7 Feeding and Management of Prolific Sheep

Prolific sheep can be raised under a wide range of management and feeding practices. This range extends from intensive systems under total confinement with accelerated mating, to extensive open-air systems with the traditional lambing of once a year. Between these two extremes several intermediate systems are applicable to particular situations. The choice of a system depends on the prevailing geographical, climatic and economic conditions, which include the cost of land, feed, labour, and the availability of markets.

This chapter presents two extreme systems investigated in two different countries. One in Canada uses intensive system and the other, in France, uses extensive management.

7.1 Under Intensive Management: the total confinement experiment in Canada

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Introduction

Traditional sheep management has evolved under conditions favouring the seasonal production of one or two lambs per ewe per year. The biological capacity of the ewe, however, is much higher than that level. Ewes of prolific breeds can lamb up to six or seven lambs per pregnancy and, with about 5 months of gestation and approximately 1 month for uterus involution, a lambing interval of 6–8 months is possible. Thus, ewes have a great potential to increase productivity.

Productivity can be improved by using prolific breeds, favourable breeding schemes, innovative management techniques, such as adopting artificial photoperiod, and applying hormonal treatments to eliminate seasonality. Increased productivity requires developing effective procedures for artificial rearing of lambs, controlling losses caused by predators, parasites and disease, and adopting nutrition programmes to support a higher level of production.

The work at Cornell University (NY, USA) on developing the STAR system in which ewes are managed to lamb every 7 months or produce five lambings in 3 years, has pioneered this approach to productivity. The system has been designed to involve a prolific genotype (Finnsheep–Dorset), but its commercial application indicated that it can be as successful with other prolific genotypes. The STAR system can be applied with varying degrees of success, to various types managements: extensive, semi-intensive or intensive.

Another major project on sheep intensification was conducted in Canada at the Centre for Feed and Animal Research (CFAR) in Ottawa, between 1965 and 1990, where a total confinement intensive system was developed and new technologies, genetic resources and management strategies were evaluated. This system can substantially increase the efficiency and output of lamb production. The technologies emerging from this research are applicable to varying levels of intensification and can be used in various countries. This section provides a short description of the various elements and the results obtained from this system. Complete details on the project have been published in a CFAR *Technical Bulletin No. 1987-11E* (Ainsworth *et al.*, 1987), and details on the economics of intensive production are provided in CFAR *Technical Bulletin No. 4 (Smith et al.*, 1982).

The Total Confinement System

Housing facilities

The experimental production flock was housed in three single-storey, windowless, insulated barns in which a complete control of the environment was possible. The breeding-lambing barn had the capacity of holding 1440 ewes and 270 rams. The other two facilities were a liquid-diet barn and a growing barn, each housing up to 1600 lambs. The barns functioned as an integrated unit, with lambs moving from one barn to another as they develop.

Feeding and management

The flock was subjected to a system of three lambings in 2 years. The breeding flock was divided into two subflocks of equal size. For several generations the two flocks were reared successfully from birth in the controlled-environment facilities. The sheep adapted well to this type of management. The problem of predators was eliminated completely, and because the flock was established from animals obtained by hysterectomy, there were no internal or external parasites, footrot, or sore mouth (contagious ecthyma). Accordingly, there was no need for dipping and dosing, thus reducing operating costs.

The breeding flock

The feeding programme for adult sheep emphasized maximum use of forages. Between breedings and during early gestation the ewes were fed an essentially all-forage diet consisting of 20% hay, 75% alfalfa silage and 5% grain. The amount of grain was increased to 18% before mating (flushing) and during the last 4–5 weeks of gestation. In some ewes whose condiition was poor during pregnancy, the grain fed was increased to as much as 30% for about 2 weeks before lambing. Research has indicated that during the first 14–15 weeks of pregnancy, the feed requirement was not higher than that required for maintenance, and that pregnancy itself, as distinct from fetal growth, reduced rather than increased the energy requirement of the ewe early in gestation, before the stage of rapid fetal growth.(Lodge and Heaney, 1973a, b, 1975).

