	Corriedale	12
Slen (1963)	-	6.30	5.40	-	-	Corriedale	8
" "	-	7.50	5.40	-	-	Suffolk	8

Barnicoat (1949) using Romney ewes made a comprehensive study of milk composition. Fat percentages varied from 3.0-9.0 with an average of about 5.4, this value being similar to those reported by Bonsma (1939) for various breeds of sheep but distinctly lower than results obtained by Pierce (1934) and Godden and Puddy (1935). Barnicoat (1957) measured the CaO and P_2O_5 components of ash these being 0.26% and 0.35% respectively.

Hart (1961) using Corriedales over a 63 day lactation period obtained a fat content of 6.7% this being an average for 2 seasons. The corresponding S.N.F. value was 11.2%. The shape of the fat curves between years were variable (one year there was a peak in the fat percentage in mid lactation, which is contary to that reported by other workers) but in general both the fat percentage and S.N.F. rose with advancing lactation, this being more pronounced with the former.

Slen (1963) cites no significant interbreed differences in the protein or fat content of the milk and concluded that these factors had little influence on the body weight gain of the lambs, or its correlation with milk production. Protein values averaged 5.0% and fat percentages about 6.8%, this being for an 8 week lactation.

There are several factors influencing the composition of ewes milk. One of the most important, the stage of lactation, has already been mentioned. The effect of the age of the ewe has a strong influence on composition as indicated by Barnicoat (1949). While there was no difference in S.N.F. between young and mature ewes, the latter did have a significantly higher fat test. However, although faster growth rates were apparent in the old ewes, no correlation between fat percentages and growth rates could be found. The plane of nutrition also has considerable influence on the composition. When it is considered that acetate is the main precusor of milk fat, while milk protein is to a large extent dependent on a supply of propionic acid as well as protein, the type of feed consumed is of considerable importance.

Hence on poor feeds with high fibre, which have a high acetate fraction of the volatile fatty acids (V.F.A.), there are likely to be high fat percentages in the milk. Conversely on lush pastures, with high propionic concentrations, fat percentages will be low, although the protein fraction will be considerably higher. Modification of the diet, such as grinding, will also alter the V.F.A. proportions and hence the composition.

Barnicoat (1949) compared a high and low plane of nutrition before and after lambing. In general the plane of nutrition during lactation was more important than the plane of nutrition during pregnancy. Associated with a low plane of nutrition or poor pasture quality were low yields, high fat contents and low S.N.F. (protein, lactose, and ash). Conversely with a high plane of nutrition, all components were high except the fat percentage. From Barnicoat's results there can be seen an opposing relationship between yields and fat composition.

Changes in S.N.F. as a result of nutrition, are characterised by changes in the protein fraction, which can account for up to 65.0% of the S.N.F. depression on a low plane diet. Lactose is the least affected by nutrition. The importance of good feeding during late pregnancy and lactation, as indicated by Barnicoat (1949, 1957) and McCance and Alexandra (1959), is reflected in the yields and composition. For these to be satisfactory a high level of nutrition is necessary.

Twin lambs, as compared with singles, produce milk higher in all components except lactose, according to Gardner and Hogue (1964). The milking interval can also affect the composition, as Grigorov and

Salichev (1962) point out, there being a higher fat content associated with a shorter milking interval. This could possibly be explained by the fact that more of the residual milk, with its associated higher fat content, is removed with the shorter milking interval.

(d) Diurnal Variation in Milk Yields

In dairy cows, milk secretion was thought to decrease with increasing interval between milkings until Turner (1953), Elliot and Brumby (1955) and McMeekan and Brumby (1956) demonstrated that secretion was continuous up to 20-24 hours and was independent upon the milking interval.

Literature on the rate of secretion in ewes up to 24 hours is meagre. McCance (1959) indicated small and non-significant differences in yields throughout the day using both 2 and 4 hour intervals on a low and high plane of nutrition. However the ewes were subjected to unnatural physical environment in that they were in a constantly illuminated shed. Whether under normal conditions of varying food intake, temperature and sunlight there is a dependence of yield on the time of day is not yet established. Most authors are concerned with total yields rather than diurnal variation in yields. However analysis of data from Coop and Drew (1963) reveal that diurnal variations were in the order of 10-20% which can be compared to McCance (1959) who cited variations of 12-15%. It is possible that the differences in diurnal milk production could be caused by the measurement procedure itself, since the peak was usually associated with the beginning of the measurement period. Towards the end of the 24 hour period the strain on both ewes and lambs increase, hence the efficiency in removal of milk is reduced with associated lower yields. This could possibly explain why McCance obtained less variation than Coop and Drew (1963) since the latter authors used the lamb suckling method of milk removal which may entail slightly less efficient milk removal than the oxytocin technique, especially towards the end of the 24 hour period.

4. FACTORS AFFECTING MILK YIELDS.

(a) Number of Lambs Suckled

It is well established that ewes suckling twins produce more milk than ewes suckling single lambs (Wallace, 1948; Barnicoat, 1949, 1957; Guyer and Dyer, 1954; Hunter, 1957; Slen et al., 1963; Lloyd Davies, 1963; Gardner and Hogue, 1964) although Burris and Baugus (1955) indicated little difference. In general, ewes with twins yield 25-60 percent more milk than singles, although the twin lamb only consumes about 68% of that obtained by a single (Barnicoat, 1957; Hunter, 1957). Barnicoat (1949),(1957) indicated a single/twin difference of 1.33 and 1.34 respectively. There was little or no peak in the lactation curves with the twins, whereas the singles reached a peak at about the 4th week. Barnicoat suggests that the high yield of twins is due to the fact that the single lamb has less capacity to draw off milk compared with the twins and secondly, it is possible that the additional suckling stimulus provided by the twins may increase the production or release of oxytocin or prolactin. The single/twin difference was greater on a high plane of nutrition, the low plane of nutrition masking the effect.

Wallace (1948) compared single and twin production in two breeds, the twins reaching a production peak earlier than the singles.

	TWINS	SINGLES	(lbs/day)
Border Leicester	4.5	2.7	
Suffolk	3.1	2.1	

Considerable work has been done since Wallace (1948). Recent values include Stark (1953) 1.50; Hunter (1957) 1.36; Alexander and Davies (1959) 1.50; Lloyd Davies (1963) 1.43; (average of three years) and Slen et al. (1963) 1.18, 1.43, (two separate years).

Alexandra and Davies (1959) indicated that it was the number of lambs suckled rather than the lambs born that was responsible for the higher yields. As well as consuming less milk than the singles, the twin lamb is less efficient (Barnicoat, 1957), this being due to the higher total maintenance cost of the twins.

(b) Birth Weight of the Lamb

Birth weight is important in that a heavy lamb will retain it's advantage through until weaning, if all other factors are held constant. Hence Thompson and McDonald (1955) were able to show that for every 1lb difference in birth weight there was a subsequent 2-3lb difference in weaning weight. Although many factors affect birth weight (nutrition of ewe, age, sex, singles or twins, breed and date of lambing) many workers have obtained relationships between birth weight and growth rate, (Hammond, 1932; Guyer and Dyer, 1954; Burris and Baugus, 1955; Thompson and Thompson, 1955; Barnicoat, 1957; Shelton, 1964). Owen (1957) observed a highly significant birth weight/growth rate correlation of 0.45 for a 0-4 week period. However correlations between birth weight and weight gain appear to depend on milk yield. Numerous investigators have reported significant correlations between birth weight and milk yields, (Bonsma, 1939; Wallace, 1948; Thompson and Thompson, 1953; Burris and Baugus, 1955; Owen, 1957), although Barnicoat (1957), Hunter (1957), Coombs, Wardrop and Tribe (1960) found no relationship. When milk yields are kept constant by partial correlations, there are no significant correlations between birth weight and weight gain, (Guyer and Dyer, 1954; Burris and Baugus, 1955).

There is a direct correlation between birth weight and udder size (Thompson and Thompson, 1953; Burris and Baugus, 1955; Owen, 1957). However as Hammond (1927) points out, size may not be a true indicator of secretory capacity if much fatty tissue is present. Wallace (1948) demonstrated that ewes on a high plane of nutrition have high milk yields and large udders, so it seems reasonable to assume that the extent of mammary development will affect the milk yield. Owen (1957) indicated highly significant correlation coefficients of about 0.6 for udder width/milk yield relationships, this being over a 0-2 week period. Similar values were obtained for birth weight/milk yield relationships. Although Barnicoat (1949) did not report any birth weight/milk yield relationships, he did observe highly significant correlations between birth weight and lamb weight at six weeks, the relationship being stronger in the older ewes. In later trials (Barnicoat, 1957) highly significant birth weight/growth rate correlations were obtained for 0-6 and 0-12 week periods, using Romney x Southdown cross lambs. However the correlations between birth weight and growth rates were in general, less than birth weight/subsequent weight relationships.

(c) Live Weight of Ewe

Bonsma (1939), Wallace (1948), Thompson and Thompson (1953) and Owen (1957) have all shown a relationship between ewe live weight and milk production, although Barnicoat (1957), Hunter (1957) and Coombe, Wardrop and Tribe (1960) found none. Barnicoat (1957) did however, find a significant correlation between live weight at two weeks post partum and yields in the three-quarter bred Cheviots, whereas in the Romneys there was none.

Mason (1954) indicated a highly significant correlation coefficient of 0.45 using Lange ewes, while Owen (1957), measured the live weight at tupping and lambing and obtained a correlation coefficient of 0.6 for 0-10 weeks, which is higher than indicated by other workers. Owen presents several possibilities as to the heavier ewes being the better milkers, (1) Larger mammary and digestive capacity. (2) Higher efficiency. (3) Better nursing qualities.

Stronger correlations were obtained with the mating weights, a 13lb difference at mating giving a 5oz per day difference in milk production. Wallace (1948) using Suffolk ewes within the 80-200lb range, obtained a strong relationship between live weight and yields. However, as Hunter (1957) points out overfatness can lead to a reduction in alveolar tissue and hence less yields. Hunter suggests the date of lambing was more important in influencing yields than live weight.

(d) Age of Ewe

It is well established that with dairy cows there is a gradual increase in yields up to maturity, followed by a gradual decline, a peak being reached in about the 3rd or 4th year (Hammond, 1932). Although the evidence is variable as regards the age effect on milk production in ewes, there has been sufficient work done to indicate that milk production is related to age in a similar way as live weight. Hence Bonsma (1939) reported a 25% increase in yields from the 1st to 3rd lactation in Merinos, while Starke (1953) obtained maximum milk production in the ewe's fourth lactation. The milk production of Sicilian sheep, as noted by Montanaro (1940), reach a maximum in the fifth year and subsequently decline.

Owen (1957) indicated differences in the order of 5% between mature and young ewes, although this comparison was limited to 3 and 4 year olds. He suggests that age influences milk yields through higher birth weights, more developed pituitary and larger body organs.

The decline after maturity, associated with a drop in live weight, could possible be explained by a reduced level of hormone output or that the milk ejection system is of less importance (Hammond, 1957). Hunter (1957) observed that mature Welsh Mountain ewes produced 47.2% more milk than did 2 year olds over a 16 week lactation, however due to insufficient numbers, no reliable comparison could be made with the Border Leicesters.

Barnicoat (1949) compared the total yields of 2 and 6 year olds over a 12 week lactation but found the latter group only 15% higher, while in 1957 there was no age effect at all. However Barnicoat's method of measuring the age effect on yields was subject to seasonal effects, since he measured one group of ewes through for five seasons, rather than taking age differences within a year, or preferably over a period of years.

(e) Sex of Lamb

This is not very well documented although it is known that males have a 8-10% faster growth rate than females and are 5-7% heavier at birth, (Underwood and Shier, 1944). Similarly Wallace (1948), Guyer and Dyer (1954), Barnicoat (1957) and Hart (1961) have all shown that males grow faster than females. However Donald and McLean (1935) cited no sex effect until 130 days, while Thompson and Thompson (1953) indicated no sex effect at all. Donald (1962) observed a difference in weaning weight of 7lb for male and female singles and 6lb for male and female twins.

(f) Breed

The breed has a considerable influence on growth rates and weaning weights. Considerable breed differences in milk yields have been illustrated by Slen et al. (1963), Hunter (1957) and Wallace (1948), the same environmental conditions being maintained in each comparison. However Barnicoat (1957) did not find any difference, although the breeds concerned (Romney and three-quarter bred Cheviot) were not strictly separate.

(g) Time of Lambing

Barnicoat (1957) and Hunter (1957) observed that the time of lambing was closely related to milk yields, early spring lambing being superior, which was explained by the quantity and quality of the feed available.

(h) Competition with Wool

Wool and milk are antagonistic growth processes as Barnicoat (1957) points out. On a low plane of nutrition both the wool and milk decrease. Corbett (1964) demonstrated that lactating ewes clipped 13-18% less wool than dry ewes where both groups were pregnant prior to study. The competition for nutrients is interesting in that although the intake of the lactating ewe doubles (Coop and Drew, 1963) the fleece weight decreases. Stevens and Wright (1951) and Ray and Sidwell (1964) both indicate that the depression in wool weight is greater between dry ewes and lactating twins as compared with dry and lactating singles although the difference was not additive. Hence as far as wool weights go, the number of lambs suckled is not as important as whether the ewe is dry or lactating.

(i) Plane of Nutrition

Ample feeding is essential for promoting maximum milk production. Barnicoat (1957), in experiments with stall feeding and grazing ewes indicated that liberal feeding during pregnancy and lactation is necessary, the latter being the most important. This has been borne out by Wallace (1948), Coop (1950), Owen (1957), Hunter (1957), McCance and Alexander (1959) and Lloyd Davies (1963). Further work is required on the effects of nutrition on milk yields and growth rates, but from the work done it appears that a low-high system is the most suitable to follow.

5. FAT PERCENTAGES AND GROWTH RATE RELATIONSHIPS

It appears that the composition of milk is related to the nutritional habits of the species and their adaption to specific environments (Hammond, 1957). For instance rabbits which have high post natal growth rates, have high fat, protein and mineral contents. However, animals with slow growth rates and relatively developed at birth (man, cow, horse) have low fat contents and high lactose contents. As between 45-70% of the energy in milk is derived from fat, it would seem that milk with a high fat percentage is likely to yield the most energy and hence influence growth rates. However Ritzman (1917), Neidig and Iddings (1919) and Barnicoat (1957) found no relationship between the fat percentage and growth rates of lambs. The solids-not-fat content of ewes milk is relatively constant so variations in milk energy are more likely to be a reflection of changes in fat content.

More recent work by Slen et al. (1963) also fails to indicate any significant relationship between growth rates and fat or protein percentages. They maintain that the variation in growth rates were caused by differences in yields rather than any qualitative effects.

6. LAMB GROWTH - MILK YIELD RELATIONSHIPS

Hunter (1957) demonstrated that lamb growth in the first two months of lactation is strongly influenced by the amount of milk consumed, but less so in the second half of lactation. Bonsma (1939) indicated a strong correlation in the first 5 weeks while Wallace (1948) obtained a correlation coefficient of 0.92 in the first month, the overall coefficient from 0-12 weeks being 0.72. It is apparent that under a low plane of nutrition the correlation coefficients are higher (Barnicoat, 1949) than under a high plane since the lamb is more dependent on the milk supply. The coefficients for singles are as follows.

Weeks	Correlation Coefficient
0-3	0.83
4-6	0.98
7-10	0.84
11-12	0.47

The "r" values were low from birth until 3 weeks which was explained as due to the lamb being unable to settle down. Highest correlations were obtained from the 3-9 week period. Barnicoat feels that this period gives a better indication than the 0-12 week estimation. The correlation coefficients were not influenced by the number of lambs suckled nor by any age differences of the ewe. A highly significant correlation coefficient of 0.8 was obtained in the first 6 weeks, by Owen (1957) the relationship weakening with advancing lactation as the milk is supplemented with grass. At the end of 10 weeks the correlation between growth and milk yield was small and non-significant, although Owen claims that at 5 months of age there is still an effect of yield. Coombe et al. (1960) cited higher correlations with the oxytocin technique as compared with the lamb suckling technique, this probably being due to a more complete milk removal with the former technique.

The correlation coefficients in a number of breeds were measured by Slen et al. (1963), the correlations varying between years and in the number of lambs suckled. However an overall value of 0.67 was obtained for singles this being an average for the five breeds involved. An overall coefficient could not be obtained for twins because of the wide interbreed range in correlation coefficients, which ranged from 0.14-0.65.

7. WEANING WEIGHT AND MILK YIELDS

Barnicoat (1957) obtained significant relationships between weaning weights and subsequent 2-tooth milk production and showed that high producing ewes have high weaning weights. Pattie and Trimmer (1964) supported Barnicoat's work as regards weaning weights and subsequent milk production, although they do not give any correlation values. However ewes with high weaning weights as lambs outyielded ewes with low weaning weights as lambs by up to 10%.

8. EFFICIENCY OF LIVE WEIGHT GAIN

Barnicoat (1957) indicated that lambs do not vary much in their efficiencies as converters of milk to body tissues. He obtained a range of 4.9-6.4oz of milk consumed per oz live weight gain, the average over a 12 week period being 5.5oz. In the first half of lactation, lambs from old ewes required less milk per unit live weight gain than young ewes, but in the second half the age differences disappeared. Twins require less than singles on a high plane diet but more on a low plane diet. It appears as though lambs from low yielders have to supplement the milk with grass, consequently require less milk per unit live weight gain. The smaller lamb is more efficient in that the maintenance requirement is less, which means more milk is available for growth purposes.

Bonsma (1939) obtained values of 5.9 (1-3 weeks) and 3.8 (9-12 weeks) which indicate how the dependence on milk decreases with age. Owen (1957) observed values ranging from 4.5-5.0 while Wallace (1948) obtained values as low as 4.0, this being for the first month.

Hart (1961) using Corriedale ewes under pen-feeding conditions over a 63 day lactation period found that up to 5.7lbs of milk were required per pound live weight gain.

Since there is such a close relationship between milk consumed and lamb gain, especially in the early stages, it has been suggested that a suitable index or graph could be established (Barnicoat, 1957) which, by measurement of growth rates could indirectly give the milk production.

III

MATERIALS AND METHODS

1. ANIMALS

(a) Numbers

Three breeds of sheep were used in the trial, there being 25 Merinos, 20 Corriedales and 18 Romneys, all of which were 6-tooths. Although only 10-12 ewes of each breed were required for milking purposes the high initial number of ewes was required to cover ewe deaths and those ewes failing to produce a lamb.

(b) Origin

Care was taken to obtain a representative sample from each breed. The Romneys were brought from the Taieri plains, Dunedin while the Corriedales came from the Tarras district, Lake Wanaka. The Merinos were drafted off from the Tara Hills flock, on which station the trial was conducted. Tara Hills is a 8250 acre High Country station owned by the Department of Agriculture of which, half is hill country the other half being comprised of shingly terraces and flats, sparcely covered and carrying $\frac{1}{3}$-$\frac{1}{2}$ a sheep per acre. The ewes were brought on to the station and tagged at least three weeks before the trial began in May in order that they could settle down and adjust themselves to the somewhat unfamiliar environment.

(c) Health

All ewes were dosed with 5mg. of Selenium before tupping and lambing to safeguard against possible barrenness and White Muscle Disease in the lambs. The lambs were injected against Pulpy Kidney (Enterotoxaemia) at about 3 weeks of age. Water was supplied by a creek running adjacent to the block.

(d) Live Weight

(i) Ewe Live Weight: Ewe weights were taken at regular intervals throughout the trial. The procedure was to take the ewes to the weighing shed one mile distant where they were weighed the next day, having been housed overnight to allow a reduction in rumen fill. They were returned to their 60 acre block the same day. There were two weighings in May followed by one in June, October and January (1965).

(ii) Lamb Growth Rates: Lambs were tagged at birth and weighed once a week thereafter for 12 weeks. Salter scales were used, the lamb being suspended in a sack to reduce struggling to a minimum. On the day of weighing, the lambs were separated from the ewes at approximately 10a.m. and weighed 5 hours later at 3p.m. just after the final milking, which allowed sufficient time for the lamb to empty out. Weights were recorded to the nearest half pound. The lambs were then rejoined with the ewes and returned to their block.

2. CLIMATE

(a) Rainfall

Rainfall from January 1964 to January 1965 was 22.5 inches, this being slightly higher than the yearly average of 20 inches. Monthly rainfall figures for the complete lactation period were October 1.02", November 2.18", December 2.21" and January 1965, 5.07". This high spring-summer rainfall was responsible for the favourable growing season that year. The heavy rainfall in January 1965, offset the usual dry conditions that prevail at that time of the year, especially on the shingly soils encountered.

(b) Temperatures

Temperatures ranged from 12deg. F. in winter to 94deg. F. in summer. The prevailing wind is from the North-West which blows continuously through the spring and summer, consequently reducing the effectiveness of the rainfall. The altitude is 1600 feet above sea level.

3. VEGETATION

(a) Botanical Analysis

The ewes were grazed on unimproved tussock grassland. Over the last century the vegetation has been greatly modified by the influence of burning, overstocking and rabbits. The predominant cover is now characterised by the hard tussock, Festuca novae-zelandiae and to a lesser extent the blue tussock, Poa colensoi.

The inter-tussock introduced annuals include sweet vernal, Anthoxanthum odoratum; hairgrass (Aria, Vulpia); bromes Bromus spp; kentucky bluegrass, (Poa pratensis) and a small amount of brown top Agrostis tenuis. After the depredations by the rabbit considerable amounts of weeds have infiltrated into the community. Most abundant are catsear (Hypochaeris radicata) and sorrel (Rumex acetosella). These two species, amongst others are gradually pushing out the scabweed (Raoulia australis) although small amounts remain especially on the more barren soils (Conner, 1964).

In summer, when dry conditions prevail, sorrel and catsear predominate, while in winter the soils are subjected to frost lift, the fescue tussock

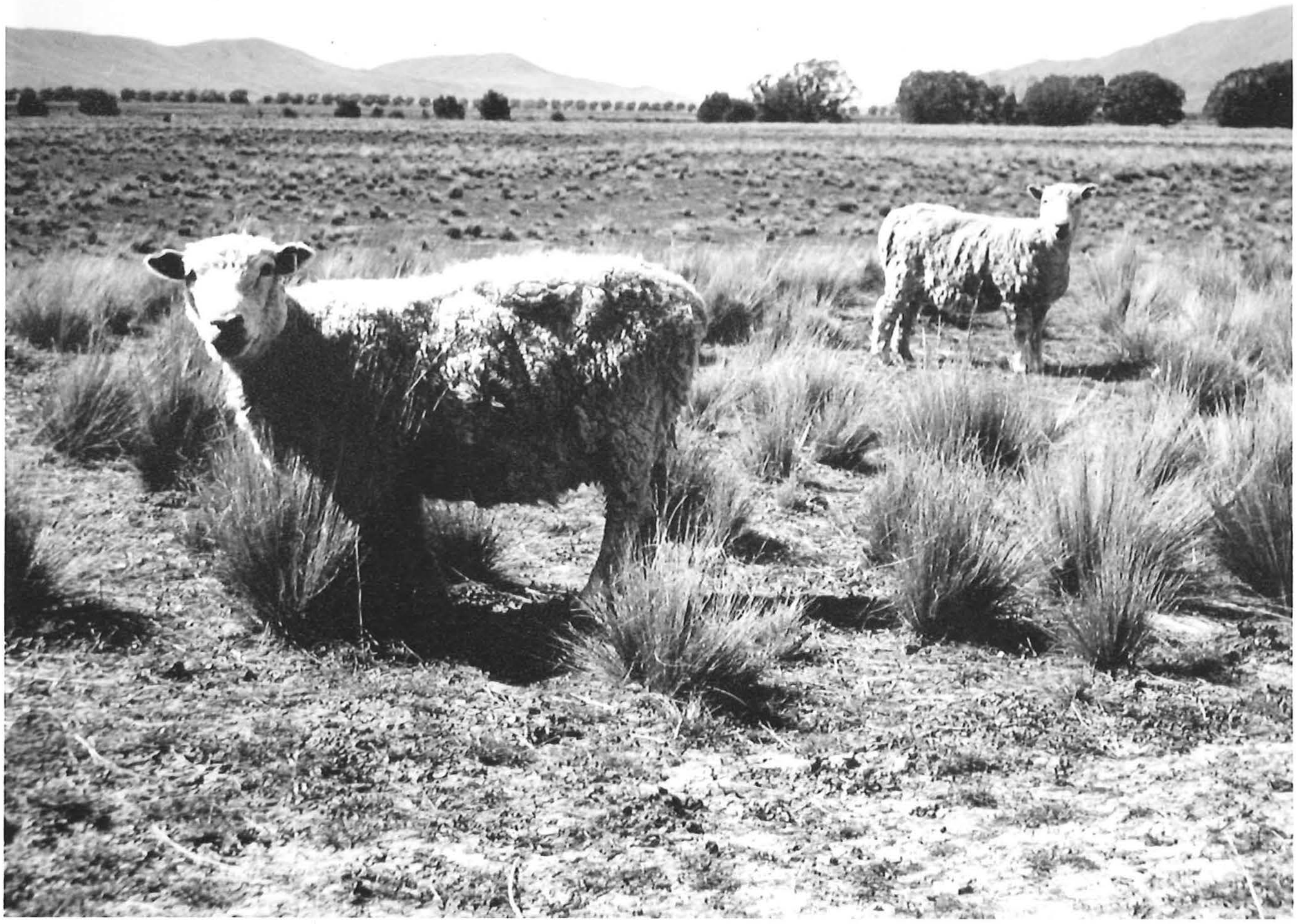


PLATE I

A view in spring of the tussock country on which the ewes were grazed. The sparce vegetation is characterised by fescue tussock and the inter-tussock annuals, sorrel and catsear together with a small amount of browntop and sweet vernal. In the foreground are two blade shorn Romneys.

providing the bulk of the grazing. In general it can be said that the vegetation is sparse and of poor quality, the abundance being closely linked with the climatic conditions prevailing.

