Selection for Lean Growth Rate in a Synthetic Line of Yorkshire-Meishan Pigs
2. Correlated Responses in Litter Traits

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Summary and Implications

Correlated responses for litter traits in a synthetic line of Yorkshire-Meishan pigs selected for lean growth rate were studied in 133 litters and 1,057 pigs. The following traits were studied: total number born; number born alive; number nursed at 21 and 42 days; litter weights at birth, 21 and 42 days; piglet weights at birth, 21and 42 days; and nipple number. Correlated responses were estimated by two methods: deviation of the selected line from a control line and multiple trait derivative free restricted maximum likelihood. Generally, estimates from the two methods were similar but tended to be more precise for the latter. Correlated responses based on the two methods were regressed on generation and cumulative selection differential. These regression coefficients were negative (P>.05) for total number born by method 1, and for number born alive and number at 21 and 42 days by method 1 and method 2. In method 1, statistically significant correlated responses occurred in 42-day litter weight and 21-day piglet weight. In method 2, statistically significant correlated responses occurred only in 42-day litter weight. Coefficients were positive (P>.05) for individual and litter weights at birth and 42 days and for 21-day litter weight by method 2. Selection for lean growth rate should have little effect on litter traits.

Introduction

Selection for lean growth rate (LGR) in swine has been practiced for several decades, and has been effective (3,4,6,9,12,13,14,15,18,20). It is important to evaluate the size and direction of correlated responses with selection on LGR. This allows breeders to design more effective selection programs that consider all possible changes in traits of economic importance to the industry (19). Correlated responses in litter traits with selection for LGR have been reported in several studies (7,8,11,21). However, correlated responses to selection for LGR in a synthetic line of U.S. and Chinese pigs have not been examined. Therefore, the objective of this study was to estimate correlated responses in litter traits during four generations of mass selection for LGR in a synthetic line of Yorkshire-Meishan pigs.

Materials and Methods

Source of data. The experiment was conducted at the Iowa State University Bilsland Memorial Research Farm from 1993 to 1998. Foundation stock consisted of nine Meishan sows that were descendents of individuals imported from the People's Republic of China in 1989 and were considered to be representative of the Meishan breed. Semen from six American Yorkshire boars was selected from two commercial companies and used to randomly inseminate Meishan sows at the farm and produced the base population (generation 0) of pigs in 1994 (5). Selection criteria for the Yorkshire boars emphasized high expected progeny differences for adjusted 10th-rib backfat thickness and number of piglets born alive per litter. From the base generation and in each subsequent generation, five boars were randomly selected after ultrasound scanning to sire the next generation of the control line. Two additional boars, also randomly selected, were kept as alternates and used when any of the originally designated boars were unable to service sows successfully. In each generation, 15 gilts were randomly selected to produce the next generation of control line pigs. In the select line, seven boars, along with two or three alternates, and 20 gilts with the highest LGR, were selected each generation without regard to pedigree to produce the next generation of select line pigs. In the base population, of the seven designated control line boars, one boar had high LGR and also was used to sire select line pigs for generation 1. In each of the succeeding generations, all boar and gilt replacements came from their respective lines, and no matings were made across lines.

In each generation, matings were made within each line to minimize the rate of increased inbreeding. Generation intervals in both the select and control lines were designed to be 13 months because females farrowed only one litter and boars were retained for use in only one 5-wk breeding period. At the end of four generations of selection, the difference in LGR between the select and control lines was 124.8 g/day. Inbreeding levels for the pigs in generation 4 were .198 and .207 in the select and control lines, respectively (5).

All sows were housed during gestation in open-fronted buildings with concrete floored pens. As the expected date of farrowing approached, individual sows were moved to farrowing pens in an environmentally controlled building. Approximately one week after farrowing, sows and litters were moved from the farrowing house to an open-fronted, concrete-floor nursery. Pigs were weaned at approximately six weeks of age and moved to growing pens to start the test. Commercially prepared corn-soybean meal diets containing 18, 16, and 14% CP were fed to pigs when they reached 30, 70, and 105 kg, respectively. Pigs were weighed off test on an individual basis at weekly intervals upon reaching a weight of

105 kg. Pigs were allowed ad libitum access to feed and water. Numbers of litters, sires, and pigs from which data were recorded each generation are shown in Table 1. Total number born (TNB), number born alive (NBA), litter birth weight (LBWT), piglet birth weight (PBWT), litter live weight at birth (LAWT), number of piglets nursed at 21 days (N21), 21-day litter weight (L21WT), 21-day piglet weight (P21WT), number of piglets weaned at 42 days (N42), 42-day litter weight (L42WT), 42-day piglet weight (P42WT), and nipple number (NN) were recorded.