Under intensive systems it is essential to control matings and parturitions. Oestrus and ovulation were synchronized by treatment with FGA-impregnated sponges for 14 days and intramuscular injections of 250 IU PMSG at sponge removal. Synchronized ewes were bred either by natural mating, or by artificial insemination (AI) 55 hours after sponge removal. Rams were introduced to the ewes within 24 hours after sponge removal and remained for 23 days to allow ewes that did not conceive at the synchronized oestrus to be re-bred at the following oestrus (Fig. 7.1.1).

Pregnancy was diagnosed with portable ultrasound equipment, which identified pregnant and open ewes and allowed feeding each

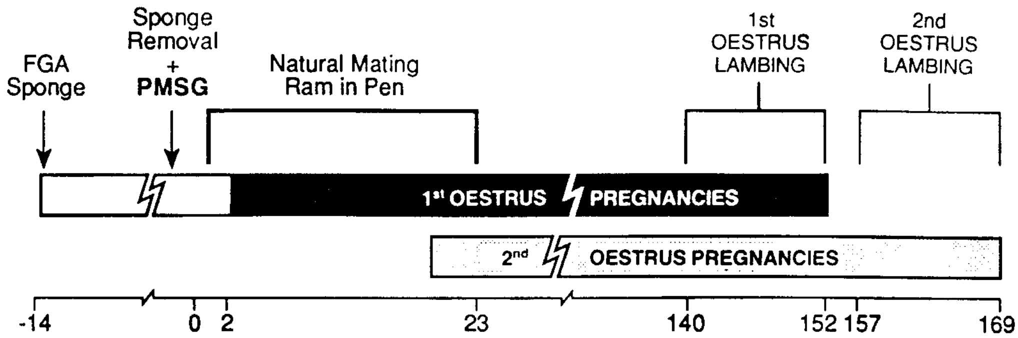

Fig. 7.1.1. Schedule for synchronization of oestrus, mating and lambing (Ainsworth *et al.*, 1987).

group separately according to its biological needs. Ewes were shorn 8–0 weeks before lambing.

At lambing, records were taken on date and hour of birth, genotype, sex, birth weight, dam and sire of the lamb(s), and any lambing and/or milking problems. Each ewe and her new-born were held in a temporary 1.2 × 1.2 m area, long enough for the lambs to consume colostrum. When the lambs were too weak to suckle on their own, or when the ewes did not produce enough colostrum, the lambs were separated and bottle-fed cow colostrum at body temperature. Once or twice a day all the lambs over 6 hours of age were transferred to the liquid-diet barn.

Artificial rearing of lambs

Lambs were trained to suck from a nipple bar in 'starter' pens. Training usually took 1–2 days but the lambs remained for at least 3 days. They were then grouped by size and moved to regular pens. After 5 days the lambs were docked, using a burdizzo and knife, and treated with 300,000 units of a long-acting penicillin to reduce the risk of infection.

Reconstituted lamb milk replacer (Table 7.1.1), containing 24% fat and 24% protein was fed *ad libitum* using a system of pipelines. Heaney *et al.* (1982a) showed that reducing the level of fat in dry milk replacer from the 30% usually contained in commercial products to 24% did not adversely affect lamb performance. Also, satisfactory lamb performance could be achieved with high quality calf milk replacer or whole cow's milk (Heaney *et al.*, 1982b). In each pen 12 nipples fed up to 50 lambs. Water was available at all times and a palatable creep feed and good quality alfalfa hay were provided from birth to encourage early consumption of solid feed. At 21 days of age the lambs were weaned abruptly onto solid feed, provided they weighed a minimum of 6 kg. Smaller lambs were left on milk replacer for up to 2 more weeks. Average weaning weight was 10–12 kg. Although the recommended age of weaning from milk replacer is 35 days and weaning should be gradual, it was possible to reduce the age to

Table 7.1.1. Composition of lamb milk replacer.

