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Principles of Beef Cattle Selection

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Selection of superior seedstock leads to lasting genetic improvement by increasing the frequency of "desirable" genes and decreasing frequency of "undesirable" genes. The definition of "desirable" varies. Nature favors genes which improve fitness to survive and thrive in the natural environment. Man should favor genes which improve biological and economic efficiency of beef production.

Selection increases frequency of desired genes in the population because the selected superior parents leave more progeny than inferior parents. This superior reproductive fitness involves more than conception; the progeny must survive and perpetuate the desirable genes.

Natural selection - survival of the fittest - is always operating. If the goals of artificial selection conflict with those of natural selection, the production environment must be modified to allow survival of the favored individuals; otherwise natural selection will cancel the effect of artificial selection. Common examples of modified environment include delivery of large calves by C-section, protection of polled cattle from preditors, and supplemental feeding of high milking cows so they will rebreed while still lactating.

Tools for Effective Artificial Selection Programs

The concepts, definitions, formulas and symbols in this section are the tools necessary for effective selection programs. Like a hammer and saw in the hands of a good carpenter, much can be accomplished through their skilled usage.

Phenotypic Variation. Phenotype (P) refers to observable characteristics, such as weight, color, disease resistance, milk yield and calving ease. The phenotype for each characteristic is conditioned by the individual's genotype (G) and environment (E). Genotype includes the composite effect of all pairs of genes — one member of each pair from each parent — on a particular phenotype; environment includes all nongenetic effects.

Genotype may be further partitioned into those gene effects which are additive (A) and those which are nonadditive (NA). Both types of gene action have considerable importance to commercial beef production. *Breeding value* refers to the average *additive* effects of genes transmitted from parent to progeny. *Non-additive* effects of genes, although generally not transmitted on average, are the basis for heterosis (GPE-8351). Phenotypic variation (V_P) results from differences among individuals in additive (V_A) and nonadditive (V_{NA}) genotypes and environmental effects (V_E); i.e., $V_P = V_A + V_{NA} + V_E$.

Heritability. That portion of phenotypic variation due to additive gene effects (breeding value) which responds to selection, is called heritability; $h^2 = V_A/V_P$. Heritability estimates vary somewhat from herd to herd, environment to environment; but experience has shown them to be remarkably uniform for most traits (table 1).

Environmental variation (V_E) includes all nongenetic effects. Reducing V_E by standardizing management, improving measurement accuracy and use of adjustment factors effectively increases h^2. For example, differences in calf age and dam's age (milk yield) are part of V_E for weaning weight. Differences in weaning weight due to calf age are removed by adjusting to a standard 205-days. Adjustment for dam age should not remove genetic effects on either calf growth potential or cow milk yield. The purpose is to adjust weight of calves from young cows to the weight expected if the same cow was mature.

Selection Differential. The difference between the average phenotype of the superior parents (P*) selected to parent the next generation and the herd average (P) is the selection differential (S=P*-P). The magnitude of the selection differential depends on the

Table 1. Heritabilities and Genetic Correlations for Traits of Major Economic Importance.[1]

Trait	Herit-ability	Genetic Correlations, R												
		F	CE	BW	WW	YW	MW	G	G/F	RG	MR	LY	P	MY
Fertility	L													
Calving ease	L	L+												
Birth wt.	M	?	M−											
Wean. wt.	M	?	L−	M+										
Yearling wt.	M	?	L−	M+	M+									
Mature wt.	H	?	L−	H+	M+	H+								
Gain[2]	M	?	L−	M+	M+	H+	H+							
Gain/Feed[2]	M	L+	L−	L+	M+	M+	M+	H+						
Relative gain[2]	M	?	L+	L−	L+	M+	M+	H+	H+					
Maturing rate	M	?	L+	L−	L−	L−	M−	M+	M+	M+				
Lean yield[2]	M	?	L−	L+	L+	M+	M+	M+	M+	M+	L−			
Palatability[2]	M	?	?	?	?	?	?	?	?	?	?	?		
Milk yield	M	?	?	L+	L+	L+	L+	L+	L+	L+	?	L+	?	
Maintenance costs	H	L+	L−	L+	L+	M+	H+	M+	L+	L+	M−	L+	?	M+

[1]Approximate values for heritability (0 to 1) and genetic correlations (−1 to +1) based on research reports and opinion of author: H, .5 to 1; M, .25 to 5; L, .05 to .25; ?, sign uncertain, probably between −.1 and +.1
[2]Postweaning traits for cattle fed grain 4-6 months prior to slaughter when approximately 20 months old.

amount of V_P, the proportion of population selected and the fertility of the superior parents. Since the selection differential is greater for bulls siring hundreds of progeny than for cows having only 4 to 5 progeny per lifetime, most genetic improvement—even for maternal traits—must come from sire selection. Artificial insemination can greatly increase the selection differential.

Direct Response. Regardless of the degree of phenotypic superiority of the selected parents, only that fraction due to superior breeding value will be transmitted to the progeny. In the example (table 2), direct response to selection for 365-day weight is 50 lb per generation or a 10 lb increase per year.

