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Texas Adapted
Genetic Strategies

Genetic—Environmental Interaction in Beef Production

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Animal response or performance is determined by two factors — genetics and environment. Environment usually means physical factors such as climate, topography, and forage properties. But environment also can include any non-genetic influences on performance such as management practices and economics.

It is not surprising that performance of cattle, regardless of genetic type, is influenced by environment. In addition, differences between genetic types can vary depending on the environment. 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 and economic conditions (the environment) with optimum performance levels;
- choosing a breeding system; and
- selecting genetic types and individuals within these types that are compatible with both the performance level needed and breeding system chosen.

Developing an effective strategy requires a thorough understanding of genetic-environmental interaction.

Environmental effects

An example of environmental effects is shown in Figure 1. British-cross and Continental X 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 and 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 difference in relative performance of the types based on location. Continental-cross cows weaned heavier calves — 39 pounds heavier at the farm and 38 pounds heavier on range — than British-cross cows. So, there was no genetic-environmental interaction, only a difference in weight occurring in the two environments. It is important to understand the distinction between environmental effects, as seen in this case, and interaction between environment and genetics.

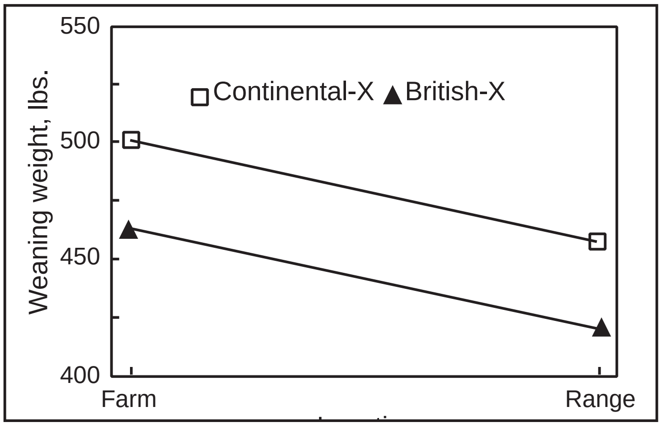

Figure 1. Weaning weights produced by two genetic types at two locations.

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,

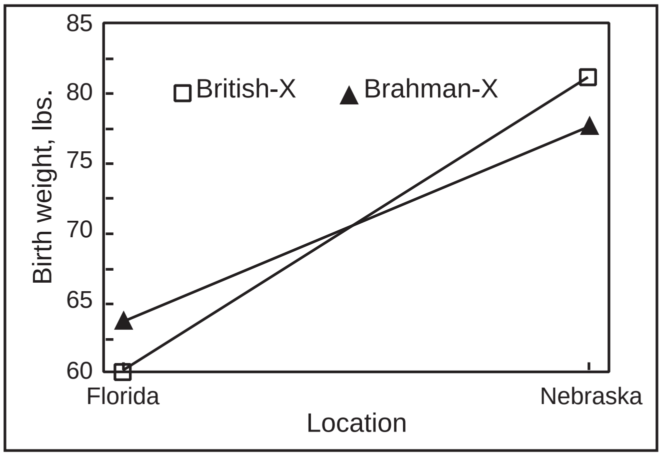

Figure 2. Birth weights produced by two genetic types at two locations.

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British-cross cows produced calves averaging 3.6 pounds lighter 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 rank, 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 originating in the British Isles and the other in India, perform differently in temperate and sub-tropical conditions. But how do cattle of the same breed perform? 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.

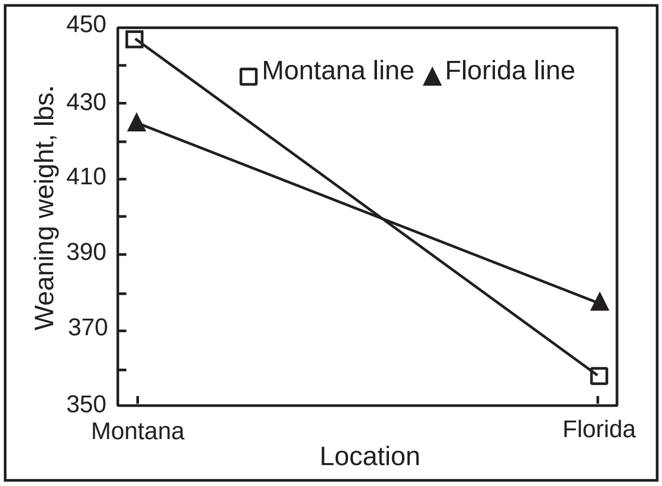

Figure 3. Weaning weights produced by two Hereford lines at two locations.

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

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 salt-limited supplement and hay 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 nutrition effect, as weights averaged 165 pounds heavier in drylot. 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.

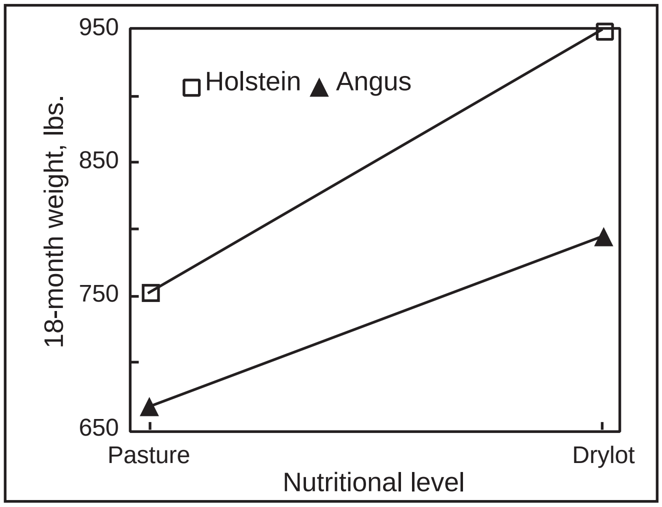

Figure 4. 18-month weights of two breeds on two levels of nutrition.

