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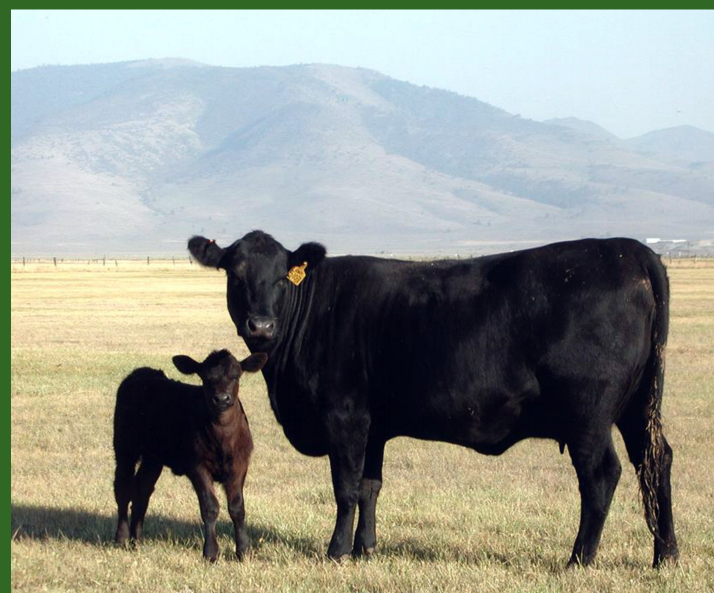
Texas Adapted Genetic Strategies for Beef Cattle II: Genetic-Environmental Interaction



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Animal response or performance is determined by two factors—genetics and environment. Environment often brings to mind factors such as climate, topography, and forage properties, but it also includes all other nongenetic influences such as exposure to disease, management practices, and economics.

It is not surprising that performance of cattle, regardless of genetic type, is influenced by environment. But, in addition, differences between genetic types can vary depending on the environment; that is, there can be interaction between genetics and environment. It is critical, then, to be aware of any interaction that affects performance and to develop an efficient strategy of genetic management accordingly. This involves:

- Matching production/economic conditions (the environment) with optimum performance levels.
- Choosing a breeding system.
- Selecting genetic types, and individuals within types, compatible with both the performance level needed and breeding system chosen.

Environmental effects

An example of environmental effects is shown in Figure 1. British-cross and Continental-British-cross cows were compared in western Canada at two locations. At the "farm" location, cows grazed improved summer pasture with unlimited winter feeding of silage plus supplement. The "range" location featured unimproved rangeland and limited winter supplement.

Weaning weights for both types were higher under the farm conditions; there was no inconsistency in relative performance of the types across locations. Continental-cross

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Texas Adapted Genetic Strategies

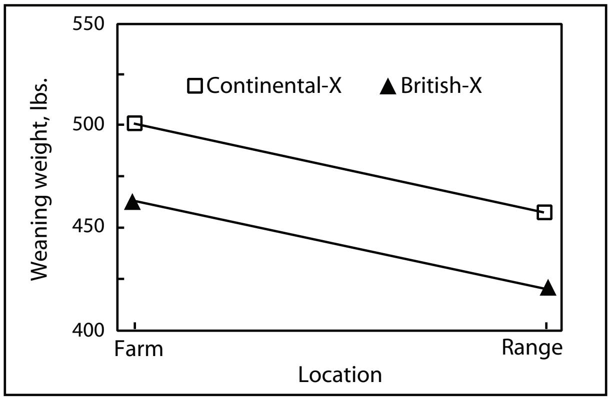

Figure 1. Weaning weights produced by two genetic types at two locations. Fredeen, H. T., G. M. Weiss, G. W. Rahnefeld, J. E. Lawson, and J. A. Newman. 1988. "Genotype X environmental interactions for beef cow performance during lactation." Can. J. Animal Sci. 68:619.

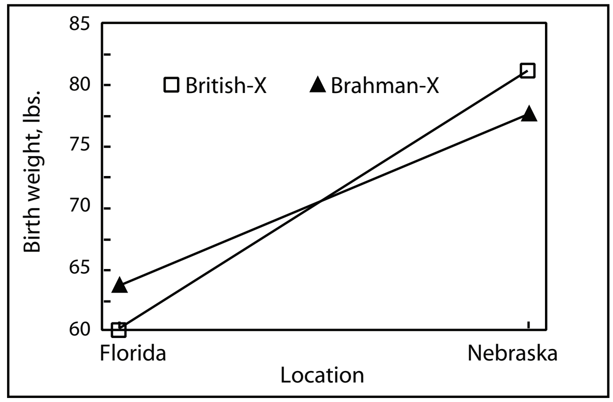

Figure 2. Birth weights produced by two genetic types at two locations. Olson, T. A., K. E. Filho, L. V. Cundiff, M. Koger, W. T. Butts, and K. E. Gregory. 1991. "Effects of breed group by location interaction on crossbred cattle in Nebraska and Florida." J. Animal Science 69:104.

cows weaned heavier calves—39 pounds heavier at the farm and 38 pounds heavier on range—than British-cross cows. So, there was a difference due to genetic type and a difference due to environment, but there was no interaction between the two. It is important to understand the distinction between environmental effects, as seen in this case, and interaction between environment and genetics.

