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Bourdon is a Red Angus breeder and since 1972 (after receiving his bachelor of arts degree from Dartmouth College in 1971) has been involved as part owner and manager of Rapid Canyon Red Angus, Sheridan, Wyo. He is presently a member of the board of directors of the Red Angus Assn. of America and wrote the following series for its official publication, American Red Angus.

A Series

Beef Cattle Breeding

by Dr. Richard Bourdon

"Animal breeding is really very simple. Just breed the best to the best."

How often have you heard that statement, or something like it? I would agree with the part about breeding the best to the best, but animal breeding, and beef cattle breeding in particular, is never simple.

Two questions come to mind right away. First, **what is best?** Is the best cow the tallest, the fastest growing, the heaviest milking, or is she some combination of these and other traits? There is enough uncertainty in the answers to this question to keep cattle breeders debating forever. Once we have decided, at least tentatively, what is best, we must then ask ourselves: **how do we measure it?** An entire academic discipline has evolved in response to this question.

In the series of articles that will follow (in this and several future issues), I hope to provide some answers to both questions. First I will deal with the issue of measurement, and in the process cover topics ranging from weight adjustment to the latest sire evaluation models. One or two articles will focus on the more controversial problem of deciding for which traits to select. In the final article, I will try to show how today's cattle breeding technology can be used to develop a viable and meaningful breeding program.

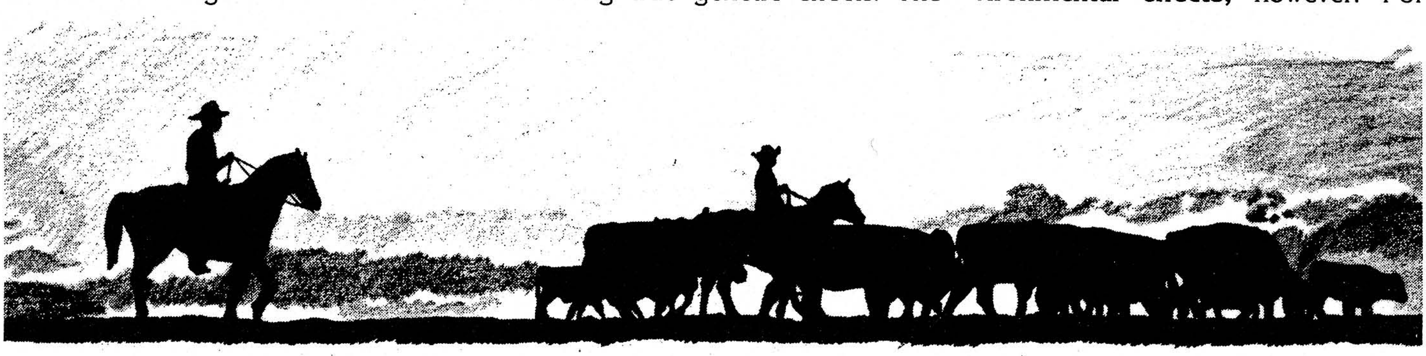
Part One

Adjusted Weights

Each trait that we measure on an animal has two components: a genetic component and an environmental one. The **genetic component** is strictly a function of the genes which that animal possesses. The **environmental component** is the net effect of all outside influences on the trait. By "outside influence" we mean any cause which cannot be directly attributed to the individual's genes. The environmental component can be comprised of many factors. In the case of weaning weight, for example, environmental effects might be age, weather, health and level of nutrition.

Genetic selection is the cattle breeder's primary tool for improving his stock. Selection operates only on the genetic component of a trait, however; the environmental component cannot be passed from parent to offspring. For this reason, environmental effects become bothersome obstacles to our measuring true genetic effects. The purpose of adjusting weights is to nullify to the greatest degree possible the influence of the environmental component of a trait, leaving a value which represents our best estimate of the genetic component.

It is not possible to adjust for all environmental effects. How does one account for an infection or a late April snowstorm? Factors like these must simply be ignored. They fall into the category of **unknown environmental effects.** We can adjust for **known environmental effects,** however. For



weight traits, there are two known environmental effects to contend with: **age of calf** and **age of dam.**

A calf's age obviously affects its weight. Age is part of the environmental component of weight because age in no way can be attributed to the calf's genes. Since it is relatively easy to calculate gain per day of age, it is also a simple matter to construct a mathematical formula to adjust for age of calf.

We know that, on the average, older cows give birth to larger calves and produce more milk than young cows. This **maternal effect** is part of the environmental component of calf weight because the calf's genes are not responsible. By compiling large volumes of data, animal scientists have been able to estimate correction factors for the effects of age of dam.