Little work has been done on the chemical composition of the herbage in this environment although Coop et al. (1953) analysed samples from the Cass area in Canterbury which is of similar vegetation and soil type but of higher rainfall and found protein contents (expressed on a D.M. basis) of 5.5-6.5%, fibre 30.0%, calcium 0.30%, phosphorus 0.13% and copper 3.0-3.6 p.p.m. These values were for the spring, the summer values being considerably lower, which was associated with the increase in fibre. The protein and phosphorus values are below the requirements of grazing sheep as recommended by the National Research Council (1954) who quote 10.0% and 0.18% respectively. Owing to the lower rainfall at Tara Hills the protein and phosphorus values are likely to be even lower.

(b) Nutrition

In order to flush the ewes as much as possible they were grazed on lucerne-phalaris pastures for 2 weeks pre and post tupping, after which time they were transferred to a native block where they remained for the rest of the trial. During the winter they were fed 1½lb of lucerne hay per day per head, the Romneys appearing to consume slightly more than the Merinos due to their more eager feeding behaviour. This state of affairs was convenient in view of the higher maintenance requirements of the Romneys, associated with higher live weights as indicated by Coop (1962).

4. SYNCHRONISATION OF MATING

(a) Materials

Two different brands of progesterone, both in arachis oil were used; Primolut (varying strengths) and Leuteostab (50mg. in 2cc.), the latter being manufactured by Boots Ltd., England. Both preparations were equally as effective, the cost being 29/6 per 300mg. The progesterone was supplied by Kempthorne and Prosser Ltd., Christchurch and Sharlands Ltd., Dunedin. Other equipment used included temporary yards, syringes and tupping harnesses.

(b) Methods

On April 10th 1964, three weeks prior to treatment all ewes were fenced off on to a 20 acre lucerne paddock. On May 1st a total of 25 Merinos, 18 Romneys and 20 Corriedales were injected intramuscularly with progesterone in an attempt to synchronise oestrus. This comprised 8 injections, each at 2 day intervals for a 16 day period. At 12a.m. on the day of injection the ewes were brought into the temporary yards adjacent to the paddock. All ewes were given 20mg. for the first 4 injections and 15mg. for the following 4. Two rams were put out with each breed on the 15.5.64, this being the final day of the injection period. Extra rams were required to reduce the chances of one ram failing to work on the required day. All rams were equipped with a tupping harness, this being necessary to indicate the number and time of ewes tupped. Observations were continued for two cycles, the colours being changed after the first cycle. After the second cycle the rams were taken out and the ewes transferred to their native block for the winter.

5. MEASUREMENT OF MILK YIELDS

(a) Layout

During the winter all breeds were run together. Immediately before lambing the block was fenced off into three comparable areas of about twenty acres each. The layout for ewes in each of the three blocks was as follows. Approximately four ewes of each breed were placed in each of the three paddocks, these ewes having lambed within six days. This randomised layout was necessary in view of the fact that if there was one breed for each paddock, a bias could be introduced in the event of a sudden onset of bad weather, which would penalise the breed concerned. By including all breeds on a given day of milking the risk is minimised.

Each paddock was filled up as the ewes lambed. Up to three days separated the mean lambing date of the first to last block although the difference was overcome by milking the first, second and third block on the Monday, Tuesday and Wednesday respectively of each week. The first milkings took place one week after the mean date of lambing and continued for 12 weeks, there being approximately twelve ewes in each block. The remainder of the ewes (those which did not lamb within six days and barren ewes) were shifted to another block of comparable vegetation. To enable accurate comparisons of milk yields to be made, ewes bearing singles were used. Although twins would be more preferable, since the full lactation potential could be measured, it would be unlikely that all the Merinos would lamb twins, therefore in the case of twins, one lamb was disposed of. According to McCance and Alexandra (1959), the number of lambs born does not have any relationship with subsequent milk yields, so this procedure appears justifiable.

(b) Materials

Pitocin, containing the oxytocic principle of the Posterior Pituitary Extract (P.P.E.) which was manufactured by Parke, Davis and Company, Sydney, was used for the major part of the trial. Over the last month, Pituitrin the whole Posterior Pituitary lobe fraction, was used. This preparation was manufactured for veterinary use by Boots Pure Drug C. Ltd., Nottingham. The pituitrin was equally as efficient and was somewhat cheaper at £4. 7. 2. per 500iu. The strength of both preparations was 10iu. of oxytocin per ml., as supplied by Kempthorne and Prosser Ltd. Other equipment included clippers, syringes, cradles and pens to separate the ewes and lambs while milking was in progress.

(c) Method

The method used was similar to that of McCance (1959) who improved the oxytocin technique. After removal of the lambs the ewes were hand milked, following an intravenous injection of 5iu. of oxytocin. This procedure was repeated four hours later, the milk obtained being that produced in the four hour interval. In the second milking the milk was withdrawn into a graduated 500ml. flask and measured to the nearest 2ml. The milk obtained in the second milking was divided by the hourly interval to give the production in millilitres per hour. The ewes were milked at 10a.m. and again at 2p.m., the four hour interval being rigidly adhered to. Lambs were kept in an adjacent pen to minimize the stress on the ewe. During the milking interval the ewes were allowed to graze in the vicinity of the pens, in an attempt to present as near natural conditions as possible.

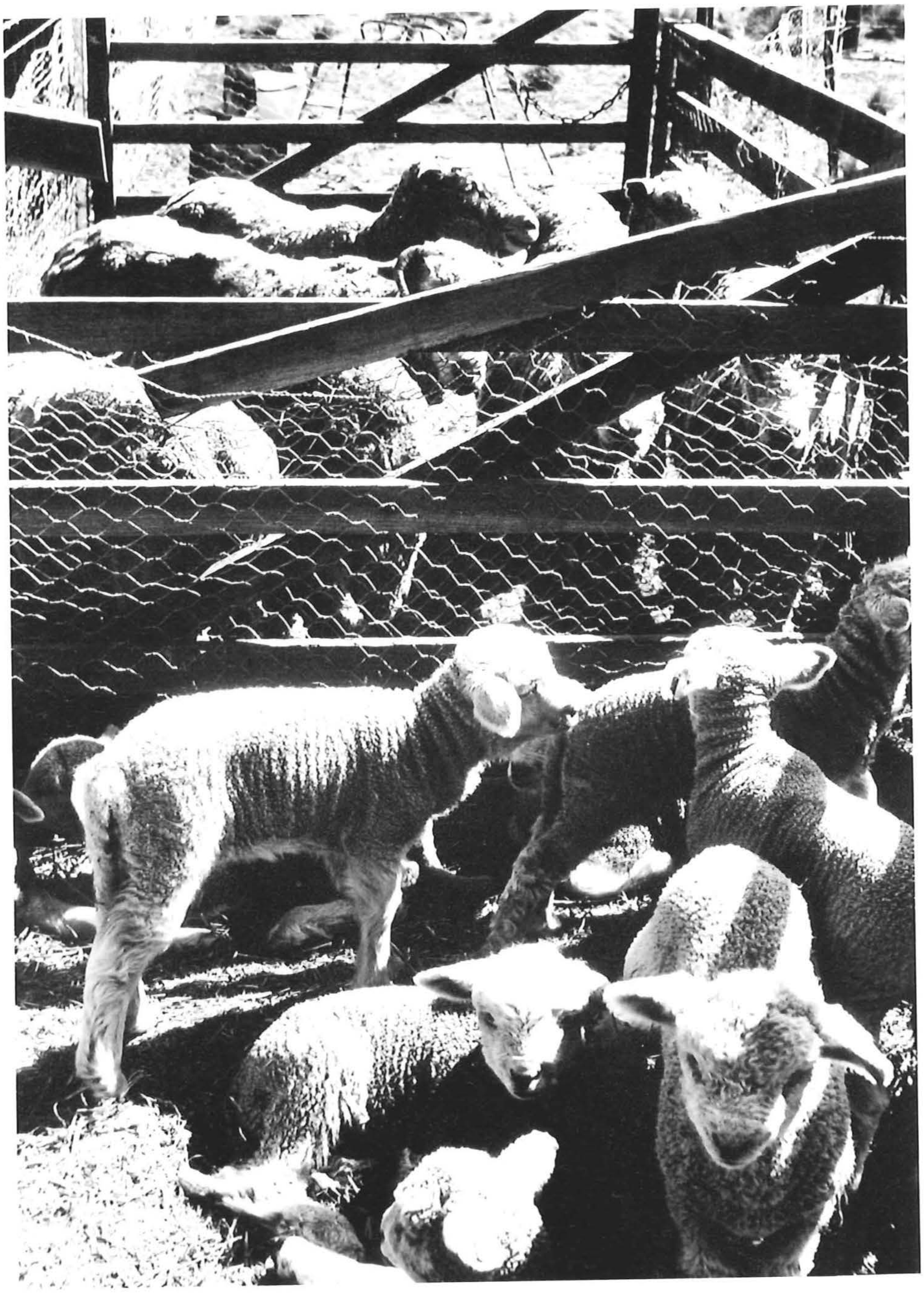


PLATE II

Illustrates the layout of the temporary yards for milk measurements showing the lambs separated from the ewes. The ewes were milked in a larger pen at the extreme top of the photograph.

Each week the wool around the neck was clipped so that the jugular vein could be easily seen to enable the injection to be given. A cyclone cradle was used to hold the ewe while milking, the back legs being tied to avoid the container from being knocked over. The ewe could be injected either while in the cradle or immediately before hand on the ground, the latter method being used in most cases. About ½ - 1 minute elapsed between injection and milking. Care was taken to ensure that the ewes were milked in the same order for the morning and afternoon milking, this being necessary to ensure a constant interval between milkings. Usually the whole operation was done by one person although on several occasions assistance was given. Up to 12 ewes could be milked in one hour by one operator each taking 1-2 minutes to actually milk.

(d) Diurnal Measurements

Out of the ewes not being used for comparative purposes, nine, comprising three ewes of each breed were used for diurnal production measurements. These ewes were milked every four hours making seven determinations to obtain yields for the 24 hour period. This was done three times at weekly intervals beginning on the 6th week of lactation. Each week the commencement time of the determinations was changed to avoid any possible bias. Water was available for the 24 hour period. During the operation the lambs were separated from the ewes in a small pen. A small paddock of 1½ acres was chosen so that the ewes could graze without being too far away from their lambs, which would promote as near natural conditions as possible. The paddock was spelled between milkings to give adequate feeding for the day under investigation. The milk was withdrawn by the same method as given earlier, 5iu. being used

PLATE III

A close up view of the method of oxytocin injection. Note the clipped area on the neck facilitating easy access to the jugular vein. The left arm restrains the ewe while the hand exerts pressure on the jugular, rendering it turgid thus enabling the injection to be given.

PLATE IV

Shows the method of restraint for milking purposes. The ewe is lifted into the cradle where it lies suspended. The back legs are tied to reduce struggling and provides easy access to the udder. Oxytocin injections may be given in this position.

at each milking. For the night recordings, lights were provided by the headlights of a Landrover, the small size of the paddock making the mustering of sheep easier. Milk samples were taken for fat analysis at each 4 hour interval.

6. MEASUREMENT OF MILK COMPOSITION

Measurements were taken of the fat content and solids-not-fat (S.N.F.) throughout lactation, while the protein and ash contents were analysed towards the end of lactation. Samples were collected in numbered bottles from each ewe at the afternoon milking, after careful mixing of the milk to ensure a homogenous sample. Fat and S.N.F. determinations were made the same day, each determination being replicated once. Towards the end of the trial it was decided that further information could be obtained from the trial by measuring the protein, lactose and ash contents of the milk. The samples for this subsidary part of the trial were collected on the twelfth week of lactation. They were dried in an oven at 100deg. C. and kept for analysis at Lincoln College some five months later. However lactose determinations were unable to be made due to lack of homogenity of the sample after the period of storage.

(a) Fat Percentage

One hundred millilitre samples were taken at the afternoon milking. The Gerber method, as outlined by Greyling (1954) was used for the determination of fat in the milk. Materials included; butyrometers with stoppers, three pipettes (11ml., 10ml., 1ml.), Gerber centrifuge, water bath, sulphuric acid (S.G. 1.825) and amyl alcohol. The method followed was as follows: Ten mls. of sulphuric acid was added to the butyrometer followed by 1ml. of amyl alcohol, these being necessary to remove the sugars and protein respectively. Eleven mls. of milk was added slowly, this forming a layer on the amyl alcohol. The butyrometers were then stoppered and shaken, and immediately placed in the water bath, kept at 65 deg. C. for five minutes. After centrifuging at about 1,000 revolutions per minute for three minutes, they were returned to the water bath for another five minutes. After adjusting the stoppers so that the fat column came on to the stem the readings were taken. The butyrometer was held vertical, the reading being taken from the top of the meniscus. About 24 samples could be done at a time, this comprising the samples from twelve ewes replicated once.

(b) Solids-Not-Fat

The S.N.F. can be determined directly by drying a known amount of milk and determining the total solids in it. The fat percentage is then substracted from the total solids to give the S.N.F. However as no suitable balance was available for these measurements, use was made of a lactometer, an instrument designed to measure the specific gravity of milk. The S.N.F. values were calculated from the formula.

$$S.N.F. = \frac{Q + F}{4} \qquad \text{where} \quad Q = \text{lactometer reading.} \quad F = \text{fat test.}$$

Samples of the afternoon milking were taken from each ewe once a week. After cooling down to 60deg. F. the milk was mixed and poured into a cylindrical tube, wide enough to accommodate the lactometer bulb so that the sides were not touching the cylinder. Care was taken to ensure that there were no air bubbles adhering to the lactometer and that the cylinder was completely full of milk while the meter was afloat. Readings were taken at the top of the Meniscus. Measurements were made four hours after milk withdrawal, this being necessary to avoid the Rechnagels phenomenon which involves considerable changes in the specific gravity associated with the evolution of CO_2 in the early stages after milk withdrawal.

(e) Protein

The protein content of the milk was determined by measuring the nitrogen in the sample using the Kjeldahl method. The milk sample was oven dried at 105deg. C. and then ground up to homogenise the material. A sample of approximately 0.1grams was added to a digestion flask. Two grams of Se $K_2 SO_4$, a catalyst were added, followed by 2mls. of concentrated H_2SO_4. The flasks were then placed on a heated digestion rack for approximately nine hours until the solution was clear. This indicates the complete oxidation of fat and sugars. The solution, together with 10mls. of 50% NaoH was washed into a Markham still. The solution was bubbled over and condensed until about 25ml. was reached, this amount being necessary to ensure that all the nitrogen was passed over. The contents of the flask was titrated with hydrochloric acid of .0140 normality. The indicator used was a boric acid solution comprising 20mg. methyl red and 100mg. Bromo cresol green. This was made up to 10ml. by the addition of water. Ten gms. of boric acid and 120ml. of alcohol (96%) were added to the solution, this being made up to 1 litre. Five mls. of this indicator was used for the titrations. By knowing the volume of hydrochloric acid required to neutralise the alkaline sample, the amount of nitrogen in one gram of protein, the amount of nitrogen in 1ml. of .0140 N HCL and the weight of the original sample, the protein percentage can be worked out, as indicated by the following formula:

$$\text{Protein } \% = \frac{\text{H.C.L.(mls)}}{1} \times \frac{1}{62.5} \times \frac{0.196}{1} \times \frac{1}{\text{Weight of sample}}$$

Where 62.5 = mg. of N in 1 gm. of protein
0.196 = mg. of N in 1 ml. of .0140 N H.C.L.

All samples were replicated once. A blank titration was made with NaOH and indicator, against the hydrochloric acid to determine the amount of nitrogen in the NaOH which was .058%. By knowing the molecular weight of nitrogen, it was possible to calculate the nitrogen content of .014 N hydrochloric acid, which in this case was 0.196mg. N per ml. Hence, assuming there is 6.25% nitrogen per gram of protein, the amount of protein can be calculated from the amount of nitrogen.

Once the amount of protein in the sample has been calculated, the amount of protein in the total solids can be arrived at by simple proportions. To express the protein as a percentage of the whole milk the protein in the total solids is divided by the weight of milk (10gms.) and multiplied by 100.

The strengths of all materials used were checked to eliminate any possible error in the calculation of normalities.

(d) Ash

Ten grams of milk were evaporated to dryness in an oven at 105deg. C. A sample of the solid was placed in a weighed crucible and ashed in a furnace at 500deg. C. for about 15 minutes. The weight of dried milk was measured by subtracting the weight of the dish from the dish plus dried milk while the weight of ash was measured by subtracting the dish weight from the dish plus ash. All determinations were replicated, the weights being measured on a Mettler balance. The ash was expressed as a percentage of the total milk, (10gms.), the ash in the total solids being divided by the weight of the total milk and multiplied by 100.

IV

RESULTS

1. SYNCHRONISATION OF MATING

On May 1st 1964, all ewes were injected with progesterone at two day intervals for eight days, in an attempt to synchronise oestrus. Two rams of each breed were added on the final day of treatment, (16th May). The number of ewes tupped within the first 4 days after cessation of the progesterone treatment are presented in table 3.

TABLE 3 - EWES SYNCHRONISED

	Number treated	Number tupped within 4 days	Percentage of total numbers used	Numbers tupped within 4 days and held to service	Percentage of total numbers used
Romney	18	18	100	16aA	88
Corriedale	20	16	80	14abAB	70
Merino	25	20	80	11bB	44

The statistical treatment involved an analysis of variance followed by the Duncan's test to determine any significant differences between the breeds. Small letters denote the 5% level while capital letters denote the 1% level. Different letters are designated to indicate significant differences between breeds.

Eighty percent of the Corriedales and Merinos were synchronised within 4 days while the Romneys were 100% successful. However, not all ewes tupped held to service, this being particularly obvious with the Merinos where out of 20 ewes tupped within four days 9 returned to service.

There was a highly significant difference (X^2 test) between the Romneys and Merinos in the number of ewes tupped and holding to service, but no significant differences between either the Romneys and Corriedales or Corriedales and Merinos. Why so many Merinos should return to service is not clear, but it is plain that the Romneys and Corriedales have met with a considerable measure of success. Out of the original numbers used, there were only 44% of the Merinos that were synchronised within 4 days held to service, whereas with the Corriedales and Romneys, there were 70% and 88% respectively.

A peak of tupping was evident on the third day after treatment, this being comparable between breeds as illustrated by table 4.

TABLE 4 - SPREAD OF OESTRUS

	1st CYCLE								2nd CYCLE				
Days	1	2	3	4	5 - - -	15	16	17	1	2	3	4 - - -	17
Romney	2	5	10	1	0 - - -	-	-	0	0	2	0	0 - - -	0
Corriedale	3	5	7	1	0 - - -	2	-	2	0	0	2	0 - - -	0
Merino	3	4	12	1	0 - - -	-	-	5	1	2	5	1 - - -	1

As can be seen the biggest proportion were tupped 48-72 hours after progesterone treatment, there being an average of 15.0, 26.0 and 52.6 percent tupped on the first, second and third day respectively. Only one ewe from each breed displayed oestrus on the 4th day. On the 15th day of the cycle two Corriedales were tupped, while on the 17th day two Corriedales and five Merinos were tupped.

It appears as though the ewes tupped on the 17th, must have come on oestrus the day before the rams were put out, or possibly had a "silent" heat on the first day of the cycle. Although the Corriedales served on the 15th have obviously come on oestrus during treatment, it is difficult to explain why such a large proportion of Merinos were tupped on the 17th day.

Lambing commenced on 11.10.64. The numbers synchronised within a given period are as follows:

TABLE 4a - SYNCHRONISATION OF LAMBING

	Number lambing within 6 days	Percentage of original numbers used
Romney	15	83
Corriedale	11	55
Merino	10	40

Only 12 ewes of each breed were originally planned for milking purposes, which left three surplus Romneys but a deficiency of one Corriedale and two Merinos. This was further aggravated by the death of one Merino lamb at four weeks of age which brought the number of ewes for milk yield studies to 12 Romneys, 11 Corriedales and 9 Merinos, although these numbers were statistically adequate for comparison purposes.

The mean lambing date of the Merinos was three days later than the Romneys, as can be seen in table 4b which gives the spread of lambing of the three breeds.

TABLE 4b - SPREAD OF LAMBING

Days	11	12	13	14	15	16	17	18	19	- - -	29	30	31	1	2	3	4	Barren
Romney	5	3	3	2	2			1			1							1
Corriedale	3	3	2	1		2		1	2		2	1		2			1	0
Merino				2		5	3				1	2	5	1	1			5

The gestation periods for the Merinos, Corriedales and Romneys were

149, 147, and 146 days respectively. The second peak of lambing occurred 17 days after the first, this being the group which failed to conceive at the first service. In general the spread of the second peak was of a similar nature to the first, extending over a period of 5-7 days. Barrenness percentages were highest in the Merinos, being in the order of 20% as compared with 5.5% for the Romneys and nil for the Corriedales. The barrenness may have been reduced by leaving the rams out longer, although two cycles should have been sufficient under the intensive mating conditions involved.

Eighty three percent of the Romneys lambed within 6 days, as compared with 40% of the Merinos while the Corriedales took up an intermediate position with 55%. A major part of the failure of the Merinos can be attributed to the fertility following synchronisation, rather than synchronisation in itself which was reasonably successful. Although fourteen Corriedales were tupped within 4 days and held to service, there were only eleven which lambed within 6 days. This was due to 3 ewes lambing just outside this 6 day period, which of course lowered the percentage of original numbers lambing down to 55%.

Lambing percentages for the three breeds were as follows: Merinos 91, Corriedales 140, Romneys 133, these being expressed as the number of lambs tailed per hundred ewes mated. Twinning percentages of the Corriedales and Romneys were 40% and 35% respectively, while the Merinos were considerably lower, being in the region of 15%. The twinning percentages are based upon the number of lambs born per ewes lambing.

2. MILK PRODUCTION

Although ten Merino ewes were available for milk yield investigations at the beginning of lactation, the number was reduced to nine after the death of a lamb. This brought the total number of ewes to twelve Romneys, eleven Corriedales and nine Merinos.

Measurements began one week after the mean date of lambing and continued once a week for twelve weeks. The yields were expressed in millilitres per hour this value having been derived by the volume secreted in four hours divided by the number of hours in the interval. Milk yields for the three breeds are presented in table 5.

TABLE 5 - MILK PRODUCTION (ml./hour)

	Mean for first 6 weeks	Mean for second 6 weeks	Whole 12 weeks
Romney	68.0a	38.0a	54.3a
Corriedale	68.9a	42.2a	56.8a
Merino	63.3a	39.9a	52.7a
Coefficient of Variance (C.V.)	14.9%	16.3%	14.5%

There was no suggestion of any significant differences between breeds in either the first or second 6 week period, or over the lactation as a whole. The variation between individuals was high, as indicated by the coefficient of variance. The differences in yields for the whole lactation are small and non-significant as can be seen by table 5 which gives the relevant values. Individual production figures for each breed are presented in table 6. Analysis of variance for the breeds is tabulated in table 7.

Total production of each breed for the 12 week lactation period expressed in pounds were Romneys 248; Corriedales 260; Merinos 241.