Ingredient	%
Skim milk	55.0
Buttermilk	19.0
Coconut oil	11.8
Tallow	10.8
Dextrose	1.4
Lecithin and emulsifier	1.3
Vitamin-mineral premix[a]	0.7

[a]Provided per kilogram of milk replacer: vitamin A 33,000 IU; vitamin D_3 5500 IU; vitamin E 25 IU; thiaesearch inmine 5.5 mg; riboflavin 11 mg; niacin 11 mg; calcium pantothenate 11 mg; choline 110 mg; ascorbic acid 83 mg; vitamin B_{12} 0.016 mg; salt 2.5 g; magnesium oxide 1.25 g; calcium iodate 1.5 mg; copper (sulphate) 2.0 mg; iron (carbonate) 62.6 mg; manganese (sulphate) 65.0 mg; zinc (sulphate) 3.75 mg; cobalt (sulphate) 1.25 mg; selenium (sodium selenite) 0.3 mg.

21 days and to wean the lambs abruptly from milk replacer. Lambs weaned abruptly at 21 days suffered a temporary growth check, typically loosing weight or failing to gain weight during the first week postweaning. Thereafter, normal gains resumed. Although feeding milk replacer beyond 21 days minimized the setback in growth, the practice was uneconomical (Heaney *et al.*, 1984). After weaning, the lambs were fed *ad libitum* a high-energy diet of approximately 90% grain and 8% hay. Vitamins, minerals and alfalfa hay were offered free choice.

The lambs were transferred from the liquid-diet barn to the growing barn at 35 days of age. Feeding from weaning to 91 days of age consisted of a postweaning diet and hay offered free choice. At 91 days, the lambs were weighed (average weight, 28–32 kg) and the daily gain from birth to 91 days (average gain, 275–300 g) was recorded. After 91 days the growing lambs were fed complete mixed diets with reduced energy levels (Table 7.1.2) to support, without excessive fattening, the rapid growth required to allow mating at 6.5–7.5 months of age . The lambs remained in the growing barn until they were either selected as breeding replacements and moved to the breeding-lambing barn or sold for meat.

The animals were exposed to various light regimens: in the liquid-diet barn the lambs were continuously exposed to lights (24 hours per day); in the growing barn they were exposed to light 16 hours per day until they reached 91 days of age, after which the light regimen was reduced to 9 hours of light per day. Ewe lambs were kept on the same light schedule as the adult ewes (Fig. 7.1.3). Ram lambs selected for breeding were exposed to 16 hours of light per day for approximately 1 month. Subsequently, they were exposed to 9 hours of light per day for 7–8 months. Rams were used for breeding twice, at 10.5–11.5 months of age and again 4 months later.

Fig. 7.1.2. Lambs nursing from the pipeline nipples.

Table 7.1.2. Growing diets fed after 91 days of age.

Ingredient	Age (days)	
	91–140	After 140
Grain	70	30
Corn silage	20	–
Alfalfa silage	–	60
Chopped hay	10	10