Birth weight

Because all calves are commonly believed to be the same age at birth, we need not adjust birth weights for age of calf. It is necessary to adjust for age of dam, though. The correction factors currently used by the American Angus Assn. are 4, 2, .5, 0 and 1 lb. for calves from cows of age 1 year, 9 months to 2 years, 9 months; 2 years, 9 months to 3 years, 9 months; 3 years, 9 months to 4 years, 9 months; 4 years, 9 months to 10 years, 9 months (mature); and over 10 years, 9 months, respectively. For example, to adjust the birth weight of a calf from a 2-year-old dam to its mature-cow equivalent, add 4 lb. to the actual birth weight. For a calf from a 12-year-old cow, add 1 lb.

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Weaning weight

By convention, weaning weight is adjusted to a standard age of 205 days. To accomplish this, we need an estimate of growth rate from birth to weaning, and the best estimate is simply the calf's own average daily gain (ADG) over the period.

ADG = (actual weaning weight - actual birth weight/age in days

The age-adjusted weaning weight is then actual birth weight plus 205 times ADG.

After adjusting the weaning weight for age of calf, we must next correct for age of dam. Association adjustment factors for calves from cows of the age breakdowns mentioned before are 45, 21, 9, 0 and 9 lb. for bull calves, and 37, 18, 7, 0 and 9 for heifer calves.

The appropriate age-of-dam correction is added to the age-adjusted weaning weight to produce the adjusted weaning weight in final form.

Yearling weight

Yearling or 365-day weight can be thought of as adjusted weaning weight plus an estimate of postweaning gain. If we calculate a calf's postweaning average daily gain as his gain from weaning to yearling (final weight minus actual weaning weight) divided by the number of days between weights, then our estimate of postweaning gain becomes 160 times postweaning ADG. We use 160 because 205 plus 160 equals 365, and we want to adjust to 365 days of age. Adjusted yearling weight is then 205-day adjusted weaning weight plus 160-day gain. No correction for age of dam is required, since age of dam has already been accounted for in the weaning weight adjustment.

Based on assumptions

In adjusting weights, we make a number of assumptions. One is that the age of dam correction factors provided are appropriate for all herds in all years. Clearly this cannot be true. Genetically different groups of animals can have inherently different adjustments, and these adjustments can also be affected by environment. Preferential treatment of an age group—2-year-old dams, for example—can cause the standard adjustment for calves from this group to be inappropriate.

By using average daily gain in adjusting for age of calf, we assume that growth is linear—in other words, constant over the period of measurement. In most cases, this assumption is valid. However, calves grow more slowly as their dams' milk supply decreases, so an older calf nursing a cow on the down side of her lactation curve should not be expected to be growing as fast at weaning as a much younger calf. The age requirements imposed for weanling calves have been developed to limit this kind of bias. (Association 205-day adjustments are applied only to calves weighed between 160 and 280 days of age.)

Weight adjustments are far from perfect, but they represent the best that can be done on a breed-wide basis to make weights indicate underlying genetic potential.

Other assumptions are that age of dam has no effect on postweaning gain (true as often as not) and that time of birth during the calving season has no effect on growth rate (rarely true, but unpredictable).

It should be clear that weight adjustments are far from perfect. They do, however, significantly reduce the environmental component of weight. They represent the best that can be done on a breed-wide basis to make weights indicate underlying genetic potential. ■

Part Two

Contemporary Groups, Deviations and Ratios

In the previous article in this series, I pointed out that every trait has a genetic component and an environmental component. As breeders, we are primarily interested in the genetic component of a trait, and would like to reduce the influence of the environmental component as much as possible. One way to do this is to mathematically adjust the trait for such known environmental effects as age of calf and age of dam. But what about all the other things which influence an animal's performance—the unknown environmental effects like feed, weather and health?

Clearly we cannot mathematically correct for these factors. However, we can largely negate their effect by expressing an animal's performance not in absolute terms—as with an adjusted weight, for example—but in comparative terms. The comparison to be made is between the animal's performance and the average or mean performance of all animals which were subjected to the same set of unknown environmental effects and which could be expected to respond similarly to them.

An explanation

As an example, consider two groups of calves. One group is raised on sparse range while the other is raised on lush pasture. The second group weans 150 lb. heavier than the first. If the two groups are genetically similar, a breeder would be making a big mistake by selecting on the basis of weight alone. He would end up with a number of genetically poorer calves from the heavy group and miss out on some genetically better calves from the lighter group. If, however, he chooses calves based on their comparative performance within a group, his chances of selecting the right animals are greatly improved.

If there is a true sin in cattle breeding, it is the willful misrepresentation of contemporary groups.

What has been described here is the concept of the **contemporary group.** It is a concept of basic importance to animal breeding theory and practice. While the use of contemporary groups cannot account for environmental effects that are specific to an individual (a case of foot rot, for example), it is the best tool available for reducing the influence of environmental effects that are common to a group.

Contemporary group— a group of animals of similar age and sex which have been managed uniformly.