The weight basis was determined by measuring the specific gravity of

TABLE 6

Milk Production per hour (mls)

(a) ROMNEY

Ewe No.	Weeks Lactation 1	2	3	4	5	6	7	8	9	10	11	12
176	56.2	71.2	66.2	52.5	61.2	48.7	55.0	51.2	30.0	27.5	-	18.7
189	43.7	75.7	82.5	75.0	73.7	71.2	51.1	42.5	38.7	37.5	-	21.2
191	60.0	86.2	96.2	75.0	70.0	62.5	57.1	41.2	43.7	30.0	-	21.2
194	42.5	96.2	73.7	51.2	46.2	47.5	46.4	41.2	31.2	26.2	-	22.5
177	70.0	70.5	71.2	71.2	55.0	53.7	45.0	37.5	37.5	28.7	-	21.2
181	75.0	77.5	65.0	60.0	67.5	65.0	55.0	47.5	50.0	38.7	-	28.7
182	65.0	71.5	63.2	60.5	50.0	41.2	33.2	33.2	30.0	23.2	-	16.2
193	55.0	68.7	67.5	57.5	50.0	43.7	38.7	33.7	28.7	26.2	-	13.7
179	100.5	100.0	100.0	103.7	91.2	75.0	70.0	57.5	58.7	46.2	-	23.7
183	58.7	73.7	52.5	45.0	35.0	48.7	46.2	40.0	38.7	30.0	-	17.5
186	73.7	78.7	83.7	71.0	66.0	60.0	56.2	47.5	46.2	43.7	-	23.7
190	71.2	93.7	86.2	90.0	85.0	71.2	61.0	53.7	50.0	47.5	-	18.7
Mean	64.3	80.1	75.6	67.7	62.5	57.3	51.2	43.8	40.2	33.7	-	20.5

TABLE 6

Milk Production per hour (mls)

(b) CORRIEDALE

Ewe No.	Weeks Lactation 1	2	3	4	5	6	7	8	9	10	11	12
501	58.7	76.2	77.5	58.7	57.5	61.2	59.5	55.0	52.5	28.7	-	31.2
551	55.0	78.7	83.7	72.5	70.2	63.7	57.0	53.7	48.7	33.7	-	25.0
572	103.7	96.2	80.0	70.2	63.7	53.7	50.0	31.2	33.7	31.2	-	26.2
571	62.5	87.5	76.2	60.0	61.2	55.0	58.3	46.2	41.2	33.7	-	27.5
573	48.7	93.7	70.0	60.0	60.0	63.7	58.3	45.0	40.0	32.5	-	26.2
514	55.0	61.2	62.5	40.0	50.0	43.7	40.0	38.7	32.5	33.7	-	18.7
700	80.0	78.7	60.0	57.5	53.7	51.2	52.5	42.5	43.7	33.7	-	26.2
542	75.0	80.0	68.7	68.7	62.5	60.8	63.7	55.0	50.0	41.2	-	28.7
687	75.0	83.7	96.2	78.7	78.7	68.7	71.2	60.0	52.5	43.7	-	32.5
506	85.0	88.7	86.0	83.7	73.7	78.7	70.0	55.0	50.0	46.2	-	28.7
568	75.0	81.2	62.5	57.5	53.7	50.0	47.5	47.5	37.5	31.2	-	20.0
Mean	70.3	82.3	74.7	64.3	62.2	59.1	57.0	48.1	43.8	35.4	-	25.6

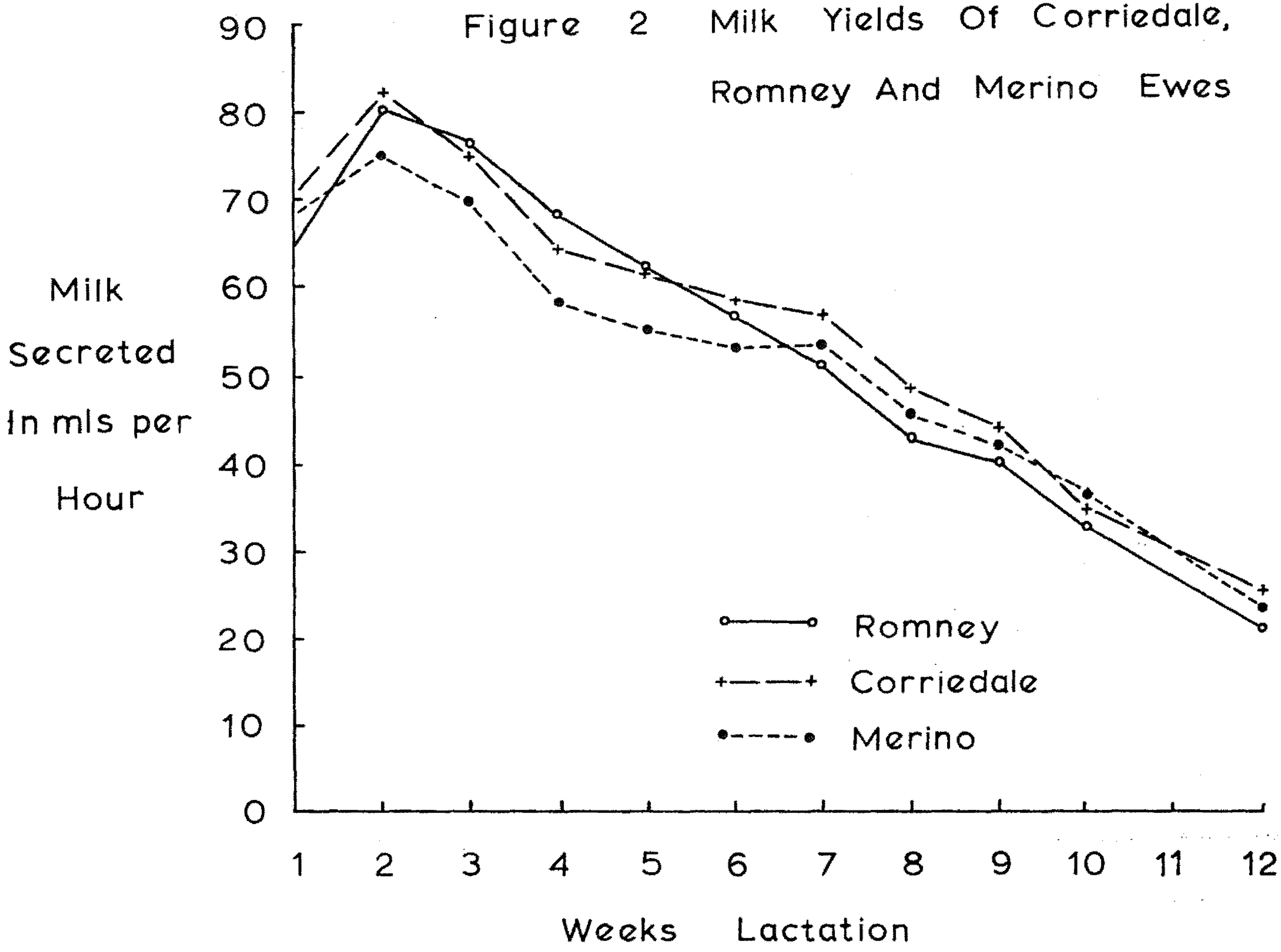
TABLE 6

Milk Production per hour (mls)

(c) MERINO

Ewe No.	Weeks Lactation 1	2	3	4	5	6	7	8	9	10	11	12
42	80.0	85.0	70.0	66.2	60.0	56.0	55.0	56.2	43.7	46.2	-	26.2
144	69.0	85.0	90.0	65.0	65.5	57.5	66.6	52.5	45.0	35.0	-	22.5
148	60.0	90.0	96.2	67.5	63.0	63.7	60.7	52.5	45.0	40.0	-	22.5
218	58.7	80.0	73.7	60.0	55.0	57.5	50.0	48.7	45.0	42.5	-	31.2
39	70.0	70.0	57.5	48.7	48.7	57.5	57.5	46.2	46.2	40.0	-	28.7
192	57.5	60.0	57.5	52.2	51.2	51.2	55.0	40.0	43.7	33.0	-	23.7
145	58.7	58.7	57.5	50.0	48.0	45.0	40.0	33.7	30.0	25.0	-	13.7
869	90.0	68.7	62.5	67.5	60.0	56.2	48.7	41.2	40.0	33.7	-	25.0
316	63.2	82.0	63.2	48.2	46.0	37.5	48.7	40.0	31.2	27.5	-	18.0
Mean	67.3	75.4	69.7	58.3	55.2	53.5	53.5	45.6	41.0	35.8	-	23.5

Figure 2 Milk Yields Of Corriedale, Romney And Merino Ewes



the milk and multiplying this by the volume, the result being divided by 454 (grams in 1lb).

TABLE 7 - ANALYSIS OF VARIANCE

Milk production averaged over 12 weeks

Due to	d.f.	S.S.	M.S.	F.
Treatment	2	85.52	42.76	0.67 N.S.
Error	29	1832.33	63.18	
Total	31	1917.85		

The lactation curves, as can be seen in figure 2, follow those of the dairy cow as reported by workers in the literature. The curves are characterised by a rise to a peak on the second week and falling thereafter at a constant rate until the twelfth week. Although there were little shape differences between breeds, the Merinos experienced a lower peak and a slower rate of decline towards the end of lactation than the Romneys. In the second half of lactation the Romneys appeared to be falling in production faster, which is probably associated with the fact that during the summer the Romney would not be able to cope with the sparce and dried off vegetation as well as the Merinos.

The peak reached by the three breeds represents approximately 4.41b of milk per day which is comparable to yields obtained by Hart (1961) and Coop and Drew (1963) while at 12 weeks the yields have fallen down to about 1.51b/day. Obviously after 12 weeks the milk available to the lamb is small. This latter production which, expressed as a secretion rate is about 20-25ml./hour, represents the ebb of secretion and hence presents the question of time of weaning, since weaning dates for Merinos have been as late as 16 weeks in this environment. Weaning trials (unpublished data) have indicated that Merino lambs can be satisfactorily weaned between 8-12 weeks of age, which ties in well with milk secretion and its relationship to lamb growth as indicated later in these results.

In general the method of milk measurement was extremely successful and proved a reliable and quick operation. Up to 12 ewes per hour could be milked by one operator and the completeness of milk withdrawal was indicated by the relatively insignificant amounts of milk obtained after a test dose with 5iu. of oxytocin. Test doses seldom gave more than 10% of the volume obtained in the preceding milking.

3. DIURNAL MILK PRODUCTION

Milk production varied little throughout the day as indicated in table 8 which is an average of three separate determinations each taken one week apart.

TABLE 8 - DIURNAL MILK PRODUCTION

	6p.m.	10p.m.	2a.m.	6a.m.	10a.m.	2p.m.	
Milk (ml/hr)	63.3	64.7	64.4	61.6	61.2	61.3	N.S.
Fat %	7.35	7.87	7.35	8.20	7.77	7.92	N.S.

The 3.5 ml/hr difference in yields between 10a.m. and 10p.m. is small and non significant, which indicates that secretion is a continuous process, as has been found with the dairy cow. Values for the four six hour periods have been plotted in figure 3 to give the daily secretion rate. A peak was reached at about 10p.m. but dropped to its lowest level at about midday. It is possible that the peak may have been influenced by the time of day when the study began, so in each of the three determinations, the time was altered to eliminate any bias incurred by this factor. In each determination the yields were lower at the end

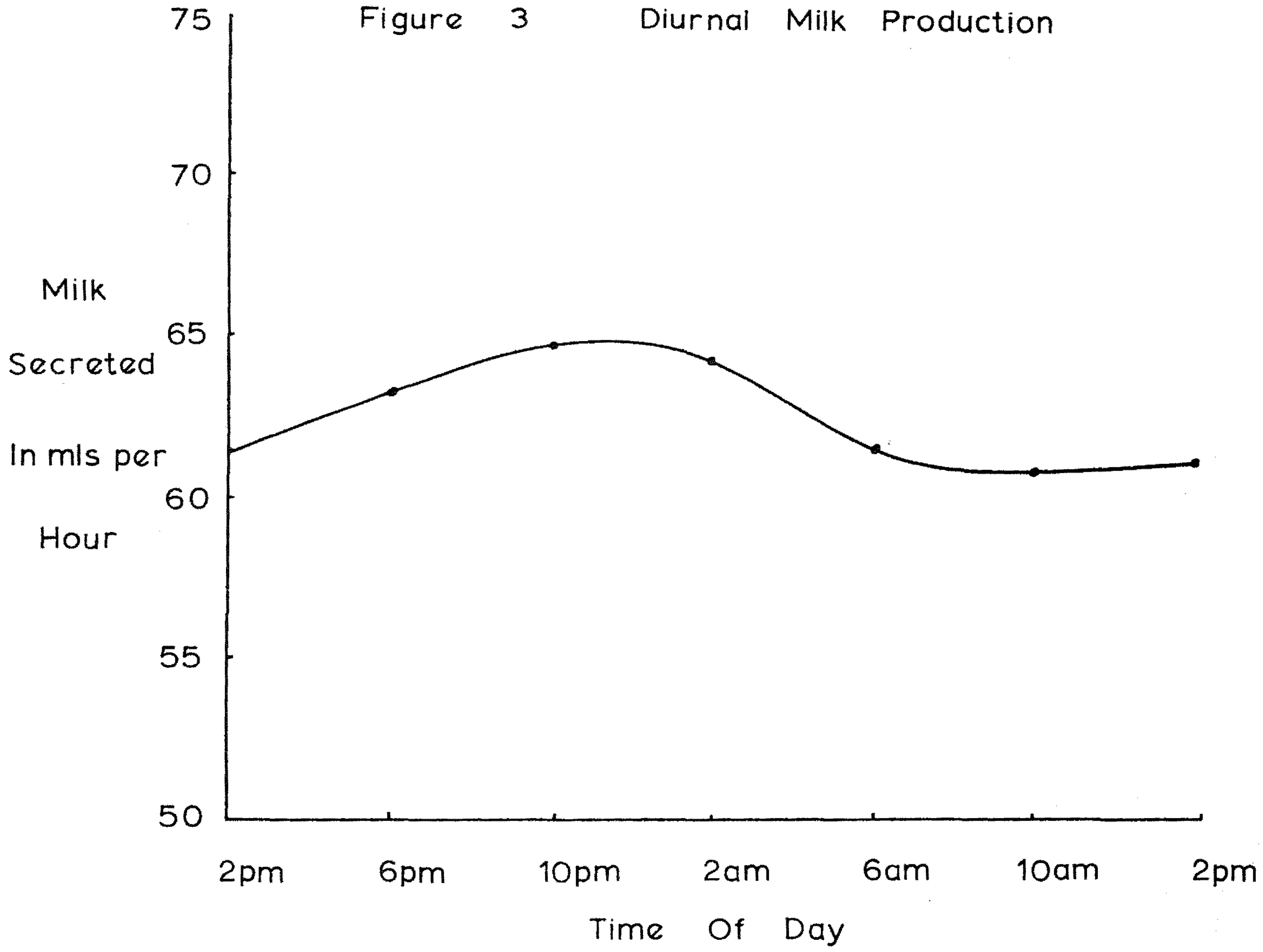


Figure 3 Diurnal Milk Production

of the measurement period this probably being associated with the strain on the ewe over the 24 hours.

In spite of this, there is still a slightly higher production at night compared with the morning. Whether this is due to the diurnal grazing habits is not known, although it was observed that the ewes did in fact graze throughout the 24 hour period, which was more intense during the daytime however. It is possible that the higher night production is a reflection on the latent period of milk synthesis arising from the higher grazing activity during the day.

Fat percentages, measured in replicate for each of the 4 hour periods did not follow any significant diurnal trend. The values are tabulated in table 8 which is an average of the three determinations used to study the diurnal yield. Individual daily milk yields are given in table 2 of the appendix.

4. LAMB GROWTH

(a) Birth Weights

Lamb weights for each of the three breeds are presented in table 9.

TABLE 9 - LAMB LIVE WEIGHTS (lbs)

	Birth Weight	6 Weeks	12 Weeks
Romney	10.1a	38.3aA	59.9aAB
Corriedale	9.9a	38.5aA	62.6aA
Merino	9.9a	32.7bB	54.5bB
C.V.	17.6%	9.6%	8.3%

There were no significant differences in the birth weights between breeds although the intrabreed differences were quite high. It would be reasonable to expect the birth weight of a Corriedale and Romney lamb to be heavier than a Merino lamb, all factors being held equal. However in this trial the percentage of twins, with their associated lower birth weights were greater in the Corriedales and Romneys, consequently their mean birth weights relative to that of the Merino would probably have been depressed. Another explanation as to the similar birth weight between breeds is the possibility that the Merino ewes may have come through the winter in a better condition with subsequent higher birth weights. This possibility is supported by the fact that the Merinos gained about 6lb between June and October whereas the Romneys and Corriedales lost 3lb and 5lb respectively.

TABLE 10 - ANALYSIS OF VARIANCE

Lamb birth weights

Due to	d.f.	S.S.	M.S.	F.
Treat	2	0.20	0.10	0.32 N.S.
Error	29	89.71	3.09	
Total	31	89.91		

(b) Lamb Weights

Significant differences were apparent at the 1% level between the Corriedales and Merinos at both the 6 week and 12 week weights, as indicated in table 9. Although differences, significant of the 1% level were observed between Romneys and Merinos at 6 weeks, they were only significant at the 5% level by 12 weeks of age. The differences between the Corriedales and Romneys were not significant at any stage.

TABLE 11 - ANALYSIS OF VARIANCE

Lamb weights at six weeks

Due to	d.f.	S.S.	M.S.	F.
Treat	2	209.86	104.93	8.33 **
Error	29	365.52	12.60	
Total	31	575.28		

TABLE 12 - ANALYSIS OF VARIANCE

Lamb weights at twelve weeks

Due to	d.f.	S.S.	M.S.	F.
Treat	2	333.77	166.88	6.91 **
Error	29	700.11	24.14	
Total	31	1033.88		

** Highly significant

The weights attained by all breeds at 12 weeks were good considering the environment in which they were being run and compared favourably with other lambs on the station at the time of this trial. Individual lamb weights for the 12 week period are presented in table 13, and the values are plotted in figure 4 to give growth curves for each of the three breeds.

(c) Lamb Gains

The weight changes, which have been analysed, are set out in table 14 which gives the weight gains for the three breeds.

TABLE 14 - LAMB GAINS (in lbs L.W.)

	First 6 Weeks	Second 6 Weeks	Whole 12 Weeks
Romney	28.2aA	21.6bB	49.8aA
Corriedale	28.6aA	24.1aA	52.7aA
Merino	22.8bB	21.8bAB	44.6bB
C.V.	9.6%	9.2%	7.7%

Over the whole 12 week period the Romneys and Corriedales grew significantly faster (at the 1% level) than the Merinos although the Romneys were not significantly different from the Corriedales.

TABLE 13

Lamb Live Weights (lbs)

(a) ROMNEY

Ewe No.	Birth	1	2	3	4	5	6	7	8	9	10	11	12
		Weeks from birth											
488	8.1	14.1	17.1	21.8	25.5	29.5	35.0	38.0	43.0	45.0	47.5	-	55.0
410	7.7	13.1	17.5	22.4	26.5	30.0	34.5	38.5	45.0	46.0	49.5	-	56.0
474	12.1	18.6	22.9	28.3	31.5	36.0	41.0	45.5	50.0	54.5	56.5	-	65.5
450	10.6	17.1	20.9	26.0	29.5	33.0	37.5	40.5	45.0	46.5	49.0	-	55.5
808	12.6	20.3	26.5	30.8	35.5	39.5	45.0	51.0	54.5	59.0	63.5	-	72.0
234	9.1	15.2	20.7	26.0	29.5	33.5	36.5	41.5	45.0	47.5	52.0	-	59.0
227	10.4	16.1	21.1	25.3	29.5	34.5	38.5	43.0	46.5	50.5	53.5	-	62.5
233	10.4	15.9	22.4	28.2	31.5	38.5	43.0	48.0	51.0	55.0	58.0	-	65.0
981	8.6	13.4	21.1	27.2	30.5	34.0	40.0	43.5	48.5	50.5	53.5	-	59.5
965	10.0	14.2	19.6	25.6	28.5	33.0	37.0	41.0	44.0	48.5	51.0	-	57.5
988	9.7	14.6	18.7	23.4	26.5	29.0	34.0	37.0	41.5	43.5	47.0	-	53.5
967	11.8	16.6	21.8	26.9	29.0	32.5	37.5	40.0	45.0	47.5	51.5	-	57.5
Mean	10.09	15.76	20.90	25.99	29.45	33.58	38.29	42.29	46.58	49.50	52.70	-	59.81

TABLE 13

Lamb Live Weights (lbs)

(b) CORRIEDALE

Ewe No.	Birth	Weeks from birth 1	2	3	4	5	6	7	8	9	10	11	12
412	7.2	12.1	16.4	21.0	24.5	28.0	33.0	36.0	41.0	43.0	46.0	-	54.0
475	10.9	14.7	18.9	24.6	28.5	33.5	40.0	44.0	50.0	53.5	57.0	-	68.0
498	11.4	17.6	21.1	25.8	29.0	32.5	38.0	41.5	48.0	50.0	54.0	-	64.5
430	12.6	17.6	22.0	28.0	31.5	35.5	41.0	45.0	50.0	54.0	57.0	-	65.5
984	7.2	12.3	16.3	21.2	24.5	28.5	33.5	37.5	42.0	44.5	48.0	-	56.0
868	13.0	14.6	20.2	26.3	30.5	35.5	41.5	45.0	50.0	53.5	59.0	-	66.0
976	9.9	14.6	20.0	25.7	29.5	34.0	39.0	43.0	47.5	51.5	55.0	-	62.5
969	11.5	14.5	20.2	26.6	31.0	34.0	41.5	46.0	50.5	53.5	58.5	-	65.0
228	7.7	14.4	19.5	24.8	29.0	34.0	38.0	42.5	45.0	50.5	54.0	-	63.5
232	9.3	16.1	20.2	23.8	27.5	31.5	35.5	40.0	44.0	47.0	49.0	-	57.5
231	8.5	15.4	21.5	27.0	32.0	38.0	43.0	47.0	50.5	54.0	58.0	-	66.5
Mean	9.92	14.90	19.66	24.98	28.86	33.18	38.54	42.50	47.13	50.45	54.13	-	62.63

TABLE 13

Lamb Live Weights (lbs)

(c) MERINO

Ewe No.	Birth	Weeks from birth 1	2	3	4	5	6	7	8	9	10	11	12
441	12.7	16.2	20.1	25.6	29.0	33.5	39.0	43.0	48.0	50.0	53.0	-	62.0
491	9.5	13.1	16.6	20.9	24.5	28.0	33.5	37.0	41.0	44.0	46.0	-	55.0
476	11.1	13.6	17.7	22.8	26.5	31.0	37.0	40.0	45.0	47.0	49.5	-	57.5
983	8.8	10.3	14.8	19.3	21.5	25.5	30.0	33.5	37.0	39.5	44.0	-	51.0
829	8.2	9.2	12.7	16.8	19.0	22.5	27.0	30.5	34.5	37.0	41.0	-	48.5
976	9.4	10.6	14.9	19.3	22.0	25.0	30.0	33.5	38.0	39.5	43.5	-	51.0
867	11.2	13.6	19.2	22.8	26.0	30.5	35.0	39.0	44.0	46.0	51.0	-	59.0
266	8.2	11.2	14.5	17.5	18.5	25.5	29.0	33.0	36.5	40.0	43.5	-	51.0
229	10.3	13.5	18.3	22.4	25.5	30.5	34.0	38.0	41.0	45.5	48.5	-	55.5
Mean	9.93	12.37	16.53	20.82	23.61	28.00	32.72	36.38	40.55	43.16	46.66	-	54.50

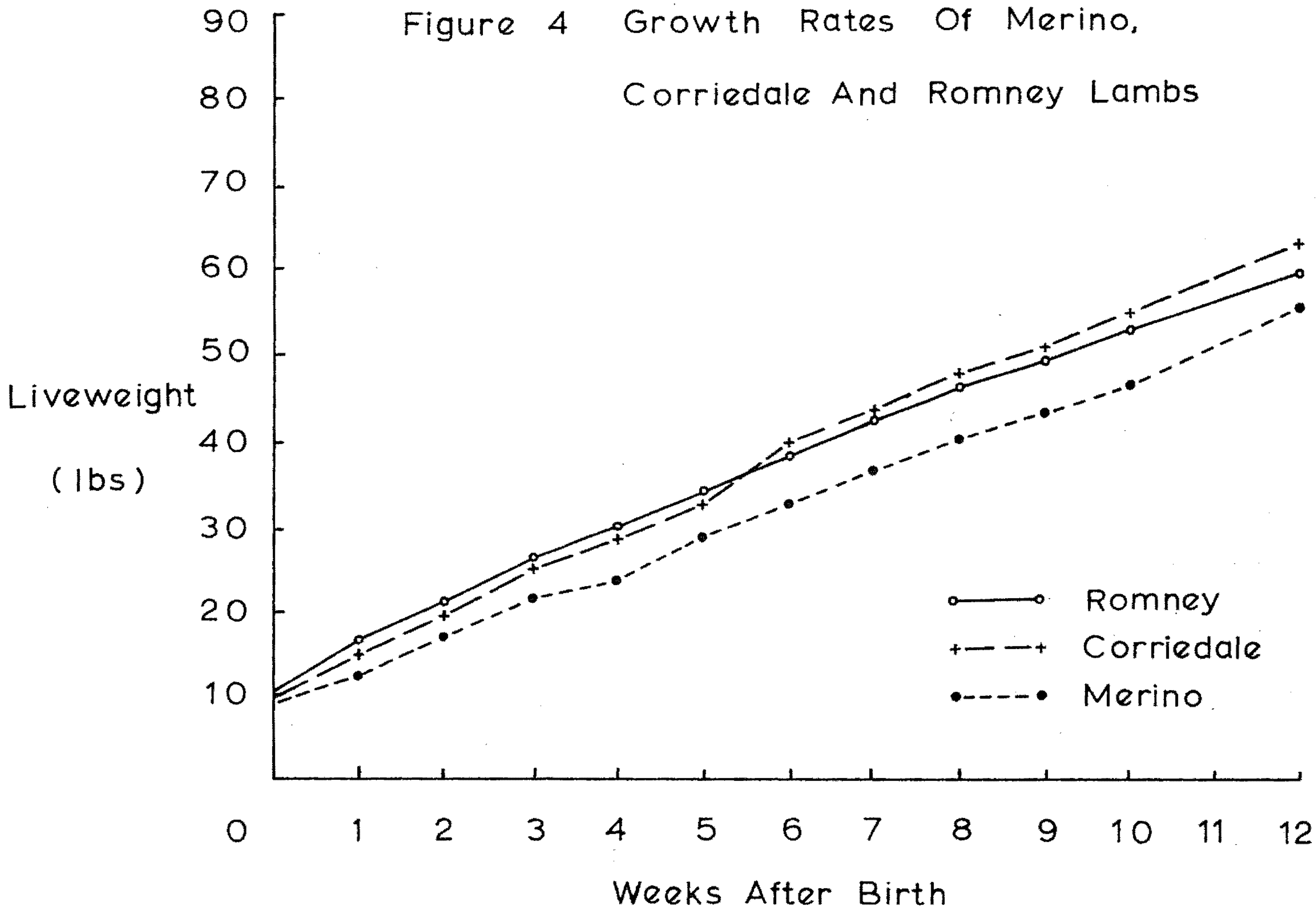


Figure 4 Growth Rates Of Merino, Corriedale And Romney Lambs

TABLE 15 - ANALYSIS OF VARIANCE

Lamb gains for the twelve week period

Due to	d.f.	S.S.	M.S.	F.
Treat	2	2.93	1.46	12.2 **
Error	29	3.50	0.12	
Total	31	6.43		

** Highly significant

In the first 6 weeks, the rate of gain was in the same order as over the whole 12 week period, in that there were no significant differences between the Romneys or Corriedales, although the slower growth rates of the Merinos were highly significant.

