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Preface and Overview

Maurice Shelton
Texas Agricultural Experiment Station (Retired)

Introduction

On a world basis, sheep are kept for a variety of reasons, but in this country the primary uses have been meat and fiber production. At present there is also a limited and growing interest in milk production from sheep. One of the more recent and growing roles for sheep is that of vegetation management, including optimum grazing and range management practices (Havstad, 1994), control or assisting in the control of noxious vegetation (Olson and Lacey, 1994), reduction of fuel loads for fire control or retardation (Taylor, 1994), and reducing vegetative competition in reforestation efforts (Sharrow, 1994). Even flocks used for vegetative management must produce a marketable commodity to justify their costs or to provide an outlet for surplus animals. Because a majority of the world's sheep are wool producers (at some level) it seems likely that in earlier periods fiber production was viewed as their more important contribution. Historically wool was an important item in world trade, but this special place is declining.

In Texas, cash receipts from wool exceeded those from meat (lamb and mutton) until approximately 1954 (Shelton and Kensing 1980). With incentive payments included, the income from wool exceeded that from meat until approximately 1964. Since 1964 the relative value of these products has shifted markedly in favor of lamb production, with some years in which wool represented 10% or less of the gross income. This situation has no doubt existed for a much longer period of time in farm states, in which medium wool sheep represented a larger percent of the total. Except for a brief period in the late 1980's, the contribution of wool to flock income has trended downward for half of a century. At the time of this writing (fall - 2001) the cost of production, harvesting and marketing wool exceeds the income obtained from it. What the future holds for the demand for wool is not known, but a reversal of this trend is not apparent at present. This is unfortunate, and the loss of wool income has no doubt contributed in a substantial degree to the decline in sheep numbers in the U.S. The genetic and nutritional resources and management practices required to produce a good clip of wool are simpler than those required to produce a good lamb crop. The situation is made more difficult by the fact that there is, to some degree, a negative relationship between meat and fiber production (Shelton, 1994; Cronje and Smuts, 1994), especially under conditions where nutrition is a limiting factor. Unless there is a significant and early reversal in the prices received for wool, the U.S. sheep industry can survive and reverse the decline in numbers only by doing a better job of lamb production.

In the past when producers have exercised selection for meat production they have primarily emphasized size (or growth rate) and conformation. Selection for size has been highly successful (Parker and Pope, 1983). As shown in Figure 1, the weights of most breeds of sheep have consistently increased over at least the last 40 years. However, size is only one component of meat production, and a continued increase in size is unlikely to be desirable in all production situations and market outlets. Conformation is a much more nebulous term, and it is not clear that selection for conformation has had a positive influence on the industry. Selection goals in respect to conformation have ranged over time from small, compact, blocky animals with a large amount of subcutaneous fat to tall, upstanding, leggy animals that lacked fitness or adaptation to grazing environments. The only legitimate goals for conformation are that slaughter animals possess the optimum amount of subcutaneous fat (to meet market demands or grading standards) or that the animals produce a carcass with a higher percent of the weight in the more valuable cuts. It cannot be shown that this latter goal has been accomplished. It is theoretically possible to change body proportions (Waldron - this issue), but this will be difficult and require more resources than have been or are likely to be devoted to this cause.

The Components of Meat Production

The most important factor contributing to meat production from sheep is numbers. The situation pertaining to stock sheep numbers in this country is all too obvious with the downward trend starting around 1940 (Figure 1). The goal of all concerned with the industry must be to reverse this trend. The purpose of this special issue of the journal is to summarize information which could be used to improve efficiency of producing and marketing quality products and thus contribute to a revival of the industry. Genetics (breeding) is one of the approaches to accomplishing this goal, but it requires that one take a long-term view.

