INCREASED EWE REPRODUCTION: 200% LAMBS

INTRODUCTION

N.M. FOGARTY*

Ewe reproductive rates in Australia are very low. Average lamb markings are less than 80% in most states. Specialist lamb producers in NSW and Victoria have higher reproductive rates, although only a very small proportion turn off 130% of lambs. The efficiency of prime lamb production needs to be improved if it is to remain viable and compete with other enterprises for scarce resources and expensive land. Sheep offer great potential for increasing productivity and efficiency because of their capacity to double reproductive rate, largely through exploitation of breed diversity and genetic variation. Genotypes are currently available in Australia that have the potential to produce 200% lambs per ewe per year. The challenge is not only to utilise and further select these genotypes, but to develop commercial management systems to ensure optimum ewe reproduction and maximum lamb survival and growth.

This contract examines the efficiency and methods of attaining increased ewe reproduction, the scope for selection, the effects of nutrition and the management systems required for commercial attainment of a 200% lambing rate.

IMPORTANCE OF EWE REPRODUCTION IN THE EFFICIENCY OF LAMB PRODUCTION

D.G. HALL*

Increasing ewe reproduction increases both biological and economic efficiency of lamb production. Additional benefits include leaner carcasses from twins than singles, higher selection pressure in self replacing flocks and the possibility of rapid increases in flock size after droughts or price slumps.

Large (1970) showed biological efficiency was greatest from small breeds of ewes producing large litters crossed with a large breed of ram. Three lambings in two years (accelerated lambing) with a litter size of two was 2.1 times more efficient than one lambing/year (annual lambing) with a litter size of one. Genetically increasing ewe reproductive rate by 0.2 increases biological efficiency by 10%, and efficiency continues to increase up to four lambs/ewe/year (Dickerson 1978). The total life cycle biological efficiency of the ewe is only 20-30% of that for poultry, rabbit and pig (Dickerson 1978). This is because yearly maintenance requirements of the ewe are spread over only one or two progeny, less efficient use of forage energy by sheep compared to concentrate energy use by monogastrics, relatively high fat deposition and relatively low slaughter weights of lambs and, within a whole farm system, the retention of 20-30% of all young ewes as replacement dams.

While biological or energetic efficiency are important in assessing maximum efficiency levels, they are of little value to the lamb producer, who is principally concerned with profitability. However, energetic efficiency will give an indication of economic efficiency, as energy input into a lambing enterprise is a major cost and the producer is paid partly on his energy output. Increased ewe reproduction results in more lambs from a similar number of ewes and area, or the same number of lambs from less ewes and area, and should result in increased profitability.

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Australian economic studies of prime lamb production are limited to 1.4 or less lambs/ewe/year. These studies (e.g. Thatcher 1977; B. Paterson, pers. comm.; D.T. Vere and D.C. Harris, pers. comm.) indicate profitability increases 5-15% for each extra 0.1 lambs between 1.0 and 1.4 lambs/ewe/year. Overseas studies have shown profitability increases up to at least 2.5 lambs/ewe using accelerated lambing systems (Anon. 1977), although lamb prices are considerably higher than in Australia. There is a need to examine economic benefits of high lamb output in a farm situation in Australia using appropriate genotypes and management.

COMPONENTS OF INCREASED EWE EFFICIENCY

There are various methods, both genetic and management, of increasing lamb output. Many depend on the following ewe components:

Fertility
Fecundity
Lamb survival
Number of lambings per lifetime

These components are not independent. For example, joining ewe lambs will result in competition for limited feed resources with older ewes, which may limit their potential, or increasing frequency of lambing may lower fertility due to post-partum anoestrus and lowered live weights.

Fertility of non-lactating autumn joined adult ewes of adequate liveweight should be close to 100%. It may be considerably lower in other seasons, particularly if ewes are lactating and in breeds which have a short breeding season. Fertility is also reduced by inbreeding, ram problems and in young and very old ewes.

Litter size varies greatly between breeds, as well as with seasons, age and nutrition. Some breeds, such as the Romanov, Finn and Booroola Merino, have litter sizes well over 2.0, while other Merinos generally have litter sizes below 1.3. Breeds used for prime lamb production, such as the Border Leicester and Dorset, have intermediate litter sizes.

