GENETIC POTENTIAL OF BEEF, PORK, AND POULTRY: TODAY AND IN THE FUTURE

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In all probability beef eating since 1953 has been the result of a legacy not of our making. The packing entrepreneurs put together meat for the millions and the pastorial nomad myth that beef eating resulted in manly virility enhanced by our cowboy hero of the silver screen helped. When coupled with increasing despesable income we ate beef. Now we find ourselves in a competitive position, like the other half has always lived. It is timely to consider the competitive position of beef.

Also we would do well to remember that livestock and especially cattle add to food production so long as they are subservient to agriculture and this means plant agriculture. Cattle have a definite long-run position in that they are the mobile harvestors of millions of acres of land with sparse vegetation. Further, they are excellent scavengers of the by-products of grain agriculture although no longer do they also provide the power. Throughout the development of our grain belts, cattle have been the marketing vehicle for vast quantities of grain along with swine and poultry. Even without the marketing use, cattle still serve a useful purpose in agricultural production. They may only be an adjunct to owning land.

For this paper, the genetic potential of a species will be defined as the kind and amount of genetic variance available to change the efficiency of producing meat of acceptable quality from available resources. What has been done about changing efficiency is circumscribed by the breeding structure of the species as well as the genetic variance. Therefore, to consider the future, requires study of both breeding structure and genetic variance. Such study is the limit of this paper. Other papers will consider the economic definitions of production efficiency, acceptable quality, and cost of available resources. The purpose of this paper is to examine the genetic potential and breeding structure of three species for making change in production efficiency.

GENETIC POTENTIAL

Traits concerned with production efficiency can be placed in two broad classes, reproduction and production. The creation of new wealth through the biological tangle of the reproductive complex is paramount in any species while production or the growth and development of this new wealth to market age is secondary but important as well. Over eons of time optimum fitness of species has been selected using as the criteria reproductive performance. Thus, little genetic variance usable by selection remains for man to use to enhance the reproductive complex of any species. This is true for poultry, swine, and cattle. Less than ten percent of the variance in measures of reproductive performance can be used by selection to affect change. However, these species differ in their reproductive potential. This potential is positively correlated with the animal size and time required to mature. The latter defines the time required to turn a generation, replace the breeding unit. The female controls the reproductive potential. Poultry have the highest reproduction followed by swine that farrow litters twice yearly and this is followed by the distant third since cattle average around eight tenths of a calf yearly. Animal size and hence its value, time to maturity, and female reproductive potential all influence the possible breeding structures and the relative economic value of changing reproductive performance since in the more prolific species breeding herd costs can be spread over more market animals.

It is indeed fortunate that traits of the reproductive complex in all three species exhibit economically important heterosis when genetically divergent groups are crossed in commercial production. However, there exists a correlation between the reproductive potential of a species and the commercial utilization of hybrid vigor today. Commercial broilers are cross combinations; market hogs are crossbreds; but only some fifty percent of our beef comes from crossbreds currently.

The class of traits involved in the growth and development of the market animals exhibits considerable genetic variation usable by selection. This is a result of these traits being less closely tied to fitness. Breeders since domestication have manipulated at least one of these traits, namely mature size. The history of these species of interest is little more than a record of the ups and downs in mature size produced by breeders who really focused on the desirable correlated responses.

For this general class of traits the relative amount of genetic variance usable by selection is correlated with the individual size and consequently negatively with the reproductive potential of the species. Table 1 gives general values of the three species for the fraction of the variance that is genetic, the percent of the individuals needed for replacement which differs with the reproductive potential, the intensity of selection possible which is a function of the necessary replacement, and the generation interval or the time in years required to replace the breeding herd or flock. A relative comparison of genetic change per generation is achieved by multiplying the first and third column of Table 1. In standard deviation units poultry has .42, swine has .45 and beef .48 indicating that the higher fraction of

Table 1. Fraction of the variance that is genetic[1], percent replacement[2], intensity of selection possible[3], and generation interval[4] for the species of interest.

Species	GV[1]	P[2]	i[3]	I[4]
Poultry	.20	5	2.1	1/2
Swine	.30	15	1.5	1
Beef Cattle	.40	30	1.2	4

variance that is genetic in beef allows it, with a much lower intensity, to result in similar genetic change per generation as poultry (.48 of a standard deviation change compared with .42 of a standard deviation change). This general result indicates that with similar breeding structures genetic change per generation is roughly equal in the three species. Genetic potential does exist for changing the beef animal for traits involved in growth and development. However, when this result is put on a yearly basis by dividing by the generation interval beef becomes .12, swine becomes .45 and poultry becomes .84. Longer life not only reduces yearly genetic change, but it also increases the value per individual. Length of association creates love bonds between individuals and the breeders of cattle, a problem less common among boars and roosters and their breeders. Genetic potential does exist in the beef population and it is equal in amount to the other species when expressed on a comparable life span basis (per generation).