TABLE 16 - ANALYSIS OF VARIANCE

Lamb gains for the first six weeks

Due to	d.f.	S.S.	M.S.	F.
Treat	2	5.57	2.78	15.03 **
Error	29	5.36	0.185	
Total	31	10.93		

** Highly significant

In the second half of the trial the growth rate of the Romneys fell off to the level of the Merinos which is indicated by their non-significant differences. The superiority of the Corriedale growth rates over the Romneys was highly significant during this period, but was only significant at the 5% level over the Merinos.

TABLE 17 - ANALYSIS OF VARIANCE

Lamb gains for the second six weeks

Due to	d.f.	S.S.	M.S.	F.
Treat	2	1.77	0.88	5.18 *
Error	29	4.90	0.17	
Total	31	6.67		

* Significant

Individual weekly weight gains for each breed are given in table 1 of the appendix. Expressed on a daily basis for a twelve week period, the Corriedale growth rates were 0.621b/day, Romneys 0.591b/day and Merinos 0.531b/day. The Romney and Corriedale gains compare favourably with gains made on the lowland where more superior pastures are in use. It must be realized however, that this was an extremely favourable season, which would help explain why gains were better than those made in other years.

5. LAMB GROWTH - MILK YIELD RELATIONSHIPS

The correlation coefficients between lamb growth and milk production for each breed have been calculated for the first and second half of lactation and over the whole twelve week period. Values are presented in table 18.

TABLE 18 - LAMB GROWTH - MILK YIELD RELATIONSHIPS

Weeks	0 - 6	6 - 12	0 - 12
Romney	0.76 **	0.71 **	0.73 **
Corriedale	0.69 **	0.32 N.S.	0.50 N.S.
Merino	0.78 **	-0.043 N.S.	0.37 N.S.
Average	0.74 **	0.33 *	0.53 **

** Highly significant
* Significant

As can be seen there is a high correlation between milk production and lamb growth in the first six weeks, the relationship weakening with advancing lactation. The Corriedales provide the best example, which also conforms to that reported in the literature. The exceptionally low value of the Merinos in the second 6 weeks, (slightly negative) could indicate how the Merino lamb quickly adapts itself to grazing, a quality often necessary for its survival in the rigorous environmental conditions.

This may be compared to the Romney, where a relatively high value of 0.71 was obtained, which indicates the dependence of the lamb on the available milk supply, the Romney lamb being apparently less inclined to graze the native pasture at this early stage of life. However in the first 6 weeks, the interbreed milk/gain relationships are very similar and from the coefficient of determination it is estimated that from 47.0% to 60.0% of the lamb growth rate can be explained by the milk production, the lower and higher values being for the Corriedales and Merinos respectively. The overall breed values of 0.74, 0.33 and 0.53 for the first and second 6 week period and the whole 12 week period respectively are similar to those values reported in the literature and indicate the importance of milk to the growing lamb in the early part of its life. As the lamb replaces the milk diet with grass, the relationship breaks down, this being subjected to considerable breed effects as indicated in the values for the second 6 weeks.

Values of 'b' which gives the slope of the regression line, were obtained for the first and second six week periods. The values averaged over breeds were 0.032 and 0.028 respectively. The regression line of growth rate on milk yields is given by the formula $Y = 66.58 + 0.032 X$, where X = gain per week and Y = milk production (mls/hour). Obviously the slope is very low, being almost flat. The value of 0.032 means that for every extra millilitre/hour in milk production there is, on average, an extra 0.032lb in weight gain in the lamb per week. As individuals varied up to 35ml/hr on any given day, this could explain up to 0.16lb a day difference in growth rate.

6. EFFICIENCY OF LIVE WEIGHT GAIN

The efficiency of gain as indicated by the lbs of milk consumed per lb live weight gain was measured for a 0-6 and 0-12 week period. Values for all breeds are presented in table 18a.

TABLE 18a - EFFICIENCIES OF LIVE WEIGHT GAIN
(lbs of milk consumed per lb live weight gain)

Weeks	0 - 6	0 - 12
Romney	5.5	4.9
Corriedale	5.5	4.9
Merino	6.3	5.4

Obviously the lambs become more efficient as the milk diet is supplemented with grass, which is indicated by the higher efficiencies in the 0-12 week period. The 0-6 week period gives the most accurate index of efficiencies since there are no complications associated with the intake of grass. The Merinos are less efficient in both periods although to a greater extent in the 0-6 week period. It must be remembered however that these values refer to the milk produced, rather than what was consumed which would tend to give slightly lower efficiency values if we assume that the oxytocin technique results in higher yields than the lamb suckling technique. However Moore (1962) indicated that the difference is small, so the assumption that the production is comparable to the consumption appears justified.

The 5.4 value for the Merinos is comparable to Barnicoat (1957), Bonsma (1939) and Hart (1961) while the 4.9 value of the Corriedales and Romneys may be compared to Owen (1957) and Wallace (1961).

7. BIRTH WEIGHT/GROWTH RATE RELATIONSHIPS

The relationships between birthweight, growth rate and milk yields were analysed over the first 6 week period. The correlation coefficients for the three breeds are presented in table 19.

TABLE 19 - BIRTH WEIGHT - GROWTH RATE RELATIONSHIPS

	Birth weight/Growth rate	Birth weight/Yields
Romney	0.23	0.48
Corriedale	0.03	0.05
Merino	0.87 **	0.69 *

** Highly significant

* Significant

The highly significant correlation between birth weights and growth rates in the Merinos may be compared to the non significant relationships in the Romneys and Corriedales. It appears as though Merino lambs require a good start for maximum growth rates hence high birth weights would be of considerably advantage. This can be compared to the Romneys and Corriedales where the genetic potential for growth is good, which in this case is irrespective of birth weight.

The slope of the regression lines as given by 'b' are 0.068 for the Romneys, 0.067 for the Corriedales and 0.24 for the Merinos. This means that for Merinos, with every extra lb in birth weight there is an extra 0.24lb increase in weight gain per week or in terms of growth per day, 0.034lb. There is of course a physical limit to which birth weight may rise before problems are encountered at lambing time.

The relationship of birth weights and milk yields were also analysed there being a significant relationship in the Merinos, as indicated in table 19. Substantial correlations although not significant, were obtained in the Romneys while in the Corriedales there was no suggestion of any relationship. On further examination of the birth weight/growth rate relationships using partial correlations, it was found that the relationship was due to the higher milk yields associated with increasing birth weight. When the milk yield was kept constant then the birth weight growth rate relationship was non significant. This agrees with the literature as regards the influence of birth weight on subsequent yields and growth rates. When all breeds were treated as a whole a similar result was obtained.

Birth weights are to a large extent, a reflection on the level of nutrition during pregnancy. Hence the level of feeding during winter is of considerable importance in influencing subsequent milk yields, especially in the Merinos. However, although Wallace (1948) and Hammond (1957) stress the importance of good feed during pregnancy it is now considered that the nutrition during lactation plays the more important role (Coop 1950, Wallace 1960).

8. BIRTH WEIGHT/WEANING WEIGHT RELATIONSHIPS

As there was a strong relationship between birth weights and growth rates in the Merinos the influence of birth weights on the subsequent weaning weights was investigated. Correlation coefficients for the three breeds are presented in table 20.

TABLE 20 - CORRELATION COEFFICIENTS FOR BIRTH WEIGHT/WEANING WEIGHT RELATIONSHIPS

	"r" value	"b" value
Romney	0.61 *	2.31
Corriedale	0.65 *	1.51
Merino	0.96 **	2.83

** Highly significant
* Significant

A highly significant correlation was obtained in the Merinos and for every extra lb in birth weight there was an extra 2.83lb in weaning weight. Obviously birth weight has an important bearing on subsequent live weights and the value of "b" compared well with that reported in the literature (Thompson and McDonald 1955). It is surprising that the correlation coefficient of the Corriedales was as high as 0.65 when the corresponding birth weight/growth rate correlation was only 0.03. However the value of "b" is lower than the other two breeds although from the coefficient of determination up to 42.3% of the differences in weaning weight can be explained by birth weight. This may be compared to 92.2% in the Merinos. The regression equation is presented in figure 5 for the Merinos.

9. MILK YIELDS/WEANING WEIGHT RELATIONSHIPS

The milk yield/weaning weight relationship was examined in a similar manner to the birth weight/weaning weight relationship, but in this case the milk yields were analysed over a 12 week period. Correlation coefficients are indicated in table 21.

TABLE 21 - CORRELATION COEFFICIENTS FOR MILK YIELD/WEANING WEIGHT RELATIONSHIPS

	"r"	"b"
Romney	0.85 **	0.48
Corriedale	0.43 N.S.	0.25
Merino	0.72 *	0.51

** Highly significant
* Significant

Average values for weaning weights and milk yields of the three breeds are presented in table 22.

TABLE 22 - AVERAGE VALUES FOR WEANING WEIGHTS AND MILK YIELDS OVER A 12 WEEK PERIOD

	Romney	Corriedale	Merino
Milk (ml/hr)	54.30	56.78	52.70
Weaning Weight (lbs)	59.87	62.68	54.56

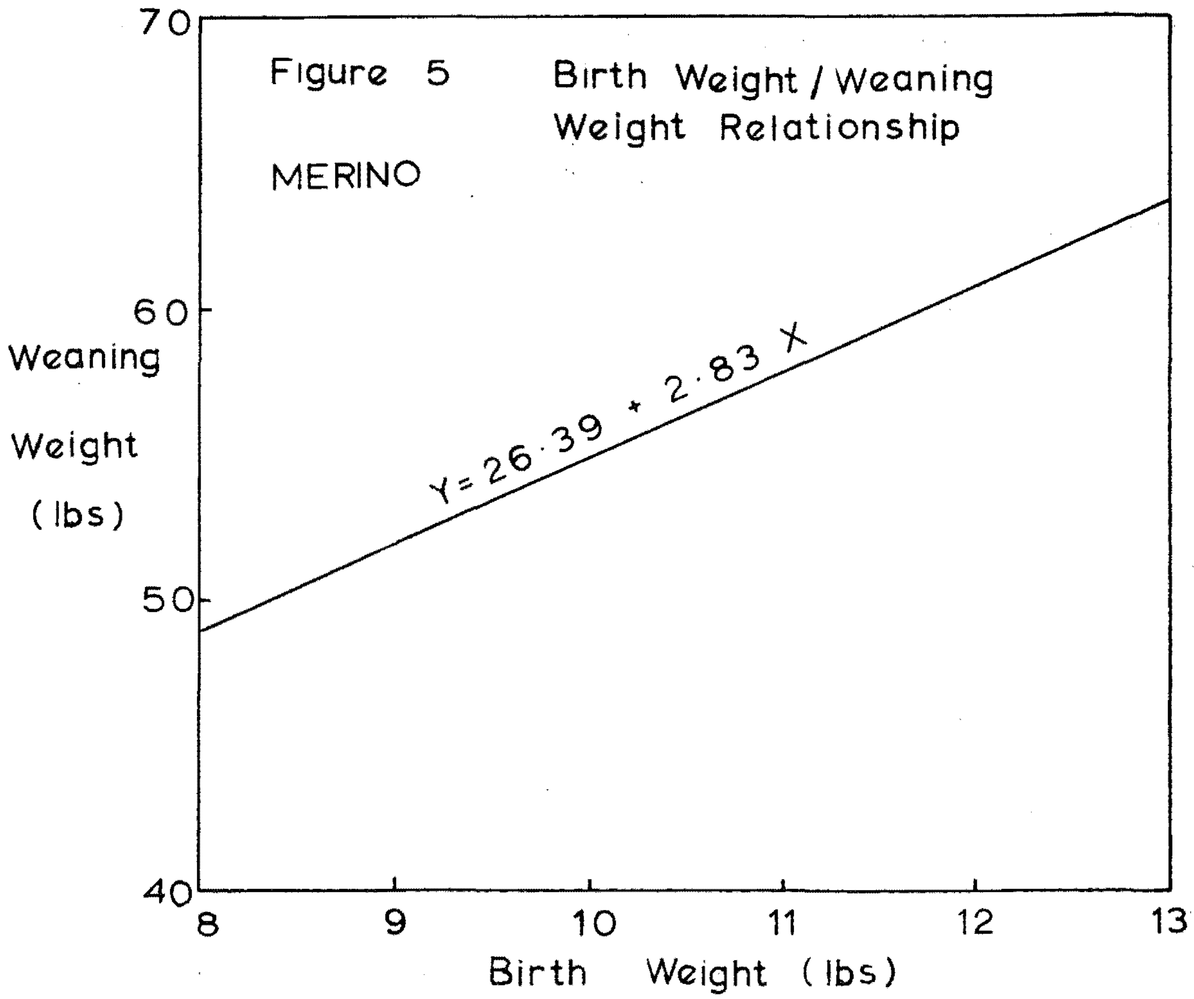


Figure 5
Birth Weight / Weaning Weight Relationship
MERINO
Y = 26·39 + 2·83 X
Weaning Weight (lbs)
Birth Weight (lbs)
70
60
50
40
8
9
10
11
12
13

In the Romneys there is a highly significant correlation between milk production and weaning weight which appears to be a reflection of the high milk yield/growth rate relationships over the 12 week period. The relationship in the Merinos was just under the 1% significance level, the value probably being depressed by the very low relationship between milk yield and growth rates in the second 6 week period. The relationship in the Corriedales has not reached significance and the slope of the regression line is lower than the other two breeds. The overall breed correlation coefficient of 0.66 which is significant at the 1% level, indicates the importance of milk in relation to the subsequent weight of the lamb, of which according to the coefficient of determination, 43.5% can be explained by milk production. The regression equation for the Romneys and Merinos are presented in figures 6 and 7 respectively.

10. EWE LIVE WEIGHTS

Average live weights from May 1964 to January 1965 are presented in table 23 together with the wool weights.

TABLE 23 - EWE LIVE WEIGHTS (lbs)

	1.5.64	18.5.64	25.6.64	2.10.64	6.1.65	Gain	Wool 2.10.64
Romney	138.7	144.5	145.2	142.6	122.5	-16.2	11.30*
Corriedale	126.3	130.9	131.1	126.2	119.8	- 6.5	11.05
Merino	96.4	107.9	109.8	115.5	108.1	+11.7	10.67

* 14 months wool

The Romneys and Corriedales were brought on to the station about 2-3 weeks before the first weights were taken so as to allow them to settle down to their new environment. The average weights over the whole trial were Romneys 139lbs, Corriedales 127lbs and Merinos 107lbs. Individual

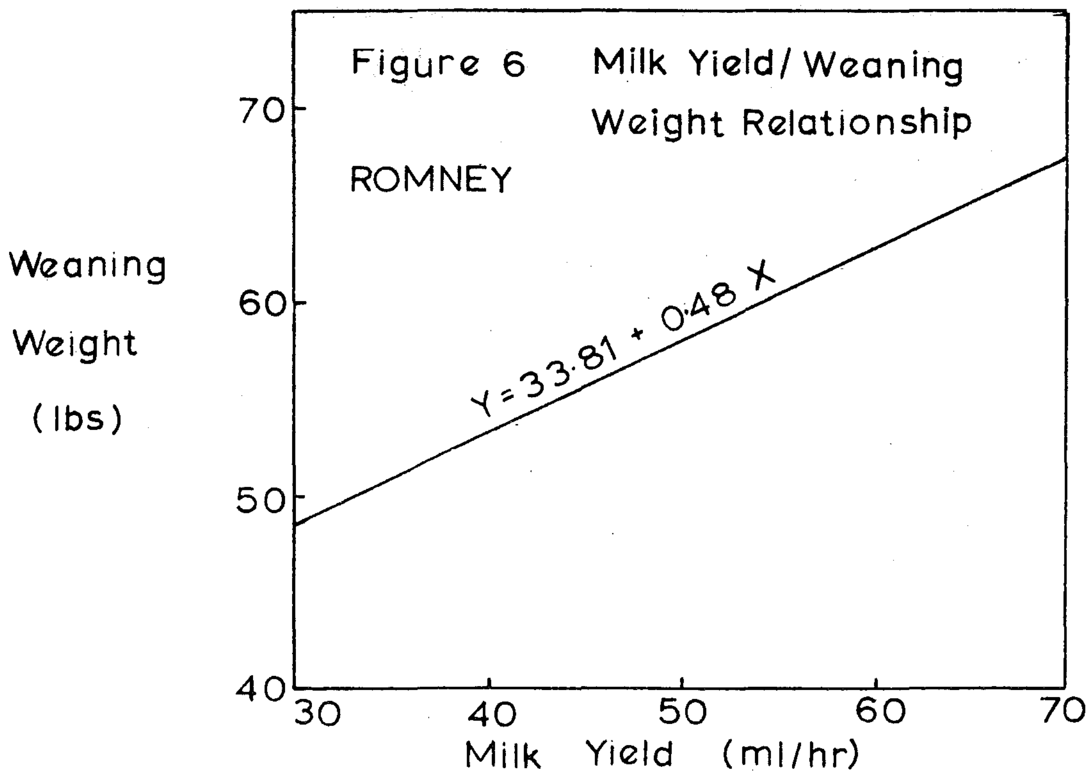


Figure 6 Milk Yield/ Weaning Weight Relationship
ROMNEY
Weaning Weight (lbs)
Y = 33.81 + 0.48 X
70
60
50
40
30
40
50
60
70
Milk Yield (ml/hr)

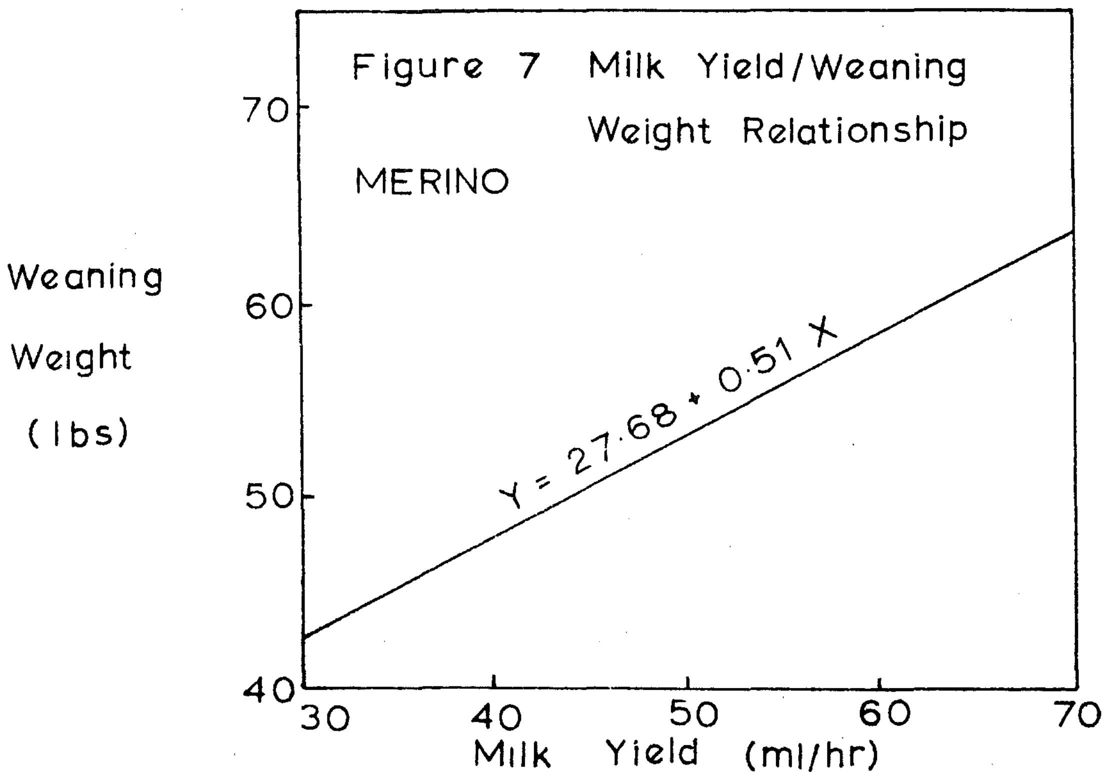


Figure 7 Milk Yield/Weaning Weight Relationship
MERINO
Weaning Weight (lbs)
Y = 27.68 + 0.51 X
70
60
50
40
30
40
50
60
70
Milk Yield (ml/hr)

weights are given in table 3 of the appendix. All ewes were flushed for 2 weeks prior to tupping on the 15.5.64. During this period the Merinos increased weight by 11.5lb, the Romneys and Corriedales 5.8lb and 4.6lb respectively.

During the winter the Romneys and Corriedales lost weight if the uterine contents are considered, while the Merinos were approaching maintenance. Over the eight months of the trial the Romneys lost 16.2lb, the major part of this drop being in the spring - summer period, associated with the dry conditions and stress of lactation, which can be compared with the gain of 11.7lb in the Merino over the same period. The wool weights of the Romney are lower than expected for 14 months growth which is indicative of the competition with milk secretion during the spring. However it must be remembered they were machine shorn before being transferred to Tara Hills, whereas in this trial they were blade shorn which could account for about 0.5lb of wool. The 108lb weight of the Merinos in January is comparatively good which is illustrated to some extent by the favourable wool production of 10.67lb.

11. EWE LIVE WEIGHT/MILK YIELD RELATIONSHIPS

The relationship between the live weight of the ewe and milk production was analysed between and within the breeds. The values are tabulated in table 24 which gives the relationship between the ewe weights at 2.10.64, just prior to lambing and the average milk production over the first 6 weeks.

TABLE 24 - EWE LIVE WEIGHT/MILK YIELD RELATIONSHIP

	Correlation Coefficient
Romney	0.31 N.S.
Corriedale	-0.27 N.S.
Merino	0.44 N.S.

There is no suggestion of any relationships within breeds, nor is there when breeds are disregarded. The slope of the regression line, averaged over the three breeds, as given by "b" was 0.089 which is fairly low.

12. COMPOSITION

(a) Total Solids

The average values for the total solids over a 10 week period are presented in table 25.

TABLE 25 - TOTAL SOLIDS %

Romney	18.6a
Corriedale	17.6a
Merino	17.8a
C.V.	6.2%

No significant differences were apparent between the breeds although the Romney was slightly higher, this being a reflection on the higher fat percentages. Individual values are tabulated in table 4 of the appendix.

TABLE 26 - ANALYSIS OF VARIANCE

	Total Solids			
Due to	d.f.	S.S.	M.S.	F.
Treat	2	6.04	3.02	2.40 N.S.
Error	29	36.45	1.26	
Total	31	42.49		

From figure 8 it may be seen that all three breeds dropped about 1.5% by the second week but maintained this constant level throughout lactation until the ninth week when the values rose, which was especially pronounced in the Merinos.