Lamb survival in Australia is approximately 80%. The level varies with breeds, nutrition, gestation length and environmental conditions. Increasing lambing rates may decrease survival. Lamb survival of the highly fecund Booroola Merinos, mostly lambing indoors, has been 0.90, 0.77, 0.55 and 0.37 for litter sizes of one, two, three and four respectively (Piper and Bindon 1982). Paddock lamb survival for adult Hyfer ewes with corresponding litter sizes in 1981-83 has been 0.86, 0.84, 0.64 and 0.39 (D.G. Hall and N.M. Fogarty unpublished data). Despite the low survival of triplets and quads, weaning rates are still increased by utilising highly fecund breeds. When contemplating increased lambing frequency, seasonal effects of hypothermia, hyperthermia and predation on lamb survival must be considered.

Increasing the number of lambings per lifetime can be achieved by joining ewe lambs, retaining and joining older ewes and increasing the frequency of lambing. Production from ewe lambs depends on breed, liveweight and age, but is generally lower than that from older sheep. Joining Border Leicester x Merino ewes at seven to eleven months of age resulted in 20-70% of ewes lambing with a maximum litter size of 1.58 (McGuirk et al. 1968; Cannon and Bath 1969; Tyrrell et al. 1974). Aged ewes have lowered weaning rates (Turner 1969) but no Australian studies have examined production from old prime lamb dams.

Theoretically it is possible to lamb twice each year but 8-monthly lambing is more feasible. Choice of a ewe breed with an extended breeding season is critical. . In Australia the Dorset and Merino are most suited to 8-monthly lambing. Post-partum anoestrus complicates 8-monthly lambings and is usually longer in spring than other seasons (Hulet 1978). Hormones are often used to overcome anoestrus in accelerated lambing systems. Overseas systems often involve indoor lambings, artificial rearing and/or early weaning. Production levels of 3.5 lambs/ewe/year from Finn x Dorset Horn ewes have been achieved in Britain (Robinson and Orskov 1975). Australian results for accelerated lambing are much lower than overseas reports (Bourke 1964; Woolaston 1975; P.E. Geytenbeek, unpublished data), but paddock lambings have been used and high fecundity genotypes have not been available.

METHODS OF ACHIEVING 200% LAMBS MARKETED

Breed utilisation

Genetic means of increasing lamb output per ewe involve utilising highly . fecund breeds and crosses and/or selection within breeds. The Booroola has an average litter size of 2.3 (Piper and Bindon 1982) and Booroola cross ewes have increased weaning rates by up to 50% (Piper et al. 1982). However, Booroola x Collinsville ewes weaned 0.22 fewer lambs than Border Leicester x Collinsville ewes (McGuirk et al. 1982), and Booroola x Dorset ewes have weaned the same number of lambs (1.4) as Trangie Fertility x Dorset ewes (D.G. Hall and N.M. Fogarty, unpublished data). Further evaluations will determine the merit of the Booroola to prime lamb production.

Border Leicester ewes have autumn ovulation rates of at least 2.0 (D.G. Hall, unpublished data) but low weaning rates because of a high proportion of dry ewes and low lamb survival (Fogarty et al. 1976). Border Leicester crosses have generally achieved the highest lamb output in Australia (e.g. Fogarty 1978; Atkins 1980a; McGuirk et al. 1982) with maximum production of about 1.6 lambs born/ewe joined and 1.3 lambs weaned/ewe joined. Joinings more than once/year with Border Leicester x Merino ewes to increase lamb output have been unsuccessful (Bourke 1964; Woolaston 1975) because of post-partum and spring anoestrus. The Coopworth, which is 50% Border Leicester, is a means of utilising the high Border Leicester ovulation rates for annuallambings.

Development of a new prime lamb breed suited to intensive lamb production is being undertaken by the N.S.W. Department of Agriculture (Hall and Fogarty 1982). The breed, called 'Hyfer', combines Poll Dorset, Booroola Merino and Trangie Fertility Merino genotypes to achieve high lambing percentages and year round joining ability. The objective of the breeding programme is a self replacing breed capable of a lamb marketing percentage of 200%/year and successful joining throughout the year. Adult ewes (Dorset x Booroola or Dorset x Trangie Fertility) have averaged 1.82 lambs born and 1.44 lambs weaned from autumn joinings. up to 73% of the adult ewes have exhibited post-partum oestrus in the spring within eight months of the start of joining. These results indicate that with accelerated lambings and selection the goal of two lambs/ewe/year is feasible.

Selection within existing breeds for higher lamb output is likely to be slow because of the low heritability of reproduction traits, relatively long generation interval and the tiered structure of prime lamb production systems. Potential for improvement involves combining appropriate genotypes accompanied by continued selection.

Technological

(i) Light Daylength controls the breeding season of sheep. Artificial daylength patterns have been used to achieve 1.86 lambs/ewe/year under 8-monthly lambings (Ducker and Bowman 1972) and to increase lambs born/ewe joined in early-mid summer from 1.32 to 1.62 (Dunstan 1977). The administration of melatonin to ewes has a similar effect as shortening daylength (E.A. Dunstan, pers. comm.).

