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MANAGING SHEEP TO OPTIMIZE PROFIT

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INTRODUCTION

Sheep production is one of the oldest human agricultural enterprises. Management techniques for improving performance date from the earliest flocks. In the beginning and for hundreds of years, improvements in management were entirely dependent on the observational skill or "eye of the shepherd." Fifty years ago, fall-lambing was limited mostly to Dorset sheep. Range sheep operators wanted only one lamb per ewe. Most of the extra lambs were sacrificed and ewes were not bred before they were 18 months of age. A sick sheep was considered a dead sheep.

Rapid progress has been achieved in recent years with the application of scientific methods. We have witnessed great changes in management goals and practices. Large flocks of ewe lambs lambing at about 12 months of age have weaned 120-140% lamb crops. Numerous flocks in accelerated lambing programs are averaging about 3 lambs weaned per ewe per year. One intensively managed flock in Montana reported weaning an average of 4 lambs per ewe in 1988. Average daily gain has also improved and the weight of market lambs has increased about 1 lb. per year over the past 30 years.

A vast library of knowledge has been compiled on the basic physiology; endocrinology; food ingestion, digestion, metabolism and nutritive requirements; genetics; biological nature of infectious disease; life cycles and destructive impact of parasites; behavior; stress factors and predation of sheep. These scientific data housed in the research literature of the world provide the basis for modern sheep management. This brief presentation can only highlight some of the more significant management principles and procedures.

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GENERAL PRINCIPLE OF GOOD MANAGEMENT

Optimum reproductive efficiency, growth rate and freedom from disease can only be achieved in a comfortable, clean, uncongested environment. Because the maximum may be too costly, the best approach is to seek for the optimum when one considers both cost and performance. This will vary greatly among geographic locations and management options.

This is not an economic analysis of management alternatives but is intended to focus on relatively new or less well-known, under-used, or less understood, management factors which might impact the future productivity and profitability of the sheep enterprise.

INCREASED RATE AND EFFICIENCY OF GAIN

Efficiency of gain is related to the amount of weight gain made by a lamb per unit of feed consumed. Ercanbrack and Knight (1988) selected for rate and efficiency of gain based on lamb performance during a 16-week test period. The superiority in efficiency of lambs from the selected line over control lambs increased 3.3 percentage points annually over the 4-year study. Selected lambs were about 23% more efficient than controls at the end of the study. This means that they were producing about 23% more profit per day from gains than control lambs. With this kind of production efficiency possible, it would be incumbent on management to obtain appropriate breeding stock and manage market lambs for efficient gain. Other Dubois studies have shown that young lambs gain much more efficiently than older lambs. This finding suggests, and the Dubois station research demonstrates, that young lambs can be fed and marketed much more economically than older lambs.

Another approach to improving efficiency of gain is through crossbreeding. The correlation between rate and efficiency of gain is well known. For example, the Suffolk is clearly recognized as a superior breed for rate of gain. In most tests, Suffolk-cross lambs have out-gained crosses derived from other breeds (Neville et al., 1958; Bradley et al., 1972).

Because of the high cost of maintaining breeding stock to produce market lambs, increasing slaughter weight of lambs can result in more efficient meat production. Heavier lamb carcasses are generally thought to be overly fat and wasty. However, the large, slow-maturing range breeds are making efficient lean gains at weights well above 110 lbs. Studies at the Dubois Sheep Station have shown that slaughter weights of Rambouillet, Targhee and Columbia ram lambs may be increased to 140 lbs. and ewe lambs to at least 125 lbs. without significantly decreasing the percentage of lean meat (Hulet and Ercanbrack, 1983). Panel taste scores for flavor, tenderness and consumer acceptance tests in Utah and California revealed that consumers liked cuts from heavier carcasses as well as lighter carcasses (Mendenhall and Ercanbrack, 1979). Slaughtering and processing costs per pound of meat are reduced at heavier weights since the costs to slaughter large and small lambs are similar. The historical average increase of about one pound per head per year in slaughter weight suggests that the more economical production of larger lambs will continue in the future.

EARLIER LAMB PRODUCTION

Breeding Ewe Lambs

The management of ewe lambs appears to be a logical starting place to improve management of reproduction. With few exceptions, ewes should be bred, selected and managed to lamb first at 1 year of age.

Three distinct advantages to breeding 7- to 8-month-old ewe lambs to lamb at about 1 year of age are: (1) reduced maintenance costs before the start of production; (2) shortened generation interval that results in more rapid genetic gains from selection and (3) increased lifetime production (Briggs, 1936; Evans et al., 1975; Hulet and Price, 1975).

