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Genetic Improvement in Sheep

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GENETIC IMPROVEMENT IN SHEEP

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The objective in a sheep enterprise is, or should be, the economical production of high-quality meat and wool. How well the producer achieves this objective is determined by a combination of several factors. They can be grouped broadly as (1) breeding, (2) feeding and management, and (3) marketing and servicing for consumption. Animal breeding is the first step in the efficient production of sheep and wool.

For centuries stockmen attempting to produce superior animals have met with variable degrees of success. The fact that their objectives were not always completely achieved indicates that the methods used were not generally the most efficient or constructive. No way has yet been found that can be offered as a sure method to consistently produce superior stock, but a better understanding of the mechanism of inheritance can now be had to suggest more promising methods.

Although the process of reproduction and the transmission of hereditary characteristics from one generation to the next appears vastly complex and so often subject to chance, it does lend itself to some control by man. With our present knowledge of genetics the transmission of hereditary characteristics from parent to offspring is, to some extent, predictable. The accuracy with which these predictions can be made is influenced by the extent to which traits are inherited and by how well the producing ability of the parent animals is known.

The Role of Inheritance

In dealing with the subject of heredity there are a few points we must recognize. First, that animals, as a rule have developed gradually but slowly by small changes over a long period of time. Second, whatever an animal has as far as its inheritance is concerned, it gets from its parents; they get theirs from their parents and so on clear back to the beginning. Nothing is imposed from the outside. Third, a very clear distinction should be drawn between the effects of inheritance and the effects of environment.

The basis of all living matter is the cell. Each body cell contains a certain number of paired, threadlike bodies called chromosomes, and the number of pairs is typical and constant for the species. Cattle, horses and sheep have 30 pairs, swine have 19 pairs and humans 23 pairs of chromosomes.

Genes are the smallest unit of inheritance and are located on the chromosomes in fixed or specific positions. Genes are so small that they cannot be seen by an ordinary microscope. Hundreds and possibly thousands of genes are located in the chromosomes. Hence both chromosomes and genes are in paired conditions in the cell. Each pair of genes exert an effect on a specific characteristic in the new animal. In some cases several pairs of genes may influence a single character but in no case does a single pair of genes influence more than one trait.

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In the reproductive process a phenomenon takes place that causes only one of a pair of chromosomes to go to each new germ or reproductive cell. In the process of mating, a male germ cell and a female germ cell unite and thus the new born animal has received a sample half of his inheritance from each parent.

"Like begets like" and "there are no two individuals alike" seem at first to be contradictory statements, but as the laws of inheritance are understood it can be seen that they are not. It is well known that offspring tend to resemble their parents. Not only is there a resemblance between related individuals but there is uniformity in the appearance and development of characters. This resemblance is in part due to the fact that related individuals tend to have more genes alike than do unrelated individuals, simply because some of the genes in each came from the same source - one or more common ancestors.

The laws of inheritance not only seek to account for the resemblance of related animals but they also recognize and seek to explain the lack of similarity between relatives. This can be understood when one recognizes the sampling nature of inheritance. Although related animals have more genes alike than unrelated ones it would be extremely rare for even the closest of relatives (excluding identical twins) to have the same genetic make-up. Heredity, however, does not need to account for all the resemblances of related animals. Likeness among relatives will be partially due to a common environment.

What causes the differences we see in sheep? This question may be raised in attempting to assess the relative importance of heredity and environment. Research by U. S. D. A. and several state experiment stations has provided estimates of the relative influence of heredity and environment on a number of important sheep characteristics. Their findings have generally shown that the effects of the two are quite different among different traits within a flock and a given trait in different flocks (Table 1). Differences observed in type and fertility, including twinning, are due largely to environmental effects. Condition and uniformity would be in this group. In such traits as weaning weight, rate of gain and mature body weight, heredity will account for 1/4 to 1/3 of the variation. The effects of heredity and environment are near equal for traits such as face cover, wrinkles, fleece weight, staple length and fineness of wool.

Table 1. Heritability of Important Traits in Sheep

Prolificacy	12 - 15%
Birth weight	30
Weaning weight	25 - 30
Type at weaning	10
Finish or condition at weaning	12
Rate of gain	30 - 40
Wrinkles or skin folds:	
Body wrinkles	50
Neck wrinkles	10 - 40
Fleece:	
Face covering	50
Yearling grease fleece weight	40
Staple length, weaning	40

Selection

Selection is the only method available to stockmen that can bring about permanent improvement in sheep performance. Deciding which individuals will be allowed to reproduce and permitting some kinds of individuals to produce more offspring than others is selection. Rate of progress in improving sheep performance by

selection will be influenced by our ability to recognize genetically superior animals, the number of characters selected for, and the heritability of the traits being considered.