(ii) Immunisation Immunisation of Merino ewes against oestrone, androstenedione or testosterone results in a 20% increase in lambs born through extra twins from an autumn joining (Cox et al. 1982), and further development of this procedure may increase lambing rates of crossbred ewes.

(iii) Controlled breeding Hormones have been used to manipulateoestrus and ovulation rate to increasethe frequency of lambing and litter size. This has resulted in 1.76 viable lambs/ewe/year from Border Leicester x Merino ewes (Robinson 1980).

(iv) Ram induced ovulation Rams can induce ewes to ovulate, and the resulting ovulation rate is higher than spontaneously ovulating flockmates (Cognie et al. 1980). This ram effect, together withprogesterone priming and prior isolation of ewes from rams, has increased lambs born/ewe joined from 1.03 to 1.21 for spring joined Border Leicester x Merino ewes (Charnley 1982).

Many of the technological procedures for increasing ewe output result in gains of 10-40%. To increase lamb output to 200%/ewe/year, appropriate genotypes and more frequent joinings are necessary. The Hyfer breed development programme is well on the way to achieving this objective.

SELECTION FOR EWE REPRODUCTION AND LAMB PRODUCTION

N.M. FOGARTY

Selection of animals to be retained in the flock has two effects. Firstly, subsequent flock performance is affected by the lifetime production of retained animals, i.e. current flock performance. Secondly, the long-term flock performance in future generations is affected. Gains in current flock performance from selection are largely determined by repeatability of the trait under selection. Repeatability estimates are generally low which indicates environmental factors greatly affect reproductive traits, and gains in performance of the current flock will be moderate. Gains from selection in the future flock are determined by the levels of heritability, phenotypic variation, selection intensity and'generation interval. Heritability estimates for the various reproductive traits are low, but are generally doubled if mean performance over two or more joinings is used. Phenotypic variation for the traits is generally high. The selection intensity that can be applied and the generation interval depend on the levelofreproduction and age structure in the flock.

DEMONSTRATED RESPONSE

Numerous experiments selecting for reproductive traits have been initiated, although few have been analysed in detail. The Trangie Fertility Merino flock, after ten years of selection of twin ewes and rams and culling ewes failing to rear a lamb at any lambing,, has higher fertility, lambs born and lambs weaned/ ewe joined than the unselected control flock; 92 v 78%, 1.47 v 1.10 and 1.24 v 0.91 respectively (Atkins 1980b). Approximately half the differences are genetic and the remainder due to current flock selection. Lambs born/ewe joined following divergent selection for high (T) and low (0) twinning in the Merino, and selection in the Booroola (B) were 1.36, 1.11 and 2.10 for the T, 0 and B flocks respectively (Turner 1978). Initial differences contributed 76% of the superiority of T over 0 and 57% of B over 0 withacontinuing divergence of .02 and .11 lambs born/ewe/year respectively. Selection of Romney flocks in New Zealand for high (H) and low (L) lambing rate, with a control (C), has resulted in fertility of 93, 89 and 84% and litter size of 1.62, 1.22 and 1.13 for H, C and L flocks respectively (Clarke 1972). The average annual increase in H over C has been .0175 lambs born and .015 lambs marked/ewe joined.

PROBLEMS IN SELECTION FOR REPRODUCTION

Reproductive traits are only directly expressed by ewes whereas much greater selection intensity can be applied on the ram side. Hence selection of ramstoincrease reproduction in ewe progeny mustuseinformation from relatives, usually dams, or indirect traits. In most situations, progeny testing of rams increases the generation interval substantially becauserepeated measures of ewe progeny are also usually required. Some components of reproductionaresubject to considerable environmental variation, e.g. survival of lambs born overashort period of the lambing may be reduced by temporarily severe weather conditions. Expression of many traits is binomial or a relatively few discreet levels, although the underlying variation may be normally distributed. Hence accumulation of two or three records of performance is desirable to improve accuracy of estimation of breeding values.

It must also be emphasised that selection is not a substitute for good management. At higher base levels of reproduction, expected genetic response is more rapid because more intense selection can be applied. Under good management and environments, genetic gains from selection will be more fully expressed phenotypically with higher levels of flock performance.