Four important factors influencing fertility of 7- to 8-month-old ewe lambs are: (1) the size and condition of the lambs at breeding time; (2) the breed and breeding of the lambs; (3) the season of birth and (4) the time of year ewes are bred. As body size varies with breed, it appears that one can expect a favorable breeding response when lambs have reached about 65% of mature body weight. Good condition reflects the health, vigor and physiological well-being of the lamb and is positively correlated with the estrous response. Stoerger et al. (1974) found that a 50% roughage ration was optimum for maximum reproductive performance in ewe lambs.

Great variation among breeds can be observed in age at estrus as shown in the following table. Puberty probably has a moderate heritability. One group of Targhee ewes selected for early puberty for 8 years was compared with another similar group of Targhee ewes not selected for early puberty. The lambs were born, reared and managed at the Sheep Station under similar conditions and kept together in one flock after weaning. They were placed in breeding at about the same time and exposed to fertile rams for about 45 days. Fifty percent of the select Targhees, but only 20% of the unselected group conceived (Hulet, unpublished).

Roger Land (personal communication), University of Edinburgh, Scotland, selected rams in two directions for testis size. After only 2 years selection, the female offspring of the rams selected for large testis size reached puberty at a significantly younger age than female lamb offspring of rams selected for small testis size. Puberty in the male and female may be associated with both testis size and ovarian weight.

Rydberg et al. (1976) showed that time of birth and season of breeding influence conception rate in lambs. In their breeding study of Finn-cross ewe lambs born in February and April, they observed that the lambing and lamb crop percentages of all ewe lambs (combined ages) exposed September 5 to October 9, October 30 to December 3 and December 24 to January 27 were 30, 60; 100, 160 and 96, 141, respectively. The effect of month of birth on reproduction was demonstrated by the lambing performance of the February- and April-born lambs exposed to rams during the three breeding periods listed above. February-born lambs had lambing and lamb crop percentages of: 66.7, 111.1; 100, 188 and 95.5, 150 for the early, mid-season and late breeding periods, respectively. These results can be compared with those for the younger, April-born lambs that had lambing and lamb crop percentages of: 8.3, 16.7; 100, 138 and 95.5, 135.7 for the three breeding periods, respectively. These results indicate that ewe lambs have a higher fertility rate if bred during the middle of the breeding season and that February-born lambs have the advantage over younger lambs.

Work done by Foote and Matthews (1969) clearly showed that puberty can be accelerated by use of hormones. However, as yearling ewes must have adequate size to bear normal healthy young and produce enough milk to nourish them, under most circumstances, a better management practice would be to put this size on the lambs early in life. This management practice would then enhance the occurrence of estrus (Allen and Lamming, 1961; Hulet and Price, 1975) and in most instances eliminate the need for use of exogenous hormones. Possible exceptions are slowly maturing breeds such as the Columbia, Targhee and Rambouillet. However, recent studies at Dubois indicate that Rambouillet lambs which have been given proper nutrition and selected for high lamb production are lambing at a high rate (70 - 75%) at one year of age.

An excellent management tool that can be used in conjunction with breeding ewe lambs to improve production efficiency is pregnancy testing. Fertility is usually lower in lambs than in mature ewes. However, unlike mature ewes, non-pregnant ewe lambs can be culled and marketed as fat lambs at slaughter lamb prices. The subsequent high fertility and fecundity of ewe

EFFECTS OF BREED AND YEAR ON FERTILITY OF EWE LAMBS BRED IN NOVEMBER AND DECEMBER AT 7 TO 8 MONTHS OF AGE

Breed	Percent pregnant (No. exposed)			
	1970	1971	1972	1973
Rambouillet	17(18)	4(27)	16(38)	37(30)
Targhee	52(27)	10(31)	57(35)	73(37)
Dorset	92(26)	35(20)	64(39)	86(42)
Finnsheep	100(66)	92(39)	94(32)	87(31)
Polypay	100(6)	77(35)	94(65)	97(33)

Source: Hulet and Price (1975).

lambs selected in this way suggests that much of the lower fertility common to groups of sheep can be eliminated by selection at lamb age when market value is high. This type of management results in increased production efficiency of mature ewes selected at this time as compared with unselected ewes bred to lamb first as 2-year-olds (see next table.

Fertility in ewe lambs is reduced when they are mated in large flocks with mature ewes (Keane, 1976). This is because ewe lambs are shy breeders and are not competitive with mature ewes in seeking out the ram, nor do they stand well for mating. Therefore, ewe lambs should be bred separately from mature ewes. Experience of Ercanbrack at Dubois (personal communication) also suggests that yearling rams used on ewe lambs will increase percent of ewes lambing over inexperienced ram lambs.

