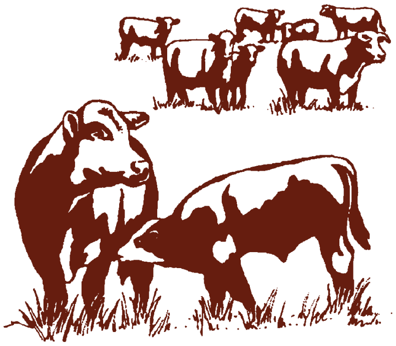

Beef Cattle Handbook

BCH-1410 Product of Extension Beef Cattle Resource Committee

Biological Types of Cattle

Larry Cundiff, US Meat Animal Research Center, Agricultural Research Service, US Department of Agriculture

Genetic changes have accrued within and between populations of cattle throughout their evolution and especially since domestication. Diversity among breeds has resulted mainly from many generations of selection directed by humans toward different goals (e.g., draft, milk, meat, fatness, size, color, horn characteristics, behavior, and other characteristics). Also, breeds that have been kept separate from each other, either by pedigree barriers imposed by humans or by geographic barriers, have diverged in frequency for genes affecting expression of many characteristics because of forces of chance, mutation, and natural selection for components of fitness and adaptation to diverse environments.

In US beef production, grading up or straightbreeding to Shorthorns, Herefords, and Angus was the dominant breeding system used from the late 1800's until the 1960's. Lush (1945) noted that stockmen were often misled by the adage that "there is more variation within breeds than between breeds" into believing that genetic differences between breeds are "not real after all" or at least, not very important. Results from experiments conducted at USDA research centers and at State Agricultural Experiment Stations have demonstrated that significant variation exists between and within breeds for most traits of importance to beef production. Breed differences in biological traits are an important genetic resource for improving efficiency of beef production. Diverse breeds are required to exploit heterosis and complementarity through crossbreeding and to match genetic potential of cattle with diverse market preferences, feed resources and climates.

Germplasm Evaluation Program

Topcross progeny out of Hereford, Angus, or crossbred dams by twenty-six sire breeds have been evaluated in the first four cycles of an ongoing Germplasm Evaluation (GPE) Program at the Roman L. Hruska US Meat Animal Research Center (MARC). The primary objective of the program has been to characterize breeds representing diverse biological types for a wide spectrum of biological traits contributing to economic beef production. Breeds are classified into seven biological types based on relative differences (X lowest, XXXXXX highest) in growth rate and mature size, lean-to-fat ratio, age at puberty and milk production (Table 1). The biological type classifications reflect historic differences in selection goals (e.g., beef alone, dual purpose milk and beef, or draft) and geographic location (e.g., British Isles, continental Europe, and Southern Asia) that have contributed to the evolution of genetic diversity among breeds.

Variation Between and Within Breeds

Genetic variation between breeds relative to that found within breeds for some biological characteristics of importance to beef production are shown in Figures 1 through 6. These results are based on pooling data over the first three cycles of the GPE program, which involved twenty different sire breeds.

Results for retail product growth to 458 days of age are summarized in Figure 1. Retail product is closely trimmed-boneless (trimmed to .3 in of external fat and boneless except for dorsal and transverse spinous processes and rib bones in rib roasts) steaks, roasts and lean trim. In Figure 1, F_1 cross means for weight of retail product at 458 days of age are shown on the lower horizontal axis. The spacing on the vertical axis is arbitrary but the ranking of biological types (separate bars) from the bottom to top reflect increasing increments of mature size. Breed rankings within each biological type are noted within each bar. Steers sired by bulls of breeds with large mature size produced significantly more retail product than steers sired by breeds of small mature size.