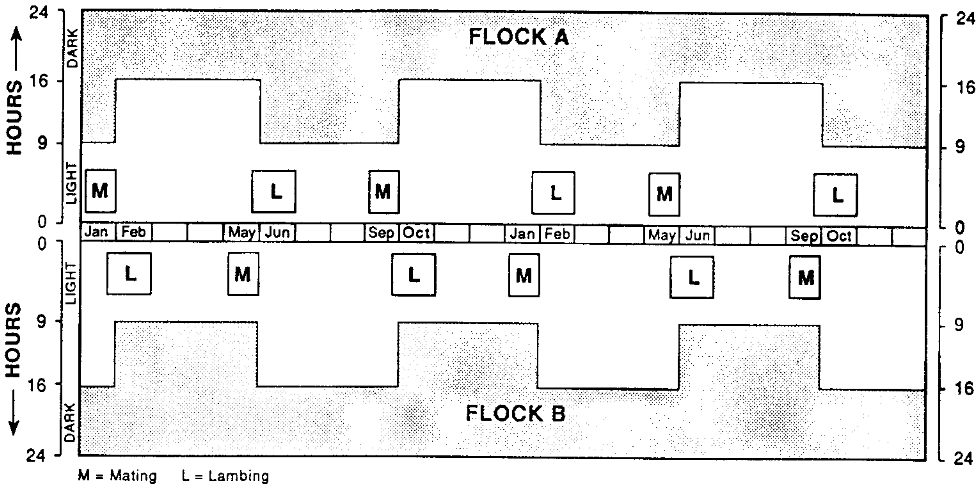

Fig. 7.1.3. The two-flock accelerated lambing cycle for the experimental lamb production system (Ainsworth *et al.*, 1987).

Flock health

The flock was established from lambs derived by hysterectomy, to eliminate infectious diseases in general and Maedi-Visna and pneumonia in particular. Because of this minimum-disease status of the flock, no preventive health measures were required, since internal and external parasites and foot rot were not a consideration. Moreover, no antibiotics, sulphonanides, arsenicals or other feed additives were fed to lambs.

The only routine preventative health programme consisted of vaccinations against clostridial infections. Pregnant ewes were vaccinated approximately 6 weeks before lambing, and the lambs were given booster vaccinations at 49 and 91 days of age.

The minimam-disease status of the flock was protected by a partial barrier system. Everyone entering the facilities was required to shower and wear clothing provided inside the barns. Also, all equipment was either sprayed with disinfectant or fumigated before entry.

Genetic resources

This intensive system was based on the concept that ewes from a first cross between two prolific strains mated to rams from a terminal sire breed would give the highest returns in term of kilograms of marketed lambs. Three new genotypes were developed, two prolific maternal breeds (the Rideau and Outaouais, see Subchapter 3.13) and one terminal breed (Canadian) (Shrestha *et al.*, 1988). In addition, Finnsheep and Suffolks were raised under the same intensive management system as the prolific and non-prolific controls.

Results

Productivity of the experimental production flock

Under this intensive system, the fertility of Outaouais, Rideau and Finnsheep ewes, was 79, 80 and 84% with a litter size of 2.6, 2.6 and 2.7, respectively. Corresponding values for the Canadian and Suffolk breeds were 75 and 61% for fertility and 1.9 and 1.8 for litter size, respectively, (Shrestha *et al.*, 1992) (Table 7.1.3). The performance of the two reciprocal crosses between Rideau and Outaouais was generally inferior to that of the two pure breeds. The fertility and prolificacy of the ewe lambs bred at 6.5–7.5 months of age were 50–60% of the values for the mature prolific ewes (Ainsworth *et al.*, 1987). Ewe lambs of the non-prolific breeds had a low rate of fertility. The total kilograms of lambs weaned per ewe lambing was highest in the Rideau (67.0) and Outaouais (65.5) breeds and lowest in the Suffolk (46.9) (Table 7.1.3).

The three prolific genotypes and the two prolific crosses showed similar lamb survival (73–77%), higher than ithe two non-prolific breeds (61–69%). Most mortality occurred at birth and soon after, prior to moving the lambs to the liquid-diet barn. Lamb mortality during artificial rearing and postweaning was somewhat low. The minimum-disease status of the flock could have been a factor in keeping lamb mortality at relatively low rates.

Productivity of adult Rideau and Outaouais ewes had been approximately two lambs reared per ewe bred per lambing. When the 8-month lambing interval was taken into consideration, annual productivity was

Table 7.1.3. Selected performance characteristics of the five breeds and two crosses at CFAR on intensive management system (Shrestha *et al.*, 1992).