Even in the same climate, there was definite interaction between breed and level of nutrition. This is an example of interaction where response by genetic types to different environments was in the same direction and without change in rank. Many important interactions in beef production are of this sort.

Interaction with management

Climate and nutrition are obvious features of environment. While differences in management systems are less apparent, they also can be important sources of interaction. As an example, consider research where steers were evaluated at different feeding end-points. 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.

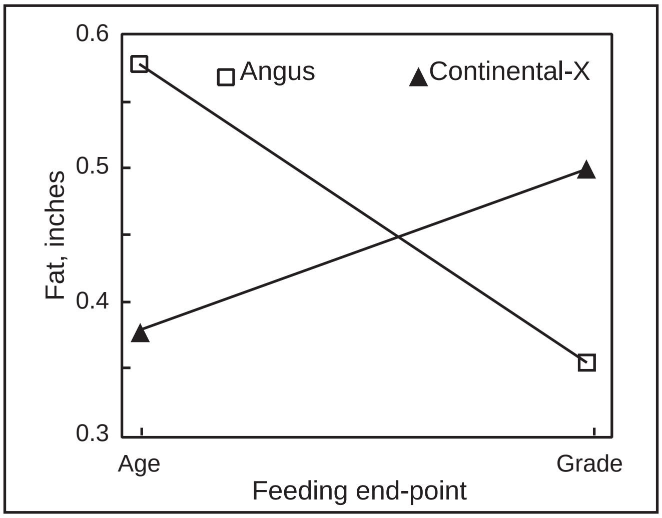

Figure 5. Carcass fat thickness of two genetic types at two feeding end-points.

When fed to the same age, Angus steers had 0.21 inch more carcass fat cover than 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 beyond their optimum carcass composition. 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 rank but also, as feeding end-point 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

Economic factors are not usually thought of as environment. But economics is another non-genetic factor that can influence production. An example is variation in cost of production inputs. A computer simulation study was made in Colorado of several genetic types of cattle, varying in body size and milking potential, over the entire production cycle from cowherd to feedyard. Comparisons were made between types with varying costs of hay and grain. Hay was used primarily for wintering cows, while grain provided the bulk of nutrition for finishing slaughter cattle.

Figure 6 shows total cost per pound of slaughter weight. Two genetic types are shown — small body size, high milking versus large size, low milking. Two sets of nutritional costs were examined. In one (2X hay), hay was valued at twice its average cost. In the other comparison (2X grain), grain was priced at twice its average.

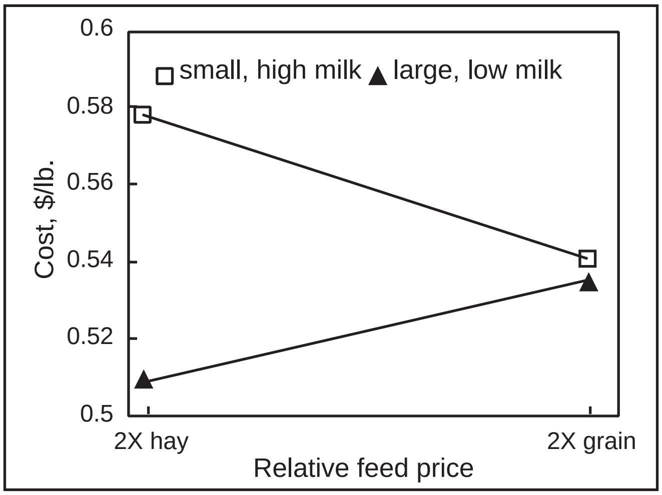

Figure 6. Cost of production for two genetic types under two relative prices for hay and grain.

When hay was expensive, relative production cost was higher for the small type by almost $0.07/pound. When grain was expensive, the difference between types declined to less than $0.01/pound. In this interaction there was considerable difference between genetic types under one set of prices, but essentially no difference under the other set.

In this study, the smaller, higher milking type finished with shorter periods in the feedyard, so cowherd hay was a significant part of total production cycle costs. Thus, when hay was expensive, relative cost of production increased for the smaller, higher milking type. The reverse was true for the larger, lower milking type; slaughter offspring required longer periods in the feedyard, so their relative cost of production increased when grain was expensive. This does not mean the large, low milking cows consumed less hay. Rather, with the large, low milking genetic type, a higher percentage of total production cycle nutritional cost was incurred in the feedyard.

Coping with environment and interaction

Some environmental or non-genetic effects can be altered rather easily and cheaply. For instance, numerous diseases can be prevented by simple, inexpensive immunization. Or, if one supplemental feed is expensive, a cheaper one 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 heavily fed immediately upon 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 climatic control and nutrition. To a great extent, environment is adjusted to animal needs.

However, in most beef cow/calf production systems, physical environment is not easily 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 sub-tropical rangeland, with extreme heat and humidity, distinct wet and dry seasons, and low quality grazing. The other is an improved pasture in a moderate climate, featuring cool 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 tropically 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 environment.

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 come from a herd located in Canada (or even in Iowa). Don't confuse environmental effects and 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.

More information on genetic management is available in other publications in this series, Texas Adapted Genetic Strategies. See, in particular, publications L-5192, *Body Size and Milking Level for Beef Production*, and L-5206, *Cattle Types and Breeds: Characteristics and Uses*.

Genetic-environmental interaction is a critical part of genetic management. Failure to allow for this factor guarantees inefficency and reduced profit.

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