In Figure 1, differences are doubled in the upper horizontal scale to reflect variation among pure breeds relative to a standard deviation change in breeding value $\delta_g = (\delta_p)(h)$ within pure breeds for weight of retail product at 458 days of age. Frequency curves, shown for Jersey, the average of Hereford and Angus, and Chianina, reflect the distribution expected for breeding values of individual animals within pure breeds assuming a normal distribution (i.e., 68, 95 or 99.6% of the observations are expected to lie within the range bracketed by the mean $\pm$1, 2 or 3 standard deviations, respectively). The breeding value of the heaviest Jersey is not expected to equal that of the lightest Chianina and the heaviest Hereford and Angus would only equal the lightest Chianina in genetic potential for retail product growth to 458 days. The range for average differences between breeds is estimated to be about 5.7 δ_g between Chianina and Hereford or Angus steers and 8.2 δ_g between Chianina and Jersey steers. Genetic variation, both between and within breeds is important for this measure of output. When both between and within breed genetic variations are considered, the range in breeding value from the smallest Jersey steers to the heaviest Chianina steers is estimated to be 180 kg, or 88 percent of the overall average.

Retail product growth is not the only biological trait of economic importance to beef production which exhibits vast genetic variation, both between and within breeds. Similar results exist for other measures of growth (i.e., birth weight, weaning weight, postweaning

Table 1. Breeds Grouped into Biological Types for Four Criteria[a]

Breed group	Growth rate and mature size	Lean to fat ratio	Age at puberty	Milk production
Jersey (J)	X	X	X	XXXXX
Longhorn (Lh)	X	XXX	XXX	XX
Hereford-Angus (HAx)	XXX	XX	XXX	XX
Red Poll (R)	XX	XX	XX	XXX
Devon (D)	XX	XX	XXX	XX
Shorthorn (Sh)	XXX	XX	XXX	XXX
Galloway (Gw)	XX	XXX	XXX	XX
South Devon (Sd)	XXX	XXX	XX	XXX
Tarentaise (T)	XXX	XXX	XX	XXX
Pinzgauer (P)	XXX	XXX	XX	XXX
Brangus (Bn)	XXX	XX	XXXX	XX
Santa Gertrudis (Sg)	XXX	XX	XXXX	XX
Sahiwal (Sw)	XX	XXX	XXXXX	XXX
Brahman (Bm)	XXXX	XXX	XXXXX	XXX
Nellore (N)	XXXX	XXX	XXXXX	XXX
Braunvieh (B)	XXXX	XXXX	XX	XXXX
Gelbvieh (G)	XXXX	XXXX	XX	XXXX
Holstein (Ho)	XXXX	XXXX	XX	XXXXX
Simmental (S)	XXXXX	XXXX	XXX	XXXX
Maine Anjou (M)	XXXXX	XXXX	XXX	XXX
Salers (Sa)	XXXXX	XXXX	XXX	XXX
Piedmontese (Pm)	XXX	XXXXXX	XX	XX
Limousin (L)	XXX	XXXXX	XXXX	X
Charolais (C)	XXXXX	XXXXX	XXXX	X
Chianina (Ci)	XXXXX	XXXXX	XXXX	X

[a] *Increasing number of X's indicate relatively higher value.*

average daily gain, final slaughter weight and carcass weight), gestation length, retail product percentage (Figure 2), fat thickness, kidney, pelvic and heart fat percentage, marbling score (the primary determinant of USDA quality grade, Figure 3), age of heifers at puberty (Figure 4), milk production (Figure 5) and mature cow weight (Figure 6).

The range for differences between breeds was comparable in magnitude to the range for breeding value of individuals within breeds for most biological traits evaluated. Significant genetic change can result from selection both between and within breeds. In the long run (at least 40 to 50 years), more can be accomplished from intrapopulation selection than from selection among breeds. However, breeds can be selected and mated to optimize performance levels in crosses with a high level of precision much more quickly than intrapopulation selection.

Trade-offs

No one breed or biological type excels in all traits of importance to beef production. When carcass and meat traits are considered, biological types that excel in retail product growth and percentage retail product produce carcasses with less than optimum levels of marbling and heavier than optimum carcass weights. Breeds representing biological types of more moderate size with higher genetic potential for marbling produce carcasses with excessive fat thickness, fat trim and relatively low retail product percentages. Genetic potential for retail product percentage, marbling and carcass weight are more nearly optimized in cattle with 50:50 ratios of Continental to British inheritance (i.e., Continental breeds such as Chianina, Charolais, Limousin, Simmental, Gelbvieh, Braunvieh, Salers, and Maine Anjou; British breeds such as Angus, Hereford, Red Poll, and Shorthorn).