Performance character	C	R	O	S	F	O × R	R × O
Fertility (%)	75	80	79	61	84	72	68
Fecundity (%)	149	205	206	111	219	177	167
Prolificacy	1.9	2.6	2.6	1.8	2.7	2.5	2.4
Lamb survival (%)	69	77	77	61	73	76	75
Ewe weight at breeding (kg)	80.7	74.4	71.2	81.4	64.5	65.8	66.8
Total lamb weight per ewe lambing:							
at birth (kg)	8.4	8.8	8.5	7.9	6.7	8.5	8.5
at 21 days (kg)	18.1	20.5	20.1	15.3	15.4	19.0	18.2
at 91 days (kg)	54.8	67.0	65.5	46.9	53.2	65.0	62.5
Individual lamb weight:							
at birth (kg)	4.02	3.40	3.26	3.88	2.37	3.28	3.11
at 21 days (kg)	10.0	9.1	9.0	8.5	6.5	8.9	8.5
at 91 days (kg)	30.8	28.8	28.3	27.0	22.8	29.5	28.6

C = Canadian, R = Rideau, O = Outaouais, S = Suffolk, F = Finnsheep.

about three lambs reared per ewe bred. Although this level of productivity is probably a conservative estimate of that obtainable in a good commercial operation, it nevertheless, demonstrates that the productivity of sheep can be improved substantially by intensifing and exploiting new technology and management strategies.

Increasing efficiency of lamb production in intensive systems

The total-confinement lamb production system at CFAR has demonstrated the potential for a substantial increase in output and efficiency by intensifing production and by careful integration of available technology and management practices. The relative importance and contribution of the various components for increasing efficiency and/or output of the production system were assessed as follows.

Advantages of controlling the environment

As lamb production systems move from extensive operations to a more intensive management, most of the production cycle is spent in some form of housing. Increased environmental control requires more sophisticated housing and, accordingly, higher capital investment. However, it allows for greater managerial control over available resources and more efficient production through the application of new technology and management strategies. In countries where sheep require housing during long winters, housing year-round would cost only a little extra. The extra cost could be offset by the economic advantages of eliminating the following: (1) losses from predators; (2) the need for costly fencing; and (3) internal and external parasites and footrot. In addition, the efficiency of harvesting forages mechanically and feeding them to housed animals was 80–90% compared with about 60% under ideal conditions of grazing management. Moreover, the preservation and storage of harvested forages ensure consistent availability of high quality year round, because the forages are harvested at the optimum time.

By intensifing and using a controlled environment, available labour can be used more efficiently, particularly at lambing time, when input of skilled labour is critical especially with prolific sheep. Also, a controlled environment allows the mechanization of two labour-intensive operations: feed formulation, processing and distribution; and manure handling. The CFAR experience has shown that sheep manure can be handled in a liquid-manure system with standard equipment. However, the manure requires more dilution than cattle manure before pumping.

Maintaining sheep in a controlled environment reduces the physical activity required to pursue food and directly reduces energy requirements for maintenance by up to 40%, or more. This saving is of major economic significance, because feeding ewes represents the largest cost item in lamb production. Feeding growing lambs in a controlled environment also increases production efficiency by eliminating or greatly reducing environmental stress, which adversely affects rate and efficiency of growth.

Choice of appropriate genotypes

To recover the increased investment costs of intensive production systems it is essential to achieve a high output of marketed lambs. Early sexual maturity, frequency of lambing and high levels of reproduction are important elements to success in such systems, and most prolific breeds exhibit them. However, an important aspect of an intensive management system is to match genotype and management resources in order to maximize output. The use of prolific breeds is advantageous only if management is capable of exploiting the greater productivity of these breeds.

The appropriate combination of breed resources to set specific performance objectives offers the most important potential for increasing reproductive efficiency by using the highly prolific Finnsheep (Dickerson, 1977) or Romanov (Razungles *et al.*, 1985) breeds in combination with domestic breeds. Litter size can be increased by 50–100% in one or two generations, from the current level of 1.2–1.6 lambs per ewe . Fifty per cent Finnsheep or Romanov ancestry may provide the desired litter size and general production potential for some management systems, whereas for others 25% prolific ancestry may be more advantageous. Moreover, the contribution of other exotic breeds can be equally valuable in more complex breeding programmes.