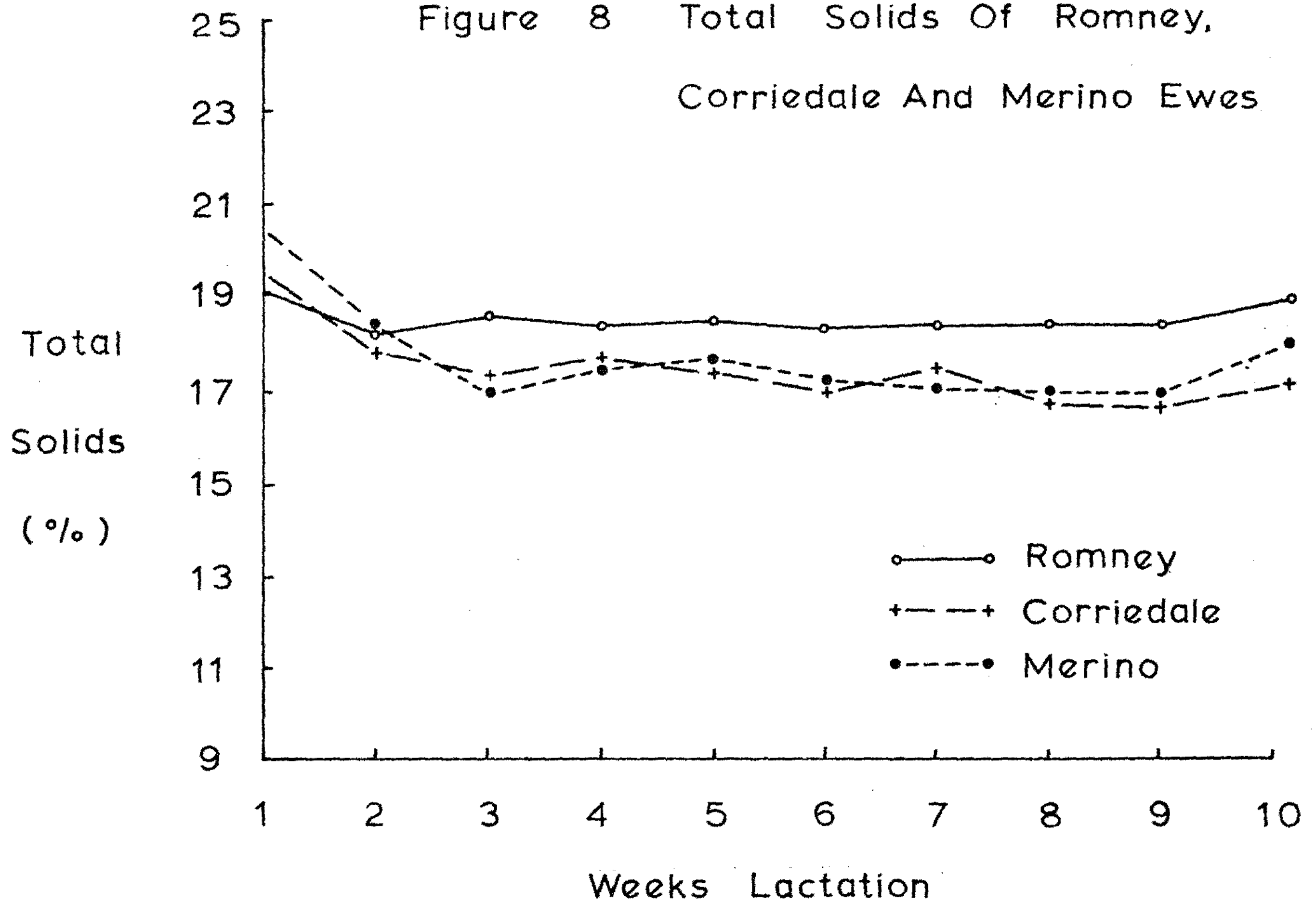


Figure 8 Total Solids Of Romney, Corriedale And Merino Ewes

(b) <u>Fat Percentages</u>

Measurement of the fat content in the milk were taken once a week from each ewe. The results were analysed for possible breed differences over the second six weeks and over the lactation period as a whole, as indicated in table 27.

TABLE 27 - FAT PERCENTAGES

	Second 6 Weeks %	Whole 12 Weeks %
Romney	9.2aA	8.6a
Corriedale	7.7bB	7.6a
Merino	7.8bAB	7.8a
C.V.	13.7%	13.4%

The coefficient of variance was relatively high in both periods. The second six weeks was the only period where significant interbreed differences were found. In this period the Romneys were significantly higher (1% level) than the Corriedales, but only at the 5% level with the Merinos. There were no significant differences between the Corriedales and Merinos.

TABLE 28 - ANALYSIS OF VARIANCE

Fat Percentages for the Second Six Week Period

Due to	d.f.	S.S.	M.S.	F.
Treat	2	15.76	7.88	6.11**
Error	29	37.33	1.29	
Total	31	53.09		

** Highly significant

TABLE 29 - ANALYSIS OF VARIANCE

Fat Percentages for the Twelve Week Period

Due to	d.f.	S.S.	M.S.	F.
Treat	2	6.16	3.08	2.66 N.S.
Error	29	33.72	1.16	
Total	31	39.88		

Individual values for fat percentages over the lactation period are given in table 30. From figure 9 trends in the fat percentages over the complete lactation are apparent. Fat levels are high immediately following parturition, this being associated with the colostrum but as this is replaced by normal milk the fat percentage decreases, the basal level being reached by the second week of lactation. The levels remained relatively constant until six weeks when all breeds gradually rose, the rise being faster in the Romneys. In the last two weeks the rise in all breeds was accelerated, associated with the drop in milk yields. The higher fat levels of the Merinos in the first week of lactation is due to the fact that the mean date of lambing was 3 days later than the Romneys. By the second week this difference had evened out and from then on the Romney took the lead but was not significantly higher than the other two breeds until the second half of the lactation period.

(c) Fat Percentage/Growth Rate Relationships

The correlation coefficients for the milk fat/growth rate relationships are detailed in table 31.

TABLE 31 - FAT PERCENTAGE/GROWTH RATE RELATIONSHIP

Romney	0.35 N.S.
Corriedale	- 0.53 N.S.
Merino	- 0.20 N.S.

There was no suggestion of any significant relationship between these two factors within breeds, nor when the breeds were disregarded (r =-0.15). The negative values obtained are contary to that reported in the literature and also in theory, however these values are non significant. It is probably that greater numbers of animals would be required for significance in view of the large coefficient of variance in the fat percentages.

TABLE 30

Fat Percentages

(a) ROMNEY

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10	11	12
176	7.35	6.15	5.75	6.85	6.50	7.05	8.55	10.10	8.90	9.70	-	12.00
189	8.20	7.05	6.40	6.20	6.00	6.00	6.05	5.95	6.90	7.10	-	8.40
191	6.25	6.35	7.65	6.40	6.40	6.40	7.25	6.80	7.85	8.95	-	8.75
194	11.00	9.30	9.15	8.85	8.95	10.35	9.90	10.45	11.20	8.75	-	12.50
177	10.70	8.50	7.75	8.45	7.00	7.65	10.00	9.25	8.50	9.25	-	9.62
181	10.65	7.60	8.05	8.20	9.15	8.95	8.95	9.10	9.35	9.90	-	10.15
182	7.35	6.50	5.15	5.85	7.85	7.35	6.35	8.60	8.00	8.85	-	10.10
193	8.20	7.10	6.95	7.10	7.80	7.25	7.30	7.60	8.15	8.15	-	10.30
179	10.35	8.75	12.00	9.55	10.60	8.90	9.40	10.00	9.70	9.50	-	11.00
183	7.70	7.30	8.20	7.90	8.35	8.25	8.40	8.50	10.90	8.75	-	10.65
186	6.95	7.75	12.20	11.10	11.40	10.30	11.00	10.20	10.50	10.85	-	12.00
190	8.45	8.10	11.50	8.05	8.45	7.80	8.30	8.05	9.25	11.60	-	10.45
Mean	8.59	7.53	8.39	7.87	8.20	8.02	8.45	8.71	9.10	9.28	-	10.49

TABLE 30

Fat Percentages

(b) CORRIEDALE

Ewe No.	1	2	3	4	5	6	7	8	9	10	11	12
	Weeks lactation											
501	12.00	8.30	7.45	7.95	8.30	6.60	8.05	8.25	8.45	8.30	-	10.70
551	9.00	6.65	6.60	6.40	7.20	6.20	5.50	5.10	6.05	6.60	-	6.90
572	6.30	7.05	7.70	6.60	6.80	6.60	9.15	7.60	7.00	6.60	-	7.75
571	6.00	6.00	5.90	6.15	5.50	5.55	6.75	6.15	6.20	6.85	-	7.85
573	8.90	7.60	6.85	8.50	8.90	8.35	8.80	7.20	7.65	8.10	-	9.65
514	8.40	8.20	8.00	7.55	7.25	7.85	8.40	8.80	8.25	8.40	-	10.55
700	13.00	8.45	6.55	7.30	7.55	7.25	7.55	8.20	8.05	7.55	-	8.95
542	7.10	6.45	6.10	6.75	6.95	7.40	6.50	7.05	7.25	6.70	-	8.70
687	8.15	7.10	6.70	7.05	5.95	4.90	5.60	6.10	6.05	5.35	-	8.00
506	9.90	7.70	9.40	9.00	8.50	8.25	7.70	7.95	8.45	8.10	-	10.10
568	10.60	8.50	10.60	8.40	8.80	7.75	7.90	8.10	8.60	8.25	-	8.10
Mean	8.85	7.45	7.44	7.33	7.42	6.97	7.44	7.31	7.45	7.34	-	8.84

TABLE 30

Fat Percentages

(a) MERINO

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10	11	12
42	8.60	7.40	8.80	8.80	8.55	8.55	8.40	8.55	8.55	10.05	-	10.15
144	7.60	6.85	6.40	5.60	5.20	5.85	6.00	5.55	6.10	5.85	-	6.75
148	10.90	9.05	7.95	7.45	7.90	8.85	7.35	7.70	9.10	9.70	-	10.55
218	8.80	7.65	6.45	5.90	6.50	5.90	6.35	6.25	6.65	7.15	-	8.30
39	11.90	6.35	4.80	5.40	4.75	5.15	5.05	5.75	5.80	5.75	-	7.05
192	11.90	7.30	6.75	7.60	6.80	7.75	8.00	7.80	7.65	7.75	-	10.10
145	11.50	8.45	6.65	7.50	8.00	6.70	6.45	7.10	7.00	7.50	-	10.15
869	12.05	7.70	7.35	9.10	8.60	8.00	8.50	8.75	8.55	8.10	-	10.50
316	9.25	7.50	7.70	7.80	11.80	6.95	7.80	7.40	8.50	11.25	-	8.95
Mean	10.27	7.58	7.23	7.61	7.56	7.07	7.10	7.20	7.54	8.12	-	9.16

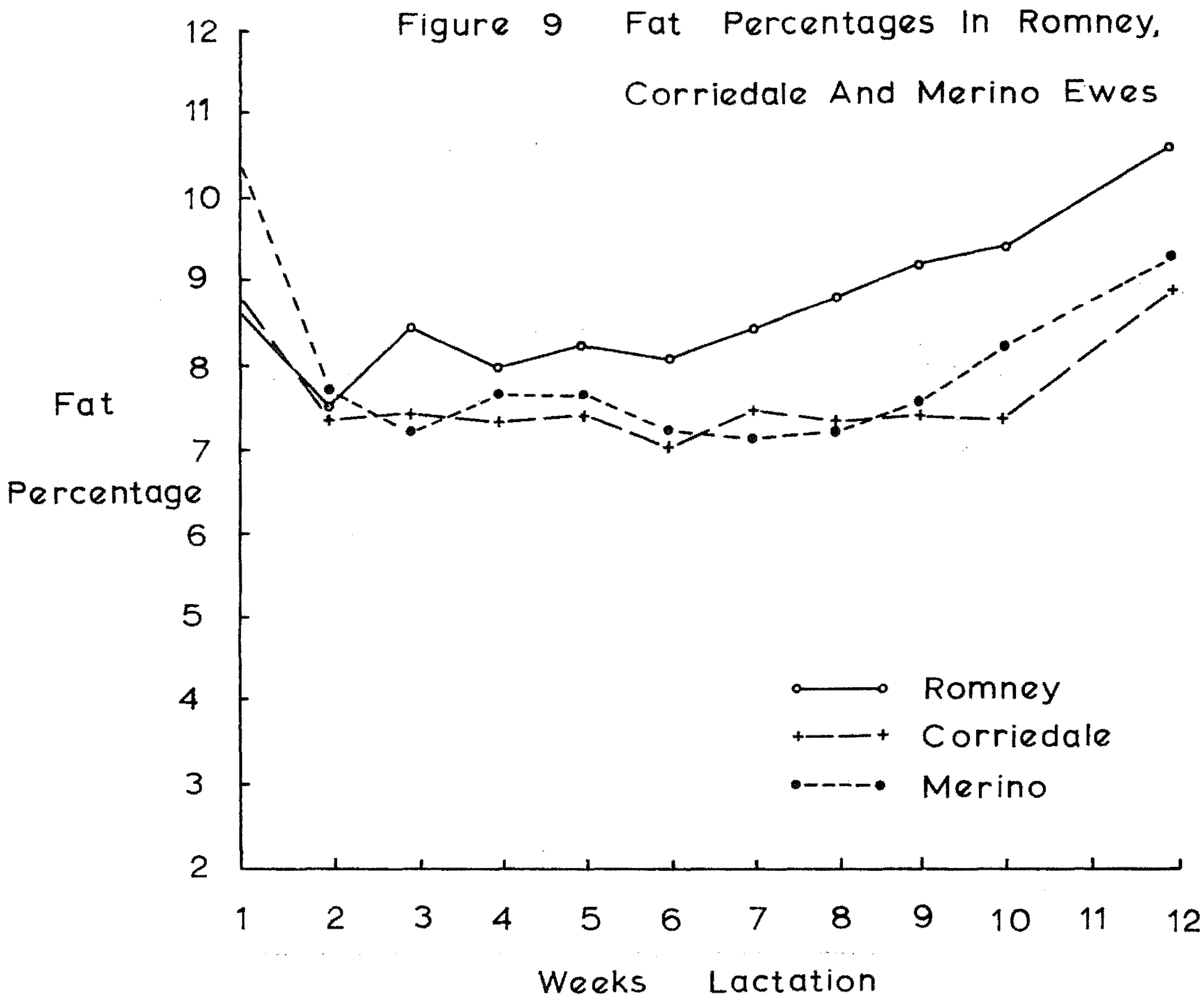


Figure 9 Fat Percentages In Romney, Corriedale And Merino Ewes

(d) Solids-Not-Fat

There were no significant interbreed differences in the solids-not-fat as indicated in table 32.

TABLE 32 - SOLIDS-NOT-FAT

	S.N.F. %	Specific Gravity
Romney	10.13a	1.0320
Corriedale	10.04a	1.0324
Merino	10.11a	1.0325

The solids-not-fat varied little throughout lactation, dropping by about 1% from the first to ninth week and rising sharply in the 10th week as seen in figure 10. Determinations of the S.N.F. values were unable to be made in the eleventh and twelfth week due to insufficient volumes of milk, which precluded the use of a lactometer. The solids-not-fat values for individual ewes are tabulated in table 5 of the appendix. Specific gravity values are presented in table 32.

(e) Protein Percentages

Samples were taken on the twelfth week of lactation and dried before analysing them for protein and ash contents. Relevant data for these results are tabulated in table 33.

TABLE 33 - COMPOSITION VALUES IN THE TWELFTH WEEK OF LACTATION

	Wt. of Milk %	Total Solids %	Fat %	S.N.F. %	Protein %	Ash %	Lactose %*
Romneys	10gm.	22.9	10.49	12.41	9.02	0.85	2.54
Corriedales	10gm.	21.0	8.84	12.16	8.88	0.83	2.45
Merinos	10gm.	21.3	9.16	12.14	9.28	0.84	2.02

* Calculated by difference

There were no significant differences in either the protein or ash

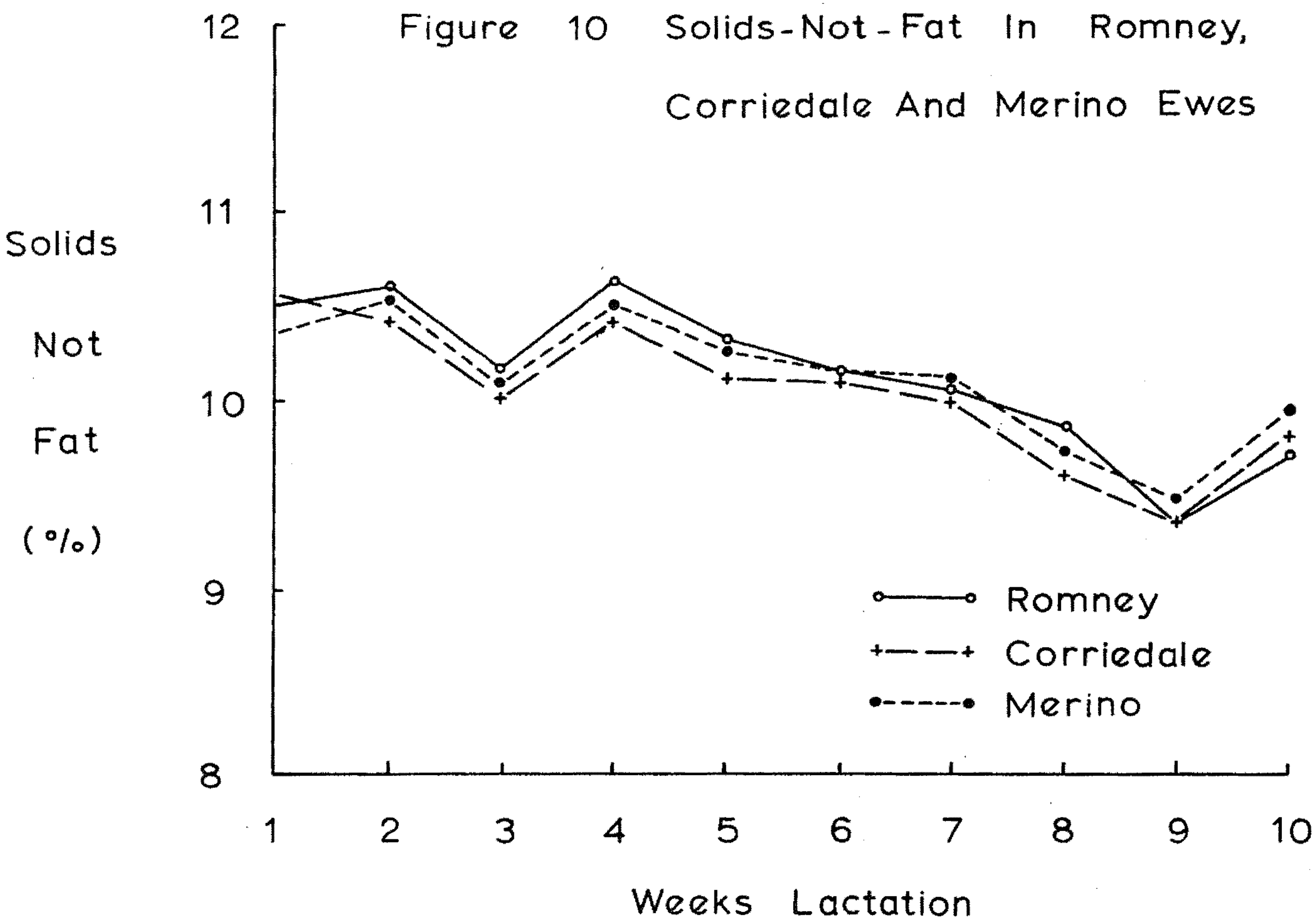


Figure 10 Solids-Not-Fat In Romney, Corriedale And Merino Ewes

percentages. The protein percentages are unusually high although all materials and calculations were checked. It has been reported by Maynard (1962) and Hammond (1957) that towards the end of lactation the S.N.F. values rise, this rise being mainly due to the protein fraction associated with a slight drop in the lactose levels. Similarly Dahlberg of the Cornell University (p. 468 Maynard and Loosli 1962) have shown that as the percentage of fat rises, the percentage of other constituents change. This is characterised by a rise in protein, ash, total solids and energy but a drop in the lactose levels. This could possibly help explain the rather high level of protein found in these samples. As can be seen from table 34 the individual variation in the protein percentage was not large.

The ash percentages were similar to that reported in the literature although are slightly low in view of the fact that the sample was taken towards the end of lactation. There were no significant differences between breeds. Individual values for both protein and ash percentages are presented in table 34.

13. MISCELLANEOUS

(a) Health

The health of all ewes in the trial was good except for some minor footrot infection in the Romneys at the beginning of the trial. After treatment with formalin this was soon cleared up. As the country in which the sheep were run is marginally difficient in selenium, the ewes were dosed with 5mg. of Selenium two weeks before tupping and lambing. However no incidence of white muscle disease occurred. The death of one Merino lamb at the age of four weeks due to pulpy kidney came as a considerable surprise in view of the native tussock being grazed. The rest of the lambs were immediately injected with pulpy kidney vaccine.

(b) Weaning

All lambs were weaned at 12 weeks of age and both the ewes and lambs detagged which marked the conclusion of the trial. Although no subsequent weights were taken it was apparent that the lambs suffered no ill effects from weaning at this time, and appeared to make good progress.

TABLE 34 - INDIVIDUAL PROTEIN AND ASH CONTENTS OF THE MILK EXPRESSED IN PERCENTAGES

	Ewe No.	Protein %	Ash %
ROMNEY	186	7.1	0.75
	190	8.7	0.91
	179	8.6	0.90
	183	10.2	0.71
	177	10.5	0.97
	181	8.6	0.79
	182	9.2	0.84
	193	9.1	0.99
	Mean	9.02	0.85
CORRIEDALE	506	8.5	0.82
	568	9.6	0.86
	572	8.2	1.01
	514	9.2	0.81
	700	9.3	0.74
	542	8.7	0.79
	687	8.4	0.83
	Mean	8.88	0.83
MERINO	316	9.2	0.88
	42	10.4	0.79
	39	9.7	0.95
	192	8.8	0.82
	145	9.3	0.81
	869	8.0	0.81
	Mean	9.28	0.84

V

DISCUSSION

1. SYNCHRONISATION OF MATING

To date there are no reports in the literature of milk yield comparisons where the lambing date has been precisely controlled by the use of a hormone treatment to synchronise mating. It is possible although improbable that this technique may in some way influence subsequent milk yields, although to what extent, if any, would be difficult to determine.

The three day difference in gestation lengths between the Romneys and Merinos is probably a reflection on the breed, since various studies throughout the world indicate that mutton breeds tend to have gestation lengths about 4 days shorter than fine wooled breeds (Rice et al. 1957). An example of this is given by Terrill et al. (1947) who indicated gestation lengths of 151.4 days for fine wooled breeds and 148.4 days for mutton breeds. These differences approach that of the Merino, (149 days) and Romneys, (146 days) in this trial, with the Corriedales, (147 days) inbetween.

The relative success of the synchronising treatment is readily seen by the high numbers of ewes synchronised within 4 days (Romneys, 100%; Corriedales and Merinos, 80% respectively). There is little information on synchronisation trials using Romneys apart from Lambourne (1955), although this was confined to the late anoestrus period. However it is obvious that the 100% value of the Romneys synchronised, reflects the complete success of the treatment. The 80% values of the Corriedales and Merinos agree well with results reported by O'Mary, Pope and Casida (1950), Robinson (1956) and are better than those reported by Hunter (1954), Denny and Hunter (1958) and Robinson (1958).

The number of ewes lambing within 6 days, (Romneys 83%, Corriedales 55%, Merinos 40%) are in the main, a reflection on the success of the synchronisation and subsequent fertility at mating.

(a) Factors Influencing Synchronisation

Whereas most authors have experienced a spread of oestrus from 48-96 hours, the spread in this trial was from 24-96 hours with a peak in the 72 hour period. This early commencement of oestrus is unusual since the progesterone effects are maintained for at least 48 hours before blood levels decline. It is possible that the time of ram addition may influence the onset of oestrus cycles in the treated ewe, since Lamond (1962d) observed that addition of rams on the day before the final injection caused ewes to come on oestrus the following day. In this trial the rams were added on the day of the final injections which may explain the relatively sudden onset of oestrus in all breeds.

It has been suggested by Robinson (1951) that different breeds could have different thresholds of circulation progesterone which introduces the breed concept as regards synchronisation. It is conceivable that the Merinos may require more progesterone than the Romneys for synchronisation, since five Merino ewes experienced oestrus during treatment. However the literature is fairly variable in that various workers have quoted from 0-25% of the ewes displaying oestrus during treatment. The stage of the cycle, (Lamond, 1964) is important in that if injections commence late in the cycle, it is likely that some animals will show oestrus and/or ovulate during treatment. However there was no way of determining the stage of the cycle when treatment began in this experiment.