INCREASING FERTILITY AND PROLIFICACY

Lambing rate is probably the most important single factor which can affect production efficiency in sheep. Fortunately, it is now possible, with existing genotypes of sheep already in this country, to select a breed or breed cross that will lamb at a rate which is optimum for each production environment. Strains of Merinos and Rambouillets are available which characteristically produce single lambs. Finnsheep, Romanovs and Boroola Merinos characteristically produce 3 to 5 lambs per lambing. Other breeds and crosses can be identified which produce lambs at various rates intermediate between these extremes. One of the most important management decisions is to select a breed that is adapted to the environment in question and continue to select for increased lambing rate within that breed and environment.

It may be possible in the future if FDA clearance is obtained to use a vaccine type product known as Fecundin to increase (0.20 -0.30%) the lambing rate of existing genotypes (Quirke et al. 1986; Croker et al., 1987).

Other important factors also affect fertility and prolificacy. These include age of ewe and season of year (next two tables), distance from the equator (increases with distance from equator), fertility of the ram, ambient temperature, nutrition, heterosis, disease and parasites. At one time, the ram was thought to have no influence on the fecundity of ewes to which he was mated. However, a study

LAMB PRODUCTION OF TARGHEE RANGE EWES BRED AND SELECTED ON PREGNANCY AT ONE YEAR OF AGE AS COMPARED TO EWES LAMBING FOR THE FIRST TIME AS 2-YEAR OLDS

Management Practice	Age of ewes, yr	No. of ewes	% of ewes lambed	% of lambs born[a]	% of lambs weaned[a]	Total lamb weaned, lb
Lambed first as 1 year old	1	47	100[b]	111	83	55
	2	47	98	143	115	84
	3 & over	78	97	158	134	107
Lambed first as 2 year olds	1	0	0	0	0	0
	2	50	88	102	82	58
	3 & over	65	89	141	115	87

[a] Percentage of lambs born or weaned of ewes in the flock.
[b] Only those ewe lambs diagnosed pregnant were saved.
Source: Hulet (1977).

EFFECT OF AGE OF DAM ON THREE LAMB PRODUCTION TRAITS

		FERTILITY	PROLIFICACY	OVERALL REPRODUCTION
Age of dam	No. of ewes bred	% of ewes lambing of ewes bred	% of lambs born of ewes lambing	% of lambs weaned of ewes bred
2	732	87	126	83
3	647	91	131	98
4	515	93	137	112
5	427	92	143	105
6	288	90	145	110
7	190	94	141	105
8	109	90	145	93
9+	54	82	153	99

Source: Sidwell et al.(1962).

EFFECT OF TIME OF BREEDING ON ESTRUS AND OVULATION IN MATURE RAMBOUILLET EWES IN IDAHO AND TEXAS

Month	Percent ewes in estrus		Percent ewes ovulating	
	Idaho	Texas	Idaho	Texas
January	100[a]	100	100	100
February	100	100	100	94
March	89	40	94	52
April	26	38	32	32
May	2	31	2	31
June	7	44	7	75
July	6	94	6	94
August	12	86	41	100
September	88	94	100	94
October	100	94	94	100
November	100	97	100	91
December	100	100	100	100

[a] Source: Hulet et al.(1974). Each statistic based 30 to 32 observations.

at Dubois (Hulet et al., 1965) clearly shows that rams with high quality semen fertilize a higher percentage of ova within ewes as well as a higher proportion of ewes than rams with low quality semen.

The last table above (Hulet et al., 1974a) also illustrates the effect of season on the occurrence of estrus, and on ovulation rate, which are closely correlated in most instances with lambing rate. Breeding season varies greatly with geographic area, therefore, the implications of breeding season and ovulation rate must be determined in each area. Because nutrition can have an important effect on lamb production, the common practice is to flush ewes just before and during breeding. Research (Hulet et al., 1974b) has shown that the time of year determines the effectiveness of flushing. Flushing during the middle of the breeding season does not appear to be beneficial, but flushing during the early and, especially, the late-season appears to be effective in stimulating higher ovulation rates. Scientists at Montana State University (Van Horn and Payne, 1951) have shown that supplementation of ewes on the range after breeding resulted in significantly higher lambing rates, presumably because of better embryo survival.

Poor sanitation can lead to severe losses from vibriosis, enzootic abortion of ewes and lamb scours. Reach-through feeders and clean water are vital to good reproduction in ewes kept in confinement. Vaccines are now available to protect against these problems, but should not be used as a substitute for good management and sanitation practices.