Increasing frequency of breeding

Increasing the frequency of breeding from the traditional once per year to once every 6–8 months, while maintaining a high fertility rate, significantly increases annual lamb output, especially when highly prolific ewes are used. The optimum interval of 8 months results in three lamb crops in 2 years. The appropriate management is to split the flock into two groups and breed each group alternately at intervals of 4 months. Ewes not conceiving at one mating time would be transferred to the group bred 4 months later. In addition to increasing the reproductive capability of ewes, this approach provides a practical means of increasing the efficiency of the production system through making more uniform use of labour; reducing the facilities required for lamb growing and finishing (and the overhead costs per unit of production); increasing the availability of lambs (provides a more uniform cash flow); and spreading the lamb crop over the year (decreases the possibility of unusually heavy losses at one time caused by disease or other adverse conditions).

Reducing age at first mating

An important element of intensive production is breeding ewe lambs early in order to produce a lamb crop by 1 year of age. Although conception and lambing rates are lower and more variable than those of adult ewes, total lifetime production of ewes mated early has been always higher than that of ewes mated late. Factors such as feeding, breed, season of birth, age and body weight at breeding can influence the outcome of mating ewe lambs at 7–8 months of age. However, the effects of some of these variables can be reduced by proper management and by induction and/or synchronization of the oestrous cycle of ewe lambs using progestagen-impregnated intravaginal sponges and PMSG.

Control and manipulation of reproduction in ewes

It is possible to use artificial day-length patterns to control oestrous cycle activity in sheep kept indoors at all times under accelerated lambing systems. An abrupt or gradual change from a long to a short day-length induces cyclic activity in non-cycling animals, usually within 30–60 days after the change in day-length. Conversely, animals will stop cycling within 30–60 days if they are exposed to an abrupt or gradual change from a short day-length to a long one. To achieve consistent results, the change between short and long day-length should be at least 6 hours and the periods of short–long or decreasing–increasing patterns should be applied in a rhythmic pattern (Hacket and Wolynetz 1982a, b, c). In the CFAR accelerated lambing system, ewes were mated at the end of a short day-length cycle, regardless of the time of the year they were bred. Because the complete production cycle was 8 months, the light changes occurred at 4-month intervals (Fig. 7.1.3).

One of the main problems in relying solely on artificial day-length to induce cyclic activity is its inability to synchronize the oestrous cycle. The use of natural and synthetic prostaglandins to control the oestrous cycle in sheep has limited application because these compounds can be used only during the breeding season, when the animals are cycling (Hacket and Robertson, 1980; Hacket *et al.*, 1981). By combining artificial day-length (which induces oestrus and ovulation), with exogenous hormones to synchronize the oestrous cycle, these problems can be eliminated (Hacket *et al.*, 1982).

Control and manipulation of reproduction in rams

Management procedures can be applied to reduce seasonal variations in semen quality and allow rams to be used for breeding year-round. Since ram fertility is important in determining the number of ewes that conceive, it is necessary to distinguish between rams of high and low fertility. Scrotal circumference is a good measure of testis size, and large size and firm tone of the testes are considered good indicators of semen-producing capability and fertility of rams (Langford, 1989).

Artificial insemination

The need for AI in sheep is increasingly apparent, particularly with the move towards more intensive production systems. The use of AI has been limited because of technical problems and cost. However, AI using fresh semen has become feasible, particularly when used in conjunction with controlled reproduction programmes where the need to detect oestrus is eliminated and the ewes can be inseminated at a predetermined time. To achieve a fertility rate 65–75% of that obtained by natural service at a synchronized oestrus, ewes should be inseminated 55 hours after removal of FGA-sponges with at least 200 million spermatozoa (Langford and Marcus, 1982; Langford *et al.* 1982). When using fresh semen for breeding ewe lambs by AI at a synchronized oestrus, the fertility was about half that of adult ewes. Early embryonic mortality in ewe lambs was estimated at 24% compared with 9% for adult ewes (Langford, 1984a).