Statistical Analyses. Litter size and weight were considered traits of the dam and were measured on gilts selected from generation 0 through 3. Correlated responses to selection were evaluated by two methods: 1) deviation from the control line (method 1), and 2) estimation of (co)variance components and prediction estimation trend using multiple trait derivative free restricted maximum likelihood (MFDFREML) (method 2) (1). In method 1, correlated cumulative genetic responses were calculated as the deviation of the mean phenotypic performance of the select line from the mean performance of the control line. Litter size and litter weight traits were analyzed with a model that included the effect of generation-line (GL) and sire of dam within GL. L21WT and P21WT were calculated using the formula recommended in NSIF Guidelines for Uniform Swine Improvement Programs (17). P42WT was analyzed with a model that included the fixed effect of GL and weaning age as a covariate. The regression coefficient of weaning weight on age was used to adjust weaning weights to 42 days of age, and adjusted weights of siblings were summed to obtain adjusted litter weaning weights. In method 2, the models for litter size and litter weight included batch and month of farrowing within year as fixed effects, and additive genetic and sow common environment as random effects. L42WT and P42WT were pre-adjusted by weaning age. To account for selection bias, the MTDFREML analysis involved each of the correlated traits and selected traits in the select line plus control line. Method 1 assumed that responses are linear and the select and control lines react similarly to the environmental effects. This method, however, ignores genetic drift in the calculation of standard errors.

Weighted cumulative selection differentials (WCSD) were calculated by deviating the record of each selected individual from its generation-line-sex subclass mean and adding it to the average cumulative selection mean of the individual's parents. Individual cumulative selection differentials were weighted by the number of progeny alive at the age of ultrasound scanning. Estimates of correlated responses from the two methods were also regressed on generation and WCSD.

Results and Discussion

Total WCSD for LGR over four generations of selection was 141 g/day in the select line and 16.2 g/day in the control line, a difference of 124.8 g/day. This corresponds to a standardized WCSD of 4.1 phenotypic standard deviation units. The regression of WCSD on generation showed that the average increase in LGR was 33.9 g/day per generation or 1.1 phenotypic standard deviations units. The estimate of realized heritability was .29 ±.12 (5). Direct genetic change for LGR from method 1 was 9.4 g/day per generation.

The estimates of cumulative correlated responses per year for each trait are illustrated in Figures 1–12. Based on the two methods, estimates of correlated responses for litter size and litter weight were similar but generally nonsignificant (Table 2). However, the correlated responses for TNB and P21WT from the two methods were in the opposite direction. With method 1, the correlated responses for TNB and P21WT were -.17 ± .3 and .23 ± .003 kg/generation, respectively. Corresponding correlated responses with method 2 were .06 ± .13 and -.03 ± .05 kg/generation. The correlated responses for NBA, N21, and N42 were negative but not significant by method 2.

Results of the present study agree with the work of Cleveland et al. (7), who reported that index selection for lean growth resulted in a negative correlated response for TNB, NBA, and N42. Vangen (21) found positive responses for TNB and NBA, and a negative correlated response for N42 to index selection for lean growth in a Norwegian Landrace line. However, none of the correlated responses in this study was significant. Fredeen and Mikami (10) noted that NBA had significant negative phenotypic trends over several years. Selection for weight of lean cuts at a constant age in a Yorkshire line (8) resulted in a negative (P>.05) correlated response for litter size at one and seven days in first-parity gilts. Correlated responses were negative (P<.05) in second-parity sows for litter sizes at one, seven, and 21 days. Kerr and Camerson (11) also did not observe a difference between a selection line for lean growth and a control line after seven generations of selection for lean growth on ad libitum feeding or on restricted feeding. However, Burlot et al. (2) found that correlated responses for litter size at birth and at weaning were slightly positive after 12 years of selection for lean growth in a composite of Chinese-European pigs.