Interaction with physical environment

A classic piece of research was conducted at two United States Department of Agriculture (USDA) experiment stations located in distinctly different environments. The Florida location is characterized by long, hot, humid summers, low-quality grasses, and persistent parasites. The Nebraska site has long, cold winters, higher-quality grasses and harvested forages, and lower incidence of parasites.

Several breed-types were produced in Nebraska, including British-cross and crosses of Brahman and British. Some of these females were transferred to Florida. Birth weights are shown in Figure 2. In Florida, British-cross cows produced calves averaging 3.6 pounds lighter at birth than Brahman-cross cows. But in Nebraska, calves out of British-cross cows were 3.5 pounds heavier. There was not only a difference between the types in relative performance but also a reversal of order, a clear interaction between genetics and environment. Evidently there was some difference between these genetic types in adaptation to these environments.

Perhaps it is not surprising that two types of cattle, one native to the British Isles and the other to southeast Asia, perform differently in temperate and subtropical conditions. But how do cattle of the same breed perform when developed in different environments? Two closed genetic lines of Hereford cattle were developed and maintained at two USDA stations in Montana and Florida. After a number of years, part of each line was transferred, so both Montana-line and Florida-line cattle were evaluated at both locations. Weaning weights from this study are shown in Figure 3.

There was a marked environmental difference, as average weaning weights were 68 pounds heavier in Montana. In Montana, the Montana line averaged 22 pounds heavier at weaning than the Florida line. But in Florida, the Montana line averaged 19 pounds lighter. Even though these lines were both Herefords, they performed like different breeds with different environmental adaptation. This is another example of an obvious interaction with a change in order, depending on the environment.

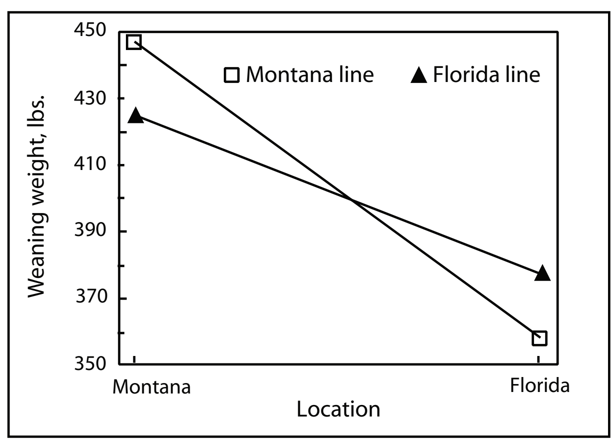

Figure 3. Weaning weights produced by two Hereford lines at two locations. Burns, W. C., M. Koger, W. T. Butts, O. F. Pahnish, and R. L. Blackwell. 1979. "Genotype by environment interaction in Hereford cattle: II." Birth and weaning traits. J. Animal Sci. 49:403.

Interaction with nutrition

Several breeds and crosses were studied at the same location in central Texas. Replacement heifers were developed both in drylot and on pasture. Drylot heifers received a full feed of 50 to 75 percent concentrate. Pasture heifers received hay and salt-limited supplement necessary for normal growth.

Angus and Holstein heifers were included in this study. Weights of heifers at 18 months of age are shown in Figure 4. There was a definite environmental effect due to nutrition, as weights averaged 165 pounds heavier on the drylot ration. In drylot, Holsteins were 157 pounds heavier than Angus, but the difference on pasture was only 85 pounds. It is probable that the larger, higher-gaining Holsteins were more affected by the restricted nutrition on pasture.