Pregnancy diagnosis

Determining whether a ewe is pregnant or not at an early stage is economically important, especially in intensive systems. Pregnant ewes can be separated and given supplemental feeding as pregnancy progresses, whereas open ewes can be fed cheaper diets, re-bred or culled. Portable ultrasonic detectors have become available, at a reasonable cost, allowing rapid, simple and accurate pregnancy diagnosis (Langford, 1984b; Langford *et al.*, 1984).

Artificial rearing and early weaning of lambs

Artificial rearing of the entire lamb crop is not recommended for commercial operations. Instead, ewes should rear at least two lambs naturally. However, in flocks with prolific sheep, many ewes produce litters larger than two. Artificial rearing technology is useful for raising extra lambs, as well as lambs that would otherwise be orphaned by lack of milk supply, death of the dam or rejection.

Intensifying production so that ewes lamb three times in 2 years can be achieved easily by weaning naturally suckled lambs at 6–8 weeks of age. The lambing interval can be reduced further by weaning at 4–5 weeks. However, at these ages the dams are still near the peak of milk production and special care and management is essential to minimize mastitis and other udder problems. In some cases it may be necessary to hand-milk high-producing ewes for a day or two during the drying-off period.

Nutrition of early weaned lambs

Under intensive management systems, it is desirable to feed lambs high-energy diets in order to maximize daily gains and feed efficiency, reduce overhead costs and shorten the time required to reach market weight. The general recommendations for lambs reared by their mothers are as follows: provide them with high-quality creep feed during nursing; wean them at 6–8 weeks of age when their mother's milk supply starts to decrease; and feed them a high-energy finishing-ration to market weight. Similarly, lambs reared artificially should be fed a finishing ration continuously from weaning at 3 weeks of age. Creep feeding is essential for artificially reared lambs and for naturally suckled lambs weaned at less than 6 weeks of age because solid food is indispensable for stimulating rumen development. The finishing rations should contain approximately 17% crude protein until the lambs are about 100 days of age and 14% thereafter until they reach a desirable market weight and grade.

Nutrition of the breeding ewe

In accelerated breeding systems, maintaining the mating weight of ewes over successive production cycles is an important problem that can be overcome by regulating the level of energy intake in relation to the physiological state of ewes. Forage-based diets, properly supplemented with minerals and vitamins, are adequate to meet most of the energy requirements. Supplemental energy and/or protein, depending on the forage quality, are required only for relatively short periods when production demands are high, such as for flushing, the last 4–5 weeks of gestation, and the first 4–6 weeks of lactation.

Economics of Intensive Lamb Production

The economic advantages of an intensive production system (three lamb crops in 2 years in total-confinement barns) were compared with those of a traditional system (a single lamb crop per year in which animals were