(b) Fertility Following Synchronisation

Eighty three percent of the synchronised Romneys lambed within a 6 day period, which clearly indicates that fertility was not adversely affected by the treatment, which conforms with Dutt and Casida (1948) and O'Mary, Pope and Casida (1950). The value of 55% for the Corriedales is satisfactory but still leaves room for improvement.

Whereas the majority of the Romneys held to service, almost half of the Merinos failed to conceive. Most of the literature referring to Merinos reports from 50-60% of the synchronised ewes lambing which may be compared with 40% in this trial. However although this value is low relative to the majority of investigators, there are some cases where the fertility has been even poorer, (Robinson, 1958, 1961; Davies and Dun, 1957; Lishman and Hunter, 1961).

The causes of low fertility in ewes where oestrus has been synchronised are not fully elucidated. In this discussion it is only possible to suggest causes as to the poor Merino fertility as none of the explanations can be proven without further experimentation. Braden et al. (1960) and Robinson (1961) reported that a high proportion of ova in the synchronised ewe were fertilised, so it seems more likely that the failure would be due to an abnormal rate of passage of the fertilised ovum down the fallopian tubule, since Edgar and Asdell (1960) have indicated that injections of progesterone can influence the transport of ova.

The early onset of oestrus as discussed earlier, raises the possibility of an oestrus - ovulation imbalance in view of the fact that ovulation usually occurs 72 hours after withdrawal (Lamond, 1964). Consequently a ewe served 30 hours after progesterone cessation would not ovulate for another 42 hours, hence the chances of fertilisation would be small. However this would not appear to make any major contribution to the poor fertility of the Merinos in this trial, as there were only 15% tupped within the first 24-30 hours after progesterone withdrawal.

The time of day of the final injection of progesterone can influence the mean interval between treatment and the onset of oestrus and hence fertility, according to Lamond and Bindon (1962), but for the reason given above this is unlikely to be a major factor. Although the ewes were tupped late in the breeding season it is doubtful whether this would have any adverse effect on fertility since Lamond and Bindon (1962) have shown that towards the end of the breeding season, less progesterone is required for the suppression of oestrus.

As the ewes were mated on lucerne, the question arises as to the effect of lucerne on fertility since Coop and Clark (1960) indicated reductions of up to 12% in Corriedale lambing percentages. The overall lambing percentages of 140 for the Corriedales and 133 for the Romneys suggest little, if any depression, but the 91% of the Merinos, considering the 15% twinning rate, indicates barrenness as high as 20%. However it is questionable whether the lucerne was responsible for the failure of the Merinos to hold to service, since Coop and Clark (1960) indicate that the problem is associated with a low ovulation rate, rather than of a barrenness nature. It would seem that if lucerne was to depress fertility, it would do so irrespective of breed, as fertility problems were also encountered with Romneys, while Braden et al. (1963) and Moule et al. (1963) have reported poor Merino fertility on leguminous pastures in Australia.

In conclusion it may be pointed out that the synchronisation was not an exercise in itself but rather a means to give a concentrated lambing and to this end the treatment was relatively successful. Attempts to explain the causes for the high percentage of Merino ewes returning to service are given, although the complexity of the problem is obvious. The gonadotrophic complex is not fully understood, nor the influence of location, season, nutrition, time of day of final injection and ram addition. Until a more complete study is made of the physiology of suppression with progesterone on fertilization, nidation and their associated factors, synchronisation problems will be difficult to solve.

2. MILK PRODUCTION

(a) Milk Yields

The inter-breed similarity in milk production is surprising when the large breed differences reported by other workers in different environments are considered. Based on a 12 week lactation, the yields of the Romneys were 248lbs, Corriedales 260lbs and Merinos 241lbs. The Merino production is well above the 136lb value quoted by Bonsma (1939) for a 12 week lactation, and considerably greater than the 147lb reported by Lloyd Davies (1963) for a 10 week lactation. Both Bonsma (1939) and Lloyd Davies (1963) used the lamb suckling method to measure yields, although the nutrition and number of lambs suckled were comparable to this trial. However, the 245lb estimate obtained by Moore (1962) for a 0-10 week lactation compares favourably with the 241lbs indicated in this trial. Moore (1962) used both the oxytocin and the lamb suckling technique of milk measurement, although he did not report any large differences between them.

Expressing the milk production in terms of a secretion rate, it is obvious that the average production of 52.7ml/hr for the Merinos reported in this trial is well above the 39.6ml/hr estimate of McCance (1959). The 51ml/hr value for Merino ewes, obtained by McCance and Alexander (1959) within the first week after birth, is also low in comparison to the 67ml/hr production in this trial over the same period. However the value of McCance and Alexander (1959) is comparable to yields reported by Pierce (1934), Bonsma (1939) and Hugo (1952), for Merinos in the early stages of lactation.

While there is little work published on the milk production of Corriedales, it is obvious that the yields reported in this trial are above those quoted elsewhere. Hart (1961) obtained yields of 259lbs for a 12 week lactation, although the ewes were suckling twins and were fed indoors. The 260lb yield of the Corriedales in this trial may also be compared with the 224lb estimate reported for the Canadian Corriedale by Slen et al. (1963) over a 0-10 week period. However their system of feeding was of a similar nature to Hart (1961).

Barnicoat et al. (1949) reported yields of 257lbs for a 0-12 week lactation using Romneys which were rearing single lambs. This is similar to the 248lb value obtained in this trial, although Barnicoat used the lamb suckling method of milk measurement, which may possibly result in lower yields relative to the oxytocin technique.

Disregarding factors such as age of ewe, strain differences and method of milk measurement, it would be natural to expect that the yields of the Romneys in this experiment would be depressed relative to that of Barnicoat et al. (1949) by introducing them into this environment, since the pastures in Barnicoat's trial consisted mainly of heavily topdressed perennial ryegrass and white clover, which would be higher in protein content and N.F.E. than encountered in this trial. However, the depression in yields does not appear to have occurred to any great extent, which may be explained by the possible overestimation of yields using the oxytocin technique, or by the fact that the level of nutrition in this trial may not be as low as is generally considered, since Coop et al. (1953) indicated relatively high protein contents in the type of vegetation that predominates in this trial.

Although the spring with its associated peak pasture growth occurred later in the year than in Barnicoat's trial, it would be difficult to determine to what extent, if any, this would influence the milk yields. It is possible that a strain difference exists between the Romneys used by Barnicoat et al. (1949) and this trial, although there is no literature available to substantiate this.

The yields of the Romneys are relatively good when it is considered that they were subjected to a somewhat different environment from which they were accustomed, not only in terms of nutrition and altitude, but in the severity of the winter with its associated low temperatures. The Corriedales were not subjected to such a great change as the Romneys, since the level of the nutrition in this trial is comparable to their previous district.

An important factor determining the relatively high yields obtained in these results was the extremely favourable spring - summer growing season. This was due to a higher than normal rainfall for that time of year, which maintained the growth until after the trial was completed.

All milk yields are reasonably high when it is considered that over the spring - summer period, the stocking rate was three-quarters of a ewe per acre, which is considerably higher than this class of country would normally carry. In the winter they were stocked at one ewe to the acre, although during this time they were supplemented with $1\frac{1}{2}$lbs of lucerne hay per day, per head.

The level of nutrition for the Merinos was relatively good in comparison to the Romneys and Corriedales, since the latter breeds lost weight over the winter whereas the Merinos gained weight. Wallace (1948) has indicated the importance of the level of nutrition during pregnancy on subsequent milk yields, which may explain the favourable yield of the Merinos. However, this may not be all that important, since Coop (1950) and Barnicoat et al. (1957) have indicated a greater dependence of yields on nutrition during lactation than during pregnancy.

It is difficult to make any comparison with yields obtained by other workers, since in most cases there are different stocking rates, ages, lambs suckled and numbers involved. An attempt was made in this experiment to reduce the age difference by using 3 year old ewes, which would represent an average age used by the majority of workers. The differences in stocking rates between authors adds confusion as regards comparisons. An example of this is given by Lloyd Davies (1963) who used stocking rates of up to 7 ewes per acre on native grazing, which would probably explain why the yields were so low in comparison to the Merino yields in this trial, where the stocking rates were three-quarter ewe per acre. The number of ewes used in an experiment would also explain why such large variability in yields between workers exist. Lloyd Davies (1963) used 6 ewes per treatment against 12 ewes per treatment in this trial which may be compared to Barnicoat et al. (1949, 1957) where up to 200 individual ewe lactations were determined. Obviously the larger numbers of ewes will provide more accurate comparisons, since the intra-breed variation is considerably greater than the inter-breed variation, which can be seen in these results where some ewes secreted almost three times as much as others.

Due to the differences in lactation lengths, number of lambs suckled, methods of milk measurements, and other factors which influence milk yields, no attempt has been made to compare the yields of the Romneys, Corriedales and Merinos in this trial with yields reported for other breeds. Obviously with so many variables the comparisons would not be reliable, since to equate all yields on a rëlative basis would require a considerable number of subjective assumptions.

(b) Shape of the Lactation Curve

There were no inter-breed differences in the shape of the lactation curves in this experiment, which is in agreement with Hunter (1957) and Slen et al. (1963). However both Bonsma (1939) and Wallace (1948) have indicated breed differences, there being more pronounced peaks in the higher yielding breeds.

The curves in this trial were characterised by a rise to a peak in the second week after parturition and falling at a constant rate until the twelfth week of lactation, which follows the type of curve reported for the dairy cow (Sanders, 1930; Brody, 1945). An average of 45% of the 12 week milk production, was secreted within the first month, which is in close agreement with the 45-50% value quoted by Owen (1957) and the 38% value of Wallace (1948) which was based on a 16 week lactation.

The lactation peaks in this experiment occur earlier than reported by Barnicoat et al. (1949, 1957), Wallace (1948), Hunter (1957) and Owen (1957) but are comparable to Coombe, Wardrop and Tribe (1960). The latter authors have presented lactation curves using both the oxytocin and lamb suckling techniques of milk measurement, for ewes rearing single lambs. Their curves, where the oxytocin technique was usëd, are almost identical to that reported in this trial, in relation to the position of the production peak (figure 2.). Coombe, Wardrop and Tribe (1960) observed that the production peak occurred one week earlier than with the oxytocin technique, as compared with the lamb suckling technique. If the earlier peak is a result of this technique, then this may explain why the peaks in these results occur one week earlier than reported by the majority of workers. The earlier peak associated with the oxytocin technique, may possibly be explained by the greater milk removal incurred with this method, since the shape of the lactation curve is influenced by the ability of the lamb to withdraw all the available milk (Wallace, 1948; Barnicoat, 1949). The shape of the lactation does not appear to be a breed factor, since similar shaped curves were obtained between breeds in this trial, while variable shaped curves have been reported within breeds (Barnicoat, 1949). It would seem that the level of nutrition and number of lambs suckled have an overriding effect on the breed, although it may be argued that yields are a characteristic of the breed, since it is well known that large inter-breed variations in yields exist.

The majority of workers show that the high yielding breeds are characterised by a production peak $2\frac{1}{2}$ - 4 weeks after parturition (Wallace, 1948; Hunter, 1957; Owen, 1957) while in low yielding breeds, like the Persian Blackface (Stark, 1953) and the Merino (Bonsma, 1939; Hugo, 1952; Lloyd Davies, 1958, 1963; McCance and Alexander, 1959) the production peak is usually ill defined, or even absent. McCance and Alexander (1959) indicated a peak 4 days after lambing, which tends to indicate, together with the rest of the literature, a gradation of the production peak towards the beginning of lactation, associated with low yielding and twin bearing ewes to a stage where the peak ceases to exist.

The work of Barnicoat et al. (1949, 1957) provides a suitable basis for comparison, in view of the large number of animals and treatments used. Although these authors obtained varying shapes of the lactation curves, it is evident that a definite pattern exists. Barnicoat et al. (1957) indicated a peak in the lactation curve, 20-30 days after lambing in ewes rearing single lambs on normal pasture grazing, whereas where ewes were rearing twins, a small and almost nonexistant peak was apparent. On low plane treatments, flat curves, similar to that reported by Hugo (1952), Hart (1961) and Slen et al. (1963) were obtained.

Barnicoat et al. (1949) maintains that twins are necessary to achieve the "normal shape of the Romney ewes lactation curve" since singles do not measure the full potential of the ewes ability to produce milk in early lactation, but tend to be a reflection on the "ad lib" consumption of the lamb.

The "normal" shape of the lactation curve, as reported by Barnicoat was flat in nature and represents the yields produced by the ewe, rather than the appetite of the lamb (figure 1). If the shape of the lactation curve is determined by the lamb(s) ability to withdraw all of the milk, it may be asked why a flat curve was not obtained in these results, since the oxytocin technique would be expected to withdraw all the milk to an even greater extent than twins. This may possibly be explained by the fact that when twins are used, a greater sucking stimulus may be expected, with a subsequent increase in milk secretion, either through oxytocin or prolactin stimulation, or simply by a more complete and continuous milk removal, associated with a reduction in the intra-mammary pressure.

The theory pertaining to this explanation is that with twins, the maximum stimulus for secretion is applied from birth, whereas singles, as in this trial, may take 2-3 weeks before they are able to provide the equivalent stimulation and effectiveness of milk removal. Consequently there would be an increase in yields until this point is reached, after which time the shape of the curve is an expression of the proclactin levels, available feed supplies and the degree of milk removal.

Although the basic shape of the lactation curve is determined by the number of lambs suckled, the level of nutrition at the beginning of lactation can modify the curve considerably. With low yielding ewes, the lamb can cope with the milk supply at birth, or within a week after birth, hence the peak would be small, if present at all. Conversely on a high plane of nutrition, considerable time may elapse before the lamb is in equilibrium with the production of the ewe. The modifying influence of nutrition applies equally well with twins, a low plane emphasizing the flat type of curve associated with twins.

The influence of the nutrition during pregnancy on the shape of the lactation curve, is of considerable interest, since Wallace (1948), Barnicoat et al. (1949, 1957) and Hunter (1957) have shown that ewes fed to gain weight during the winter, outyielded ewes fed to lose weight. Barnicoat et al. (1949) observed that the persistency of lactation was increased by feeding ewes well throughout pregnancy. However, although the Merinos gained weight relative to the Romneys and Corriedales during the winter, they do not appear to have a higher level of production in the twelfth week of lactation.

There is a remarkable similarity in the persistency of lactation reported between workers, the average level of production in the twelfth week being about 1.5lb a day, which is in close agreement with the results reported in this trial.

(e) <u>Method of Milk Measurement</u>

The oxytocin method of milk measurement has proved extremely successful, although it is possible that the relatively high yields obtained in these results are a reflection on this technique, since Coombe, Wardrop and Tribe

(1960) have quoted 16-28% higher yields with the oxytocin method, as compared with the lamb suckling method, although Moore (1962) does not indicate differences greater than 6%. However, as Moore (1962) points out, Coombe et al. (1960) used a 5 hour interval for the lamb suckling technique and a 2 hour interval for the oxytocin technique, instead of a 4 hour interval for both. This would tend to exaggerate the differences, which is illustrated by the variation between Moore (1962), who obtained a 2% difference in favour of the oxytocin technique in the first 2 weeks of lactation, and Coombe, Wardrop and Tribe, (1960) who cited a 16% difference, which increased to 28% towards the end of lactation.

It is surprising that both of these authors used single lambs, since singles would underestimate the yields as measured by the lamb suckling technique. If twins were used, the divergence between the two methods may be expected to decrease. Moore (1962) maintains that the difference between the techniques is due to the characteristic unwillingness of some ewes to stand until the lambs had emptied their udders, which would tend to underestimate the yields as measured by the lamb suckling technique. With the oxytocin technique this problem does not occur, since the ewe is suspended in an immovable cradle. This was of considerable advantage in this trial since the New Zealand Merino is generally very excitable and it would be difficult to get them to stand for their lambs, especially towards the end of lactation.

Although the Merino is easily excitable, no previous training was required. Even though a ewe may have been agitated prior to milking, complete milk removal was obtained following an injection of oxytocin. Under these circumstances the lamb suckling technique would result in considerable error, since the lamb would not obtain all the milk, due to the inhibition of the "let down" hormone. Another reason why the lamb suckling technique was not preferred in this trial, was due to the fact that twins are necessary for complete milk removal, which would provide complications as far as the low twinning percentages in Merinos are concerned. However although the oxytocin technique is especially useful for comparative purposes, the lamb suckling technique provides an indication of the milk consumed by the lamb, rather than what is available, which is more important in terms of milk yield/lamb growth relationships.

McCance (1959) and Coombe, Wardrop and Tribe (1960) obtained complete milk removal following test doses of 5iu. and 2.5iu. of oxytocin respectively. McCance (1959) found that lambs put with ewes after being milked following oxytocin injection, could obtain little or no milk. Complete emptying of the udder in this trial, was indicated by the insignificant amounts of milk withdrawn after a test dose of 5iu. of oxytocin, which was given at regular intervals throughout the trial. Test doses never yielded more than 10mls.

Up to 12 ewes were milked in an hour by an experienced operator, although in early lactation, each determination took slightly longer. However with the advance in lactation the ewes became more accustomed to the procedure. The milk production, expressed in millilitres per hour was extrapolated to give the yields for the 24 hours, which was based on the assumption that the diurnal milk secretion was constant.

McCance (1959) observed variation of 12% in diurnal yields as compared with 5.6% in these results. Although McCance (1959) used an unnatural physical environment in that the ewes were housed in a constantly illuminated shed, it is obvious that little diurnal variation in milk production exists, hence the calculation of the daily production from the hourly secretion appears justified.

(d) Efficiency of Live Weight Gain

The efficiency of conversion of milk to body tissues, as measured by the lbs of milk consumed per lb live weight gain, was higher in the second half of lactation. The Romneys and Corriedales required 5.51bs of milk per lb live weight gain in the first half of lactation as compared with 4.91bs over the whole lactation period. The corresponding values for the Merinos were 6.31bs and 5.41bs respectively. Coombe, Wardrop and Tribe (1960) indicated up to 20% lower efficiencies using the oxytocin technique of milk withdrawal, as compared with the conventional lamb suckling technique, so if comparisons with other workers are to be made, this factor must be borne in mind.

The 4.91b value of the Romneys may be compared to the 5.51b value of Barnicoat et al. (1949). These authors quote higher efficiencies with a low plane of nutrition, so it is possible that the lower plane of nutrition in this experiment, relative to that of Barnicoat's, may explain the higher efficiencies. However, the 4.5-5.0 values reported by Owen (1957) for a 0-10 week period, compare favourably with the Romneys and Corriedales in this trial.

The lower efficiencies of the Merinos in comparison to Bonsma (1939), who indicated values approaching 5.0 for a 0-12 lactation period, and the 4.2 figure of Lloyd Davies (1963) for a 0-10 week period, are difficult to explain. The possibility of the influence of the technique of milk measurement cannot be dismissed, since both Bonsma and Lloyd Davies used the lamb suckling method. The literature is too variable for any definite conclusions to be drawn, but it appears as though the Merinos are as equally efficient in converting milk to body tissues as the Romneys.

Although the Merino lambs were less efficient than the Romneys and Corriedales in this trial, the ratio narrowed with advancing lactation as the Merino lamb supplemented the diet with grass. The fact that the Merino lambs were able to supplement the diet with grass to a greater extent than the Romneys and Corriedales, is indicated by the lack of any milk yield/growth rate relationships after 6 weeks, which may be compared with the high relationships obtained in the Romneys up to 12 weeks. Gardner and Hogue (1964) indicated higher maintenance requirements per unit body weight with small lambs as compared with large lambs, which may explain why the Merinos were less efficient in this trial, since more of the milk would be partitioned towards maintenance and less to growth.

The higher efficiency of the Romneys and Corriedales may also be explained by the observation of Brody, (1945) and Ricordeau and Boccard, (1961) who found that efficiency increases with increasing live weight gain. Hence the faster growing Romneys and Corriedales would be likely to be more efficient than the slower growing Merinos.

Bonsma (1939), Wallace (1948), Barnicoat (1949), Owen (1957) and Lloyd Davies (1963) all indicate increasing efficiencies with advancing lactation. However the term "efficiency", is confusing, since with advancing lactation there is an increased consumption of grass, with a consequent partitioning of the energy source. This means that considerable part of the weight gain is derived from the grass, although by the method of calculating the above efficiency values, all this gain is attributed to the milk consumed, with a consequent increase in the apparent efficiency. However, in actual fact, the efficiency expressed in terms of units of milk consumed per unit live weight gain derived from the milk, may not have altered at all. Consequently it may be preferable to express efficiencies for the first 6 weeks, since this period is relatively uncomplicated by the grazing effects of the lamb.

3. GROWTH RATES AND CORRELATIONS

(a) Growth Rates

There is little work published on Romney, Corriedale and Merino lamb growth rates in this environment, although considerable information has been made available for the Romneys in other New Zealand environments by Barnicoat et al. (1949, 1957), Coop and Clark (1952) and Coop and Drew (1963) and for the Corriedales by Coop and Clark (1952). From these authors, a general growth rate value from 0-12 weeks of 0.55-0.65lb/day for the Romneys and 0.45-0.55lb/day for the Corriedales may be designated, these values being for a low to medium plane of nutrition.

The growth rates of 0.62lb/day for the Corriedales and 0.59lb for the Romneys in this trial are surprisingly high for the level of nutrition encountered and reflects on the extremely favourably season. The faster growth of the Corriedales in the second half of lactation, may possibly be explained by the fact that they were more suited to this environment than the Romneys, in spite of the good season. It is obvious from the correlation coefficients between milk yield and lamb growth rates, that the Corriedale lambs began supplementing the milk with grass at an earlier age than the Romneys, which would tend to increase their energy intake relative to the Romneys.

The favourable growth rates of the Romneys and Corriedales, presents the possibility that the native vegetation may not be so poor as previously considered. From the chemical composition work on native pastures by Coop et al. (1953), it appears as though the protein contents of catsear and sorrel, which are the predominant species present in this trial, are better than the native grasses and equal to the clovers. The protein values of catsear and sorrel in spring are about 14.0 and 9.0% respectively.

The 0.531b/day growth rate of the Merinos compares well with Lloyd Davies (1963) who indicates gains of 0.52-0.551b/day for a 0-10 week period. The gains for single lambs presented by Lloyd Davies (1963) and in these results appear to be above the average, since Geytenbeek et al. (1962) indicated gains of 0.371b/day for a 0-12 week period, while Lloyd Davies (1962) quoted gains of 0.451b/day. The rate of gain is obviously influenced to a greater extent by nutrition than the breed factor, since Franklin et al. (1964) reported extremely low growth rates under drought feeding conditions.

In this trial the growth rate of the Merinos was significantly lower than the Romneys and Corriedales, although there were no significant difference between the latter two. In the first 6 weeks of the trial the Romney gains were significantly higher than the Merino, but fell off to comparable levels in the second 6 weeks (figure 4). The Corriedale lambs overtook the Romneys within 6 weeks after birth and maintained their advantage for the remainder of the trial.

(b) Growth Rate/Milk Yield Relationships

The lamb growth/milk yield relationships follow similar trends to that reported in the literature, with highly significant correlations in early lactation, the relationship weakening as the lamb replaces the milk diet with grass. The correlation coefficients, where the milk is measured by the oxytocin technique, are considerably higher than where the lamb suckling technique is used. (Coombe, Wardrop and Tribe, 1960; Moore, 1962). These authors quote 0.05 and 0.1 higher correlation coefficients respectively in favour of the oxytocin technique.

The correlation coefficient of 0.73 for a 0-4 week period as obtained by Coombe, Wardrop and Tribe (1960) and the 0.8 value for a 0-10 week period of Moore (1962) may be compared with the 0.78 value of the Merinos in this trial for a 0-6 week period. These highly significant values refer to single lambs, where the oxytocin method was used for milk withdrawal. However there were no significant relationships in the second 6 weeks (r = -0.043) which was surprising considering the fact that the milk yields were still relatively high. As the Merino breed has more of a foraging nature than the Romney and Corriedale counterparts, they may be expected to commence grazing at an earlier age, although not to the extent as indicated in these results, since Bonsma (1939), Coombe, Wardrop and Tribe (1960) and Hugo (1952) have all indicated substantial although non significant correlations in the latter part of lactation. The independence of the Merino lamb on milk yields after 6 weeks of age, is of considerable interest in respect to early weaning, since it provides theoretical support for the practice.

Wallace (1948), Stark (1953), Hunter (1957), Owen (1957) and Coombe, Wardrop and Tribe (1960) all indicated higher correlation coefficients in the first half of lactation. Wallace (1948) cited correlation coefficients of 0.91 in the first month for Border Leicester x Cheviot ewes, whereas by the 0-12 week period the value had fallen to 0.72. Similarily Coombe, Wardrop and Tribe (1960) indicated correlation coefficients of 0.73 for a 0-4 week period, but only 0.33 for a 7-10 week period.

The 0.67 value of Slen et al. (1963) for a 0-8 week period, the 0.68 value of Barnicoat et al. (1957) for a 0-6 week period and the 0.70 value of Owen (1957) for a 0-10 week period, may be compared with the inter-breed value of 0.74 for the 0-6 week period in this trial.

