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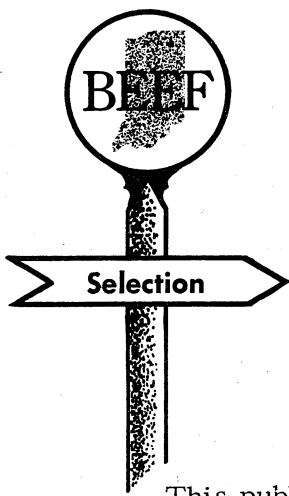
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Animal Improvement Through Selection

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This publication is designed as a teaching aid for the intensive cattle breeding schools conducted by the Indiana Cooperative Extension Service. The purpose of this publication is to help the producer more clearly understand the application and basic principles of animal genetics in livestock selection.

This publication is also included in the Beef and Dairy Production Handbooks for County Extension Workers.

Introduction

Deciding which male or female shall enter the breeding herd is the most important decision of the livestock breeder. This decision is called selection. The ability of the breeder to make timely and correct selection decisions determines whether the genetic productivity of a herd or breed will increase, remain the same, or decrease. Although real genetic progress cannot be brought about rapidly, such improvement is generally permanent.

Four factors determine the amount of yearly or annual genetic improvement which can be made by selection. These factors are: (1) heritability of the trait, (2) amount of selection pressure (selection differential), (3) genetic association of traits, and (4) generation interval.

Traits to consider

If animal selection is to be used to increase the inherited ability of livestock for efficient production, the performance and production of each individual animal must be measured and recorded. What characteristics should be considered? Selection should be directed only toward improving traits which have real economic importance. These traits are listed below for beef and dairy cattle.

Beef: weaning and yearling gain, conformation (as it reflects structural soundness and carcass merit), and carcass cutability and quality.

Dairy: milk production, fat test, fat production, type (as it reflects structural soundness), feed efficiency, mastitis resistance, longevity, and dairy temperament.

A trait which does not have a high economic importance may also be used in selecting replacements if it is genetically correlated with a second trait that is quite important. The observed relationships (phenotypic correlations) between traits may be due to the effect of either genes or environment. The phenotypic, genetic and environmental correlations may vary from -1 to +1. With some traits, the observed phenotypic correlation is due primarily to environmental

effects and with others primarily to genetic effects. In some cases the phenotypic correlation is close to zero since the genetic and environmental effects tend to cancel each other or there are no associations between factors affecting the two traits.

Feed efficiency and gainability are traits of meat producing animals which show a high positive relationship. The genetic and phenotypic correlations between these traits are of such size that selecting animals with rapid gains will also result in the selection of animals with the necessary genetic factors for efficient weight gains.

In all species of livestock, breeders have paid attention to traits which do not have a high economic value. For instance, many breeders in the different species cull a proportion of their animals which do not have certain color markings or other items of general appearance. Most of these traits have little or no net economic value.

These breeders maintain that this practice is not harmful and does not lessen their progress in improving their herd's productivity, but this is not the case. Whenever prospective herd replacements are discarded because of an unimportant or non-hereditary trait, the breeder loses some of his opportunity to make true herd or breed improvement.

The more traits considered in a herd improvement program, the lower the amount of selection intensity for any one trait. Selection intensity is a measure of how diligently the breeder seeks genetic improvement.

For instance, if only one trait is considered, all of the opportunities for selection can be directed toward improving that particular trait. However, research has shown that if two traits are considered, then selection for either of the two traits can be only about 70 percent as intensive as when selection is practiced for only one of the two traits. If three traits are considered, then selection can be only 58 percent as intensive as selec-

tion for only one trait. For four traits, 50 percent; five traits, 45 percent and eight traits, 35 percent. These figures emphasize the fact that only the minimum number of important traits should be considered in a selection program.

Individual versus family selection

With individual selection the herd or flock replacements are selected on the basis of their own performance or individuality. In family selection, lines or families are selected or culled on the basis of the group average performance. The type of selection which will result in the most rapid genetic improvement generally depends on the heritability of the traits. If the heritability of the trait is medium or high, then the individual's own performance is a relatively accurate measure of its real genetic abilities.

Family selection may be used to improve traits with low heritabilities and to support individual selection. It is better to select an individual with an outstanding record from a family known to be superior than an individual with the same performance record from a mediocre or poor family. Generally, most of the economically important beef and dairy cattle traits (growth rate, milk production, carcass merit) are sufficiently heritable to make genetic improvement through individual selection.

Pedigree selection

Pedigree selection is most useful when selecting young animals before their individual performance or progeny's performance is known. The relative emphasis to be placed on the pedigree decreases after the individual and progeny performance records are known for an animal being considered.

Pedigree information is also useful when selecting for traits which are measured late in life and for traits which are expressed only in one sex.

