

SELECTION FOR FEED EFFICIENCY

Hal I. Sellers
Farmers Hybrid Companies, Inc.

Introduction

Feed accounts for approximately 70 percent of the cost of producing pork, and there is little sign that this will lessen in the future. Unfortunately, feed costs are not reflected directly in the price received for our product. Market hogs are purchased by the processor based on estimated value as a retail commodity only, and none of the production costs are included in that equation. Thus, efficient use of feed has not received a great deal of attention, relative to say carcass quality, as to its role in reducing pork production costs. At this point our understanding of feed efficiency (FE) in the hog is rather meager. There is a lack of understanding of its component parts, of how it should be measured for selection purposes, and of the relationships between FE and other traits. All of this has important bearing on whether or not we can expect to change the intrinsic utilization of feed by the pig. However, with what little we do know, there appears to be opportunity to increase the efficiency of feed utilization. The purpose of this paper is to describe our experience in selecting for FE over the past twenty years and to discuss some of the lessons learned in terms of measuring and selecting for FE and correlated production traits.

Materials and Methods

The results reported in this paper are based on data gathered from the Farmers Hybrid Elite breeds. Although Farmers Hybrid Companies, Inc., has been in the swine seedstock business since 1943, five of the six breeds as we know them today were formed in 1960 and the sixth in 1967. Each was developed from a two-breed foundation and closed. Until 1969 there was one herd of each breed when each was doubled in size and split based on pedigree to populate a second farm, a total confinement facility. From the beginning replacement boars and gilts have entered the Elite breeds based on ranking in a performance test. Over time performance testing facilities have been expanded to the point where we now have 754 test pens. Also, the number of sibs tested as penmate has decreased from four or five to two or three. FE is expressed as the ratio of feed to gain while gain is expressed as average daily gain (ADG) and backfat as the average of three probes. Beginning in 1960 the selection index included ADG, FE, and backfat probe (PB), each with equal weighting coefficients. The present study includes data from 1966 through 1980. This was done to avoid the possible effect of residual heterosis influencing performance during the formative years.

The format of the performance test itself has changed over time reflecting improved understanding of what the test was measuring and in response to increases in the average market weight of hogs. Gilts have always been tested over a constant weight gain interval. Until 1972 boars were tested on a constant amount of feed per test pen of full sibs.

This was changed to a constant weight gain interval in 1973. Each Elite breed is managed to maintain an eighteen-month generation interval. The Elite herd production schedule calls for two farrowings per year. Fifty percent of the boars and forty-two percent of the gilts are replaced two times per year.

A control population has not been maintained in this selection program. Therefore, estimates of response to selection are based on time trends accounting for as much environmental variation as possible.

Results and Discussion

Selection Indices and Differentials

Selection differentials by years of ADG, FE, PB, and average daily feed consumption (ADC) averaged across breeds and locations are presented in Figure 1. Although ADC has never been included in the selection index directly, it is part of the feed-to-gain ratio and has a bearing on the interpretation of later results. Therefore, it is included as a correlated trait. From 1966 through 1968 the selection index included ADG, FE, and PB, each with equal coefficients. The selection differentials for FE were smallest of any time during the fifteen-year period studied. In addition, the differentials for consumption were uniformly positive and largest in the positive direction during this period. An analysis of the results through 1968 indicated selection differentials for FE were not as great as expected. This led to the decision to reduce the coefficient for ADG by one-half. The result was that over the 1969-1972 time period the selection differentials for the FE ratio were approximately doubled without reduction of those for ADG and PB. The differentials for ADC were reduced in both sexes but more so in gilts than in boars.