For birth and weaning traits, all calves in a herd that are of the same sex and born in the same season will typically comprise a contemporary group. In herds where pasture differences or management practices are likely to affect the relative performance of groups of calves, more appropriate contemporary groups should be defined. Since preweaning environment often affects postweaning performance, contemporaries for postweaning traits should not only receive equal treatment after weaning, but should have been members of the same weaning contemporary group.

Assumptions

Two assumptions are linked to the contemporary group concept. The first assumption is that we have a reasonable estimate of the contemporary group mean. This is important because our measure of individual performance is now a comparison involving that mean, and if the mean is off base, so will be our performance measure. With large contemporary groups, this is rarely a problem. Small contemporary groups are another matter. Consider, as an extreme example, a contemporary group consisting of only two calves. The first calf gets very sick and records an adjusted weaning weight of only 350 lb. The second calf remains healthy and weans at 550 lb., resulting in a contemporary group mean of 450 lb. If individual performance is expressed simply as a **deviation** from the contemporary group mean, calf number 1 will be -100 lb. and calf number 2 will be +100 lb. for weaning weight. But do these numbers really reflect genetic worth? As a general rule of thumb, contemporary groups should contain at least ten animals whenever possible.

The second assumption involving contemporary groups is that all contemporary groups have the same genetic mean. Clearly this is a poor assumption, but it is made because there is no easy way to show genetic differences among groups. We simply have to be aware that a +50 lb. deviation for weaning weight in herd A may not be genetically equivalent to a +50 lb. deviation in herd B, or that a +4 lb. deviation for birth weight in 1954 probably means something quite different than a +4 lb. deviation in the same herd in 1984.

The contemporary group concept works best when it is used to make selections within groups. Comparisons of individuals from different contemporary groups can be made using deviations or similar measures, but those comparisons should be made cautiously.

Valid comparisons

The importance of accurately identifying contemporary groups cannot be overemphasized. If there is a true sin in cattle breeding, it is the willful misrepresentation of contemporary groups. This is because contemporary group definition affects not only individual performance records, but also the results of any national sire evaluation computers. And there is no statistical way to account for faulty contemporary groups. The breeder who pampers the calf by a famous sire and then lists him in the same contemporary group as calves that received no special treatment does a disservice to the entire breed.

Show and sale cattle present a special problem. They often receive extra feed and care, and should not, therefore, be compared with other animals. Special contemporary groups constructed for these cattle are usually so small, however, that resulting performance records are almost meaningless. While there is no good solution to this problem, I would opt for the small contemporary groups; information may be lost, but at least records will not be intentionally biased.

We should be careful to identify management differences between groups. Breeders often provide special management for some animals without thinking about devising appropriate contemporary groups. First-calf heifers provide a good example. If we give them special treatment, and then adjust the weaning weights of their calves using standard correction factors for 2-year-old dams, the adjusted weaning weights will be inflated. Comparing calves from this group with calves from older cows by lumping them all in the same contemporary group will be unfair. If, however, we make a separate contemporary group for calves from first-calf heifers, the comparison will be more valid.

The contemporary group concept works best when it is used to make selections within groups.

Ratio, a definition

A deviation from a contemporary group mean is one way of expressing comparative performance. Another more commonly used measure is the trait **ratio.** Ratios are calculated simply by dividing an animal's own performance—adjusted weaning weight, for example—by the mean of his contemporary group, and then multiplying that result by 100. A weaning ratio of 110 indicates a weight 10 percent heavier than average, and a ratio of 90 indicates a weight 10 percent lighter than average.

The advantage of ratios over deviations is that ratios do not require us to keep a mental scale of the variability of any given trait; 10 percent heavier than average is 10 percent heavier than average whether we are speaking of birth weight or mature weight. As with deviations, however, our interpretation of trait ratios should be conditioned by knowledge of the assumptions associated with contemporary groups.

Selection bias

One complaint that breeders have with ratios is that despite the fact that calves are culled heavily at weaning, yearling ratios of the calves saved still average 100. By rights they ought to be higher, and they would be if the potential yearling weights of the culled calves had been figured in.

We can get around this problem by calculating the contemporary group mean for yearling weight in a different way. Instead of using the mean of the selected animals, we can estimate the average yearling weight of the whole unselected group. This is calculated by adding the average 160-day postweaning gain of the selected animals to the average adjusted weaning weight of the entire group. This procedure assumes that the culled calves would have gained at the same rate as the selected calves—an assumption which, research shows, is not too bad.

As a general rule of thumb, contemporary groups should contain at least ten animals whenever possible.

Lately, ratios have fallen into disfavor among academic animal breeders, primarily because ratios cannot be used with the new sire evaluation techniques. So we may see them gradually being phased out.

The concept of contemporary groups will always be with us, however. The use of contemporary groups eliminates much of the confusion caused by differences in environment, and in so doing, allows us to predict genetic value much more accurately.

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NEXT:
Heritability, Breeding Value and Correlations Between Traits.