The Romney correlation coefficients for the first and second 6 week period in this trial, were 0.76 and 0.71 respectively. It is obvious that the Romney lamb is very dependent on milk production over the whole 12 weeks, which tends to indicate the inability of the Romney lamb to adapt itself to this environment. In a dry season when the milk production would be severely reduced, the Romney lamb would be forced to supplement the reduced milk supply with what grass was available, with resultant deleterious effects to their growth rates. In such circumstances the Merino lamb would be more adapted in coping with the burnt off vegetation.

The 0.32 correlation coefficient of the Corriedales over the last 6 weeks of lactation approaches the values obtained by the majority of workers for this period and falls between the values of the Romneys and Merinos.

A departure from the normal pattern of growth rate milk yield relationships, was shown by Barnicoat et al. (1949). High relationships for the 3-9 week period were obtained, but the values for the 1-3 week period were small and irregular. However, these values must be accepted with caution, since practically all authors have indicated highly significant relationships over this period. As the lamb does not supplement the milk diet with grass until 3 weeks of age (Wardrop, (1961), it would appear that this period is the only time when the lamb is entirely dependent on milk.

(c) <u>Birth Weight and its Relationship to Productive Characters</u>

Significant positive correlations between birth weight and milk yields have been reported by Bonsma (1939), Wallace (1948), Burris and Baugus (1955) and Owen (1957). The latter author suggests that this may be due to large lambs being able to consume more milk than small ones in early lactation and that the larger lamb provides a stronger sucking stimulus. However Hunter (1957) and McCance and Alexander (1959) did not find any relationship while Thompson and Thompson (1953) reported a negative correlation.

The significant correlation coefficient of 0.69 for the Merinos (table 19) between birth weight and milk yields up to 6 weeks, may be compared with the non significant relationship in the Romneys and Corriedales. Wallace (1948) indicated a highly significant coefficient of 0.70 for Border Leicester x Cheviot ewes, although this was for a 0-28 day period. Wallace concluded that birth weights and yields are affected by the level of nutrition during pregnancy, while the size of the lamb at birth largely determines its ability to utilise all the milk.

In the three months prior to lambing the Merinos gained about 6lb (table 23) compared with a live weight drop of 3-4lb in the Romneys and Corriedales. This indicates a satisfactory level of nutrition as far as the Merinos are concerned, but definitely sub-maintenance as regards the Romneys and Corriedales. The average Merino birth weight of 9.9lb was reasonably high in relation to the Romneys, although it must be realized that the percentage of lambs born as twins were greater in the Romneys which would depress the birth weights relative to that of Merinos.

The birth weight/growth rate relationship followed a similar trend to the birth weight/milk yield relationship, in that a highly significant correlation coefficient was obtained for the Merinos. The 0.72 value obtained by Wallace (1948) for the Border Leicester x Cheviot ewes was considerably lower than the 0.87 value indicated in these results, since Wallace's value refers to a 0-28 day period, as compared with a 0-6 week period in this trial. Obviously the weight of the Merino lamb at birth has a great bearing on subsequent milk yields and growth rates.

The importance of the birth weight/growth rate relationship may be seen by the high birth weight/weaning weight relationships (table 20). There was a significant relationship in all breeds, although the correlation coefficient of 0.96 for the Merinos was highly significant. It was calculated that for every lb increase in birth weight there was a corresponding 2.83lb increase in weaning weight, which is quite a substantial amount for a Merino. This value may be compared with Shelton (1964) who also obtained a highly significant relationship and concluded that for every lb increase in birth weight, there was an increase of 6.81b in the 120 day weight. It would be expected that the birth weight/weaning weight relationships would be higher than the birth weight/growth rate relationships, since the variation in birth weight in itself is sufficient to influence later weights, quite apart from growth rates.

The highly significant relationship of 0.85 between milk yield and weaning weight for the Romneys is surprising, since the growth rate/weaning weight relationship was just significant at the 5% level. The 0.72 value for the Merino was just outside the 1% significance level. A possible reason as to why it was not highly significant, may be explained by the low milk yield/growth rate relationship in the second 6 weeks, which would tend to lower the relationship between milk yields and subsequent weights based on a 0-12 week period (table 21).

It appears from the literature that the birth weight, growth rate and milk yields are all interrelated and depend on each other for their reciprocal effects. When milk yields are kept constant by multiple regression (as in these results) the birth weight/growth rate relationship breaks down. Hence the increase in growth rate, associated with increasing birth weight, is facilitated through an increase in milk yields, which are also associated with higher birth weights.

(d) Ewe Live Weight and Milk Yield Correlations

The decline in live weight of the Romneys and Corriedales over the nine months of the trial (table 23), tends to indicate the unsuitability of these breeds in this environment, in spite of their relatively high milk yields and lamb growth rates. Their decline may be compared to the 11.7lb gain of the Merinos over the same period. Although some of the weight loss in the Romneys can be attributed to settling down in the new environment, it is not thought that this factor would be of great consequence, since the main period of live weight decrease was in the spring-summer period, when competition between live weight gain and milk production was at a maximum. It appears as though the Romneys were less able to cope with the burden of lactation and wool growth than the Merinos.

All ewes were on a sub-maintenance diet over the winter, if the uterine contents are taken into account, in spite of the 5.7lb gain of the Merinos. While the level of nutrition during this period is adequate for the Merinos, it obviously represents a low plane for the Romneys and Corriedales.

There were no significant relationships between ewe live weight and milk yields, either within, or between breeds. This was to be expected as there were considerable inter-breed differences in live weights, yet there were no significant differences in yields. Bonsma (1939), Wallace (1948), Barnicoat et al. (1957) and Owen (1957) all indicated a significant relationship between live weight and yields, although Barnicoat et al. (1949), Hunter (1957), McCance and Alexander (1959) and Coombe, Wardrop and Tribe (1960) observed none.

It would be reasonable to expect a relationship between ewe live weight and milk yields, since it is well known that within a particular breed of dairy cow, milk yields tend to increase with live weight (Edwards, 1936). It is of interest to note that Owen (1957) indicated a stronger relationship between live weight at tupping and milk yields, than live weight at lambing and milk yields. No evidence was given to suggest whether it was the size or condition of the ewe, which was the most important factor influencing the yields.

4. MILK COMPOSITION

(a) Fat Percentages

The fat percentages, based on a 12 week lactation, (table 7) are higher than obtained by other workers. This may be explained by the fact that the oxytocin technique, could result in a greater removal of the residual milk, with its associated higher fat content. No data on composition values using the oxytocin technique have been reported, so if the composition is influenced by the method of milk removal, then comparisons will be difficult to make.

The Romneys were 1.0% higher in fat test than the Corriedales and 0.8% higher than the Merinos. This is contary to that reported in the literature, which quote Merino fat percentages 1-2% higher than the Romneys, although Bonsma (1939) did not find any significant differences. It is possible that the high Romney fat percentages obtained in these results, can be interpreted as a decline in the volume of milk associated with a change in the level of nutrition, rather than any change in the fat content level, which would have the effect of increasing the fat percentage. The value of the Merinos are comparable with Pierce (1934) who indicated 7.9% for a 0-9 week period. Both the Romney and Merino fat percentages as obtained by Bonsma (1939) are well below those reported in this trial, although Bonsma used a 0-8 week lactation period.

The inter-breed average of 8.0% fat is higher than reported by Ritzman (1917) and Slen et al. (1963) who quote 6.8% and 6.5% respectively over a range of breeds. Similarily the 8.6% value of the Romneys is considerably higher than the 5.3% and 5.5% obtained by Barnicoat et al. (1949,1957) while the Corriedales average of 7.6% may be compared to Hart (1961) who cited tests of 6.68% based on an average of two lactations. Although Wallace (1948) obtained similar fat percentages to this experiment, using Border Leicester x Cheviot ewes, there were insufficient numbers used, and the sampling period too short for reliable comparisons to be made.

The shape of the milk fat curve for the 12 week lactation period (figure 9) is comparable to Barnicoat et al. (1949), and appears to follow the type of curve reported for the dairy cow (Hammond, 1957). This is characterised by a decline immediately after parturition, when the colostrum is replaced by normal milk. After remaining steady over the first two thirds of lactation, the levels rise again, which appears to be associated with a reduction in the milk yields. However the fat curves obtained by Barnicoat et al. (1957) differ from those reported in this experiment, in that Barnicoat's curves were characterised by a trough between the 5th - 9th week period, whereas in this trial, the levels were at their lowest ebb in the second week. Barnicoat indicated that ewes on a high plane of nutrition experienced a larger, but earlier drop in fat percentages, whereas the low plane, although being less variable, did not reach the lowest point until the ninth week of lactation.

The shape of the curves illustrated by Hart (1961) also differ from that obtained in this experiment. Hart's curves are characterised by a peak in mid lactation which is difficult to explain, since no great fluctuations in milk yields were observed. While there was an increase in the fat level towards the end of lactation, there was no indication of a decline following parturition as illustrated in figure 9.

(b) Solids-Not-Fat

The inter-breed S.N.F. values (table 32) were not significantly different and are slightly lower than the 10.95% value of Barnicoat et al. (1949), although the latter author's value applies for a 100 day period, compared with 70 days in this trial. The values obtained by Pierce (1934), Bonsma (1939), Owen (1957) and Hart (1961) are on average, 1.0-1.5% higher than the 10.1% value indicated in this experiment. Although Barnicoat et al. (1957) reported a sharp decline in the S.N.F. levels following parturition, the work of Barnicoat et al. (1949), Hart (1961) and these results do not confirm this. While the S.N.F. levels of Barnicoat et al. (1949, 1957) were characterised by a gradual rise with advancing lactation, Hart (1961) indicated no such rise, the values remaining relatively constant, whereas in these results the levels tended to decline until the ninth week, before rising (figure 10). Hart (1961) detected a small peak in the S.N.F. curves in the fourth week of lactation which was also evident in these results, although no great importance is attached to this feature.

It is possible that the lower S.N.F. values reported in these results are a reflection on the plane of nutrition, since Barnicoat et al. (1957) observed higher S.N.F. values associated with a high plane, which is probably related to an increased protein intake.

While no significant differences in ash percentages were recorded, it is apparent that the values (table 33) were lower than the average of

0.9% obtained by Pierce (1934), Bonsma (1939) and Barnicoat et al. (1949), considering that the values reported in this experiment refer to late lactation, when the percentages of ash in the milk would be expected to be high. However the 0.87% figure of Barnicoat et al. (1957) compares favourably with the 0.84% reported here.

The protein percentages are considerably higher than reported by other workers, in spite of the fact that the determinations were made in the twelfth week of lactation. While the most common values recorded are between 4.5-6.5% (Barnicoat et al., 1949, 1957; Owen, 1957; Slen et al., 1963) it must be remembered that these are averaged over the lactation period as a whole. The high protein levels are difficult to explain, since the materials and method used for the protein determinations were thoroughly checked. It would appear that the protein percentages are likely to be the main factor influencing the S.N.F. levels since the lactose percentages remain relatively constant (Maynard, 1962).

The total solids reported in this experiment, which are a reflection on the fat percentages since the S.N.F. levels were relatively constant, are higher than reported by Bonsma (1939) and Barnicoat et al. (1949) who quote values of approximately 16.25-16.50%, although lower than 19.3% obtained by Pierce (1934) for Merinos. However the 17.5% value of Owen (1957) is comparable with the inter-breed value of 18.0% quoted in this experiment.

(c) Fat Percentage/Growth Rate Relationships

The non significant correlations obtained in this trial conform to Ritzman (1919), Neidig and Iddings (1919), Barnicoat et al. (1957) and Slen et al. (1963) who all concluded that the fat content is of no detectable importance in influencing the growth rate of lambs. Hence it appears the quantative effects of the milk, are more important than the qualitative effects in determining lamb growth rates. The negitive correlation coefficients obtained in this trial, are probably a reflection on the extreme variability of the fat percentages, since it is well established that most species of animals thrive best when their diet contains a certain proportion of fat (Hammond, (1957; Maynard, 1962). However the "critical" fat percentage level would be well below the 8.0% levels indicated in this trial.

VI

CONCLUSIONS

Considering that the hormonal technique of synchronisation has given variable results in the past (Lamond, 1964), the number of ewes synchronised and holding to service was extremely successful, although the Merino fertility was lower than expected. However, the original aim of concentrating lambing over the shortest possible period was by and large accomplished. A similar situation was apparent in the method of milk yield estimation, since the oxytocin technique has not been fully accepted by some investigators as a reliable method for the measurement of milk yields. However this technique was completely successful in this experiment, as was indicated by the speed and efficiency of milk removal.

The milk yields and lamb growth rates were in general, better than expected in view of the results obtained by other workers in similar environments. The Merino milk yields are considerably higher than reported elsewhere, which may be a reflection on the technique used, or possibly a strain effect of the New Zealand Merino, since the general level of nutrition was comparable to that used by overseas investigators working with this breed.

While no significant differences in milk yields were apparent, it is obvious that the nutritive value of the tussock grassland, as far as milk yields and lamb gains are concerned, is not as poor as generally considered. Although the milk yields of the Romneys do not appear to have been depressed to any great extent relative to Barnicoat et al. (1949, 1957), it must be remembered that Barnicoat's figures were derived to a large extent, from ewes grazing on hill country, which in some seasons, was consistent with "hard" grazing. However, on high planes of nutrition, the yields obtained by Barnicoat were considerably above those reported in these results. Although the milk yields in the Romneys were relatively high, their loss of weight throughout the year and the mediocre wool weights, suggest that this breed is not siuted to this environment, in spite of the favourable season. While the Corriedales fell into an intermediate position as far as ewe live weights and wool production are concerned, their milk yields and lamb growth rates were higher than the Romneys, although the differences were not significant.

The highly significant correlations obtained in all breeds between milk yields and lamb growth rates are indicative of the importance of milk production, a fact well established by other investigators in this field. The highly significant relationships between birth weight and subsequent milk yields, growth rates, and weaning weights in the Merinos, are of considerable practical importance, since birth weight is influenced amongst other things, by the level of nutrition during pregnancy (Wallace, 1948). Hence in the light of these results, birth weights as high as practically possible, would be desirable.

The interesting feature of the milk composition was the high fat percentages which were above the values reported in the literature. Whether this is a reflection on the oxytocin technique of milk withdrawal with its associated greater apparent removal of residual milk, cannot be confirmed. The literature quotes the Merinos as being higher in milk fat content than the Romneys, although the reverse was found in this trial. This also is difficult to explain, but it appears that fat test values are inversely related to the yield. Apart from the fat percentages in the last 6 weeks of lactation, no significant differences in the milk components were obtained.

A large percentage of the variability of yields and composition obtained by many workers appears to be due to the small numbers of animals used. Although milking large numbers of ewes presents practical difficulties, more continuity could be expected with larger numbers, or alternatively a reduction in the number of treatments. While the number of ewes used for milk comparison purposes in this trial were greater than quoted by many other workers, some of the correlation coefficients, although being high, did not reach the significance level due to a shortage of numbers.

In summary, it may be said that this experiment has provided information on the milk yields and composition of three breeds grazing in a tussock grassland environment. Considering the fact that no records are available on the milk yields of Merinos in New Zealand, the collection of this data in itself appears justified. The performances of Corriedale and Romney ewes, normally run under lowland conditions were also investigated, in the hope that the added information would help fill the gap in the knowledge of the factors affecting lamb growth rates.

Before any definite conclusions can be drawn from this experiment, repetition over two or more years would be desirable, since this environment is subject to considerable seasonal fluctuations. Whether with a severe winter and dry spring, any inter-breed differences in yields would arise requires further experimentation.

VII

SUMMARY

Milk yields and milk composition of Romney, Corriedale and Merino ewes rearing single lambs in a tussock grassland environment were compared. Mating was synchronised in order to concentrate lambing, which enabled milk yield comparisons to be made with lambs of comparable ages. The pertinent features of the experiment are as follows.

1. The synchronisation of mating entailed a series of progesterone injections given intramuscularly at 2 day intervals over a period of 16 days. Dose rates used were 20mg. for the first 4 injections and 15mg. for the second 4 injections. Rams were added on the final day of treatment. The percentage of Romney, Corriedale and Merino ewes synchronised within 4 days and holding to service were 88%, 77% and 44% respectively. A comparable percentage of ewes lambed within a 6 day period. Possible reasons for the low Merino fertility are discussed.

2. Twelve Romneys, 11 Corriedales and 9 Merinos were used for milk yield determinations over a 12 week period. The oxytocin technique of milk measurement was used, and the success and suitability of this method discussed. Five international units of oxytocin were used for all determinations.

3. No significant differences in milk yields between breeds were reported. Average milk yields in millilitres per hour for the 12 week lactation were Romneys 54.3, Corriedales 56.8, and Merinos

52.7. The total values expressed in lbs for the 12 week lactation were 248, 260 and 241 respectively. The shape of the lactation curves were similar to that reported for the dairy cow, being characterised by a rise to a peak in the second week of lactation and declining uniformly with advancing lactation.

4. The diurnal variation in milk yields was measured. A small and non significant variation of 5.6% was apparent, which indicates a constant rate of secretion.

5. Highly significant differences in fat percentages were evident between the Romneys and Corriedales over the last six weeks of lactation, although they did not differ significantly at any other stage. The fat test values over a 0-12 week period were Romneys 8.6%, Corriedales 7.6% and Merinos 7.8%. The shape of the fat test curves were characterised by a fall following parturition, followed by a gradual rise associated with the decline in milk yields. Relationships between fat percentage and lamb growth rates were small and non significant.

6. No significant inter-breed differences were apparent between the solids-not-fat over a 10 week period. Average values were Romneys 10.13%, Corriedales 10.04% and Merinos 10.11%. There were no inter-breed differences between the shape of the S.N.F. curves, which were characterised by a gradual decline for eight weeks with a sharp rise in the ninth week.

7. The total solids followed similar trends to the S.N.F. in that there were no significant differences at any stage of lactation. The values fell following parturition and remained relatively constant for the remainder of the lactation. Relative values for the Romneys, Corriedales and Merinos were 18.6%, 17.6% and 17.8%

respectively. Protein and ash percentages were measured in the twelfth week of lactation, the inter-breed differences being small and non significant.

8. Favourable growth rates were made by all lambs. The Romneys and Corriedales grew 0.59lb/day and 0.62lb/day respectively, which were significantly higher than the 0.53lb/day growth rate of the Merinos. Although the Romneys made the most rapid growth of all breeds in the first 6 weeks, they slowed down to a comparable level of the Merinos in the second 6 weeks.

9. Highly significant correlations coefficients were obtained between milk yields and lamb growth rates in the first 6 weeks of lactation, the relationship weakening with age. Correlation coefficients for the Romneys, Corriedales and Merinos over this period were 0.76, 0.69 and 0.74 respectively. The influence of milk yields on lamb weight at 12 weeks was also highly significant, the relationship being strongest in the Romneys with a correlation coefficient of 0.85.

10. Birth weights were strongly correlated with lamb growth rates (0.87), milk yields (0.69) and weight at 12 weeks (0.96) in the Merinos. Although there was a significant relationship between birth weight and weight at 12 weeks in the Romneys and Corriedales, the former two relationships were non significant.

11. Ewe live weights, measured 2 weeks prior to lambing, were not related to milk yields. Over the eight months of the experiment, the Romney and Corriedale ewes lost weight relative to the Merinos. It was suggested that the Romneys were less suited to this environment than the Merinos, in spite of the favourable milk yields and lamb growth rates.

VIII

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr. D.S. Hart, Senior Lecturer in Animal Science, Lincoln College, for the advice and guidance given throughout this study. Appreciation is also extended to Mr M.G. Hollard, Senior Lecturer in Animal Science, for his interest and helpful discussions and Mr V.R. Clark, Lecturer in Animal Science, for his advice and criticisms of the manuscript.

Appreciation is expressed to Mr N.S. Mountier, Senior Lecturer in Biometrics, for his advice pertaining to the statistical analysis. Thanks are also due to Mr J. Kinder and Mr J.G. Hondelink of Tara Hills Research Station, Omarama, for their valued assistance given.

Finally, I would like to thank my wife for her patience and typing of the script.

IX

REFERENCES

Alexander, G., and Davies, H.L., (1959). Aust. J. Agri. Res. 10 : 720.

Barnicoat, D.R., Logan, A.G., and Grant, A.I., (1949). J. Agri. Sci. 39 : 49, 237.

Barnicoat, C.R., Murray, P.F., Roberts, E.M., and Wilson, G.S., (1957). J. Agri. Sci. 48 : 9.

Bindon, B.M., Roberts, E.M., and Houlahan, P.M., (1963). Aust. J. Expt. Agri. Anim. Husb. 3 : 78.

Bindon, B.M., and Roberts, E.M., (1964). J. Reprod. Fertil. 7 : 397.

Bonsma, F.N., (1939). Univ. Pretoria Publ. Agri. Ser. 1., No. 48.

Bonsma, F.N., (1944). Fmg. S. Afr., 19 : 311, 395.

Braden, A.W.H., Lamond, D.R., and Radford, H.M., (1960). Aust. J. Agri. Res. 11 : 389.

Braden, A.W.H., Moule, G.R., (1964). Aust. J. Agri. Res. 15 : 937.

Braden, A.W.H., Southcott, W.H., and Moule, G.R., (1964). Aust. J. Agri. Res. 15 : 142.

Brody, S., (1945). "Bioenergetics and Growth" p. 814. Reinhold. Publ. Comp., New York.

Brunner, M.A., Hansel, W., Hogue, D.E., (1964). J. Anim. Sci. 23 : 32.

Brush, M.G., (1962). Proc IVth Int. Congr. Animal Reprod. 2 : 345.

Burris, M.J., and Baugus, C.A., (1955). J. Anim. Sc. 14 : 186.

Clark, E.A., (1954). Proc. Ruakura. Farmers Conf. : 45.

Connor, H.E., (1964). N.Z. J. of Botany. 2. No. 4. : 325.

Coombe, J.B., Wardrop, I.D., and Tribe, D.E., (1960). J. Agri. Sci. 54 : 353.

Coop, I.E., (1950). J. Agri. Sci. 40 : 311.

Coop, I.E., and Clark, V.R., (1952). N.Z. J. Sci. Tech. 34A : 153.

Coop, I.E., Darling, M., Anderson, C.H., (1953). N.Z. J. Sci. Tech. 34 : 507.

Coop, I.E., Clark, V.R., (1960). N.Z. J. Agri. Res. 3 : 922.

Coop, I.E., Drew, K.R., (1963). N.Z. Soc. Anim. Prod. 23 : 53.

Coop, I.E., (1965). Personal Communication.

Corbett, J.L., (1964). Aust. Soc. Anim. Prod. 5 : 138.

Davies, H.L., and Dun, R.B., (1957). Aust. Vet. 33 : 92.

Davies, H.L., (1960). Aust. Vet. J. 36 : 20.

Denny, J.F., and Hunter, G.L., (1958). S.Afr. J. Agri. Sci. 1 No. 4. : 381.

Donald, H.P., and McLean, J.W., (1935). N.Z. J. Sci. Tech. 17 No. 3. : 497.

Donald, H.P., (1962). An. Prod. 4 : 369.

Dun, R.B., and Haywood, L.T., (1962). Aust. Soc. An. Prod. 4 : 178.

Duncan, D.B., (1955). Biometrics. 11 : 1.

Edgar, D.G., and Bilkey, D.A., (1963). N.Z. Soc. Anim. Prod. 23 : 79.

Edgar, D.G., and Ronaldson, J.W., (1958). J. Endocrinology. 16 : 378.

Edgar, D.G., and Asdell, S.A., (1960). J. Endocrinology. 21 : 315.

Edwards, J., (1936). J. Dairy. Res. 7 : 211.

Elliot, G.M., and Brumby, P.J., (1955). Nature. 176 : 350

Espe, D., (1941). Secretion of milk. Iowa State College Press. U.S.A.

Evans, J.S., and Dutt, R.H., Simpson, E.C., (1962). J. Anim. Sci. 21 : 804.

Folley, S.J., (1952). Marshall's Physiology of Reproduction. Ed. A.S. Parkes 3rd Edition p. 587.

Franklin, M.C., Briggs, P.K., McClymont, G.L., (1964). Rural Research in C.S.I.R.O. 48 : 22.

Fuller, J.G., and Kleinheins, F., (1904). 21st Ann. Rep. Wis. Agri. Exp. Sta.

Gardner, R.W., and Hogue, D.E., (1963). J. Anim. Sci. 22 : 410.

Gradner, R.W., and Hogue, D.E., (1963). J. Anim, Sci. 23 : 935.

Gerring, J.C., and Scott, J.D.J., (1955). N.Z. J. Agri. 91 : 581.

Geytenbeek, P.E., Goode, J.R., Schuller, W.J., (1962). Aust. Soc. Anim. Prod. 4 : 130.

Godden, W., and Puddy, C.A., (1935). J. Dairy Res. 6 : 307.

Grigorov, H., and Salichev, Y., (1962). XVI Int. Dairy. Cong. Vol A., Sec 1. : 258.