Pedigree selection has been and is being misused. For instance, some breeders select replacements solely on the basis of a grandsire or great-grandsire without regard to the production of the individual or his parents. The fallacy of this practice is emphasized by the fact that only 25 percent of the individual's genes are similar to the genes in the grandsire and only 12 1/2 percent are similar to genes in the great-grandsire.

Progeny testing

One of the best methods of estimating the actual breeding worth of a sire or dam is progeny testing. Selection on this type of information means that the animals are compared on the basis of their offspring. Progeny tests are very useful in selection of traits which are expressed in only one sex, such as milk production in cows. Even though a bull does not produce milk he carries genes for these traits and supplies one-half of the inheritance of each daughter for that particular trait. Progeny testing in dairy cattle has done much to improve the inherent producing ability of dairy cows.

In meat-producing livestock, progeny testing can serve an equally important function. Most of the sires in these species, especially beef cattle, cannot be visually evaluated for their ability to produce progeny with high carcass cutability and quality. Carcass traits are highly heritable, which means that carcass merit can be improved if animals with superior genetic ability can be identified.

The present swine breed certification programs are good examples of the application of progeny testing in a meat-producing species. In these programs growth rate, carcass backfat, loin-eye and length are measured on two pigs from the litter. Records from several litters (usually five from unrelated sows) serve as the progeny test for the sire.

Certain precautions must be taken in using progeny testing if an accurate comparison is to be made. These are: (1) sires must be mated to a random group of dams, (2) a random sample or all of each progeny group must be tested for the traits under consideration, and (3) the nutritional levels and management practices for testing the progeny must be the same for all progeny groups. In addition, sex distribution or adjustments for sex of progeny must be considered when progeny testing sires from the meat producing species.

The accuracy of the progeny test in predicting breeding value of a sire is determined by the heritability of the trait and the number of progeny measured. The minimum number of progeny for an adequate progeny test of a beef bull should be eight. Research shows that with dairy bulls a minimum of 40 daughters in 25 or more herds are required for an adequate progeny test. In the dairy cattle progeny test the daughters of a sire are compared with the herdmates to evaluate milk production.

Swine breeders are also using the certification records on two animals from the litter as the measure of the genetic ability of the litter. Persons selecting littermate boars or gilts on this basis must realize that the records for the two pigs represent the average record for the litter and that the boar or gilt may be either better or poorer genetically. (The certification records should be obtained on a gilt and a barrow from each litter). Since the performance traits in swine are from low to medium in heritability, both individual and certification records should be used in selecting herd replacements.

Full brothers and sisters are less common in cattle and half-sibs are only 25 percent related. Hence, both individual and progeny records must be used for maximum genetic progress.

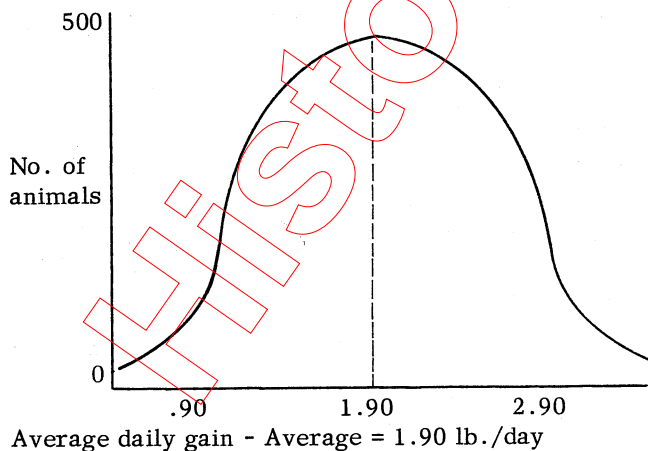
The period of time to test a sire limits the use of progeny testing in most species, particularly in cattle. Adequate progeny records can naturally be collected more rapidly in swine, but even with swine the boars are often slaughtered or sold before they are completely tested. However, beef and dairy cattle breeders are in a position to collect some progeny information on sires in their herds with little cost involved.

Selection differential

The intensity with which a breeder practices selection is the most important factor in determining the amount of genetic improvement. The best measure of selection intensity is the selection differential, which is the difference between the herd or breed average and the average of all of the male and female herd replacements.

Most herds or populations have nearly as many individuals above the herd average production level as below the average. Figure 1 is a graph of the yearling daily gains of beef calves and the number of animals at each rate of gain.

Figure 1. Yearling daily gains of beef calves



The average of the entire population was 1.90 pounds of gain per day. As shown in Figure 1, approximately one-half of the calves gained more than the population average and the remaining one-half gained less than the average.

Let's assume that the breeder needs 20 percent of the heifers as herd replacements, and that the selected group of heifers average 2.30 pounds of gain per day. This means that the selection differential for the heifers is 0.40 pounds (2.30 - 1.90).

Let's also assume that the breeder has selected bulls which gained an average of 2.50. Then the selection differential for the bulls is 0.60 pounds of daily gain (2.50 - 1.90).