In addition, biological types that excel in retail product yield and growth to market ages sire progeny with heavier birth weights, greater calving difficulty, reduced calf survival, and reduced rebreeding in dams; tend to reach puberty at an older age unless they have had a selection history emphasizing milk production (Figure 5); and generally have heavier mature weight (Figure 6). Heavier mature weight increases output per cow, but also increases nutrient requirements for maintenance. Thus, differences in output tend to be offset by input differences for maintenance and lactation so that differences in life cycle efficiency are generally small.

Bos indicus X *Bos taurus* F1 crosses (e.g., Brahman X Hereford, Brahman X Angus, Nellore X Hereford, etc.) have been exceptionally productive cows, especially in subtropical climates in the Southern US. Part of this advantage is likely attributable to extra heterosis in *Bos indicus* X *Bos taurus* crosses compared to that found in *Bos taurus* X *Bos taurus* crosses.

However, these advantages are tempered by older age at puberty and reduced meat tenderness as proportion of *Bos indicus* inheritance increases. Also, during colder seasons in temperate regions of the US, calf mortality increases and average daily gain decreases as the proportion of Bos indicus inheritance increases. To limit costs per unit of production, cows may require as much as 50% *Bos indicus* inheritance (Brahman, Sahiwal, Nellore) in the Gulf Coastal region of the US, about 25% *Bos indicus* inheritance in more intermediate climatic

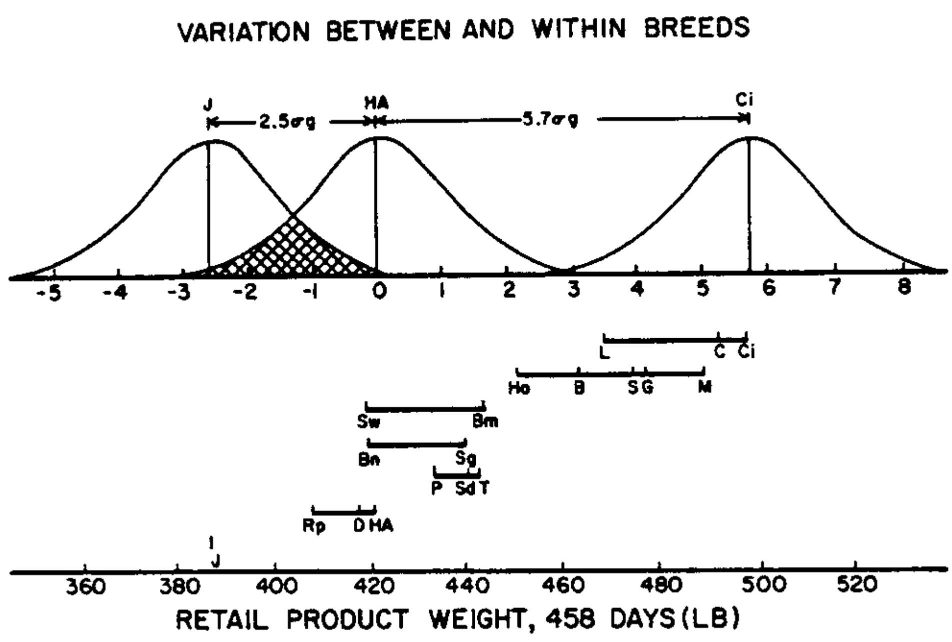

Figure 1. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Weight of Retail Product at 458 days. See abbreviations in Table 1.