A study of accumulated performance test data was undertaken to better understand the relationships among the traits under selection. Only gilt performance test data were used in the study because gilts had been tested under the same format (constant gain test) throughout the period. The first step was to look at the phenotypic relationships among ADG, FE, PB, and ADC. When computing a selection index in the classical manner, the input parameters (phenotypic and genetic variances and covariances) assume linear relationships. This may be so about the mean. However, selection does not generally take place at the mean but at the extremes. The question was whether or not the relationships hold over the range of observations. In this part of the study, each performance variable was alternately permitted to be the independent variable while the remaining variables were regressed on the independent variable one at a time. The resulting quadratic regression equations for each dependent variable were plotted simultaneously. The results are presented in Figure 2. The plots show that phenotypically the relationship between ADG and FE is not linear throughout the range of values studied and that the relationship between ADG and ADC appears close to being linear. These results also suggest that when ADG is included in the selection index along with the FE ratio, rapid growing pigs could be selected at the expense of feed efficiency. In addition, selection for high intake could also occur. In terms of consumption there may be a critical point beyond which selection for gain comes at reduced, rather than improved, feed efficiency. By the same token, the regressions suggest that selection for feed

efficiency would bring about favorable response in both gain and backfat. Genetic and phenotypic parameters were estimated from these data (Table 1) and selection indices including ADG, FE, and PB and FE and PB alone computed. Although an index including the three traits was expected to yield the greatest net economic improvement, in view of the phenotypic relationships among the traits, an index including only FE ratio and PB was chosen. The computed coefficients for each trait in this index were equal. In addition to changing the selection index in 1973, the boar performance test format was changed from a constant feed intake test to a constant weight gain test. The result of these changes was near doubling of the selection differentials for FE between the 1969-1972 period and the 1973-1980 period. This occurred in both boars and gilts. Selection differentials for ADG averaged across the sexes changed little over these two periods. However, the differential in boars was reduced approximately 30 percent while that for gilts nearly doubled. Selection differentials for PB changed only slightly. These results suggest that within a constant feed test where full-sib groups of boars share a fixed amount of feed and each is credited with the same feed efficiency, the boar with the most rapid rate of gain may have a large appetite relative to his sibs and be above the mean of the group in feed efficiency. Therefore, his selection based on an index including ADG might not contribute to improving FE. This hypothesis is supported by the change in selection differentials in boars for intake from positive in the 1966-1972 period to nearly zero in the 1973-1980 period. The reason for the increase in selection differentials for gain in gilts in the 1973-1980 period is not clear. However, it may well be a true manifestation of the index taking effect.

Selection Response

In the absence of some form of a control population from which selected populations can be deviated and in the presence of the changes in facilities and performance test format, estimation of response to selection is difficult. Using the regression of gilt performance test year means over time within periods of similar test formats and weighting these regressions, estimates of the response to selection have been computed (Table 2). For comparative purposes results from two other selection experiments are included. Hetzer and Harvey (1967) reported on selection for high and low backfat in Yorkshire and Duroc pigs. A control population was included. Response to selection for backfat in the present study is estimated to be about half that obtained by Hetzer and Harvey. This is expected in comparing index selection to single trait selection when the trait is accurately measurable. Ellis and Smith (1979) reported their response as a percentage. Based on 1966 means, total response in the present study has been approximately 8, 14, and 20 percent for ADG, FE, and PB, respectively. These are comparable to the results reported by Ellis and Smith. Estimates based on the shorter 1973-1979 period suggest greater response has occurred in recent years.

Considerations

Although the results indicate selection has been effective in improving FE in addition to ADG and PB, the responses have not approached expectation. Part of the reason has been that sire selection has not been by true truncation but within sire families, reducing selection intensity. This is done to avoid high levels of inbreeding. In addition, pen measurement of FE is

expected to reduce the observed variance for FE. The number of pens for testing has been increased and the number of sibs per pen reduced in order to increase the phenotypic variance for FE. Also, the expectations of response may be larger than possible because of incorrect phenotypic and genetic parameter estimates. The parameters were reestimated (Table 3) and show only minor differences. The heritability estimate for FE decreased and the phenotypic correlation between ADG and ADC was nearly halved while this genetic correlation showed only slight change. The method of measuring feed is also a consideration. The ratio of feed over gain as a measure of FE may not be the most effective in terms of selection response. There is some evidence that this is particularly true when selection is intense, such as in boars. Use of gross gain in computing the feed-to-gain ratio does not account for differences in deposition of fat and lean. Intuitively lean tissue growth makes more sense. However, the problems of accurately estimating lean tissue growth in the live animal have not been entirely solved.