With a constant or stable number of sheep, the most important factor contributing to meat (lamb) production is net reproductive rate (percent lamb crop raised and marketed). The only lambs available for slaughter are male or wether lambs plus any ewe lambs that are surplus to replacement needs. If flock numbers are to be increased, relatively few ewe lambs would be available for slaughter. Mutton (meat from older animals) production is largely limited to cull or older ewes. Assuming a stable population, the numbers of ewes available for slaughter represent the replacements (ewe lambs added to the flock) less the death losses over the productive life of the ewes. Typical annual replacement rates are on the order of 25%. Contributing factors to the lamb crop raised are age at sexual maturity, frequency of lambing, the percent of ewes bred and lambing, ovulation and/or lambing rate, lamb survival and the length of productive life of the ewes. Many of these factors are discussed by authors contributing to this special issue. All of these factors have genetic, environmental and management components and thus are subject to some degree of control by producers.

The third factor contributing to meat production is slaughter weight, and yield (dressing percent) and percent of the carcass in retail or consumer cuts. The average slaughter weight for sheep in this country has continuously increased from 1960 through 1990 (Williams and Davis, 1998). This has resulted from larger breeding stock (Parker and Pope, 1983), from an increase in the proportion of the lamb crop that spends some time in feedlots (Field and Whipple, 1998) and from a tendency to hold these in the feedlots to heavier weights. The merchandising of heavier lambs may be viewed as positive to some segments of the industry, as there will be some improvement in efficiency to the feedlot operator, as well as the packer and in the merchandising process. However, there are almost certainly problems associated with an ever-increasing slaughter weight. It should be remembered that it is not the feedlot operator, packer or the end processor that determine sheep numbers in this country, but it is the producers who maintain the ewe flocks and produce the lambs. If it is assumed that the average weight of the breeding stock is held constant, any increase in slaughter weight will result in an almost linear increase in the amount of fat in the carcass (Bradford - this issue). This has been documented in many studies as having happened in the U.S. and to have contributed to the perception that lamb meat is high in fat content (Berg, et al., 1998). This is thought to have contributed to the decline in lamb meat consumption.

If size of the breeding ewe is increased (or is allowed to increase) as has happened with most breeds, any improvement in efficiency at the producer level will be minor, and may be negative if the increase in size results in a reduction in adaptation to the production environment or has an adverse effect on other traits such as reproductive rate. Barlow (1984) stated that "there is little justification for selecting for growth rate (e.g. size) to improve efficiency of meat production of cattle or sheep that function largely as maternal breeds." Scholtz and Roux (1984) state that "there are indications from the literature that selection for increased body mass or growth rate may have adverse effects on fertility." The contrast in trend lines between the numbers of stock sheep in this country and the average slaughter weight is very evident (Figure1). This does not prove a cause and effect relationship, but it is obvious that an increase in slaughter weight has not resolved the problems of this industry. Across species and across breeds within species (especially sheep) there tends to be a negative relationship between size and realized reproductive rate. Even within species and breeds it has been shown that extremes in weight suffer some loss in reproductive rate and longevity (Shelton, 1959).

In respect to slaughter weight, it is not clear that consumers have a strong preference for cuts from any specific size of carcass, although there must be a preference for larger loin chops that would derive from larger carcasses. In present market channels heavier carcasses are priced lower, but this in part represents discrimination against their actual or perceived higher fat content. This discrimination might be reduced or eliminated if carcasses could be marketed based on their yield of fat-standardized consumer cuts (Waldron - this issue).

It should be noted that the two growth market outlets for lamb (exports to Mexico and the ethnic markets in this country) express a strong preference and pay a premium for smaller animals. Exploiting these markets equates well with the development and use of more prolific types of sheep. On a world basis and in areas where the sheep industry has persisted and thrived, the industry is based on a type or breed of sheep which is well adapted to the environment and production conditions and which produced a product or products that are in demand. There are many examples that fit this description. One example of this is the Merino, or breeds such as the Rambouillet and Targhee derived from the Merino. The Merino sheep thrived at many places in the world when wool prices were reasonably favorable. However, it can be shown that it is possible to put "too much" wool on these animals, resulting in some reduction in their ability to thrive under adverse conditions and produce a good lamb crop (Willingham et al., 1994). Many strains of Merino must be crossed to other breeds to produce an acceptable market lamb. This cross may be a terminal sire breed to produce market lambs or to a breed specifically chosen to produce a desired type of F1 ewe for market lamb production, e.g. the Border Leicester breed, which has been extensively used for this purpose in Britain, Australia, and New Zealand. The use of such specialized "ewe sire" breeds has not been a common practice in the U.S. (especially in the Southwest), but it is a practice that should be reconsidered in light of current wool prices. One of the problems may be the lack of a suitable breed that is adapted to this region. This should perhaps be addressed in future research or development projects.