Early accurate information on the pregnancy status of a ewe opens many management opportunities for the producer. Real time B-mode ultrasonic imaging is an accurate pregnancy testing technique now available to the sheep producer (Fowler and Wilkins, 1982; Fowler and Wilkins, 1980; Gearhart et al., 1988). It can reduce maintenance cost and increase production efficiency by identifying ewe lambs that are pregnant following breeding so that non-pregnant lambs can be marketed profitably as fat lambs. It can also be a real management benefit in identifying out-of-season bred ewes so that the open ewes can be removed to maintenance diets while the pregnant ewes are managed for lambing. Accuracy now is sufficiently high that it is practical to separate ewes carrying multiple fetuses for preferential feeding and more intensive lambing management while the single bearing ewes are kept at a lower and more economical nutritional and management level. However, because selection opportunities are low, an economical benefit from pregnancy testing high fertility, prolific flocks of mature ewes is unlikely. However, the ewe flock could be examined for visual evidence of pregnancy at the start of lambing. All ewes that do not show positive evidence of pregnancy can be separated using a cutting gate and then these few ewes tested for pregnancy. Any open ewes can be removed from the lambing flock and put on a maintenance diet.

Real time ultrasonic scanners are very expensive. However, an arrangement permitting a large group of sheep owners to use an instrument cooperatively, perhaps using the expertise of a county extension agent, could make it economical. A blood test based on a pregnancy specific protein shows promise of becoming an accurate, efficient, inexpensive pregnancy testing device that may also predict multiple births (Ruder-Montgomery et al. 1988).

RAM MANAGEMENT

Ram fertility is as critically important to lamb production efficiency as ewe fertility. Hot humid weather is especially detrimental to ram fertility. Behavior studies (Hulet, 1966) have shown that in the first 24 hours after a ram is put into breeding that he is nearly twice as active as later in the period. If introduction coincides with hot weather and the ram is introduced to the ewes in mid-morning, he may be sterile by evening due to elevated testicular temperature from a combination of physical exertion and ambient temperature. There are several safeguards to help protect rams from high temperature sterility: (1) provide pre-breeding conditioning exercise, if possible, (2) keep in strong condition but not fat, (3) shear three to six weeks before breeding (Hulet et al., 1956), (4) introduce to the flock in the evening after temperatures are dropping, (5) provide cool water and shade, (6) keep the number of ewes per ram relatively low (<50), (7) check testes repeatedly at frequent intervals (15 - 30 days) before breeding and use only rams with satisfactory breeding soundness examinations (Ruttle and Southward, 1988). This includes only rams with satisfactory semen quality (including freedom from leucocytes) with firm large testes ($\geq$30cm) free of palpable lesions. Testes size increases with age so selection on testes size should be made within age.

A knowledge of mating behavior in rams can improve production efficiency. A small percentage of rams have either greatly reduced libido (sex drive) or will not breed at all (Hulet et al., 1964). Other rams are aggressive and dominant, and in multi-sire mating flocks, will prevent or greatly reduce mating by subordinate rams. Therefore, it is important to make sure when rams are put into breeding that they have adequate libido and mating ability. It has been proposed that inhibition might be an effect of monosexual group rearing (Hulet et al., 1964; Mattner et al., 1971). Sexual inhibition was prevented by rearing ram lambs in isolation from other rams (Zenchak and Anderson, 1980). Keeping a few ewes with ram lambs during rearing may also reduce sexual inhibition in rams. In multi-sire breeding flocks, it is important to use a minimum of three rams of uniform age in pastures large enough so that the dominant ram cannot prevent the other rams from breeding (Hulet, 1966).

EXTENDED BREEDING SEASON

Domestic sheep in general breed during a somewhat restricted season, mainly during late summer, autumn and early winter in temperate zones. Some breeds such as the Dorset, Rambouillet and Polypay have extended breeding seasons in contrast to breed such as the Suffolk, Southdown and Border Leicester. In the tropics and subtropics where variation in day length is minimal, sexual activity continues throughout the year (Hafez, 1953).

The seasonal nature of reproduction in sheep limits the times available to management for producing lamb for market, resulting in an uneven cyclic supply and market price of lamb. It also limits use of certain commercial and by-product feeds to times when lambs can be produced, which may not coincide with the most economical utilization of the feed.