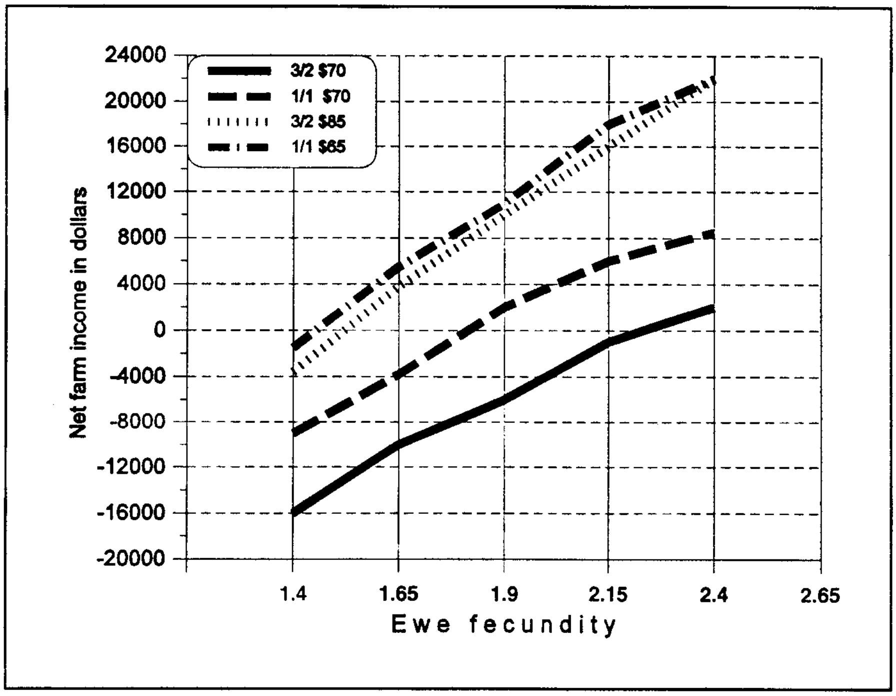

Fig. 7.1.4. Effect of slaughter lamb price and ewe fecundity on net farm income with a single lamb crop in one year (1/1) and three lamb crops in 2 years (3/2). (Adapted from Smith *et al.* 1982.)

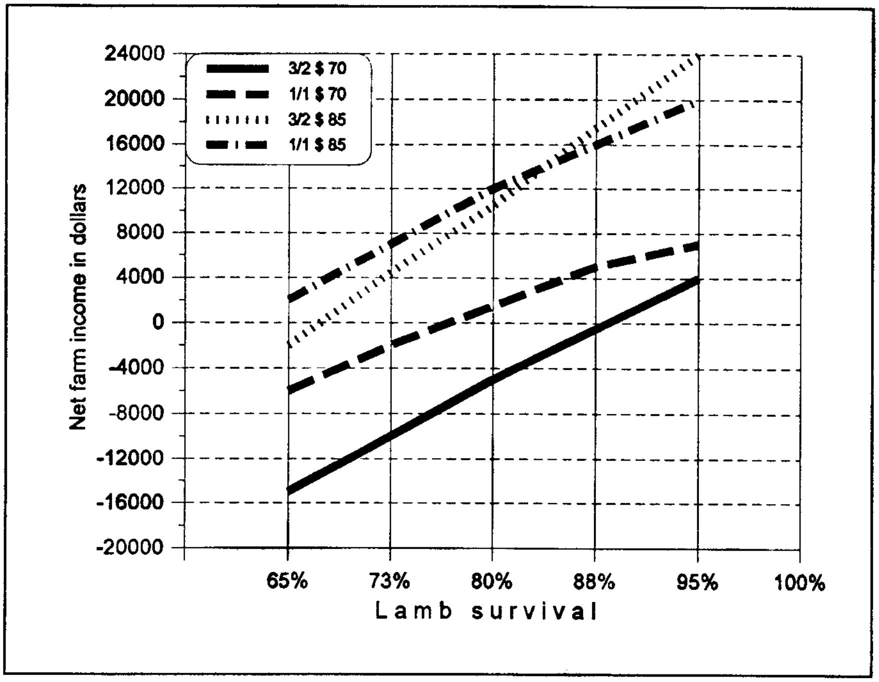

Fig. 7.1.5. Effect of slaughter lamb price and lamb survival rate on net farm income with a single lamb crop in one year (1/1) and three lamb crops in two years (3/2). (Adapted from Smith *et al.*, 1982.)

housed on drylots with sheds) (Smith *et al.*, 1982). In the intensive system, lambs were removed from their dams 8–24 hours after birth and fed milk replacer, whereas in the traditional system lambs suckled their dams until weaning.

When lamb prices were high, an intensive production system returned a higher net income than did a traditional system (Fig. 7.1.4). The intensive system, with its greater productivity, was able to capitalize more effectively on increases in lamb prices and profitability could be increased faster than in the traditional system. The key components identified for an economically viable, intensive lamb production system were increased lambing frequency combined with larger litter size and improved lamb survival (Fig. 7.1.5). On the other hand, although a much higher production potential could be realized by intensification, this system was associated with a higher risk of financial loss because of increased investment costs, labour, feed and other related expenses. Also, intensified production required a much higher level of management capability and expertise than the more traditional lamb production system.

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