COMPONENTS

Ewe reproduction and lamb production are complex traits and can be defined as number or weight of lamb weaned/ewe joined. Fertility, litter size (largely determined by ovulation rate), lamb survival and lamb growth are major components. In intensive lamb production systems, fertility may be affected by age at puberty and length of breeding season (including post-partum anoestrus). Past selection recommendations for increasing ewe reproduction have emphasised litter size. However, recent evidence suggests genetic variation exists for all components and they should be included in selection (Piper 1982). The relative emphasis placed on each component in selection will vary with the production system and mean performance level of each component. Under an accelerated lambing system and with relatively high lamb mortality, component weightings for indices of both weight and number of lambs weaned/ewe joined were highest for lamb survival (Fogarty et al. 1982). Index weightings were also higher for fertility than litter size. Fertility and extended breeding season would be expected to be more important components in an 8-monthly lambing system than in an annual spring lambing system. In the latter, breeding season is not limiting and fertility is close to its upper limit of 100%.

There is considerable between-breed variation in ovulation rate, ranging from one to over three. Estimates of heritability range from .05 ± .07 in the Merino (Piper et al. 1980) to .45 ± .07 in the Finn and .58 ± .28 in the Galway (Hanrahan 1982). Selection for ovulation rate has been successful in Finn sheep with a difference of over one ovulation between high and low lines and a realised heritability estimate of .50 ± .07 (Hanrahan 1982). Estimates of heritability for ovulation rate are higher than those for litter size where both have been measured in the same flock. In his extensive review, Hanrahan (1982) concluded that responses to selection for litter size were largely due to increased ovulation rate. The contribution of embryo survival was considered minor, despite evidence of breed variation.

Genetic variation for lamb survival is low. Average heritability estimates, reviewed by Cundiff et al. (1982), are .08 for lamb survival expressed as a trait of the ewe, i.e. maternal rearing ability, and .04 for lambs. Inclusion of maternal rearing ability in selection for increased reproduction was advocated by Piper (1982) and results achieved in commercial and research flocks are encouraging (McGuirk 1982).

Lifetime reproduction of ewes is affected by age at first lambing and by their frequency of lambing. Many breeds reach puberty in their first breeding season and lamb at one year of age. Baker and Morris (1982) concluded that age and weight at puberty were moderately heritable and would respondto selection. However, age at puberty would have to be reduced sufficiently to allow breeding in the first year to affect lifetime reproduction and this would be difficult in some breeds (Piper 1982). Estimates of heritability for fertility are low for ewes, but higher for associated traits in rams (Baker and Morris 1982).

There is considerable between-breed variation in length of the breeding season and post-partum anoestrus interval. These traits are affected by gestation, lactation, season and presence of rams. Few estimates of heritability exist for these traits, but there is evidence of genetic variation (Ricordeau 1982).

INDIRECT SELECTION

More rapid response to selection could be achieved by a better understanding of the relationships between components of reproduction and indirect selection traits that can be measured early in both sexes and are genetically correlated with reproductive performance. Walkley and Smith (1980) theoretically explored expected response from indirect selection using three types of physiological traits, male sex-limited (e.g. testis size), female sex-limited (e.g. ovulation rate) and traits measurable in both sexes (e.g. hormone levels) compared with direct selection for litter size and combined selection. Their results show there is usually scope for improvement in the rate of response with combined selection, which can be large if the heritability of the physiological trait and its genetic correlation with litter size are high. They conclude by cautioning that realised response depends on the levelofthevarious parameters, and lament the dearth of reliable estimates, especially for genetic correlations.

Various indirect traits have been advocated in selection for increasing reproduction (Land et al. 1982). The basis for this is the presumed common genetic control of underlying physiological parameters and the phenotypic expression of reproduction. Selection for early testis growth, adjusted for live weight, resulted in earlier onset of the breeding season rather than anincrease in ovulation rate (Land et al. 1982). It seems feasible that physiological traits may be found that are highly correlated with certain production traits, such as ovulation rate. However, the search for such traits over the last ten years has beenlargely unsuccessful. The chance of a single physiological trait being highly genetically correlated with a complex reproductive trait, such as weight of lamb weaned/ewe joined, seems remote. Such a complex trait encompasses the diverse components of ovulation rate, embryo survival, maternal rearing ability and lamb growth, which are under very different physiological control.

SELECTION UNDER 8-MONTHLY LAMBINGS

The selection objective of increased weight of lamb weaned/ewe joined/ year, encompasses all the components of lamb production; namely fertility, including seasonal breeding and post-partum joining ability, litter size, lamb survival and lamb growth. Under 8-monthly lambings at least one joining in each two year cycle will occur whenoestrous activity is reduced. Depending on the breeds involved, one or both of the other two joinings in the cycle may occur at times of sub-optimaloestrous activity and ovulation rate (Fogarty1981). Increased weight of lamb weaned/ewe/joined/year can be the selection trait for ewes, but performance of female relatives or indirect traits must be used to select rams. Accuracy of selection can be improved by incorporation of performance of various relatives. For ewes with three lambing records, inclusion of dam and paternal half-sib performance improved accuracy by 12% and a further increase of 8% with one offspring record (Martin and Smith 1980).