How much will daily gain be increased in the next generation because of the breeder's selection for daily gain? To predict the genetic improvement from selection, the heritability of the trait must be estimated. For yearling daily gain, an estimate of 50 percent may be used. The amount of improvement from bull selection can be estimated by multiplying heritability (50 percent) by the bull selection differential (0.60 lb.). This results in 0.30 pounds of daily gain. Because the bull contributes only one-half of the calf's genes, 0.30 must be divided by two, resulting in an improvement of 0.15 pounds. The improvement from selecting a rapidly gaining bull would show up in the daily gain of the next calf crop.

Multiplying the heifer's selection differential (0.40 lb.) by the heritability estimate (0.50) equals 0.20 pounds. The female herd is composed of animals of practically all ages and several generations. In this example, 20 percent of the cow herd was culled and replaced with young heifers. Therefore, only 20 percent of the 0.20 (or 0.04 lb.) will be obtained as the genetic improvement of the

cow herd. This means that the average genetic ability of the cow herd was improved 0.04 pounds in daily gains. The cow herd will pass one-half of its increase (0.02) on to the next calf crop. This may be increased or even doubled if the breeder culls the lower producing 20 percent of the cows. However, this can seldom be accomplished since breeders must cull some average or top producing animals because of old age or structural unsoundness.

The amount of improvement possible through bull selection compared to the amount from heifer selection emphasizes the importance of correctly choosing a herd sire. Heifer progeny will also eventually be saved from the superior sires, which would further improve the genetic ability of the cow herd.

The next generation of this herd should have an average daily gain of 2.07 pounds (1.90 lb. average of herd + .15 lb. for bull + .02 lb. for cow). This amount of improvement actually required several years to make. The generation interval (average age of the parents when their off-spring are born) is about four and one-half years. Dividing the total genetic progress (0.17 lb.) by 4.5 equals 0.038 pounds. This is the average annual progress in improving the inherent producing ability of the herd.

Breeders may look at this amount of improvement and question whether it is enough to seek. However, over five years this amounts to a change of about 0.20 pounds in daily gain which is certainly worthwhile. Another factor must be considered in this example, and it is the improvement which will be obtained in feed efficiency because of selecting on daily gain. This will be brought about by the high genetic and phenotypic correlations between daily gain and feed efficiency.

Type of selection

The necessity for selecting traits which have real economic value has been emphasized. After a breeder has collected information on several prospective herd replacements, he would probably find that some animals have very high performance in certain traits and low performance in other traits. Essentially there are three ways to select replacements by using performance records. They are: (1) Tandem selection in which the breeder selects only one trait until the production in that particular trait has been increased to a desired level. Then selection is applied for a second trait until desired improvement has been made, then selection for a third, and so forth. Generally this method of selection is the least useful selection method and should not be used in livestock improvement programs. (2) Independent culling in which the breeder may practice selection for two or more traits at the same time, but sets a minimum performance level for each of these traits. Under this selection system, an animal that does not meet the minimum requirements for each trait cannot be saved as a replacement. (3) Selection index which allows high performance in one trait to offset slightly deficient performance in another trait. An index is usually obtained by multiplying each of the traits by an appropriate factor. The amount of emphasis given to each trait considered in the index depends on the economic value and heritability of each trait, and the genetic and phenotypic correlations among the various traits. This results in one numerical figure that can be used to compare the breeding value of the prospective herd replacements. This is the most accurate method of selecting replacement animals.

Independent culling versus selection index

Many breeders in the different species are presently using independent culling levels. To show the disadvantage of this method, let's use an example in a swine herd where the breeder has set minimum standards. Let's assume that all replacements must be from a litter of 8 weaned, weigh 200 pounds at 5 months of age, and have no more than 1.3 inches of backfat at 200 pounds live weight. If gilt A was from a litter of 9 weaned, weighed 200 pounds at 5 months, and had 1.3 inches of backfat, she would be kept in the herd. However, if gilt B was from a litter of 6 weaned, weighed 225 at 5 months, and had 0.95 inches of backfat, she would be culled and slaughtered.

Gilt B was quite superior to gilt A in weight at 5 months of age and backfat thickness. Both gain and backfat are highly heritable, whereas the heritability of number weaned per litter is low. Therefore, gilt B

may have been culled because of a deficiency in a trait that is influenced only slightly by genetic factors. It is quite probable that gilt B was actually genetically superior when all of the economic traits are properly considered.

If a selection index which considered the heritability and economic value of each trait were used, gilt B may have been selected instead of gilt A.

Independent culling levels are convenient and can serve a useful purpose if, (1) the true economic value and heritability of each trait is considered when the culling levels are set, and (2) only a few traits are considered. However, because of the tremendous variation in nutritional levels and management practices between individual farms, the standards should usually be allowed to vary from herd to herd.

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