Scientists are now using genetic selection to overcome this problem. This is a slow process and will require a number of years of research. The Polypay breed, as well as the Dorset and Rambouillet, is showing real promise in this area. Polypays are also highly prolific. Some immediate benefit can also be derived by manipulating behavior. Exposing rams to ewes in advance of the breeding season stimulates testes development and sex drive, and improves semen quality in rams (Illius et al.,1976). When rams are introduced into a flock (which has been isolated from rams for a few weeks) during the transitional period between anestrus and the breeding season, it leads to ovulation, followed by estrus and ovulation in advance of the normal breeding season (Martin and Scaramuzzi, 1983). The ram effect is probably augmented by social facilitation through the exhibition of estrus in responsive ewes, which in turn triggers estrus and ovulation in additional ewes. This early breeding response is maximized when rams are introduced in the morning (Martin et al., 1985). Manipulation of breeding behavior, especially in long-breeding season sheep, can produce fall lambs. A short-day light treatment (8 hour light, 16 hour dark) alone (Schanbacher, 1979) or in combination with melatonin implants (Regulin) six weeks before breeding can improve ram fertility and libido during seasonal anestrus (Fitzgerald et al., 1988).

Sixty to 80% of Rambouillet and Polypay ewes bred at the Jornada Experimental Range in New Mexico during May and June lamb in the fall. All the ewes are exposed again in September and October in a catch-up breeding so that any open ewes have an opportunity to breed and lamb in the spring. This gives a good supply of market lambs throughout most of the year. Ewe lambs and yearling ewes do not breed well out-of-season, and ovulation and twinning rate are lower in fall-lambing ewes (about 150% vs. 175% in spring averaged over breeds). Polypay ewes have a high percentage of twins in the fall (170% in fall vs. 205% in spring at Dubois).

ACCELERATED LAMBING SYSTEMS

Successful accelerated lambing systems usually require higher resource and management inputs than once per year lambing. Accelerated lambing should be considered under those conditions where a producer can provide adequate nutrition for the ewe and lamb. Accelerated systems are not recommended for extensive range conditions lacking the necessary feed resources and management options.

The economics of an accelerated lambing program need to be carefully studied. Increased income from extra lambs must pay for the extra cost and adequately compensate the producer for the extra labor input. Some systems for accelerated lambing are described below:

Three Lamb Crops in Two Years

Several variations of this system have been tried in order to attempt an average lambing interval of eight months, or a lambing frequency of 1.5 lambings per ewe per year. These systems have generally been characterized by a fixed mating and lambing schedule such as: May mating/October lambing, January mating/June lambing, September mating/-February lambing. Others have modified these dates slightly to 7-7-10 or 7-8-9 month intervals to better fit their climatic, management and feed resources. If a ewe misses once in two years, her potential is one lambing per year.

Producers have developed a variation of this system that provides for a more continuous lambing schedule. The flock is divided into four groups on a staggered eight-month lambing interval schedule. If a ewe fails to conceive with her group, she has a second chance to mate two months later, or on a ten-month lambing interval. A ewe that missed only one mating period in three cycles (two years) would average 1.39 lambings per year, and 1.29 lambings per year if she failed to conceive during two mating periods.

Research results have varied from a 10 to 15% increase in percentage lamb crop marketed per ewe with Hampshire x Rambouillet and Suffolk x Rambouillet ewes in Virginia, to a 43.5% increase in lamb production with Rambouillet ewes in Texas.

Researchers at Oklahoma State University reported results from studies involving various combinations of the Dorset, Finnsheep and Rambouillet breeds in which all breed groups averaged over two lambs born per ewe per year. These results represented a 30 to 35 percent increase over conventional annual lambings. Scientists at Purdue University reported that Rambouillet ewes performed better than Columbia ewes on the accelerated schedule.

Producers using the staggered two-month interval schedule have reported up to 40% increase in lamb production over previous conventional systems. They also suggested that, by dividing the flock into four groups, substantial savings in facility costs are possible. Increased management attention can be given to critical lambing and early lactation periods since all ewes are not lambing at the same time.

Five Lamb Crops in Three Years

In this system, developed by Cornell University and often called the Star system, the calendar year is divided into five segments (the points of the star) that each represent one-fifth of a year, or 73 days. The star can be rotated to give the most suitable dates. Two-fifths of a year is 146 days, which is approximately the gestation length of a ewe. The flock can be divided into three groups in this system. When the system is in operation, during the first 30 days of each segment one group lambs at the same time another group is being bred. The next 35 days in each segment would represent lactation for one group, late gestation for the second group, and early gestation for the third group. The second and third groups can be managed together, thus reducing the system to two groups. Lambs from the lactating ewes would be weaned seven to eight days before beginning the next breeding/lambing period. Ewes bred at the first period or point of the star would lamb 146 days later at the third point and could mate 73 days later at the fourth point to lamb 146 days later at the first point in the next year.