Under 8-monthly lambing systems, expected ewe performance and variation will vary with lambing season. Actual performance needs to be standardised to compare ewes with different lambing histories. Standardisation can take the form:

$$Y_{ij} = (X_{ij} - \bar{X}_{.j})/S_j$$

where Y_{ij} is the standardised weight of lamb weaned (deviation) for the ith ewe in the jth season.

X_{ij} is the actual performance of the ith ewe in the jth season.

$X_{ij} = \Sigma Z_{ijk}$ where Z_{ijk} is the weaning weight (adjusted to a constant age and age of dam) of the kth lamb.

$\bar{X}_{.j}$ is the mean performance of all ewes in the jth season.

S_j is the standard deviation for performance in the jth season.

PREDICTED RESPONSE TO SELECTION

The Hyfer is being developed as a self-replacing breed for intensive lamb production with a high lambing rate and extended breeding season. The selection phase entails joining ewes at 8-monthly intervals in a two year cycle. Ewes are selected into a nucleus flock to breed replacements on the basis of weight of lamb weaned over the three joinings. Rams are selected on the basis of their dam's cumulated performance. Sire lines are maintainedtoreducetherate of inbreeding. Predicted response to selection for weight of lamb weaned/ewe/year, assuming the following parameters (Fogarty 1981): heritability (over three lambings), $h^2 = .15$; coefficient of variation, CV = 40%; proportion selected, ewes .5 ($i = .8$), rams .05 ($i = 1.9$); generation interval, ewes 4.5, rams 1.5 ($L = 3$); is: Response = $i.h^2.CV/L$ = $[(.8 \times .5 + 1.9 \times .5).15 \times 40]/3 = 1.75\%$/year.

EWE NUTRITION TO INCREASE FECUNDITY AND LAMB SURVIVAL

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Late summer or autumn mating, which favours a high lambing percentage, is common for ewe flocks grazing on improved pastures in south-eastern Australia. These flocks lamb in late winter and early spring when the risk of losses from exposure amongst new-born lambs is high. Moreover, the nutritional demands of pregnant and lactating ewes reach a maximumatatime when the winter shortage of pasture is most severe. In this paper, the possibility of improving ewe fecundity and lamb survival through better nutrition is discussed using information from experiments with Merino and Border Leicester x Merino ewes grazing at a range of stocking rates on perennial pastures on the southern tablelands of New South Wales.

THE EFFECT OF NUTRITION ON THE FECUNDITY OF EWES

Positive relationships exist between mean flock weight at joining and lambing percentage for flocks mated in autumn when the effects of photoperiod on the reproductive system are maximal (Morley et al. 1978; Donnelly et al. 1982). These authors emphasised the distinction to be made between that component of mean flock weight which is associated with nutritional plane and that which is associated with skeletal size because of maturity or genetic differen-

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ces. For both Merino and crossbred flocks, the average increase in the number of lambs born was about two per 100 ewes joined, for each additional kg in weight at joining (Donnelly et al. 1982). The response was linear overtherange of weights likely to be found for ewes of these genotypes in commercial flocks and was not restricted to gains in weight made in the weeks immediately prior to joining. Indeed, for autumn joined ewes, responses to weight gains that are independent of weight at joining seem rare (Morley et al. 1978), although gains near mating could be important for ewes joined outsidethepeakbreeding period.

The level of fecundity in a ewe flock may vary from year to year independently of weight or weight changes near joining, although the response in lambing percentage within years is remarkably consistent (Donnelly et al. 1982). The variation in fecundity between years may be due, in part, to nutritional stress experienced in the previous winter and spring sincethis has been shown to reduce ovulation rates in summer (Fletcher 1974).

The correlation between Iiveweight and lambing percentage reflects the effects of nutrition on both the weight of the ewe and on the size of the pool of circulating metabolites which may stimulate the reproductive system. Although this is at present only poorly understood, a direct causative relationship between weight and reproduction is not implied and a large ewe in poor condition is not expected to perform as well as a small-framed ewe of the same weight but in good condition. Therefore, if differences among ewe liveweights reflect size of frame rather than nutritional effects, the full response to improved nutrition is possible only if the weight of the whole flock is increased. If only the lighter ewes in a flock are given supplementary feed, only that portion of the flock will respond. The heavier animals may be just as undernourished but this is concealed because they have bigger frames.