BREEDING STRUCTURE

Now turn to a consideration of the delivery systems for this genetic potential or the breeding structures of these three species. The structures differ primarily because of the vast differences in the reproductive potentials, but contributing are size of the individuals, their lifespan, and their resulting value. Advantage has already been taken of the species' strong points in the existing breeding structures. Broiler production is most commercial followed by swine while beef except for the feeding is the least commercial or structured.

Broilers: The germ plasm for broiler production is centralized in the hands of a few commercial companies who use the services of trained breeders. Because of their reproductive ability, the corn model of forming and reconstituting inbred lines can be practiced. Selection is based on selection indexes that include the measurable traits of importance for the breeding herd and the market bird. Lines are combined that complement each other and maximize maternal and market performance besides contributing heterosis to the marketable product. Germ plasm multiplication has been achieved and the crossbred chick is acquired by the producer who raises them in mass. Profit is made by volume production. The breeders merchandize a proprietary product since the lines in the combination marketed are the property of the breeding company. The chicks being crossbred combinations cannot be used for breeding and the producer must return to the source for his germ plasm. Direction of selection in the population relies on competition of the companies to deliver the bird with the highest profit potential. One looks at the system from the outside and marvels at the efficiencies, but plastic the industry is not. Response to rapid economic shifts by changing the germ plasm quickly would appear to be difficult. However, the breeding structure can deliver a uniform product that is near optimum for the current systems of broiler production.

Pork: The germ plasm for pork production is generally dispersed in the hands of individual breeders but it is structured into breeds that when crossed produce economic heterosis. Inroads have been made on this structure by swine companies that produce genetic change in their nucleus herds and that have a multiplication structure to produce boars for breeding and some gilts.

One such company has produced lines along with the selection such that the commercial producer can participate in a systematic rotational crossbreeding program by using the lines of the company in rotation. Thus, a commercial breeding program rather than just a boar is merchandised. The percentage of producers using such programs is on the increase. Genetic change in the purebred herds of the breeds is difficult to measure. Some breeders use boar testing stations to evaluate their product and merchandise it while others rely on the swine shows for evaluation. Direction of genetic change has little real focus, thus the swine population remains extremely plastic since differences among breeds exist and vast differences among herds within breeds exist. It is easy with the reproductive potential of swine to spread a selected type once it is found across the breed. Almost any type exists somewhere. Even with their reproductive potential, swine suffer from the fact that the individuals are costly but not enough so that artificial insemination has become a useful technology. Record keeping is spotty even in purebred herds. Breed associations although interested have not made records of performance a significant part of their activities. Purebred swine breeders in general do not consider this their primary occupation since many are farmers first. Therefore, for a number of reasons, the swine industry has a breeding structure that must be described as being decentralized. However, since the turn of the century, the swine industry has managed to change types at least five times. The average backfat has been reduced significantly of late. Increases in mature size have allowed pigs to be slaughtered at heavier weights with reasonable fat.

Beef: The beef cattle population is large. The industry is highly segmented; market animals go through several hands before slaughter. The seed stock is sub-divided into pedigree isolates or breeds. Within each breed are many breeder herds. The pyramid structure from elite to multiplier herds exists giving a directional gene flow. It has been only some fifteen years that the commercial producer has been able to select breed combinations to enter his program from around thirty different breeds. Before there were the three British breeds that all belonged to the same biological type. Since the characterization of the newly introduced breeds by U.S. MARC and the state experiment stations, commercial producers have been able to put breeds together that compliment each other and that produce heterosis and that have the genetic potential to match their given set of resources.

The performance movement in beef has shown a steady increase in participants. This is due to several factors. The Beef Improvement Federation has developed guidelines for performance evaluation and through BIF new breeding technology has been introduced and used. The estimation of breeding values both for growth and maternal performance and the use of the reference sire concept to evaluate sires over breeds both in designed and field data evaluations have become common in breed association programs. Once the breeds took on performance evaluation seriously, they have developed sophisticated programs for the use of their breeders. The other factor is the use of artificial insemination as a breed improvement tool. This use has reduced the confounding of sires with herds such that through the sires used in many herds bulls of a breed can be fairly compared. In the sire evaluation analysis it has been possible to ascertain the genetic trend of the breeds by comparing the average performance of bulls born in different years. Table 2 gives the statistics of this genetic trend for the Angus and Hereford breeds. The trends in both breeds have been quite linear. If one looks at this genetic change from what is possible in a single herd where selection is for weight gain, the change of roughly three pounds per year is small compared to ten pounds per year possible. However, since some 10,000 sires are involved in each breed, this represents the change of the whole breed over the fourteen year period. I think it is a phenominal change. It says that if breeders are given a direction or goal as they were in the middle 1960's by the commercial producers, they can respond as a group to a need.