Correlated Response. Quite often, genes with additive effects on the selected trait also have additive effects on other traits. The degree to which traits 1 and 2 are genetically related is measured by the genetic correlation (R_{12}), which may vary from −1 to +1. If R_{12} does not equal 0, selection for trait 1 will yield a correlated response for trait 2. The direction of change in trait 2 is indicated by the sign of R. In the example (table 2), correlated responses resulting from selection for 365-day weight would be average increases of .5 lb/year for birth weight and 15 lb/year for mature weight.

Table 2. Prediction of Direct and Correlated Responses Due to Selection for 365-Day Weight.

Fomulas for Response per Generation:
Direct Response for trait i = $h^2(P^*_i - P_i) = h^2 S_i$.
Corr. Response for trait j from selection for

$$\text{trait i} = R_{ij}\sqrt{V_{A_i} V_{A_j}}\, S_i / V_{P_i}$$

Trait		P,lb	V_a	V_p	h^2
365-d wt	(1)	850	3600	7200	.5
Birth wt	(2)	70	25	62	.4
Mature wt	(3)	1600	19000	27000	.7

Generation interval = .5 yr; R_{12} = .6; R_{13} = .65
D.R. for 1=.5 (950-850) = 50 lb or 10 lb/yr
C.R. for 2=.6√3600.25 100/7200=2.5 lb or .5 lb/yr
C.R. for 3=.65√3600.19000 100/7200=75 lb or 15 lb/yr

Multi-Trait Selection. Examples of single-trait selection (table 2) do illustrate basic concepts; however, in the real world of practical beef production, it is necessary to simultaneously select for many traits. All traits which affect costs and returns—fertility, survivability, growth rate, milk yield, maintenance costs—should be considered for the selection program. Increasing the number of selected traits decreases the amount of change per trait, so it is critical not to squander valuable selection pressure on traits of no real economic value.

The key is to apply selection pressure to each trait according to its net economic effect. This is accomplished by weighting each trait by its Relative Economic Value, which measures the relative net economic effect of changing the trait. Relative Economic Values are not the same for all breeds or all environments (table 4). Some important traits are difficult or even impossible to observe on the selected individuals. For example, maintenance cost of the cow herd is the major single expense of calf production, but measuring nutrient consumption of individual cows is impractical. However, using the high positive correlation (table 1), maintenance costs may be decreased by selecting for smaller mature weight. Similarly, observations on relatives may be used to indirectly assess breeding value of selected individuals. For example, a sire's breeding value for maternal traits—milk yield,

calving interval - may be evaluated through his female relatives—dam, half-sisters and daughters.

It is possible to select simultaneously for many traits and maximize profitability; it is possible to improve traits even though they are not observed directly; it is possible to use observations on relatives to assess breeding value of selected individuals. The most accurate, efficient way to do all these is to use a Selection Index. Admittedly, the details of computing a Selection Index are complicated and professional assistance may be necessary, but the improved selection efficiency justifies the effort.

Selection Goals for Profitable Beef Production

The basic goal of selection is to develop superior genotypes for future production and market requirements. Too often, temporary fads and fancies take precedence over practical, economically sound criteria. Many generations of selection toward consistent goals are required for appreciable success, so the challenge is to identify the requirements of the commercial industry ten years or more from now.

Market preferences and production conditions do fluctuate from year to year, but certain long term trends seem clear enough to develop goals. There will be increased emphasis on efficiency of ruminant utilization of feed resources such as forage, crop residues, non-protein nitrogen, and industrial by-products, instead of competing with man and non-ruminants for high energy, natural protein, low fiber feedstuffs. Cattle will usually harvest much of their feed to conserve dwindling supplies of fossil fuels. They will graze extensive range lands, rather than highly fertilized, irrigable farm land usable for grain production, except to harvest residues.

Secondly, the commercial beef industry will increasingly turn to crossbreeding in order to gain the benefits of hybrid vigor plus complementarity among the three basic components of the beef production unit - sire, dam and produce. The sire and dam components affect the total efficiency of the production unit in two ways: direct effects on production costs and returns (fertility, maintenance costs, etc.) and indirect genetic effects on traits expressed by the produce. Most of the traits (table 3) with major direct impact on production efficiency are expressed by the dam and produce; however, sire selection offers the best opportunity for permanent genetic improvement of these traits. Thus, sire breeding value for growth rate, mature size, feed efficiency and milk production is extremely important.

Table 3. Direct Contribution of Each Component of Beef Production Unit to Profitability.[1]

Sire	Dam	Produce
Fertility	Fertility	Survivability
	Maintenance costs	Rate and efficiency of gain
	Calving ease	
	Milk yield	Lean yield and palatability

[1]Includes only direct phenotypic effects, not breeding values for traits expressed by another compenent.