Another point that affects the decision to exploit the relationship between liveweight and fecundity is that ewes grazing on improved pastures at commercial stocking rates are usually in good enough condition at mating to produce one lamb. The benefits of higher fecundity may be limited by lower neo-natal survival in dangerously chilling conditions often experienced during lambing in late winter.

THE EFFECT OF PRE-NATAL NUTRITION ON LAMB SURVIVAL

Autumn rainfall is erratic throughout most of south-eastern Australia, contributing to the unreliability of food supplies in autumn as well as winter when pasture growth is severely limited by low temperatures. Unless ewes have adequate reserves of energy, low birth weights, particularly for twin lambs, are likely, thus increasing the risk of losses from exposure.

These losses are highly correlated with increasing levels of environmental chill which can be estimated as a single index from mean daily temperature, wind speed and rainfall (Donnelly 1984). The distribution of chill indices calculated from 20 years of meteorological records at Ginninderra Experiment Station during the colder months is shown in Table 1. Expected losses amongst twin lambs during the first three days of life in response to different levels of chill are shown in Table 2. If the level of chill exceeds 1000 $kJ/m^2/h$ then losses from exposure in excess of 30% can be expected for twin lambs born to Merino ewes. Therefore, shifting the lambing date within the period June through to September is unlikely to have much influence on lamb mortality. Losses are lower for single lambs or for lambs born to crossbred ewes.

Losses are also lower if the ewes are heavier at lambing (Table 2), although the reduction is of practical significance only if the probability of mortality from exposure is high. In mild weather the probability of death from exposure is low so reductions in mortality associated with high maternal weight are unlikely to be important.

Table 1 Monthly distribution of chill index (kJ/m²/h) at Ginninderra.

	April	May	June	July	August	Sept.	Oct.
Maximum	1138	1146	1251	1217	1267	1204	1213
Upper quartile	912	970	995	1017	1008	992	945
Median	870	937	971	987	983	953	907
Mean	882	937	974	994	983	953	912

Table 2 Probability of death within 3 days for twin lambs born to Merino and Crossbred ewes of varying maternal (conceptus free) weight.

Merino					Crossbred				
	Chill index (kJ/m²/h)					Chill index (kJ/m²/h)			
Maternal weight(kg)	800	900	1000	1100	Maternal weight(kg)	800	900	1000	1100
35	.09	.20	.41	.65	45	.06	.12	.23	.40
45	.06	.15	.32	.55	55	.04	.09	.19	.34
55	.04	.11	.24	.46	65	.03	.07	.15	.28

THE VALUE OF IMPROVED NUTRITION

Although there is little doubt that increasing the weight of ewes through better nutrition leads to more lambs and reduced lamb mortality in cold conditions, it seems unlikely that the responses are large enough to be routinely useful if food supplements have to be purchased. A 40kg ewe requires about 40MJ of metabolisable energy or about 3.5kg of wheat, in addition to maintenance requirements, to gain 1kg in weight (A.R.C. 1980). Since the whole flock must be fed to obtain an extra 2% lambs, each extra lamb must be sold for $29 to cover feed costs, assuming wheat costs $165 per tonne.

Similarly, increasing lamb survival through better ewe nutrition is unlikely to be profitable if supplements have to be purchased. Ewes with twins can be identified in mid-pregnancy (Fowler and Wilkins 1982) and if only these are fed, 34kg of wheat will be required for each ewetoincrease her weight from 35 to 45kg (conceptus free). From Table 2, at an average chill index of 1000 kJ/m²/h an increase in weight of this magnitude would reduce mortality of twins by 9%. The cost of supplementation for this purpose alone is $32/lamb for the extra 18 lambs surviving/100 twin bearing ewes, plus the cost of scanning all ewes. Hence other measures such as providing shelter may be more economical in reducing losses from exposure.

Obviously, improving the nutrition of ewes simply to increasethe number of lambs surviving to weaning is unlikely to increase profits, particularly if supplements cost as much as wheat. Profits are more likely if cheaper supplements can be grown on the farm but problems remain, including ensuring that all animals eat the supplement and that substitution of the supplement for pasture can be avoided. On the other hand, increases in lamb growth and wool production and the use of management techniques that reduce exposure may compensate for some of the costs.

MANAGEMENT STRATEGIES FOR HIGH LAMBING RATES

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Highly fertile and prolific sheep are available in Australia, and the challenge is to exploit this potential commercially. Several management options are available to the grazier: annual lambing, 8-monthly lambing, or more intensive, such as the French 49d system (Robinson 1974) and the Australian 2-monthly system (Robinson 1980). Whatever system is chosen, the full potential of the sheep will only be realised by good sheep managers who are able to:

* meet the nutritional requirements of ewes bearing various litter sizes;
* optimise conception rates, through ram and ewe management;
* optimise lamb survival by management during pregnancy and lambing;
* further increase lambs by increasing the frequency of lambings.