Table 2. Genetic trends for the Angus (A) and Hereford (H) breeds from 1964 to 1978 for weaning and yearling growth.

Statistics	Weaning	Yearling
A. Regression (pounds/year)	+ .79	+ 2.48
A. Accumulation (pounds)	+11.85	+37.20
H. Regression (pounds/year)	+ 1.64	+ 3.27
H. Accumulation (pounds)	+22.96	+45.78

The average bull of these two breeds born in 1978 produced calves which were almost 40 to 50 pounds heavier at a year of age than the average bull born in 1964. This evidence demonstrates that genetic potential for growth and development exists within the breeds and that the breeding structure using performance evaluation can produce genetic change for commercial producer use. Today, ways of including maternal trait evaluation are under study so the breeds can have sound criteria with which to select germ plasm that shows some gain in the reproductive complex.

Commercial producers, at this point in time, can select breed combinations that compliment and produce heterosis and select within these breeds germ plasm that has superior performance. Specification of product being offered for sale is slowly being achieved. That is, breeding value or the value of the animal as a parent in the herd of the buyer is being specified. However, as with swine, the majority of beef cows are in small herds that are scavengers. The incentive for producers to improve their management to include a systematic crossbreeding program using superior sires is scant.

The simple breed and herd within breed structure of the breeding industry is decentalized with regard to direction decisions. This gives it plasticity since there are some nuts doing their thing and these herds can be used to adjust to rapid economic shifts as the industry did when type changed from small to large. When artificial insemination becomes easier to do than turn a commercial bull out, then germ plasm use can skip the multiplier phase and be realized more quickly in the commercial product. If breeders can adopt the appropriate breeding technology to evaluate sires, they can just as easily sell one sire for a high price every other year to the bull studs as sell the top half of their bull crop every year. The use of artificial insemination can increase the intensity of sire selection, but will do little on the female side from which comes half the heredity. Correct use of embryo transfer can double the rate of genetic change in elite herds, but artificial insemination must be used to transmit the genetic change to the commercial producer in the minimum of time.

Now consider the direction or goal to change production efficiency. Much work remains to be done in the beef systems area to sort out the interaction among traits influencing the production efficiency of a species such as beef since cattle are produced from border to border in this country. It is crystal clear that improvement in the reproductive complex has a higher relative economic value in beef than the other species since the breeding herd costs cannot be spread over several market animals.

PHYSIOLOGY

Since cattle produce in very diverse ecologies, careful attention needs to be given to what the physiology of the genetic change really is. Cattle could be rendered incompetent in some systems. Corn breeders have made dramatic changes in yield of commercial hybrids. Uniformity of plants has been achieved. However, recent responses have been due to the ability of a grass to response to high levels of fertilization and denser plantings. This is fine if the cost of fertilizer does not negate the advance and it rains. Response in milk yield in the dairy breeds of late may be the response of a ruminant mammal to high concentrate feeding. Clearly more water is being included in the milk since lactation totals of solids not fat and fat have become the criteria. Improvement in broiler production efficiency is the response of birds to precision balanced rations. Watered protein and increases in fat deposition may have resulted. Improvement in pork is simply a reduction of fat deposition. The stress syndrome and the resulting poor quality pork produced indicates again the acquisition of undesirable genes when extremes are sought. Selection for small size in beef resulted in the devistating dwarf genes. Really in beef, breeders have changed mature size down and up again. The correlated responses we talk about, while mature size in the breeding herd simply increases the costs of production.

I suspect the key to competitive survival is the utilization of cattle as harvestors of sparce vegetation and by-products of grain agriculture not as marketers of harvested grain. Poultry and swine are simply marketers of harvested grain and in direct competition with humans for this food resource.

SUMMARY

The beef industry is evaluating its competitive position with other meats. There exists more than enough genetic potential in the traits involved in growth and development to make appropriate genetic change. The breeding structure of the industry is such that the commercial producer can make adequate selection decisions among the possible breed cross combinations to achieve a desirable breeding female and superior market stock. Further he can select within the chosen breeds and use superior germ plasm.

Utilization of artificial insemination within the breeds can increase the rate of change and increase the precision of evaluations over herds. Direction is decentralized, but genetic change has been documented. The seedstock industry can still respond to rapid economic shifts. Therefore, obtaining germ plasm that can be used to optimize commercial stock is possible and will be available if the correct economic signals are sent.

LITERATURE

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