This system produces five lamb crops in three years, at a 7.2 month lambing interval. A ewe that did not miss a mating period in three years would lamb at each point of the star, and average 1.67 lambings per year. Missing one 73 day cycle in three years would result in an average of 1.56 lambings per year, while missing two cycles would result in 1.47 lambings per year.

Missing three cycles would reduce it to 1.33 lambings per year.

The Cornell University Dorset flock, which has been on some form of accelerated lambing for 15 years, averages approximately 1.5 lambings per ewe per year. The 1/2 Finnsheep x 1/2 Dorset ewes have had a longer lambing interval, with approximately 1.33 lambings per ewe per year, but this is more than overcome by the extra 0.5 lambs per lambing in the 1/2 Finnsheep ewes. More information is needed regarding expected lambing intervals and rates for sheep managed on this system.

Opportunistic Lambing

This system implies breeding for an extra lamb crop when conditions are desirable. These could be a favorable forage year because of adequate rainfall at the right time, or when lamb prices are unusually favorable, or for one last lamb crop before aged ewes are marketed for slaughter. These ewes can be pregnancy tested following breeding and only the pregnant ewes are retained for lambing. If it can be determined that there are several dry ewes in the flock, it may be desirable to breed before waiting for the next season. It is likely that some version of opportunistic lambing which is unique to the individual producer is the most widely used form of accelerated lambing.

Continuous Lambing

In this system rams are kept with the flock throughout the year. When ewes lamb, they may be removed from the flock for a week or two. Replacements are selected from lambs born during the least likely seasons from the most productive ewes. This system was used in the development of the Beltsville Morlam strain. Fifteen years of selection for the ability to lamb at any time of year indicated the effects of season on mating ability can be reduced by selection.

Two Lamb Crops Per Year

Scientists at Oklahoma State University using Dorset, Rambouillet, and Dorset x Rambouillet ewes reported that percentage lamb crop born was increased by 25% to 30% by lambing twice a year. The crossbred eyes performed better than either of the parent breeds.

Current studies on developing new breeds or lines of sheep that will lamb at six-month intervals are in progress at the Roman L. Hruska Meat Animal Research Center at Clay Center, Nebraska. In theory, this system would permit the maximum number of lambings per ewe, but it is unlikely this will be realized in practice. Even though this system is not recommended for commercial use at this time, it is hoped these important studies will result in production systems which approach twice per year lambing.

SELECTING THE BEST SYSTEM

Before selecting a specific mating and lambing system, one should consult with successful accelerated lamb producers in a geographic area that most nearly matches his own area. Determine how they do it and carefully study and evaluate economic and management advantages before launching into an accelerated program.

Other Factors to Consider

Types of accelerated lambing systems and the appropriate genetic resources for these systems are important determinants of success. Ewes must have the genetic potential for high prolificacy and frequent lambing and the system must permit optimum expression of these traits. Of equal importance are such factors as management capabilities, feed resources, facilities required for total or partial confinement systems and capital investment requirements. The individual producer must carefully consider all of these factors before starting an accelerated lambing program. As an example, more uniform distribution of labor requirements throughout the year may be considered an advantage to the person interested in specializing in sheep production. Yet it may be a disadvantage for the person having large investments in other enterprises that require high labor inputs at certain times of the year.

IMPROVED LAMB SURVIVAL AND PERFORMANCE

Reducing Losses in Postnatal Lambs

Often great disparity exists between lambs born and lambs reared. Most of this loss occurs during the first 30 days; the first 3 days are the most critical. Drs. Norman Gates at the U. S. Sheep Experiment Station, Dubois, Idaho (1977) and Joseph Rook at Michigan State University (1989) have conducted cause of death studies in baby lambs during their first 21 or 91 days of life. At Dubois, 66% of all losses could be attributed to starvation and lambs scours.

Recognizing the fact that many newborn lambs die from starvation because of chilling or insufficient milk production of the dam and that stress increases the incidence and severity of scours, the following procedure was implemented at the Dubois Sheep Station in 1976: (1) increase the number of individual lambing pens; (2) keep the lambs in pens longer (preferably 3 days, the time required for lambs to fully develop their thermoregulatory mechanism and an opportunity to observe for adequate nutrition; (3) provide more help to suckle lambs; (4) check all lambs in individual lambing pens and mixing pens for scours at least once each day and treat all sick lambs; (5) observe lambs carefully to see that they are getting enough milk and (6) graft hungry lambs to ewes having adequate milk (slime, wet, skin, stockinette and stanchion graft). Lamb losses during spring 1975 were compared with losses during spring 1976 lambings after the improved management input. Losses in 1975 were 12.6% of live lambs born; those in 1976 were only 4.1%, or an estimated net saving of $17,000 as an apparent product of the changed management practice.