Evidence presented here and elsewhere (Robertson, 1973; Magee, 1962; Eisen, 1977; Whittemore and Fawcett, 1974) suggests that feed consumption determines to a large degree what the efficiency of its use will be. At this time our understanding of consumption in terms of its component parts is meager. That is, what portion of the total intake can be attributed to intrinsic appetite, learned stimuli, behavioral patterns, ration nutrient levels, and other environmental influences. If it is hypothesized that feed consumption beyond a critical point is antagonistic to selection for FE and carcass composition and selection is based on ad libitum feeding and a constant weight gain test, then rather than selection for FE directly, selection might be based on the variables intake, time, and body fat deposition over the given weight gain period. The sign for each coefficient would be negative. Selection would be for the most rapid growth (least time) on the least amount of feed resulting in the least amount of fat deposition. Other alternatives include selecting with consumption restricted to zero change and selection under limited feeding conditions. The latter method is common in Europe.

Summary and Conclusions

The results of long-term selection for improved feed efficiency, as measured by the ratio of feed to gain, in combination with growth rate and live animal backfat probe in closed herds of swine are presented. It is shown that reducing and finally eliminating average daily gain from the selection index increased the selection differentials for feed efficiency. Study of phenotypic quadratic regressions among gain, feed efficiency, backfat probe, and feed consumption suggest that intake beyond some critical point may result in an antagonism between selection for gain and selection for feed efficiency as measured by the ratio. Response to selection in these herds is estimated to be + .010 lb, - .030 lb., and - .017 in. per year for average daily gain, feed efficiency, and backfat probe, respectively. Estimates from recent years are + .023 lb, - .046 lb., and - .015 in. for these traits, respectively. Responses of these magnitudes have a significant positive effect on pork production costs. However, achieved response to selection for feed efficiency has not met expectation. Part of the reason may be in our method of estimating feed efficiency as the ratio of feed to gain. Other methods which more closely reflect the component parts of consumption and which partition composition of product should be considered.

Clearly, feed efficiency is a complex trait with large economic impact for the pork producer. One method for the pork producer to increase feed efficiency in his operation is through the seedstock he purchases. As seedstock suppliers we must strive to better understand feed efficiency and through intense selection programs make improvement available to the pork producer.

References

- Eisen, E. J., 1977. "Restricted selection index: An approach to selecting for feed efficiency," *Journal of Animal Science*, 44:985.
- Ellis, M. and W. C. Smith, 1979. "Correlated responses in feed intake to selection for economy of production and carcass lean content in Large White pigs," *Animal Production*, 28:424.
- Hetzer, H. O. and W. R. Harvey, 1967. "Selection for high and low fatness in swine," *Journal of Animal Science*, 26:1244.
- Magee, W. T., 1962. "Relationship between daily feed consumption and feed efficiency," *Journal of Animal Science*, 21:880.
- Robertson, A., 1973. "Growth rate, appetite, body composition and efficiency," *British Poultry Breeders Roundtable*, 1973.
- Whittemore, C.T. and R. H. Fawcett, 1974. "Model responses of the growing pig to dietary intake of energy and protein," *Animal Production*, 19:221.

TABLE 1. Heritabilities (diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) estimated from 1966-1973 performance test data.

	ADG	FE	PB	ADC
ADG	.25	-.61	.28	.74
FE	-.40	.35	.28	-.04
PB	.13	.07	.32	.60
ADC	.85	.09	.18	.20

TABLE 2. Estimated response to selection

Source	ADG	FE	PB	Time period
FHC Elite Breeds (1966-1979)	+0.010	-.030	-.017	Annual
(1973-1979)	+0.023	-.046	-.015	Annual
Hetzer and Harvey (1967)			-.035	Annual
Ellis and Smith (1979)	0%	12.1%	15.7%	10 generations

TABLE 3. Heritabilities (diagonal), genetic correlations (above diagonal), and phenotypic correlations (below diagonal) estimated from 1966-1977 performance test data.

	ADG	FE	PB	ADC
ADG	.27	-.62	.19	.66
FE	-.36	.27	.27	.13
PB	.04	.12	.35	.54
ADC	.46	.32	.13	.20