Correlated response in litter size to selection for LGR was variable among experiments. However, based on the two methods used in this study, our results suggest that selection for LGR in a synthetic line of Yorkshire-Meishan pigs will not have a large effect on litter size.

Based on the two methods, LBWT, LAWT, L21WT, and L42WT had positive responses (Figures 5–8). However, none of the regressions on generation and WCSD for litter traits were significantly different from zero except for L42WT (Table 2). Vangen (21) reported that correlated responses to index selection for rate of lean growth were positive for litter weight at birth but negative for litter weight at 42d (P>.05). DeNise et al. (8) found that selection for weight of lean cuts resulted in negative correlated responses for litter weights at birth and 21 days in first and second parity females. However, the correlated responses were significant only for litter weights in the second parity. Fredeen and Mikami (10) observed a significant negative phenotypic trend over years for litter weights at birth. Cleveland et al. (7) noted consistently heavier litter weights at birth and 42 days in a line selected for rate of lean growth when compared to a control line. However, the regressions on cumulative selective differential for the index were not significant. Kerr and Camerson (11) also found that there were no significant differences for litter weights at birth, 21 days, and 42 days between a selection line and a control line after seven generations of selection for lean growth rate based on ad libitum feeding or on restricted feeding. Our results, and those of similar experiments reported in the literature, suggest that selection for LGR in a synthetic line will have very little effect on litter weights.

The estimates of cumulative correlated responses per year for PBWT, P21WT, P42WT, and NN are presented in Figures 9–12. Based on the two methods, the regression coefficients on generation and WCSD were positive except for P21WT by method 2. None were significant except for P21WT by method 2. Vargen (21) reported positive correlated responses for PBWT ($P<.05$) and P42WT ($P>.05$) to index selection for rate of lean growth. Cleveland et al. (7) observed positive, but not significant, correlated responses for PBWT and P42WT. Kerr and Camerson (11) also reported that there were no differences in PBWT and P21WT between the select line and control line after seven generations for LGR.

With both methods in this study, the regression coefficients of nipple number on generation and WCSD were positive but not significant, which is consistent with the results of Cleveland et al. (7). Burlot et al. (2) also found that the correlated response for nipple number was slightly positive after 12 years selection of LGR in a composite line in France.

This experiment has demonstrated that selection for lean growth rate in a synthetic line of Yorkshire-Meishan pigs over four generations had little effect on litter traits. Therefore, to meet the needs of the swine industry in producing a synthetic terminal dam line, a selection program could include LGR while maintaining the advantage of litter traits from some Chinese breeds. The estimates of correlated responses should be useful in designing improvement programs for a synthetic line.

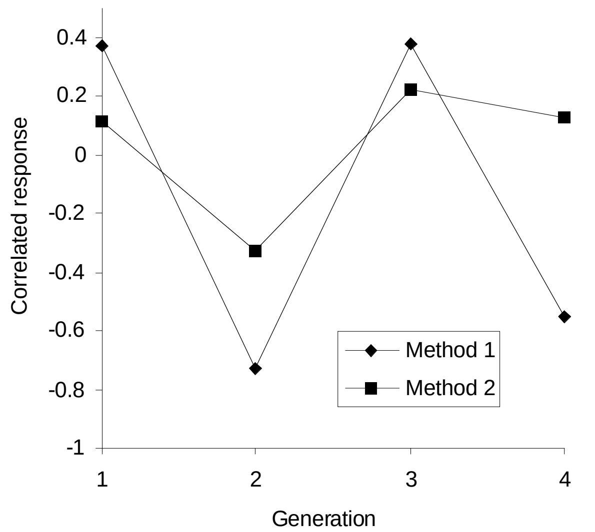

Figure 1. Correlated response for total number born (TNB) from two methods.

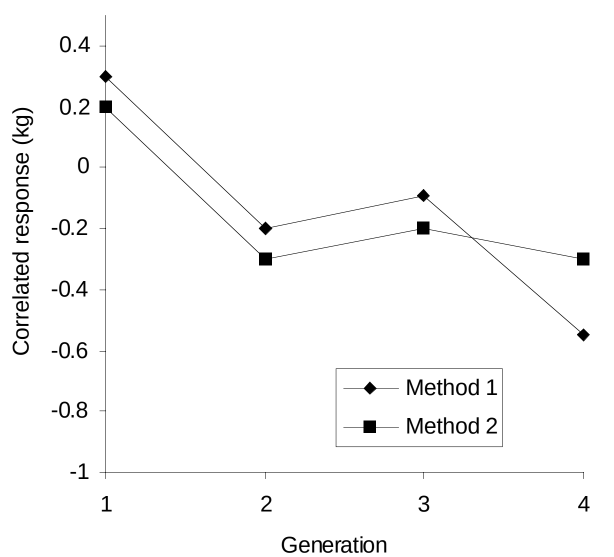

Figure 2. Correlated response for number born alive (NBA) from two methods.