Production records offer the most efficient and effective tools for identifying animals of superior performance. It is very difficult, if not impossible, to look at a prospective breeding animal and tell how he will perform. We can see very little that indicates how the progeny will perform, in terms of growth rate, efficiency and quality. Even in wool production, where we can see something of the amount and quality of wool on the animals, we still cannot tell with a great deal of accuracy. Australian workers have reported that selection by visual appraisal is about 30 per cent as effective in increasing wool production as selection based on objective measurements. Selection by eye is probably much less accurate for traits such as weaning weight and rate of gain.

Selection on the ram side probably accounts for 75 - 90 per cent of the improvement in sheep. This comes about largely from the fact that, within a flock, about one-half the ewe lambs must be kept as replacements while only 2 - 4 per cent of the ram lambs are needed. This means that intensity of selection among ram lambs can be more than three times that of ewe lambs. This emphasizes the importance of purebred breeders and producers of range rams. Improvement in sheep production will be realized largely through their efforts, since commercial producers must depend on them for high quality rams. Since the opportunity for sheep improvement lies largely with the purebred breeder the importance of complete production records and the use of them in making selections cannot be over-emphasized. Records have little value unless they are used in culling and selecting replacements.

The sheepman, attempting to improve his flock by selection, will find it necessary to consider more than one characteristic in his selection program. Even though different stockmen may emphasize different characteristics, each will want to give some attention to all traits considered important in his type of operation. Although the "genes" are the units of inheritance, the animal is the smallest unit which can be selected or rejected at any one time. A stockman may consider the different traits of each animal as separately as he cares to. He may like some of its characteristics very much and at the same time he may strongly dislike other characteristics about it. Or, he may give all his attention to only one trait. But what he does with that animal applies to all of its characteristics, the admired ones as well as the disliked ones. An animal is selected or rejected for breeding purposes according to the stockman's opinion of how much his good qualities outweigh his weaknesses.

The decision to select for improvement in a particular trait should be based on the contribution of that trait to net income. The most important trait is probably lamb production - simply pounds of lamb produced. Second would probably be pounds of wool and, next, quality of the two products. Selection should be directed largely to weight and quality of lamb and wool. For the purebred breeder some attention must be given to such traits as breed type, uniformity of fleece cover, face cover and wrinkles. However, the importance of lamb and wool weight should not be overlooked.

The more characteristics selected the slower the progress will be in improving each. Only so much selection can be done and if this is spread over several traits it naturally follows that only a little progress can be made in each one. For example, if equal attention is given to four independent traits the rate of change in any one will be only one-half of that expected if only one trait were considered. Selection for nine characteristics will reduce progress in any one to one-third.

Progress by selection is also influenced by how much of the differences we see and measure are genetic - heritability of the traits. As shown in Table 1, heritability for most traits is less than 50 per cent. For some traits it is much less. The more highly heritable characteristics should generally receive more attention than those which are less heritable. It would be a disappointment to attempt to improve a trait by selection that is affected largely by environment. For traits low in heritability, improvement in nutrition, management, health and sanitation would likely be more fruitful.

Selection may be practiced in at least three general ways. The first, normally, referred to as the tandem method, is to select for only one trait at a time until the desired improvement in that particular trait is reached, following which selection is made for another trait, etc. The major disadvantages of this type of selection are that it is usually not possible to select for only one trait and income is usually dependent on several traits. The second method is to establish minimum standards for each characteristic and reject for breeding purposes all animals which fall below these standards. This is probably the most common system of selection. The chief weakness of this method is that an individual may be culled for being below the minimum standard in only one trait, although he may be superior in all other characteristics. The third method is to establish some kind of a total score or selection index to measure net merit. The index method is more effective than the other two because it allows us to select for more than one trait at a time and permits unusually high merit in one characteristic to make up for slight deficiencies in another.

Mating Systems

Mating systems are concerned with the decision as to which animals within the breeding flock will be mated together. Mating systems may be based on blood relationship or characteristics of the individual animals. The following classification illustrates the kinds and definitions of breeding systems.

Systems of Mating:

1. Mating like to like
   a. by pedigree - inbreeding, including linebreeding, staying within one family, etc.
   b. as individuals - mating big with big, little with little, compact with compact, rangy with rangy, active with active, etc.

2. Random mating - mates no more and no less alike, than if they had been mated by drawing lots from within the group selected to be parents.

3. Mating unlikes together
   a. by pedigree - outbreeding, ranging from species crossing through cross-breeding, to crossing strains within the breed.
   b. as individuals - compensating for defects, crossing extremes to produce intermediates, mating large with small, coarse with refined, etc.

The mating of like to like on the basis of pedigree means that the mates have a closer blood relationship to each other than if mating were at random and is referred to as inbreeding in the broad sense. Inbreeding may vary in degree or intensity depending on how closely the mates are related. The primary effect of inbreeding is increased genetic purity. It increases the proportion of like gene pairs, without regard to their effect. It "fixes" the good as well as the bad traits in direct proportion to their frequency in the flock. This emphasizes the importance of practicing inbreeding only with superior breeding stock. Under certain conditions inbreeding may be an important aid to selection. For inbreeding to be useful as an aid to selection the flock must be superior with relatively few undesirable recessives in their genetic make-up and the level of inbreeding mild enough that the undesirable individuals can be culled as they appear. Otherwise, undesirables will show up much faster than they can be discarded, allowing these traits to become fixed in the flock. Considerable research has been done on inbreeding in sheep and it appears to have promise as an aid to selection, particularly for traits low in heritability. However, the method is still experimental and is not yet proven for sheep. More research is needed before conclusions are drawn or before practical ways of using inbreeding can be recommended. With the information we have now it would be safe to say that we should do all we can with selection before resorting to inbreeding.