Realized Fertility. Cows must conceive and calves must survive before other important traits can be expressed, so Realized Fertility has preeminence for profitable beef production. The components of realized fertility tend to be lowly heritable and, in some cases, adversely correlated with other key traits (table 1); however, their economic importance is so great that they must be considered in a breeding program. Some fertility problems are actually indirect responses to other production traits; e.g., increased milk yield on extensive range conditions will likely increase the postpartum anestrous period.

Mature Size, Growth and Maturing Rate. Rapid growing cattle tend to be large; early maturing cattle tend to be small, especially when fully mature (table 1). Earlier this century, preference for cattle which matured (fattened) early on high forage diets led to emphasis on small cattle. More recently, preference for rapid growth, without excessive fattening on high concentrate rations, has increased size at all ages with the related problems of increased calving difficulty and cow herd maintenance costs.

The preferred direction and degree of selection emphasis on growth largely depends on the potential use of the selected cattle (table 4). Terminal sire lines should be selected for rapid growth; terminal dam lines for small mature size. Other alternatives include selection for relative growth rate (Gain/Avg Wt Maintained) or for changed shape of growth curve. Selection for relative growth rate should increase growth rate without increasing birth weight. Selection to change shape of growth curve can favor early maturing cattle, which fatten on high roughage rations, without reducing growth rate or size.

Feed Efficiency. Efficiency of feed utilization is second only to realized fertility in biological and economic importance, but direct selection is difficult and expensive. Instead feed efficiency is usually improved as a correlated response to selection for traits, such as growth rate, lean yield and milk yield. From a total systems standpoint, even greater improvements in feed efficiency can be accomplished by selecting for complementarity and then crossing complementary genotypes. The obvious example is large sire lines mated to relatively small dam lines to yield fast growing, efficient slaughter produce from small, low maintenance cows.

A major aspect of feed efficiency is adaptation to the production environment. Well adapted cattle will gain more weight, produce more milk and be more

fertile on the same or less feed than poorly adapted cattle.

Maternal Ability. The ability of a cow to raise a healthy, profitable calf is affected by milk yield, calving ease and maternal behavior. Milk from a beef cow, unlike from a dairy cow, is not an end product. Feeding the cow to feed the calf is not efficient unless the feed resource cannot be digested by the calf. Milk is best used as a high quality protein-energy supplement for all but the youngest calves. Poor calving ease or maternal behavior can be partially compensated for by more intensive management, but economics require that most commercial cows calve and suckle their calves without assistance under range conditions.

Carcass Traits. Quantity and quality of beef are the end product. Increased lean yield is a correlated response to increasing growth rate. Palatability, especially tenderness, is generally quite good for young cattle finished on high grain rations and tenderization techniques are available if cattle must be finished at older ages on lower quality rations. Thus, direct selection for carcass traits should be necessary only to avoid the extremes of low yield or poor palatability.

Other Traits. Visual appearance will continue to be economicaly important as long as subjective evaluation must be substituted for objective measures of performance. Calves of specific type and color sell higher because these types have made cattle feeders more money. Conformation and color are phenotypic substitutes for knowledge of the cattle's genotype for growth, efficiency and carcass value. Soundness, temperament, longevity and polledness may also have real economic value in some situations.

Between vs Within Breed Selection. The acceptance of crossbreeding for beef production has allowed the commercial industry to tap the genetic variation which exists between breeds. A lifetime of selection for increased milk in a herd of Hereford cows would not achieve the increase attainable by using Holstein bulls to sire replacements. Selection for growth rate in our smaller breeds seems similarly inefficient when genes from large, fast growing breeds are more easily available.

Table 4. Relative Economic Values and Direction of Favorable Response for Selection Criteria Depending on Commercial Use of Selected Cattle.

	Systems of Commercial Beef Production		
Trait	Straightbred, Synthetic or Rotational Cross	Terminal Sire Line	Maternal Line
Fertility	++++	++++	++++
Survivability	++++	++++	++++
Gain	++	+++	0
Gain/Feed	+++	+++	+
Calv. ease	+	+	++
Maint. cost	--	0	---
Milk yield	0	0	+
Lean yield	0	+	0
Palatability	0	+	0

Symbols indicate direction of favorable change: +, increase; –, decrease; 0, no change or direction of change relatively unimportant. Number of symbols indicates relative value per unit change.

Obviously, the goals for all breeds or even all herds should not be the same. But how should they differ? The answer depends on how well cattle from the breed (herd) be used by and in the commercial beef industry. Table 4 provides some guidelines to this difficult question. Usually, emphasis should be on further improving the particular advantages of the breed, such as rapid growth, and correcting related disadvantages, such as calving difficulty.

Reference Material:

Cartwright, T. C. 1970. Selection criteria for beef cattle for the future. J. Animal Science 30:706.

Dickerson, G. E., N. Kunzi, L. V. Cundiff, R. M. Koch, V. A. Arthaud and K. E. Gregory. 1974. Selection criteria for efficient beef production. J. Animal Science 39:659.

Fitzhugh, H. A., C. R. Long and T. C. Cartwright. 1975. Systems analysis of sources of genetic and environmental variation in efficiency of beef production: heterosis and complementarity. J. Animal Science 40:421.

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