In Michigan, the loss pattern was different. The largest losses were caused by dystocia/stillbirths followed by starvation/ hypothermia, pneumonia and abortions. Attention to the causes of loss by the producers brought about a decline in losses caused by starvation/hypothermia and pneumonia. These studies identify the importance of knowing the time and cause of lamb losses so that effective corrective action can be taken. A gross postmortem examination by a local veterinarian or experienced producer is probably the only economical way to arrive at a diagnosis of cause of death. A checklist for a postmortem examination is outlined by Rook (1989).

A lamb survival study in Texas under range conditions (Shelton and Willingham, 1989) showed that by shifting from a mid-winter to a mid-fall or early spring lambing season, lamb mortality was markedly reduced (41.9% and 15.8%, respectively). However, a reduction in conception rate and lambs born per ewe lambing, occurred in the fall, suggesting the need for extending the breeding season or having a catch-up breeding later on. Seasonal effects were minimal for single-born lambs but twin-born lambs had mortality rates of 29.9% for those born in mid-winter and 17.5% and 17.1% mortality rates for fall- and spring-born lambs, respectively.

Putting Lambs Where the Milk Is

Interest in artificial rearing of orphan lambs has increased with the advent of liquid milk replacer formulas. Very successful techniques have been developed both in labor-saving, self-feeding systems and in diets. However, costs remain high, and profits are often marginal.

The most economical way to raise lambs is on their dams. However, some ewes have more lambs than they can supply adequate milk for, and other ewes have more milk than the lambs can use. Efficient management requires putting the lambs where there is adequate milk. This requires a procedure to graft or foster lambs with an inadequate supply of milk to a ewe with surplus milk. Procedures for doing this were outlined by Hulet et al. (1979). Lamb-specific odor is used by the ewe to distinguish their own lambs from other lambs. Lamb fostering techniques in general are designed to transfer sufficient odor to induce the ewe to claim and mother the orphan lamb. These techniques include slime grafting (transferring placenta fluids or birth slime to the orphan lamb), wet grafting (after newborn lamb is mostly dry, both "own" lamb and "extra" lamb are immersed in salt water and both lambs are thoroughly and systematically rubbed together), skin grafting (skin of ewe's dead lamb is put on the orphan; head, legs, and tail are smeared with blood and body fluids from the dead lamb), and cloth stockinettes (a stockinette is first placed on the ewe's own lamb as soon after birth as convenient. After about 24 hours, it is taken off the natural lamb and put on the orphan lamb [Price et al., 1984; Martin et al., 1987]).

Grafting or fostering is more successful when attempted as soon after parturition of the ewe as possible. This sensitive period varies greatly among ewes. The sensitive period can be extended with tranquilizers or with high doses of estrogen (Poindron et al., 1980). Some restraint of the ewe is often required for a highly successful fostering program (Alexander and Bradley, 1985).

SOCIAL BOND DISRUPTION AND STRESS

Stress, psychological and social factors influence the relative ease and efficiency of handling and working sheep, and can have profound effects on production efficiency. Weaning is an extreme example of the disruption of close social relationships. When lambs are early-weaned, they characteristically exhibit a stasis of growth. Nutritionists have tried without success to formulate diets which would eliminate this reduction in rate of growth. Stress associated with removing the lamb from its mother, a strange new environment and, frequently, a new type of feed probably account for the marked reduction in gain for a period of time following weaning. Lambs should be adapted to the feed they will be given at weaning starting at least a week before weaning, and the ewes should be moved away from the lambs and not the lambs away from the ewes. This permits the lambs to stay in familiar surroundings on a familiar feed which should reduce stress and improve post-weaning performance.

Disruption of social or companionship groups even later in life can be psychologically disturbing and can negatively affect performance for a period of time. If disruption of social groups occurs at breeding time, ovulation and fertility could be adversely affected, as has been observed in the human menstrual cycle. This may explain why some small farm flocks with one owner-operator have superior lamb production performance compared to large flocks where the sheep are sorted by various criteria into many small, single-sire breeding pens disrupting many close associations.

Sheep may also be stressed by inexperienced and abusive handlers. The consequence of the caretaker's attitude and behavior on livestock performance was demonstrated in a study evaluating operator attitude on milk production in dairy cattle. Production was better in cattle attended by a kindly, gentle person than one who disliked cattle (Seabrook, 1972).