Linebreeding is a mild form of inbreeding and involves the continued mating of descendants from an admired ancestor to keep them closely related to that ancestor. They differ only in that inbreeding does not require the concentration of inheritance from any particular ancestor. The effects are the same as with inbreeding except in degree.

The mating of individuals which tend to have "similar characteristics" has little effect on the flock unless accompanied by selection. This type of mating tends to scatter a population toward the two extremes with respect to each character for which such mating is practiced. It increases the variability of the flock if all animals are kept. The effects of mating like to like are temporary and disappear almost at once when ramdom mating is resumed.

As the name implies, outbreeding is the opposite of inbreeding and can be defined using the same basis. In outbreeding the mates are less closely related to each other than they would be under random mating. Outbreeding generally leads to individual excellence but low breeding worth. It tends to make the flock temporarily more uniform than if outbreeding were not practiced.

Crossbreeding is a special form of outbreeding where the parents belong to different breeds. It generally results in increased size, vitality and fertility; but the amount of this increase is variable in different crosses. In a long-term study of cross-breeding, USDA researchers compared two- and three-breed crosses with the average of the parent breeds. The two-breed crosses were made with mutton-type sheep while both mutton-type and fine wool sheep were used in the three-breed crosses. In these studies they found that lamb mortality in the two-breed cross was reduced about one-fourth. In the three-breed cross, it was reduced about one-third. The number of lambs weaned increased about 10 per cent with both kinds of crosses. Weaning weight was increased about 11 pounds for the two-breed crosses and about 18 pounds for the three-breed crosses. Fleece weight was increased about 25 per cent with the two-breed crosses about 28 per cent with the three-breed crosses.

It should be emphasized that these results were obtained by crossing high quality purebred strains of sheep. Consistent improvement in performance of the magnitude indicated above cannot be expected from indiscriminate crossing of sheep. This would be particularly true in crossbreeding with grade ewe flocks or with ewes of mixed breeding.

Crossbreeding, like any other form of outbreeding, tends to lower the breeding value of the individual, increases the uniformity among crossbred individuals and thereby makes selection among them less effective. When the crossbreds are used for breeding purposes, their offspring tend to be more variable than the crossbred parents were and generally average somewhat lower in individual merit, often below their purebred grandparents in individual merit. Whether crossbreeding is a sound practice for the sheepman should be determined by weighing the advantages of the extra size, vigor and fertility which is usually gained by crossing against the extra cost of obtaining good quality replacements. For those producers who normally buy replacement ewe lambs, the production of hybrid lambs should be a sound practice for increased sheep productivity.

The mating of unlike individuals on the basis of their individual characteristics is commonly practiced to correct defects by mating each animal to one which is equally extreme but in the opposite direction. This type of mating system, in the absence of selection, generally leads to a more uniform flock. However this increased uniformity reaches its full extent in the first generation. Mating unlikes is most useful when the desired type is an intermediate.

Selection Based on Performance Records

Production records offer the most efficient and effective tools for permanent sheep improvement. Good production records allow us to combine all the important traits into a single index of net worth, stressing those traits for which we receive the greatest pay. If we are to select for more than one trait, we can do a much more effective job of improving each one by combining them into an index and selecting on the index as if it were a single characteristic.

A prerequisite to any selection program based on production records is that each animal be positively identified by ear tag or tattoo. This can best be done at or near birth at which time, birth date, type of birth (single, twin, etc.) sex and number of its sire and dam is also recorded. A small pocket record book is convenient for recording the information at this time as it will undoubtedly be transferred to a permanent ewe record card later.

Weight should be taken when the lambs average 90 days of age. To be most accurate lambs should not vary more than 15 days either way from 90 days; in other words all lambs should be in an age range of 75 to 105 days of age. Lambs can also be scored for breed type, face cover, skin folds, uniformity and density of fleece at this time if it is desirable.

If lambs are kept beyond weaning, post-weaning records can be kept for rate of gain, fleece, etc. All lambs of a given sex should be fed and handled alike and the period should be of sufficient length for records to be accurate, probably 120 days. The level of nutrition should be high enough to insure normal growth and development.

Since many traits are highly influenced by non-genetic factors, records should be adjusted before they are used in selection. Age of lamb, type of birth, age of dam are examples of these factors.

Production testing furnishes a producer records on which he can select the superior producing animals in his flock. Improvement through the use of records is permanent if continued. It adds little, if any, labor to the purebred producer and will undoubtedly be time well spent by the commercial sheep man.