Efficiency of Production

Efficiency of production may be expressed as a function of any of the resources or inputs required. Producers will usually be concerned about the most limiting or most expensive inputs. For ruminant species this most likely would be feed or nutrients. Some producers who choose to increase reproductive rate through intensive management, especially at lambing, may view labor or facilities as limiting resources. For many, efficiency is defined as gain per unit of feed consumed by an individual animal and most will be aware that this efficiency decreases with age of the animal. This is due primarily to two factors: feed intake relative to body weight is higher in younger animals, resulting in a lower proportion used for maintenance, and gains made by the young animal consist mostly of lean growth as opposed to fat. However, on a flock or industry basis, the cost of gains for an individual market animal represents only a small part of the total feed cost. It is generally assumed that as much as 70% of the feed required to produce a pound of lamb meat is that consumed by the breeding flock (mostly the ewe). If ewe replacement costs are included, this would be even greater. This is a major reason why meat production from ruminant animals cannot compete (on the basis of efficiency) with that of swine or poultry where the breeding animal cost per market animal is much lower.

Thus any factor which tends to reduce the ewe or flock maintenance cost per market animal has a major impact on efficiency of production from sheep. Traditionally wool income has been viewed as a means to recover or reduce flock maintenance cost. Numerous studies have shown that the ewe component in production costs (more appropriately nutrients required) can be reduced through spreading this cost over a higher level of productivity by marketing more or heavier lambs or both (Hogue,1968; Large, 1970). Of the two, the simpler or most easily accomplished is to market larger lambs, and as shown in figure 1, the industry has moved markedly in this direction. However, in a purebreeding system, producing larger lambs through maintaining larger ewes represents little or no gain in efficiency at the producer level, whereas producing larger lambs from the same sized parent results in overfat lambs. This has been documented in many studies (Tatum et al., 1988) and resulted in an image of lamb meat as being overly fat.

A series of modeling studies (Wang and Dickerson, 1991) were carried out based on data from the U.S. Meat Animal Research Center. These authors report the following traits in order of their contribution to efficient meat production from sheep (TDN per lb. of lean meat): lamb survival, lambing rate, and conception rate (fertility). Other traits, including size of ewe and milking ability, were of much less importance with near zero contribution. It is important to remember that these calculations are based on inputs from the research flock involved and that this flock included animals from some of the more prolific types of sheep.

Although the case for improving the net reproductive rate and the potential (with sheep) for doing so is quite great, the industry has not readily endorsed recommendations for improvement in reproductive efficiency through genetic means (see Hamilton and Hamilton - this issue - for an exception). No doubt lamb mortality, which certainly increases with higher prolificacy, and the time and effort required to change these factors through selection provides a partial explanation. However, the very survival of the industry may require more effective application of this approach.

Improvement in reproductive efficiency through genetic means may be approached through selection within breeds or lines, crossbreeding to realize the gains offered through heterosis or breed complementarity, or by introduction of inheritance from more prolific breeds (Leymaster - this issue). The latter two, especially the use of more prolific genotypes, offers the potential for immediate gains, but long term selection within breeds for fitness and reproductive rate (overall productivity) should be strongly considered as well.