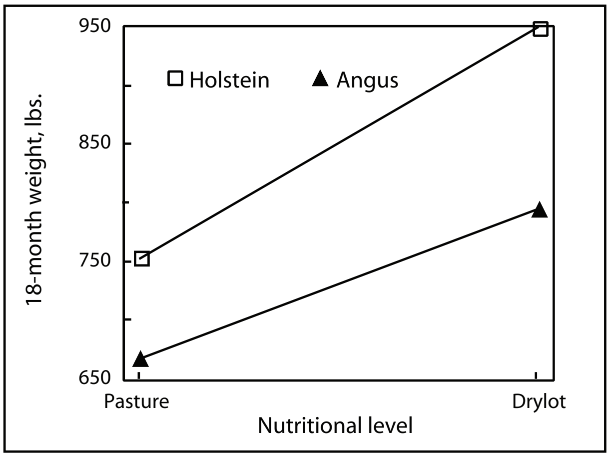

Figure 4. 18-month weights of two breeds on two levels of nutrition. Long, C. R., T. S. Stewart, T. C. Cartwright, and J. F. Baker. 1979. "Characterization of cattle of a five breed diallel: II. Measures of size, condition, and growth in heifers." J. Animal Science 49:432.

Even in the same climate and location, there was interaction between breed and level of nutrition. But here the response by the breeds to different nutritional levels was in the same direction and without change in rank between the two environments. There are many important interactions in beef production like this and they need to be understood by producers.

Interaction with management

Climate and nutrition are obvious features of environment. While differences in management systems may be less apparent, they also can be important sources of interaction. As an example, consider research where steers were evaluated at different feeding endpoints. One comparison was of steers fed to the same age, about 16 months. Another comparison was made when feeding ended at the same estimated USDA Carcass Quality Grade of low Choice. Results are depicted in Figure 5.

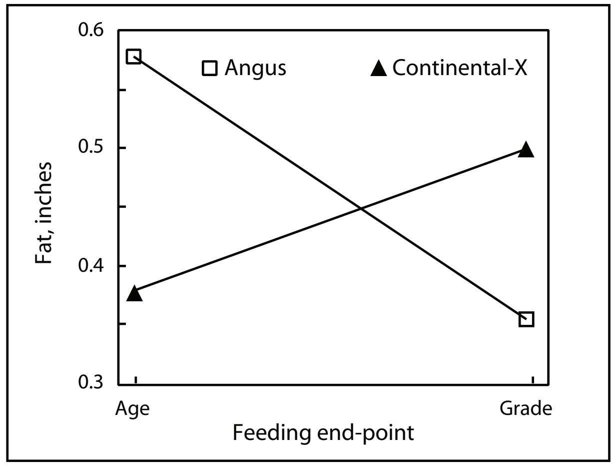

Figure 5. Carcass fat thickness of two genetic types at two feeding endpoints. Koch, R. M., M. E. Dikeman, R. J. Lipsey, D. M. Allen, and J. D. Crouse. 1979. "Characterization of biological types of cattle - Cycle II: Carcass composition, quality, and palatability." J. Animal Sci. 49:448.

When fed to the same age, Angus steers had 0.21 inch more carcass fat cover than did Continental-British cross steers. But when fed to the same quality grade, Angus had 0.12 inch less fat. When fed to 16 months, the Angus were fatter than desired. Conversely, the Continental crosses had to be fed longer, thus increasing in fat, to reach Choice grade. This is an example of extreme interaction. There was not only a difference in response and change in order but also, as feeding endpoint changed, one genetic type increased in fat by almost three-fourths of the amount that the other type decreased.

These two genetic types differ in body size and maturing rate. Therefore, their body composition depends on how they are managed nutritionally to various stages of maturity.

Interaction with economics

Although economics is not usually thought of as environment, it is another nongenetic factor that can influence production and interact with genetics. An example is value of carcasses of differing composition. An increasing number of fed cattle are now marketed on the basis of carcass weight, USDA Quality Grade, and USDA Yield Grade, often called grid pricing. With grid pricing, higher Quality

Grades and numerically lower (higher percent lean) Yield Grades receive higher prices. Typical grids usually also have price discounts for carcass weight outside a desired range, dark-cutting lean, stag/bullock features, and hard bone (excessive maturity). On most price grids, discounts for undesirable carcasses are considerably higher than bonuses for desirable carcasses.

A Colorado study examined the relative importance of differences in carcass merit under various price grids. Several grids were constructed emphasizing bonuses for either Quality Grade or Yield Grade and with baseline value differences between Low Choice and Select Quality Grades of $5/cwt, $10/cwt, or $20/cwt. A USDA study compared British-cross steers to Continental-cross steers. The British crosses averaged 86 percent Low Choice or higher and 23 percent Yield Grade 4. Continental crosses averaged 57 percent Low Choice or higher and 3 percent Yield Grade 4.

These two research results can be combined to see the effects on relative carcass value of different genetic types with various types of price grids. The two most divergent grids in the Colorado study were a grid emphasizing Quality Grade (with a $20/cwt difference between Low Choice and Select and minor bonuses for improved Yield Grade) and another grid emphasizing Yield Grade (with a $5/cwt Low Choice-Select price difference and higher bonuses for improved Yield Grade). Applying those two grids to the distribution of carcass Quality Grade and Yield Grade for the British and Continental types in the USDA study results in the relative carcass values shown in Figure 6.