The major challenge is undoubtedly to adjust nutritional levels to meet the widely varied requirements of ewes bearing zero to five foetuses. For this we must know foetal number for individual ewes, and the nutritive value of feed sources. Real time ultrasound can determine pregnancy with 100% accuracy and presence of multiple foetuses with 98% accuracy, between 40 and 100 days of gestation (Fowler and Wilkins 1982). Low ewe blood glucose levels 90 days after joining indicate ewes are carrying multiple foetuses, while non-pregnant and single bearing ewes tend to have high glucose levels (Parr et al. 1982). The major commercial stumbling block is to assess, cheaply and quickly, the nutritive value of pastures or grazing crops. A system of 'pasture allowances' is being developed in New Zealand (Rattray and Jagusch 1978) to allow better ewe management, but the prospects of a similar system being developed for Australia's extensive and variable pastures are limited.

MANAGEMENT BEFORE AND DURING JOINING

Ram management

Current recommendations on ram preparation for joining, such as physical soundness, good nutrition, health and shearing, are critical if high reproductive potential is to be achieved. Serving capacity tests (Blockey 1980), photoperiod regulation (Schanbacher 1979), increased ram percentage and 'neighbourhood' ram pools may be useful additional refinements. Selection of rams based on a reproductive index is desirable.

Ewe management

For most breeds and crosses each additional lkg of Iiveweight at joining results in an increase of .015 to .02 lambs born/ewe (Morley et al.1978). This increase may be greater for breeds of higher fecundity. Restricted nutritionof ewes in the previous year has reduced ovulation rate, even though liveweights had recovered (Fletcher 1974). This has important repercussions for high fecundity flocks, especially after droughts, and requires further research.

Nutritional management is the major challenge of running highly fecund flocks. If peak nutritional requirements coincide with periods of limited feed availability in autumn and winter, special crops may need to be grown, extra hay or grain stored or stocking rates reduced. Winter fodder crops have been successfully used to boost winter feed supplies and carrying capacities on the slopes and tablelands. For example, from May to August, dry matter production in the higher altitude areas of the NSW Central Tablelands ranges from 7kg/

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ha/d for ryegrass/clover pastures to 20kg/ha/d for grazing oats. The extra 13kg /ha/d dry matter from oats is sufficient to support 10 to 15 crossbred ewes. The value of legumes is not to be underrated, especially for summer-autumn grazing to promote high lamb growth rates. Summer forage crops are of little value for fattening lambs, although they may be useful to maintain ewe condition in summer and autumn. Buying fodder, especially in years of grain and hay surplus, is always an option requiring less labour and capital than on property fodder conservation. Pasture types containing phyto-oestrogens may restrict the potential of high fecundity flocks. Producers need to be aware of and be able to identify those species/strains, especially clover, that could cause a problem.

Nutrition of the ewe can be readily manipulated by varying stocking rate. Reduced stocking rate results in higher twinning percentage and wool cut/ ewe (Donnelly et al. 1982).

Time of joining

Ewes capable of lambing rates of 200% will require producersto drastically alter their management. The ensuing large proportion of multiple births will require special consideration. Joining at the peak of oestrus is recommended, but may not always be possible. Joining, as it effects lambing time, may be altered because of labour availability, likely weather patterns, feed availability and likely market trends at lamb marketing. It may be necessary to split joining, such as in an 8-monthly lambing system, to spread marketing risk and better utilise labour and rams.

Whatever breeding schedule is adopted, the use of ram harnesses to identify the time and pattern of joining is essential. Identification of ewes as to time of lambing over a short period, such as a week, would greatly assist management. The use of progesterone, ram pheromone and photoperiod control may be as useful to synchronise joining as to bring ewes out of seasonal anoestrus.

MANAGEMENT DURING PREGNANCY

All research indicates that ewes bearing multiples must be in good condition at parturition if their twins (or more) are to survive and grow to weaning with minimal maternal handicap. Ewes must utilise reserves to support the growth of multiples. Just as importantly, if a high level of fertility is to be maintained, the ewes must be back in good condition for the following mating. This will generally necessitate the ewe being in good body condition at lambing and even at 100 days of pregnancy. Twin bearing Merino ewes need to gain approximately 200g/d during the last trimester of pregnancy to avoid lambs suffering maternal handicap (File 1981). Early pregnancy diagnosis would be an integral part of management to identify foetal number and likely nutritional requirements.