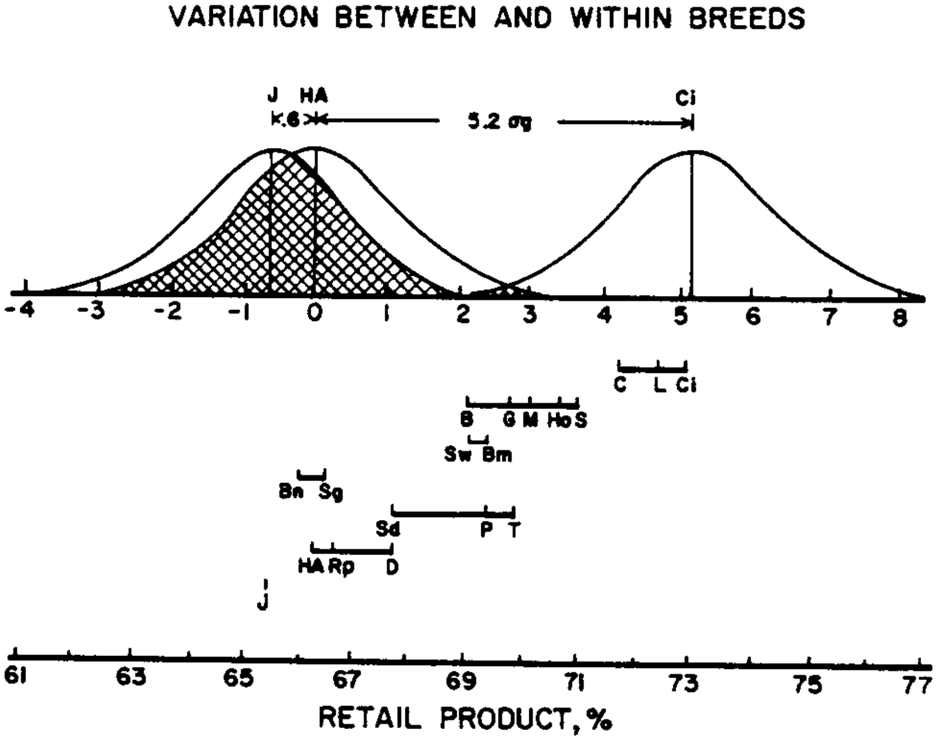

Figure 2. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Retail Product as a Percentage of Carcass Weight at 458 Days of Age. See abbreviations in Table 1.

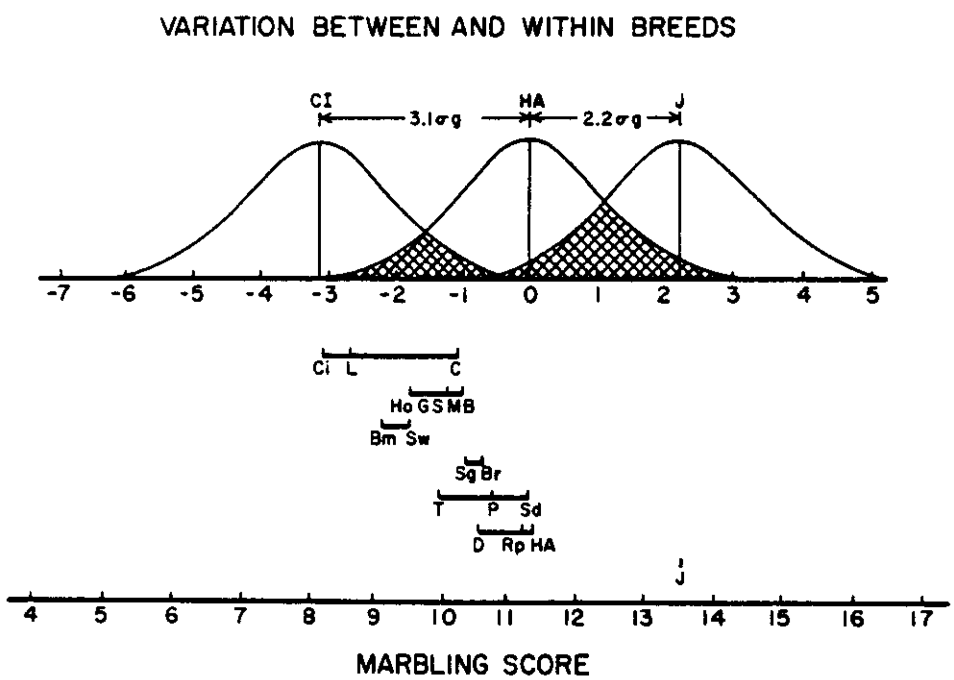

Figure 3. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Marbling Score. See abbreviations in Table 1.

