THE USE OF PRODUCTION RECORDS AS A METHOD FOR IMPROVING THE
REPRODUCTIVE PERFORMANCE OF SHEEP

RON LEWIS and MAURICE SHELTON, USA
Texas A&M Agricultural Experiment Station
San Angelo, Texas 76901

SUMMARY

One method for improving the reproductive performance of a flock is to emphasize lambing rate in the breeding program. However, in order to identify animals with a history of high prolificacy, some degree of record keeping is necessary. Furthermore, to maximize the rate of flock improvement for lamb production, selection decisions should be based on an animal's genetic merit for the trait rather than on phenotypic performance. This review presents the framework of a computerized flock recording scheme designed to meet these two objectives, namely to facilitate the mechanics of record keeping and to summarize production records such that animals with superior genotypes for lambing rate can be identified.

INTRODUCTION

Since lamb sales are a predominate source of income to sheep producers, a considerable amount of research effort is being devoted to devising methods to improve the reproductive rate of sheep. Unfortunately, the industry's demand for more efficient lamb production is antagonized by the relatively low reproductive performance of many flocks (Turner, 1969; Shelton and Kensing, 1980). Past emphasis on visual selection for wool and weaning weight has likely reduced overall reproductive efficiency. Phenotypic selection of ewes at an early age as replacements favors single born lambs since they are larger and in better condition at weaning. Discrimination against twins is of particular concern in range flocks where birth data are seldom available and environmental conditions may restrict the growth of lambs from multiple births (Turner, 1961; Purser, 1965; Vogt et al., 1967). Identifying and favoring lambs from multiple births is essential if prolificacy is to be increased. By collecting more intensive lambing records, animals with superior genotypes for litter size can be identified and greater selection pressure placed on this character (Shelton and Menzies, 1970).

In order to improve reproductive rate within a flock, some degree of record keeping is necessary (Bradford, 1985). Since sufficient gains in fleece and weaning weight can be accomplished simply by selecting on phenotypic performance, extensive recording is likely only warranted if lambing rate is considered primary in a breeding program. Although record keeping is widely recognized as important by sheepmen, the actual mechanics of collecting and summarizing data is sometimes difficult, particularly in the case of large flocks. The purpose of this study is thus two-fold. First, to develop a computerized recording scheme that will both encourage and facilitate record keeping. Secondly, to develop a methodology for summarizing the collected data such that animals of superior genetic merit can be identified and selected for breeding purposes. At present, considerable progress has been made in the development of the mechanics of a recording scheme and this project objective will be stressed throughout the remainder of this paper. Although preliminary work in summarizing the collected records has been completed, more extensive analyses are necessary to make the most efficient use of the data.

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RECORDING SCHEME DEVELOPMENT AND METHODOLOGY

Records from six purebred Rambouillet flocks were used for the development of the recording scheme. Two of these flocks are the property of the Texas Agricultural Experiment Station (TAES) while the remaining four are under private ownership. The breeding program in one TAES flock has emphasized reproductive performance by selecting sires whose dams have a high twinning rate. The flocks are located throughout the Edwards Plateau region of Texas and are under various levels of management. The number of records and specific data collected on each flock are also variable although most date from the early seventies and include lambing records, wool characteristics and some measure of body size or conformation. Approximately 2,500 ewes with more than 20,000 records will be considered although numbers are continually increasing as additional ewes and records are added into the system. Although the recording scheme has been developed using data provided by Rambouillet breeders, a considerable amount of its organization and principles could equally be applied to other breeds of sheep.

In order for the recording program to be flexible enough to handle differences in ranching operations, a wide range of inputs are allowed although few are required. Since reproductive performance is considered primary, every mature ewe is required to have a lambing record for each year; failure to produce a lamb would be considered a valid record. The production records are divided into three distinct data sets: animal identification, fleece production and visual scores, and lambing records; these data sets are referred to as A, B, and C, respectively. The animal identification inputs include the animal's owner, ear tag and tattoo number, birth year, type of birth and pedigree, namely their sire and dam. Registration information is allowed although registration is not a prerequisite for inclusion in the project. Fleece production and visual score inputs include grease fleece weight, staple length, face, belly and conformation scores, body weight, identification re-tags, and the animal's fate (died, sold, etc.). Breeding records can also be added to this data set. The third data set, lambing records, includes the lamb's identification, dam, sire, sex, birth date, weight and condition, weaning date and weight, face, belly and conformation scores, fate, and coded remarks. Producers also have the option to identify lambs they intend to register so that a registration application can be generated upon request at a later time. Each flock will consist of these three unique data sets for their breeding ewes. Since only a relatively few rams are maintained in each flock, all rams' records are combined on the same data sets with each ram categorized by their respective owners. Only data sets A and B, with some modifications, apply to ram production.