LAMBING MANAGEMENT

Normal principles of good lambing management, such as nutrition, climate, topography of lambing site and shelter are essential. Expectation of a high proportion of multiple births necessitates extra strategies to ensure survivalof the weaker lambs, particularly for any quads. With knowledge of foetal number, single bearing ewes can be lambed separately with minimal supervision provided that nutritional management has been adequate. Those ewes carrying multiples should be divided into small groups according to litter size, e.g. twins, separated from higher order multiples. Group sizes can be further reduced by separating ewes into those expected to lamb each fortnight.

Data from Leeton suggests that Border Leicester x Merino ewes on adequate pasture are able to rear triplet lambs successfully. Consideration maybegiven to removal of weak twinsortriplets for artificial rearing or fostering onto ewes which have lost lambs or have only singles. We suggest removing half the quad lambs because of their generally lower birthweight and vigour. Fostering lambs is the preferred choice economically, but we have yet to be convinced of a consistently successful technique. Artificial rearing of large numbers of lambs has been conducted successfully at Leeton for a number of years and commercial systems are available. Artificial rearing is a high cost operation and the costs need to be weighed against the value of the lamb saved. Each lamb will require a minimum of 5kg of milk replacer ($2.00/kg). Closely supervised pen lambing systems allow actual lambing times to be fully programmed by the use of hormones to synchronise mating and further synchronise lambings by induction of parturition.

The above represents some of our current thoughts on lambing management for highly fecund ewes. It is largely speculative and this whole area requires considerable research to determine and evaluate optimum management strategies.

INCREASED FREQUENCY OF LAMBING

Comparative studies have yet to be undertaken with highly prolific sheep in Australia under annual or accelerated lambing programmes. However, overseas data (Hulet 1978) indicate up to 0.53 more lambs/ewe/year from 8-monthly compared with annual lambings, without exogenous hormones. An 8-monthly programme offers the most practical accelerated lambing system based on experience with a modified French 49d, Robinson's 2-monthly and a commercial 8-monthly system, all using hormones.

If a single flock of ewes is lambed at 8-monthly intervals, the feed requirements of the flock vary greatly from year to year, as there is onelambing in one year and two lambings in the next. Variation in feed and labour requirements are minimised if the flock is divided into two groups which are joined four months apart. Such a programme results in approximately half the flock lambing every four months. Lambing times are consistent-from year to year, e.g. March, July and November. Prior to each joining, the non-pregnant ewes from the alternate group, detected by ultrasound, can be transferred and rejoined. Only half the flock lambs at one time and requirements for rams, lambing paddocks and other facilities are reduced.

Accelerated lambing systems can only be employed where nutrition and environment are favourable on a year-round basis. Ewes have to be kept in good condition and adequate summer/autumn feed supplies are essential for ewe maintenance, lamb growth and prejoining build-up of ewes. The ability of ewes to be rebred successfully while lactating is affected by the number of lambs born and the number suckled (Cognie et al. 1975) with seasonal interactions. There is an urgent need to investigate the extent of these effects in highly prolific ewes under 8-monthly lambing systems in Australia.

EARLY WEANING OF LAMBS

Recent work with Border Leicester x Merino and Dorset x Merino ewes (S.T. Dawe, unpublished data) showed that lactating ewes, mated seven weeks post-partum in autumn and nine weeks in spring, had half the conception rates of ewes with lambs removed at birth. In addition, weaning lambs two weeks prior to mating ewes ten weeks post-partum in the spring increased conception rate from 40 to 61%. These results indicate that early weaning at six to eight weeks may be necessary if high reproductive rates are to be reliably achieved. Such effects in genetically highly fertileand prolific ewes have yetto beassessed and will form part of the ongoing research with the Hyfer programme at Leeton.

CONCLUSION

N.M. FOGARTY

* If specialist lamb production is to remain viable on expensive land, productivity and efficiency must be improved. Substantial improvement in productivity and efficiency can be achieved by increases in reproductive rate.

* Sheep have great potential for increasing reproductive rate and lamb production. Overseas work and recent Australian research has shown that by utilisation of appropriate genotypes 200% lambs per year is feasible.

* Selection can be used to improve most components of ewe reproduction and lamb productionand will provide continued cumulative gains.

* Optimum nutrition is important for high ewe reproduction, lamb survival and lamb growth, and to ensure that the genetic potential of flocks is achieved.

* Management systems urgently need to be developed to cater for high levels of ewe reproduction. Research areas that have been highlighted include lambing systems and management of ewes to reduce lamb mortality, and ewe management during late pregnancy and lactation, together with time of weaning, to enhance post-partum joining ability.

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