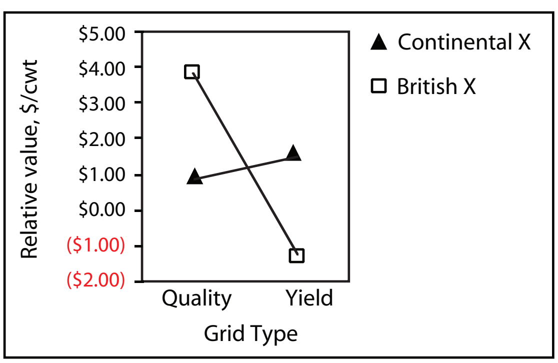

Figure 6. Relative value of carcasses of two genetic types marketed on different carcass price grids. Grids from Tatum, J. D., K. E. Belk, T. G. Field, J. A. Scanga, and G. C. Smith. "Relative importance of weight, quality grade, and yield grade as drivers of beef carcass value in two grid-pricing systems." Prof. Anim. Sci. 22:41. Genetic-type values from Cundiff, L. V. "Breed differences and taking advantage of breed complementarity." National Beef Cattle Evaluation Consortium Seminar on "Crossbreeding – opportunities for the U. S. beef industry," Oct. 11, 2005.

On the grid emphasizing Quality Grade, British-cross carcasses were valued at $3.78/cwt above base. But on the grid emphasizing Yield Grade, the value of British-cross carcasses declined to $1.23/cwt below base, or $5.01/cwt less than on the quality grid. Conversely, Continental-cross carcasses were valued at $0.83/cwt above base on the first grid and $1.52/cwt above base on the second grid.

Value of British crosses varied greatly depending on the grid and Choice-Select price spread. But there was little effect due to grid or spread in the value of Continental crosses. Therefore, the value of different genetic types interacted with carcass pricing factors.

Coping with environment and interaction

Some environmental or non-genetic effects can be altered rather easily and at relatively low cost. For instance, numerous diseases can be prevented by simple, inexpensive immunization. Or, if one supplemental feed is expensive, a less costly but appropriate feed might easily be substituted.

Also, some genetic interactions with management and economics are relatively easy to accommodate. For example, to avoid over-finished carcasses at acceptable weights, an early-maturing, easy-fleshing genetic type can be managed after weaning for moderate growth before being placed on high concentrate feeding. Conversely, late-maturing, inherently lean cattle can be full-fed immediately after weaning, without a growing period, to avoid excessive carcass weights at desired fatness. Both genetic types can be managed for desirable results.

Most animal enterprises—modern dairy, poultry, and swine production—feature high levels of environmental control. To a great extent, their production conditions, particularly nutritional, are adjusted to the animal's needs. However, in most beef cow/calf production systems, physical environment is not easily or economically altered. Beef cows, which have the ability to use low quality forages in harsh climatic conditions, must fit the physical environment.

Consider two production locations. The first is an extensive subtropical rangeland with extreme heat and humidity, distinct wet and dry seasons, and low-quality grazing. The other is an improved pasture in a climate featuring moderate temperatures, evenly distributed precipitation, and unlimited high-quality grazing or harvested forage year-round.

In the first set of conditions, the applicable genetic type is likely to be relatively small to medium in body size, of lower milking potential, with some content of tropical-adapted genetics. A large, high-milking Continental European type would be unsuited to these harsh conditions. But in the more favorable environment, the Continental type could be productive and efficient. A small, low-producing type might not perform well enough to fully exploit the better conditions. However, most beef cows are managed under less than ideal circumstances. These genetic-environmental interactions require intelligent choices of genetic types, not difficult and costly modifications of the environment and management.

In view of the many important genetic-environmental interactions in beef production, evaluation and selection of breeding stock should be conducted under applicable conditions. For instance, bulls for use near the Gulf Coast probably should not be bred and developed in Montana, or maybe even in the Panhandle of Texas. Don't confuse environmental effects with genetics or overlook interaction between the two. Study available research and the experience of other producers to identify important interactions, then select genetic types accordingly.

Genetic-environmental interaction is a critical part of genetic management. Failure to allow for its influence guarantees inefficiency and reduced profit.

For further reading

To obtain other publications in this Texas Adapted Genetics Strategies for Beef Cattle series, contact your county Extension office or see the Extension Web site http://AgriLifeBookstore.org and the Texas A&M Animal Science Extension Web site http://beef.tamu.edu.

Acknowledgment

The photograph at right on page 1 is courtesy of the American Angus Association.

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Revision