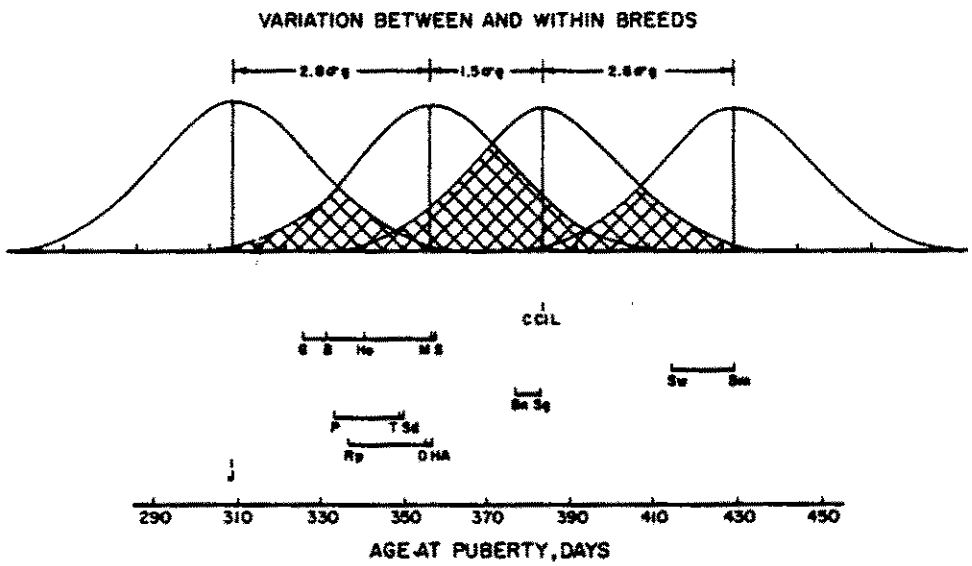

Figure 4. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Age of Heifers at Puberty. See abbreviations in Table 1.

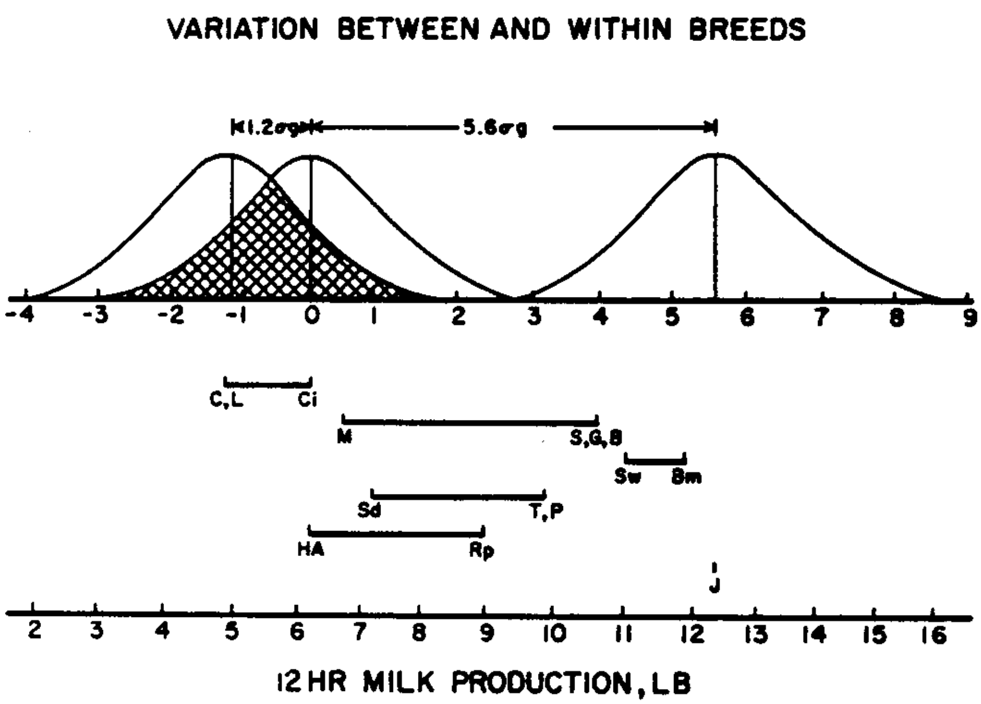

Figure 5. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Average 12-hour Milk Production. See abbreviations in Table 1.