An estimated breeding value (EBV) for mean lambing rate, the average number of lambs born per lambing season throughout the animal's life, is calculated for ewes, rams, and lambs. Being a maternal characteristic, estimates on males and lambs are based on the performance of female relatives. The estimation formulas are modifications of those proposed by Clarke and Rae (1976) and Baker (1983). The prediction of breeding value is based on available, relevant information from direct pathways. The EBV of a lamb, for instance, may be based on his dam's, paternal half-sibs', paternal grandam's or maternal grandam's performance depending on both the amount and type of information available. The chosen method for prediction is that which maximizes accuracy. At most, two sources of information are used in the prediction. An attempt to account for differences in age, number of lambings, and year effects is made by expressing the EBV as a deviation from ewes of the same age during the
same year; in other words, as a deviation from contemporaries (Baker, 1983). This method of estimation may cause considerable fragmentation of the data which is of concern particularly in small flocks. Therefore, it may be necessary to compare the performance of ewes of the same age irrespective of the year in which they reached that age. Heritability and repeatability values used in the estimations are taken from the literature.

Weaning weights are adjusted to a 120-day equivalent by methods recommended by Warwick and Cartwright (1958) and Meyer and Clarke (1983). The adjustment factors attempt to account for the lamb's sex, birth and rearing type and the age of the lamb's dam. In certain instances, a birth or weaning date is not available; in such cases the actual weaning weight is reported.

RECORDING SCHEME FORMAT

As mentioned earlier, one goal of this project was to provide producers with some assistance in the mechanics of record keeping. Consequently, a series of data collection or input forms have been designed to help with this task. Input forms for each of the three general areas of the production records, namely animal identification, fleece production and visual scores, and lambing records, are generated either seasonally or yearly and distributed to each producer. Maintaining a unique identity for each animal throughout their lifetime, although essential, has proved to be quite problematic. Consequently, each form is both labeled and arrayed by each animal's identification number; if an animal has been re-tagged, the most current tag number is used. In certain instances, additional information besides the animal's identification number is included on the input forms. For example, in a form generated for recording lamb weaning dates and weights, the lamb's birth type and an estimated breeding value for lambing rate is also listed; this information may be valuable to producers who select their replacements at weaning and would like to consider a lamb's birth type or a prediction of the lamb's future lambing rate in their decision.

Identifying inaccuracies and inconsistencies within production records is both time consuming and tiresome. One distinct advantage to a computerized recording system is that many errors can be identified through routines within the program itself. Once a producer completes and returns his input forms, his records are key punched into the system and then "read" into a program designed to identify, and if appropriate, correct data errors. Examples of such errors include duplicate entries, inconsistencies in tag numbers or pedigrees, and unrealistic lambing intervals, fleece measures or body weights. Unfortunately, some "hand checking" of the records is still necessary since certain clerical errors are quite difficult to identify through automated procedures alone.

Once the production records have been received and data errors have both been identified and corrected, a variety of output forms or printouts are available to the producer. Each output form is designed to summarize an individual animal's or the entire flock's performance in each of the previously mentioned production areas. Animal identification output simply lists numerically those animals still considered active in the flock along with their immediate pedigree, that is their sire and dam. A cross-reference listing arrayed by tattoo number is also available to help identify animals who have lost their ear tag. Fleece and score data are summarized on an individual animal basis; both a lifetime average and the most recent shearing or weighing record is provided. Two lambing record summaries are available for the producer. The first is arrayed by the year and lambing season and lists numerically the lambs born during the given season. Besides the lamb's tag
and tattoo number, the form lists the lamb's EBV for lambing rate, the accuracy of the EBV, the lamb's birth and adjusted 120-day weaning weight, and the lamb's dam, sire, and fate, i.e., died, sold. In addition, each seasonal record is summarized to indicate the number of ewes joined and lambing, the number of lambs born, their average birth, actual and 120-day adjusted weaning weight, along with the percent lamb crop born and reared. The second lambing output separately reports each ewe's lifetime lamb and fleece production. Included on this printout are the ewe's, her dam's and sire's birth type, EBV for lambing rate, the accuracy of the EBV, average lamb birth and adjusted 120-day weaning weight, and average fleece weight. Records on each of the ewe's lambs are also included. All of the output forms are designed to both standardized and summarized information on a wide range of production characters. Although reproductive traits are emphasized, a producer can choose those traits he perceives as most important and base selection decisions on measured performance for such traits.

**ESTIMATING BREEDING VALUE FOR LAMBING RATE**

In order to maximize the rate of genetic gain for lambing rate, animals with superior genotypes for the trait must be identified. Selection decisions based on phenotypic performance likely constitute a less efficient method for improving reproductive rate. Consequently, a central aspect of the recording system is to predict a ewe's, ram's or lamb's genetic merit for lambing rate by estimating their breeding value for the trait.

In estimating the breeding value, a number of factors which may influence genotypic performance are considered, namely, the number of lambing records on the ewe, the ewe's age, the years or time frame the ewe was in the flock, as well as environmental conditions. By comparing the performance of ewes who are contemporaries, that is ewes born in the same year and of comparable age, estimate error is reduced. Furthermore, differences in the types and amounts of records available on an animal are represented by the relative accuracy of the estimate. For instance, EBV values for young animals tend to have low accuracies since they often can only be predicted from the performance of the lamb's dam and maternal grandam. As an animal becomes reproductively active, the EBV can be based on their own and, particularly in the case of rams, their offspring's performance and thus the accuracy of the estimate tends to increase.