Some Conclusions and Recommendations

1. Producers should exercise caution in selecting for increased size in dam breeds or general purpose breeds where fitness and reproductive rate make the greatest contribution to production efficiency.
2. Selection for size and/or growth rate and carcass merit may be largely restricted to sire breeds. Limitations on size might be considered in the case of poor breeding efficiency of rams or where dystocia becomes a problem in ewes to which they are bred. Efforts to improve carcass merit, aside from the amount of fat, will likely require a group effort such as group breeding schemes or multiflock efforts.
3. Major emphasis in dam lines or breeds and general purpose breeds should be in selecting for ewe fitness and productivity. These may be accomplished through three different approaches:
(a) Selecting within breeds or flocks (Bradford - this issue). The heritability of the different components of reproductive efficiency is low and thus progress in selecting for these individually will be slow. Thus it may be preferable that selection be exercised for a composite trait such as total lambs weaned. The heritability of this trait is improved if the records are compiled over a period of years (Shelton and Menzies, 1968). Another alternative is to select for total lamb weight weaned (Snowder - this issue). This is a composite trait that not only includes reproductive efficiency, but weight of the lambs weaned as well. In the study on which the above report was based, selection for total weight weaned resulted in some increase in the size of the ewe as well as level of milk production. These latter measures require more feed intake and may not result in the same relative gain in efficiency as selecting for reproductive efficiency alone. Also this paper reports greater gains from selection than most other studies of this nature. This may reflect in part the fact that a larger population of animals was involved than is the case with many research projects, and thus highlight the fact that larger numbers are needed to bring about genetic progress in difficult traits such as reproductive efficiency, carcass composition or meat quality. This suggests the need for some type of group effort such as the NSIP.
(b) Crossbreeding to obtain the advantages of heterosis and breed complementarity. The advantages of crossbreeding are well documented in the literature (Leymaster - this issue). However, there may be problems or questions as to choice of breeds. Although there are nearly 50 breeds of sheep in the U.S., many of these may not be adapted to the production conditions involved or may not possess the traits desired in crossbreeding programs. The choice of sire breeds usually represents less of a problem than the choice of the most desirable breeds to produce Fl ewes unless one chooses to use one of the more prolific types. Space does not permit the discussion of the individual breeds at this point, but the breeds are discussed in detail in the Sheep Producers Handbook (1997).
(c) Crossing with one of the more prolific breeds or genetic types (Hamilton and Hamilton - this issue). Clearly the best opportunity to increase reproductive rate

in the near term is to introduce prolific breed inheritance into existing flocks. The two best known prolific breeds are the Finnish Landrace and Romanov, both examples of the North European Short Tailed group. These breeds have the advantage that they transmit their high prolificacy additively, thus permitting adjustment of flock mean prolificacy to the desired level by varying the proportion (e.g. 0.25, 0.38, or 0.50) of prolific breed inheritance introduced. In addition to the above breeds, the Booroola gene (FecB) should be considered. This can produce an immediate large increase in number of lambs born, but has the limitation that the increase achieved may be more than desired. The use of the homozygous individual (two copies of this gene) should be ruled out in commercial programs, and even the heterozygous individual often gives more lambs than desired. The (Booroola) package in which this gene was introduced was found to be somewhat unsatisfactory for lamb production in this country, but the potential exists and has been accomplished to transfer this gene to other breeds or types in which it may be more useful, especially in smaller and more intensively managed flocks.

4. Producers should be open to the potential offered by accelerated lambing programs. One of the advantages of sheep, at least as compared to cattle, is their ability to reproduce at less than 12 month intervals. This potential advantage has not been pursued by the industry to the extent that it might be. Complications in the management of accelerated lambing programs are obvious. Also there is a need to identify or create populations of animals without serious seasonal restrictions to mating (Notter - this issue). This trait has been shown to be both repeatable and heritable. One management system (the Star System) is outlined in the above-mentioned paper. It is likely that the most desirable accelerated lambing system is unique to the resources available to each producer.
5. In view of the present low prices for wool and the difficulties of getting sheep sheared, there is no doubt a need for development work with non-wooled sheep as an option. This need is almost certainly greater at the more southern locations, but there is interest in this type of sheep throughout the country. At present, the available genetic resources are short in both quality and quantity. The hair sheep option may be of greater interest for the potential they offer in accelerated lambing programs.