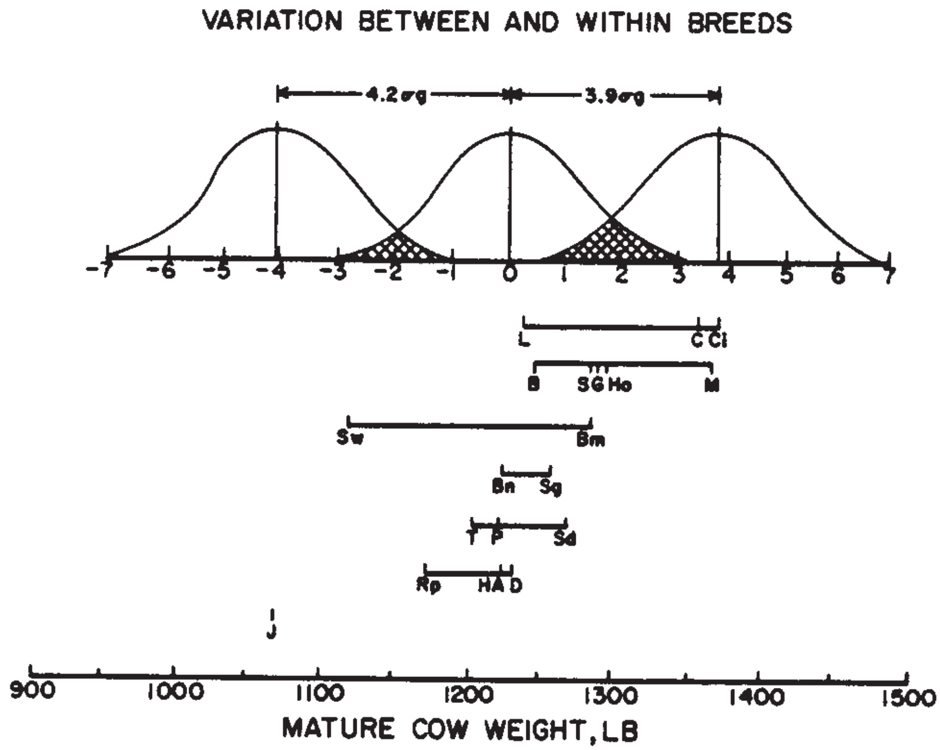

Figure 6. Breed Group Averages (lower axis) and Genetic Variation Between and Within Breeds (upper axis) for Cow Weight at 7 Years of Age. See abbreviations in Table 1.

zones (e.g., South and North Carolina, Tennessee, Arkansas, Southeastern Oklahoma, and the Southwestern and Western coastal regions of the US), and 0% Bos indicus inheritance in the temperate climates of the central and northern regions of the US.

Because of trade-offs resulting from antagonistic genetic relationships among breeds, it is not possible for any one breed or biological type to excel in all characteristics of economic importance to beef production. Use of crossbreeding systems that exploit complementarity by terminal crossing of sire breeds noted for lean tissue growth efficiency, with crossbred cows of small to medium size and optimum milk production, provide the most effective averages of managing trade-offs that result from genetic antagonisms.

Author:
Larry Cundiff, US Meat Animal Research Center, Agricultural Research Service, US Department of Agriculture

This publication was prepared in cooperation with the Extension Beef Cattle Resource Committee and its member states and produced in an electronic format by the University of Wisconsin-Extension, Cooperative Extension. Issued in furtherance of Cooperative Extension work, ACTS of May 8 and June 30, 1914.

BCH-1410 Biological Types of Cattle