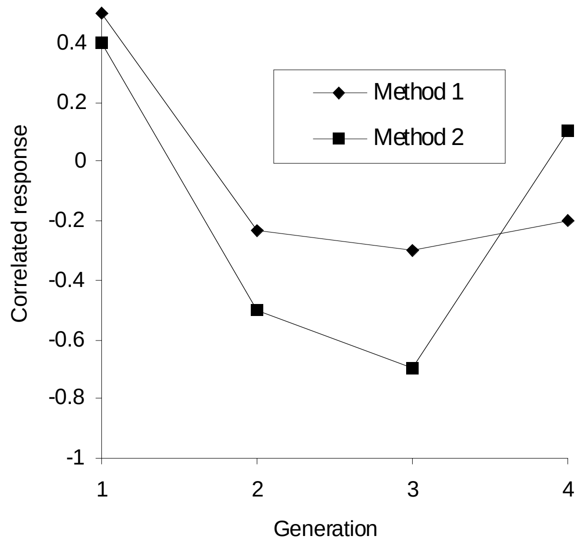

Figure 3. Correlated response for number at 21 days (N21) from two methods.

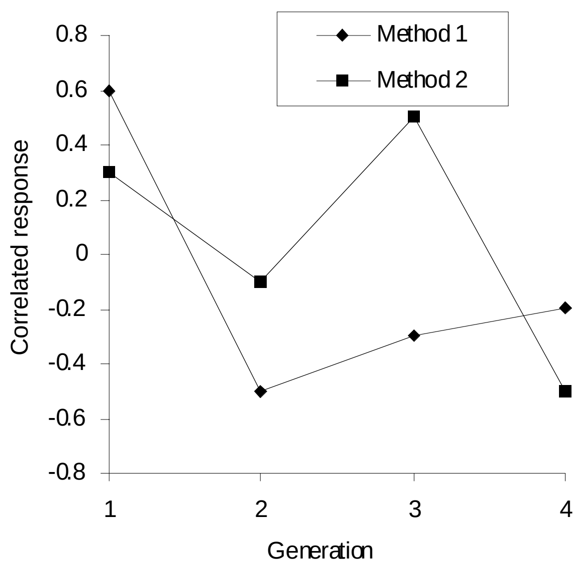

Figure 4. Correlated response for number at 42 days (N42) from two methods.

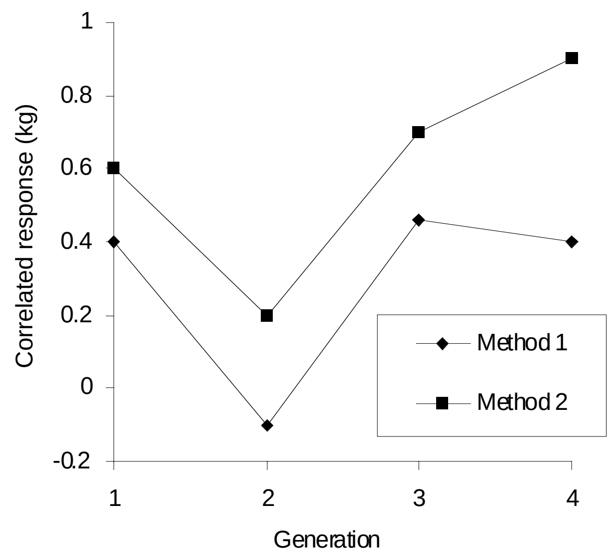

Figure 5. Correlated response for litter birth weight (LBWT) from two methods.