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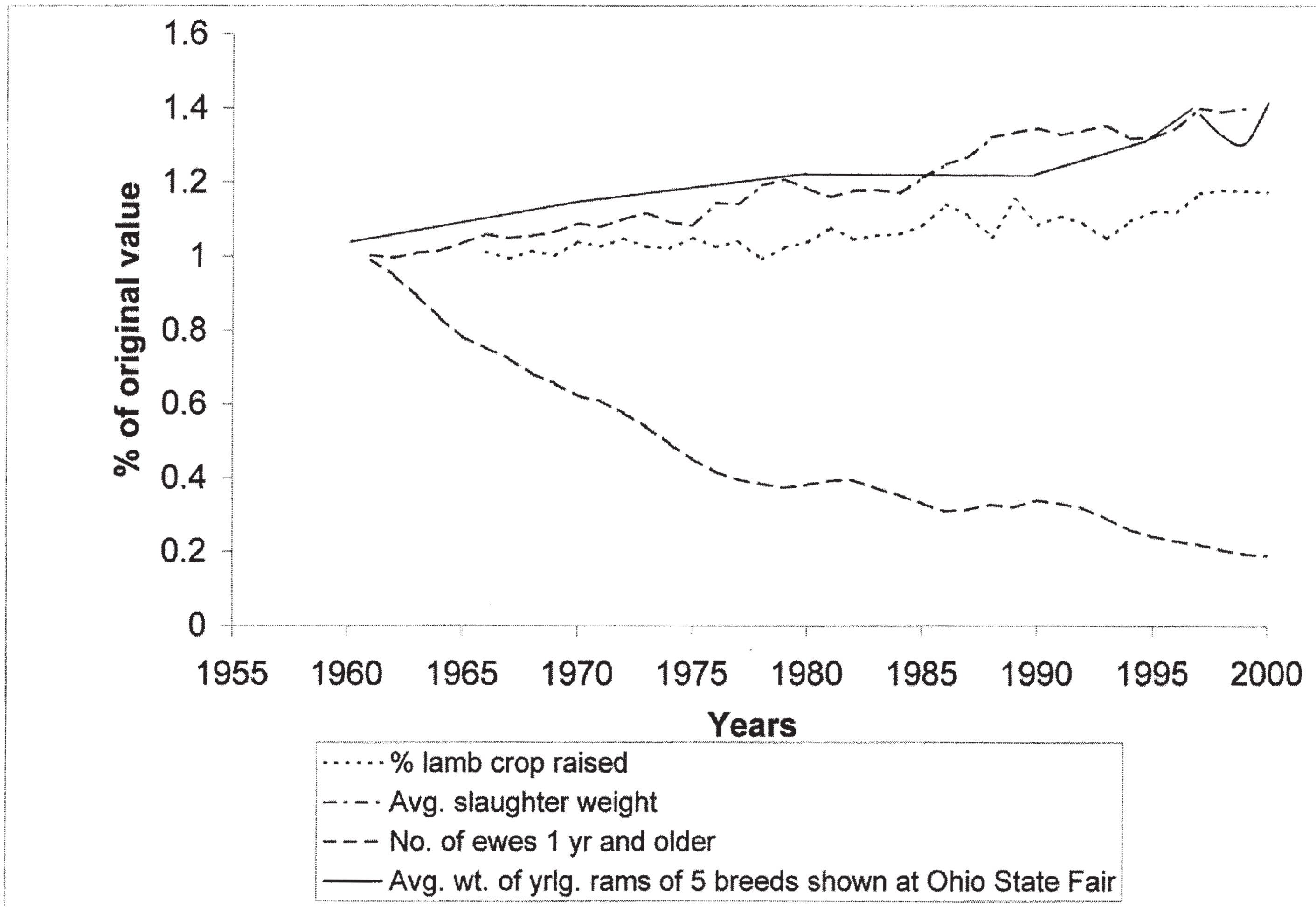

1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
% of original value
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Years
% lamb crop raised
Avg. slaughter weight
No. of ewes 1 yr and older
Avg. wt. of yrlg. rams of 5 breeds shown at Ohio State Fair