The general prediction equation used in the recording scheme is as follows:

\[
EBV = b_1(P_{R1} - P_{cont1}) + b_2(P_{R2} - P_{cont2}),
\]

where \( b_1 \) and \( b_2 \) are weighted regression coefficients, \( P_{R1} \) and \( P_{R2} \) are the mean phenotypic performance of two groups of relatives for lambing rate, and \( P_{cont1} \) and \( P_{cont2} \) are the mean phenotypic performance for lambing rate of contemporaries to the two groups of relatives, respectively. In many instances, the ewe's own performance represents one of the two groups of relatives. The regression coefficients are defined as follows:

\[
b_1 = K_1 - (J_{21} b_2) \quad \text{and} \quad b_2 = K_2 - (J_{12} b_1),
\]

where \( K_1 \) and \( K_2 \) represent the coefficients that would be used to estimate the breeding value for the animal of concern from the respective groups of relatives, \( J_{21} \) is the coefficient that would be used to estimate the breeding value of the first group of relatives from the mean phenotypic performance of
the second group of relatives while $J_{12}$ is the coefficient that would be used to estimate the breeding value of the second group of relatives from the mean phenotypic performance of the first group of relatives. These coefficients are defined as follows:

$$K_1 = \frac{R_{X1Y} h^2 Q}{(1+R_{X1X1} h^2 Q(j-1)/j)} \text{ and }$$

$$K_2 = \frac{R_{X2Y} h^2 N}{(1+R_{X2X2} h^2 N(k-1)/k)},$$

where $R_{X1Y}$ is the relationship of the first group of relatives to the animal whose breeding value is being estimated, $R_{X2Y}$ is the relationship of the second group of relatives to the animal whose breeding value is being estimated, $R_{X1X1}$ is the relationship of the first group of relatives to one another and $R_{X2X2}$ is the relationship of the second group of relatives to one another. $h^2$ is the heritability for lambing rate and $j$ and $k$ are the number of animals in the first and second group of relatives, respectively. $Q$ is equal to $q/(1+(q-1)t)$ and $N$ is equal to $n/(1+(n-1)t)$ where $q$ is the mean number of lambing records on the first group of relatives, $n$ is the mean number of lambing records on the second group of relatives while $t$ is the repeatability estimate for lambing rate. The remaining coefficients are calculated as follows:

$$J_{21} = \frac{R_{X1X2} h^2 Q}{(1+R_{X1X1} h^2 Q(j-1)/j)} \text{ and }$$

$$J_{12} = \frac{R_{X1X2} h^2 N}{(1+R_{X2X2} h^2 N(k-1)/k)},$$

where $R_{X1X2}$ is the relationship of the two groups of relatives to one another. The remaining terms in these two coefficients are defined as above.

Often, depending on the source and the number of records available on an animal, the prediction equation simplifies considerably. However, by using a general equation, the most accurate estimate can be determined and reported.

**WEANING WEIGHT ADJUSTMENT**

In order to standardize lamb weaning weights, actual weights are corrected to a 120-day equivalent. The correction formula is:

Corrected Wt = (((Weaning Wt - Birth Wt)/Age at Weaning) X 120) + Birth Wt.

If birth weights are unavailable, an alternate formula is used:

Corrected Wt = (Weaning Wt/Age at Weaning) X 120.

Once the weaning weights have been corrected to a 120-day equivalent, they are adjusted using a multiplicative factor that attempts to account for the lamb's sex, birth and rearing type, and the age of the dam. The adjustment factors currently used are recommendations of the Sheep Industry Development Program. An alternative table of adjustment factors, based on weaning data in the recording system, will be constructed at a later date.

**CONCLUSIONS**

The sale of fat and feeder lambs is currently the predominate source of income in most sheep operations. Therefore, considerable research effort has been invested in devising methods to improve the reproductive performance of
flocks. One approach to increasing the number of lambs weaned and marketed within a breed is by selecting ewe's with a history of a high lambing rate; in other words, to increase the number of lambs born per ewe. However, in order to identify prolific ewes, some degree of record keeping is required. Although record keeping is recognized as being important to most sheepmen, the difficulties, particularly in large flocks, associated with collecting and summarizing the records makes the task unattractive. One method to ease the chore of record keeping is through the use of a computerized recording system. Although the program described in this review would fail to meet the demands of every producer, its general design and organization would apply to most operations. A recording system should likely provide a means for organizing and posting the production records, provide some degree of automated error checking, and summarize and report individual animal and flock performance in a clear and useful manner. The system should also include routines for estimating and reporting an animal's genetic superiority or inferiority for traits of particular importance, such as reproductive performance. By facilitating the mechanics of record keeping, this and similar systems will hopefully encourage more extensive use of production records in flock breeding programs.

REFERENCES