MORE EFFICIENT UTILIZATION OF THE FORAGE RESOURCE

Research indicates that grazing more than one animal species on the same pasture contributes to more uniform and efficient utilization of the forage resource (Cook, 1954; Bennett et al., 1970; Kautz and Van Dyne, 1978; Parker and Pope, 1983), providing a higher economic return (Hamilton and Bath, 1970; Terrill, 1975; Ospina, 1985). However, when this management is practiced, the cattle and sheep seldom graze together and sheep losses to predators may be too high.

We observed that cows normally protect their calves from coyotes as long as calves stay near their mothers. Would it be possible to socially bond young lambs to heifers so that the lambs would consistently stay with the cattle and would be protected from predation? We have since successfully bonded 45- to 90-day old lambs to heifers by close confinement in groups of 7 lambs with 6 heifers or 7 lambs with 3 heifers for 60 days (Anderson et al., 1987). When turned to pasture, the bond needs to be solidified in small open pastures with one watering place. Lambs may become separated from the cattle while they are young, but normally get back together at the watering trough or while grazing. It is good during this developmental period to put them together whenever they are observed apart. Lambs that are bonded to cattle get good protection from predation (Hulet et al., 1987). We studied the defense mechanism using a trained Border Collie dog (Anderson et al., 1988). Bonded sheep always stayed close to cattle. Whenever the dog chased bonded sheep, they always ran to the middle of the cattle herd, leaving a perimeter of threatening cows. When the dog was urged, she was able to move the herd, but as they moved, the sheep stayed within the protective perimeter of cattle. At no time during many observations did the sheep separate from the cattle. In contrast, unbonded sheep, even when threatened by the dog, ran away from the cattle and thus were vulnerable to attack by predators. We observed a coyote approach a group of bonded lambs and heifers. One heifer chased the coyote out of the pasture. Mohair goats formed loose bonds with cattle, but did not stay with them consistently enough to get protection from predation. However, when mohair goats were also bonded to sheep that were bonded to cattle, they got good protection (Hulet et al., 1989). In contrast, Spanish goats appear to have as strong an affinity for cattle as for sheep.

Studies (Baxter, 1959; Bennett et al., 1970; Barger and Southcott, 1975) have also shown that multi-species grazing reduces the parasite load in cattle, sheep and goats. Rotational grazing not only maximizes forage production but it also reduces parasite problems.

PREDATOR CONTROL

Predation has been a very serious problem to sheep producers for many years. Coyotes have been singled out as major contributors to the decline of the sheep industry. Many individuals and rural families whose flocks and herds have suffered depredation have been forced to sell or to abandon operations (Senate Oversight Hearings Regarding Predators, 1980). Not only for the sheep operation to stay in business but to be profitable, a good predator control system appropriate to the particular farm or ranch environment must be in place. Electric fences can be very effective on open productive pastureland, but are not satisfactory in extensive range country especially where the terrain is rough and brushy. Guard dogs, when properly managed, are often more effective and reliable than most other systems in many situations (Green and Woodruff, 1983; Green and Woodruff, 1988). Donkeys and sheep bonded to cattle can be effective in some circumstances (Hulet al., 1987, 1989; Anderson et al., 1988) Hunting, denning, trapping, snaring and M-44 devices may be needed to supplement the basic guard protection system.

CONCLUSIONS AND FUTURE EXPECTATIONS

After years of frustration, a successful method has been devised for separating sperm carrying x and y chromosomes. Recently, females fertilized with the y-separated sperm cells gave birth to 90% males; those fertilized with x-carrying sperm cells gave birth to 94% females (Johnson, 1989). Thus with the new and more sensitive sophisticated biological assays, computer analytical techniques, genetic engineering with its spin-off of cellular and subcellular manipulations, advances in immunocytochemistry, immunology, and immunotherapy, the relative explosion of synthetic biologicals all strongly suggest that we can expect great changes in the animal industries in the near future.

We are very close to the time when the majority of sheep will be bred to produce a first lamb crop of two lambs per ewe at one year of age. Strains of sheep will be available that will breed and produce twins at any season of the year and will be capable of producing more than one lamb crop per year. These lambs will gain faster on less feed than we now think possible. Furthermore, sex of the lamb will be decided at breeding time. Sheep will have a longer productive life and will be free of many of the diseases that reduce longevity and performance. The vision, courage, and untiring efforts of men like Dr. Clair E. Terrill have contributed and will continue to contribute much to the realization of these marvelous achievements.

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