Greyling, C.P., and du Toit, J.J., (1954). Manual for Milk Testers. S. Afr. Dept. Agri. No. 319 : 41 - 50.

Guyer, P.Q., and Dyer, A.S., (1954). Missouri Agri. Exp. Stat. Res. Bull., No. 558.

Hammond, J., (1928). The Growth and Development of Mutton Qualities in Sheep. Edinburgh and London.

Hammond, J., (1940). Farm Animals. London : Arnold.

Hammond, J., (1957). Progress in the Physiology of Farm Animals. Butterworths Publication Vol. 3.

Hart, D.S., (1961). P.H.D. Thesis.

Hogue, D.E., Hansel, W., and Bratton, R.W., (1962). J. Anim. Sci. 21 : 625.

Hugo, W.J., (1952), Fmg. in S. Afr. 27 : 503.

Hunter, G.L., (1957). J. Agri. Sci. 48 : 36.

Lamond, D.R., and Bindon, B.M., (1962). J. Reprod. Fertility. 4 : 57.

Lamond, D.R., (1962a). Artifical Breeding in Sheep in Australia. Ed. by E.M. Roberts (Kensington) : University of New South Wales p. 42 - 47.

Lamond, D.R., (1962b). Aust. J. Agri. Res. 13 : 707.

Lamond, D.R., (1962d). Nature 19 No. 3 : 85, No. 4 : 57.

Lamond, D.R., (1963a). Aust. J. Agri. Res. 14 : 483.

Lamond, D.R., (1963b). Aust. Vet. J. 39 : 192.

Lamond, D.R., (1964). Anim. Breeding. Abst. 32 No. 3 : 269.

Lambourne, L.J., (1955). N.Z. J. Sci. Tech. 37 : 187.

Lang, D.R., (1964). Aust. Soc. Anim. Prod. 5 : 53.

Leather, J.H. (1961). Sex and Internal Secretion. Ed. by W.C. Young. London:- Bailliere, Tindall and Lox. Vol. 1.

Lishman, A.W., and Hunter, G.L., (1961). S. Afr. J. Agri. Sci. 4 : 35.

Lloyd Davies, H., (1958). Aust. Soc. Anim. Prod. 2 : 15.

Lloyd Davies, H., (1962). Aust. Soc. Anim. Prod. 4 :113.

Lloyd Davies, H., (1963). Aust. J. Agri. Res. 14 : 824.

Lush, J.L., (1937). Animal Breeding Plans. Collegiate Press, Inc. Ames, Iowa.

Mason, I.L., and Dassat, P., (1954). Anim. Breeding. Abst. 22 : 223.

Maynard, L.A., Loosli, J.K., (1962). Animal Nutrition. Fifth Edition McGraw - Hill Publication.

Maule, J.P., (1937). Emp. J. Exp. Agri. 5 : 298.

McCance, I., (1959). Aust. J. Agri. Res. 10 : 839.

McCance, I., and Alexander, G., (1959). Aust. J. Agri. Res. 10 : 699.

McMeekan, C.P., and Brumby, P.J., (1956). Nature 178 : 799.

Moore, R.W., (1962). Aust. Soc. Anim. Prod. 4 : 66.

Morley, F.H.W., Axelsen, A., and Bennett, D., (1964). Aust. Soc. Anim. Prod. 6 : 58.

Moule, G.R., Braden, A.W.H., and Lamond, D.R., (1963). Anim.Breeding. Abst. 31 No. 2 : 139.

Munro, Joan., (1955). J. Agri. Sci. 46 : 131.

Neidig, R.E., and Iddings, E.J., (1919). J. Agri. Res. 17 : 19.

O'Mary, C.C., Pope, A.L., and Casida, L.E., (1950). J. Anim. Sci. 9 : 499.

Owen, J.B., (1957). J. Agric. Sci. 48 : 387.

Pattie, W. A., and Trimmer, B., (1964). Aust. Soc. Anim. Prod. 5 : 156.

Peirce, A.W., (1934). Aust. J. Exp. Biol. Med. Sci. 12 : 7.

Phillips, R.W., (1937). Bull Mass. Agri. Exp. Stat. No. 339.

Radford, H.M., and Watson, R.H., (1957). Aust. J. Agri. Res. 8 : 460.

Ray, E.E., and Sidwell G.M., (1964). J. Anim. Sci. 23 : 989.

Rice, V.A., Andrews, F.N., Warwick, E.J., Legates, J.E., (1957). Breeding and Improvement of Farm Animals. McGraw - Hill Book Company Inc., p. 103.

Riches, J.H., and Watson, R.H., (1954). Aust. J. Agri. Res. 5 : 141.

Ricordeau, G., and Boccard, R., (1961). Ann. Zootechnie 10 : 113.

Riddet, W., and Campbell, I.L., (1943). N.Z. Soc. Anim. Prod. p. 86.

Ritzman, E.G., (1917). J. Agri. Res. 11 : 607.

Robinson, T.J., (1951). J. Agri. Sci. 41 : 6.

Robinson, T.J., (1956). Aust. J. Agri. Res. 7 : 194.

Robinson, T.J., (1958). Aust. J. Agri. Res. 9 : 693.

Robinson, T.J., (1960). N.Z. Soc. Anim. Prod. 20 : 45.

Robinson, T.J., (1961). J. Agri. Sci. 57 : 129.

Sanders, H.G., (1930). J. Agri. Sci. 20 : 145.

Shelton, M., (1964). J. Anim. Sci. 23 : 355.

Short, R.W., and Moore, N.W., (1959). J. Endocrinology 19 : 288.

Short, R.V., McDonald, M.F., and Rowson, L.E.A., (1963).
J. Endocrinology 26 : 155.

Slen, S.B., Clark, R.D., and Hironkaka, R., (1963). J. Anim. Sci. 43 : 16.

Southcott, W.H., Braden, A.W.H., and Moule, G.R., (1962).
Aust. J. Aust. Res. 13 : 901.

Stark, J.S., (1953). S. Afr. J. Sci. 49 : 245.

Terrill, C.E., and Hazel, C.N., (1947). Amer. Jour. Vet. Res. 8 : 66.

Thompson, W., and Thompson, A.M., (1953). Brit. J. Nutr. 7 : 263.

Thompson, W., and McDonald I., (1955). Brit. Soc. Anim. Prod : 38.

Thompson, D.G., and Schinckel, P.G., (1952). Emp. J. Exp. Agri. 20 : 77.

Turner, H.G., (1953). Aust. J. Agri. Res. 4 : 118.

Turner, H.G., (1955). Aust. J. Agri. Res. 6 : 145.

Turner, H.N., (1958). Aust. J. Agri. Res. 11 : 576.

Underwood, E.J., Shier, F.L., Davenport, J., (1944). J. Dep. Agric.
W. Aust. 21 : 135.

Volcani, R., Eyal, E., and Sharav, E., (1959). Anim. Breeding. Abst.
27 : 62.

Wallace, L.R., (1948). J. Agri. Sci. 38 : 93.

Wardrop, I.D., (1961). J. Agri. Sci. 57 : 335.

Wardrop, I.D., and Tribe, D.E., (1959). Past. Rev. 69 : 721.

Wright, G.M., and Stevens, P.G., (1952). N.Z. J. Sci. Tech. 34A : 430.

APPENDIX

TABLE I - Lamb Growth Rates (lbs)

(a) ROMNEY

	Weeks from birth											
Ewe No.	1	2	3	4	5	6	7	8	9	10	11	12
488	6.0	3.3	4.4	3.7	4.0	5.5	3.0	5.0	2.0	2.5	-	7.5
410	5.4	4.4	4.9	4.1	3.5	4.5	4.0	6.5	1.0	3.5	-	6.5
474	6.5	4.3	5.4	3.2	4.5	5.0	4.5	4.5	4.5	2.0	-	9.0
450	6.5	3.8	5.1	3.5	3.5	4.5	3.0	4.5	1.5	2.5	-	6.5
808	7.7	6.2	4.3	4.7	4.0	5.5	6.0	3.5	4.5	4.5	-	8.5
234	6.1	5.5	5.3	3.5	4.0	3.0	5.0	3.5	2.5	4.5	-	7.0
227	5.7	5.0	4.2	4.2	5.0	4.0	4.5	3.5	4.0	3.0	-	9.0
233	5.5	6.5	5.8	3.3	7.0	4.5	5.0	3.0	4.0	3.0	-	7.0
981	4.8	7.7	6.1	3.3	3.5	6.0	3.5	5.0	2.0	3.0	-	6.0
965	4.2	5.4	6.0	2.9	4.5	4.0	4.0	3.0	4.5	2.5	-	6.5
988	4.9	4.1	4.7	3.1	2.5	5.0	3.0	4.5	2.0	3.5	-	6.5
967	4.8	5.2	4.9	2.1	3.5	5.0	2.5	5.0	2.5	4.0	-	6.0
Mean	5.67	5.16	5.09	3.47	4.12	4.70	4.0	4.29	2.91	3.20	-	7.36

TABLE I

Lamb Growth Rates (lbs)

(b) CORRIEDALE

Ewe No.	Weeks from birth 1	2	3	4	5	6	7	8	9	10	11	12
412	4.9	4.3	4.6	3.5	3.5	5.0	3.0	5.0	2.0	3.0	-	8.0
477	3.8	4.2	5.7	3.9	5.0	6.5	4.0	6.0	3.5	3.5	-	11.0
498	6.2	3.5	4.7	3.2	3.5	5.5	3.5	6.5	2.0	4.0	-	10.5
430	5.0	4.4	6.0	3.5	4.0	5.5	4.0	5.0	4.0	3.0	-	8.5
984	5.1	4.0	4.9	3.3	4.0	5.0	4.0	4.5	2.5	3.5	-	8.0
868	1.6	5.6	6.1	4.2	5.0	6.0	3.5	5.0	3.5	5.5	-	7.0
976	4.7	5.4	5.7	3.8	4.5	5.0	4.0	4.5	4.0	3.5	-	7.5
969	3.0	5.7	6.4	4.4	3.0	7.5	4.5	4.5	3.5	5.0	-	6.5
228	6.7	5.1	5.3	4.2	5.0	4.0	4.5	2.5	5.5	3.5	-	9.5
232	6.8	4.1	3.6	3.7	4.0	4.0	4.5	4.0	3.0	2.0	-	8.5
231	6.9	6.1	5.5	5.0	6.0	5.0	4.0	3.5	3.5	4.0	-	8.5
Mean	4.97	4.76	5.31	3.88	4.31	5.36	3.95	4.63	3.36	3.68	-	8.50

TABLE I

Lamb Growth Rates (lbs)

(c) MERINO

Ewe No.	Weeks from birth 1	2	3	4	5	6	7	8	9	10	11	12
441	3.5	3.9	5.5	3.4	4.5	5.5	4.0	5.0	2.0	3.0	-	9.0
491	3.6	3.5	4.3	3.6	3.5	5.5	3.5	4.0	3.0	2.0	-	9.0
476	2.5	4.1	5.1	3.7	4.5	6.0	3.0	5.0	2.0	2.5	-	8.0
983	1.5	4.5	4.5	2.2	4.0	4.5	3.5	3.5	2.5	4.5	-	7.0
829	1.0	3.5	3.9	2.2	3.5	4.5	3.5	4.0	2.5	4.0	-	7.5
976	1.2	4.3	5.6	2.7	3.0	5.0	3.5	4.5	1.5	4.0	-	7.5
867	2.4	5.6	2.4	3.2	4.5	4.5	4.0	5.0	2.0	5.0	-	8.0
266	3.0	3.3	3.0	1.0	7.0	3.5	4.0	3.5	3.5	3.5	-	7.5
229	3.2	4.8	4.1	3.1	5.0	3.5	4.0	3.0	4.5	3.0	-	7.0
Mean	2.43	4.16	4.26	2.79	4.39	4.72	3.66	4.17	2.61	3.50	-	7.84

TABLE 2

Diurnal Milk Production (mls/4 hours)

				11.11.64						20.11.64			
Romney	Ewe No.	6p.m.	10 p.m.	2a.m.	6a.m.	10a.m.	2p.m.	6p.m.	10p.m.	2a.m.	6a.m.	10a.m.	2p.m.
	178	200	180	225	175	210	190	190	165	160	155	155	165
	184	245	280	275	220	245	255	240	230	225	215	205	205
	188	252	280	260	265	280	250	235	245	260	235	240	245
Corriedale	523	265	260	265	250	260	245	245	250	285	260	240	250
	686	270	290	330	290	290	285	250	250	250	275	260	220
	541	315	335	350	335	235	365	320	330	330	300	305	295
Merino	684	380	390	370	375	335	330	335	410	340	335	320	325
	230	320	355	300	295	305	295	305	260	265	250	230	240
	386	315	325	290	280	305	285	250	240	230	230	225	215
Average (ml/hr)		71.1	74.8	74.0	69.0	69.8	69.4	65.5	65.8	65.2	61.7	60.5	60.0

TABLE 2

Diurnal Milk Production (mls/4 hours)

	Ewe No.	4.12.64 6p.m.	10p.m.	2a.m.	6a.m.	10a.m.	2p.m.	Average 6p.m.	10p.m.	2a.m.	6a.m.	10a.m.	2p.m.
Romney	178	135	140	140	140	140	140	175	161	175	153	168	165
	184	205	190	220	215	215	215	230	233	240	216	221	225
	188	215	220	220	220	190	205	234	248	246	240	236	233
Corriedale	523	205	215	205	205	190	205	238	241	251	238	230	233
	686	195	185	190	185	185	190	238	241	256	250	245	231
	541	285	290	300	285	275	285	306	318	326	306	288	315
Merino	684	310	290	285	265	300	310	341	363	331	325	318	321
	230	210	200	195	195	190	205	278	271	253	246	241	346
	386	190	200	210	220	245	220	251	255	243	243	258	240
Average (ml/hr)		54.1	53.3	54.5	53.3	53.3	54.8	63.3	64.7	64.4	61.6	61.2	61.3

TABLE 3

Live Weight of Ewes

(a) ROMNEY

Ewe No.	Weights 13.4.64	1.5.64	18.5.64	25.6.64	2.10.64	6.1.65	Wool Wt. 2.10.64
176	138	134	141	145	136	125.5	11.8
177	163	159	167	167	160	129.5	12.3
178	152	147	146	150	151		10.1
179	141	139	140	141	140	120.0	10.3
181	155	150	151	152	140	121.0	14.5
182	136	129	137	134	135	115.0	12.5
183	126	115	119	123	131	110.0	9.8
184	143	136	142	142	138		10.9
185	141	134	144	143	140		14.1
186	154	145	150	152	136	130.0	11.9
187	144	141	150	145	161		10.1
188	143	132	143	143	142		12.6
189	134	129	137	141	133	127.0	11.7
190	151	143	154	150	146	108.0	11.6
191	143	141	146	148	151	148.0	10.2
192	169	164	168	168	164		9.8
193	134	130	137	142	144	120.5	9.6
194	140	130	130	128	121	115.5	10.3
Mean	144.8	138.7	144.5	145.2	142.6	122.5	11.3

TABLE 3

Live Weight of Ewes

(b) CORRIEDALE

	Weights					Wool Wt.
Ewe No.	1.5.64	18.5.64	25.6.64	2.10.64	6.1.65	2.10.64
501	124	131	131	128	119.5	10.1
506	121	124	125	119	112.5	9.8
514	139	144	141	128	118.0	12.3
523	119	127	127	124		11.2
537	113	123	124	126		12.6
538	134	140	142	138		9.7
540	121	131	122	120		12.8
542	124	121	125	128	130.5	11.0
541	132	131	136	131		11.2
551	134	139	141	136	135.0	9.7
571	119	123	122	118	117.0	11.2
572	120	123	125	115	94.0	10.9
573	137	146	142	139	131.5	10.6
568	137	135	135	129	125.5	13.6
576	137	141	137	127		10.4
652	102	107	111	104		10.1
685	124	131	129	124		10.1
686	131	133	141	131		12.5
687	131	136	137	133	120.0	9.9
700	127	133	130	126	115.0	11.3
Mean	126.3	130.9	131.1	126.2	119.8	11.05

TABLE 3

Live Weight of Ewes

(c) MERINO

Ewe No.	1.5.64	18.5.64	Weights 25.6.64	2.10.64	6.1.65	Wool Wt. 2.10.64
39	90	106	106	119	100.5	10.8
42	86	98	98	104	98.5	10.2
92	104	111	117	114		14.3
50	86	105	105	110		14.5
137	99	112	115	122		10.7
138	92	102	102	103		11.2
144	101	109	104	118	117.5	10.9
145	89	105	106	116	105.5	13.6
147	112	114	117	116		11.1
148	104	119	121	133	114.5	12.6
189	100	112	114	120		11.4
191	113	121	123	120		10.0
192	81	96	98	106	98.5	10.1
217	103	115	118	117		10.9
218	100	109	112	118	113.5	10.7
231	101	120	126	133	122.0	12.2
316	89	99	104	114	103.0	10.8
326	97	109	108	115		10.8
371	83	96	98	105		8.6
386	105	113	118	122		10.0
400	78	88	88	95		9.6
421	88	99	101	107		8.9
435	106	117	118	125		8.8
490	85	97	97	101		11.6
684	117	126	132	136		10.5
Mean	96.4	107.9	109.8	115.5	108.1	10.67

TABLE 4

Total Solids

(a) ROMNEY

Weeks Lactation

Ewe No.	1	2	3	4	5	6	7	8	9	10
176	18.31	17.31	16.16	18.01	17.05	17.38	18.88	20.30	18.40	19.77
189	18.90	17.68	16.47	16.72	16.00	16.12	16.38	15.86	16.20	17.00
191	17.23	17.48	17.93	17.67	16.87	16.97	17.73	16.97	17.18	19.16
194	21.62	20.20	19.56	20.08	18.81	21.01	20.80	20.98	21.27	18.51
177	20.60	18.90	17.91	18.98	17.52	17.83	20.02	18.83	18.10	19.08
181	20.48	17.92	17.98	18.27	19.26	18.51	18.51	18.25	18.51	19.12
182	17.35	16.95	14.73	16.03	18.18	17.26	15.73	17.67	17.02	18.18
193	18.27	17.40	16.81	17.30	17.95	17.23	17.17	17.27	17.01	17.91
179	20.72	18.71	22.12	20.01	20.52	18.60	19.20	19.67	19.00	18.85
183	18.65	18.00	18.87	18.65	18.75	18.48	18.62	18.45	20.35	18.81
186	17.75	18.46	22.92	21.85	21.72	20.65	21.20	20.22	20.20	21.03
190	19.30	18.55	21.45	18.23	18.43	17.95	18.07	17.68	18.63	20.77
Mean	19.09	18.13	18.57	18.48	18.50	18.16	18.52	18.51	18.48	19.01

TABLE 4

Total Solids

(b) CORRIEDALE

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10
501	22.92	19.35	17.78	18.96	18.65	16.92	18.51	18.23	17.78	18.47
551	19.87	17.56	16.72	17.07	17.25	16.45	15.72	14.90	15.43	16.77
571	16.57	16.85	16.10	17.08	15.35	15.58	16.96	15.71	15.17	16.68
573	19.67	18.12	16.73	19.00	18.67	18.26	18.72	16.97	16.68	17.75
514	18.32	18.52	18.07	17.86	17.68	17.98	18.30	18.47	17.73	18.17
700	23.82	18.83	16.86	17.45	18.21	17.48	17.68	17.92	17.63	17.66
542	17.50	16.98	16.25	17.16	17.48	17.72	16.45	16.71	16.86	16.75
687	18.46	17.35	16.55	17.23	16.13	15.10	15.42	15.65	15.48	15.16
506	20.35	17.70	19.22	19.37	18.40	18.13	17.47	17.36	17.88	17.60
568	21.32	18.55	20.27	18.67	18.55	17.41	17.47	17.45	17.87	17.53
572	16.30	16.98	17.45	16.57	16.47	16.57	19.71	16.85	16.37	16.22
Mean	19.55	17.89	17.45	17.85	17.53	17.05	17.49	16.92	16.80	17.16

TABLE 4

Total Solids

(c) MERINO

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10
144	18.50	17.58	16.72	16.27	15.50	15.73	16.17	15.51	15.40	15.88
148	21.20	20.13	17.91	17.88	18.00	18.53	17.41	17.40	18.40	19.50
218	19.65	18.56	16.83	16.82	16.87	16.02	16.71	16.28	16.01	17.26
39	21.70	16.61	14.57	15.52	15.01	14.98	14.73	15.06	15.07	15.46
192	21.40	17.75	16.61	17.82	17.07	18.06	18.17	17.72	17.43	17.86
145	21.15	18.63	16.73	17.82	18.67	17.75	16.63	17.10	16.87	17.90
869	22.23	18.25	17.66	19.45	19.12	18.22	18.47	18.53	18.21	17.90
316	20.53	17.70	16.97	18.07	21.47	16.76	17.82	16.77	17.30	21.31
42	19.32	17.82	18.87	19.32	18.66	18.91	18.42	18.36	18.36	19.93
Mean	20.63	18.11	16.98	17.66	17.81	17.21	17.17	16.97	17.00	18.11

TABLE 5

Solids - Not - Fat

(a) ROMNEY

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10
176	10.96	11.16	10.41	11.16	10.55	10.33	10.33	10.20	9.50	10.07
189	10.77	10.63	10.07	10.52	10.00	10.12	10.33	9.91	9.30	9.90
191	10.98	11.13	10.28	11.27	10.47	10.57	10.48	10.71	9.33	10.21
194	10.62	10.90	10.41	11.23	10.86	10.66	10.90	10.53	10.07	9.76
177	9.90	10.40	10.16	10.53	10.52	10.18	10.02	9.58	9.60	9.83
181	9.83	10.32	9.93	10.07	10.11	9.56	9.56	9.15	9.16	9.22
182	10.00	10.45	9.58	10.18	10.33	9.91	9.38	9.07	9.02	9.33
193	10.07	10.30	9.86	10.20	10.15	9.98	9.87	9.67	8.86	9.76
179	10.37	9.96	10.12	10.46	9.92	9.70	9.80	9.67	9.30	9.35
183	10.95	10.70	10.67	10.75	10.41	10.23	10.22	9.95	9.45	10.06
186	10.80	10.71	10.72	10.75	10.32	10.35	10.20	10.02	9.70	10.18
190	10.85	10.45	9.95	10.18	9.98	10.15	9.77	9.63	9.38	9.17
Mean	10.50	10.59	10.18	10.60	10.30	10.14	10.07	9.84	9.38	9.73

TABLE 5

Solids - Not - Fat

(b) CORRIEDALE

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10
551	10.87	10.91	10.12	10.67	10.05	10.25	10.22	9.80	9.38	10.17
571	10.57	10.85	10.20	10.93	9.85	10.03	10.21	9.56	8.97	9.83
573	10.77	10.52	9.88	10.50	9.77	9.91	9.92	9.77	9.03	9.65
514	9.92	10.32	10.07	10.31	10.43	10.13	9.90	9.67	9.48	9.77
700	10.82	10.38	10.31	10.15	10.66	10.23	10.13	9.72	9.58	10.11
542	10.40	10.53	10.15	10.41	10.53	10.32	9.95	9.66	9.61	10.05
687	10.31	10.25	9.85	10.18	10.18	10.20	9.82	9.55	9.43	9.81
506	10.45	10.00	9.82	10.37	9.90	9.98	9.77	9.41	9.43	9.50
568	10.72	10.05	9.67	10.27	9.75	9.66	9.57	9.35	9.27	9.28
572	10.00	9.93	9.75	9.97	9.67	9.97	10.56	9.25	9.37	9.62
501	10.92	11.05	10.33	11.01	10.35	10.32	10.46	9.98	9.33	10.17
Mean	10.52	10.43	10.01	10.43	10.10	10.09	10.04	9.61	9.35	9.81

TABLE 5

Solids - Not - Fat

(c) MERINO

Ewe No.	Weeks lactation 1	2	3	4	5	6	7	8	9	10
218	10.85	10.91	10.38	10.92	10.37	10.12	10.36	10.03	9.36	10.11
39	9.80	10.26	9.77	10.12	10.26	9.83	9.68	9.31	9.27	9.71
192	9.50	10.45	9.86	10.22	10.27	10.31	10.17	9.92	9.78	10.11
145	9.65	10.18	10.08	10.32	10.67	11.05	10.18	10.00	9.87	10.40
869	10.18	10.55	10.31	10.35	10.52	10.22	9.97	9.78	9.66	9.80
316	11.28	10.20	9.97	10.27	9.67	9.81	10.02	9.37	8.80	10.06
42	10.72	10.42	10.07	10.52	10.11	10.36	10.02	9.81	9.81	9.88
144	10.90	10.73	10.32	10.67	10.30	9.88	10.17	9.96	9.30	10.03
148	10.30	11.08	9.96	10.43	10.10	9.68	10.06	9.70	9.30	9.80
Mean	10.35	10.53	10.08	10.42	10.25	10.14	10.07	9.76	9.46	9.98