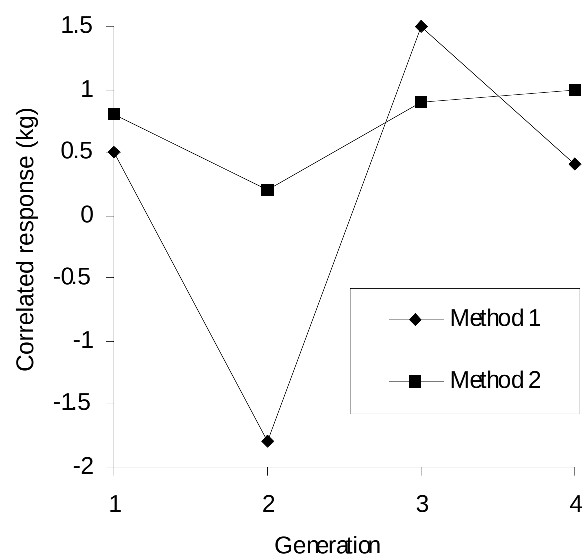

Figure 6. Correlated response for litter live weight at birth (LAWT) from two methods.

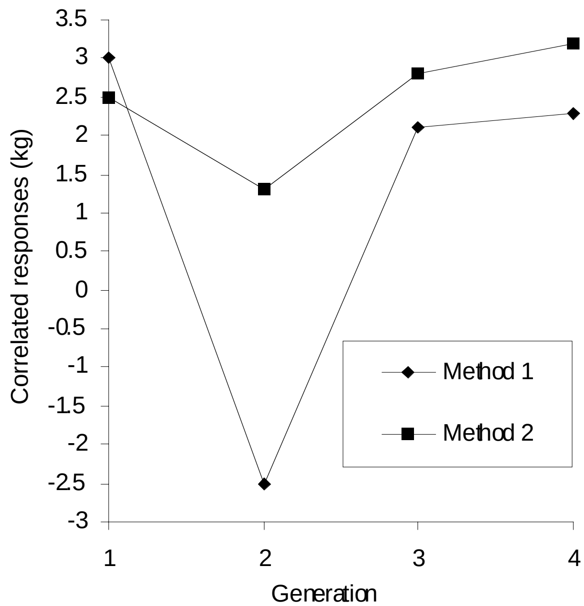

Figure 7. Correlated response for litter weight at 21 days (L21WT) from two methods.

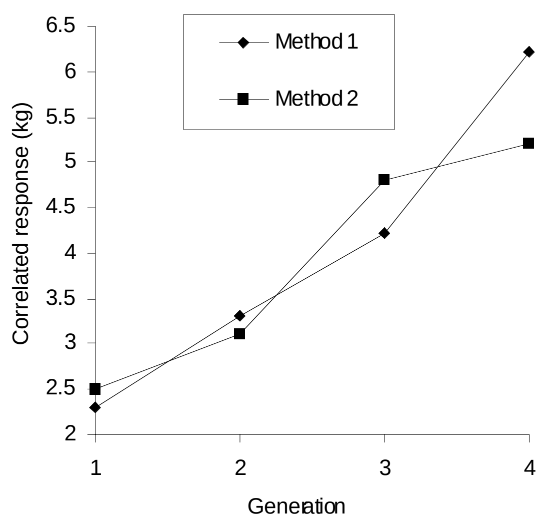

Figure 8. Correlated response for litter weight at 42 days (L42WT) from two methods.

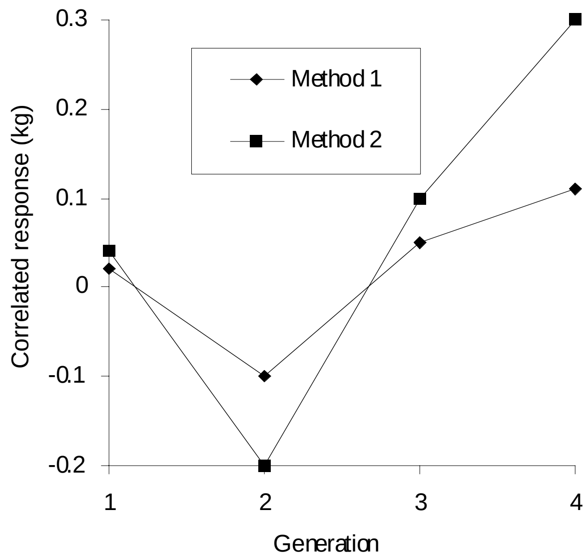

Figure 9. Correlated response for piglet birth weight (PBWT) from two methods.

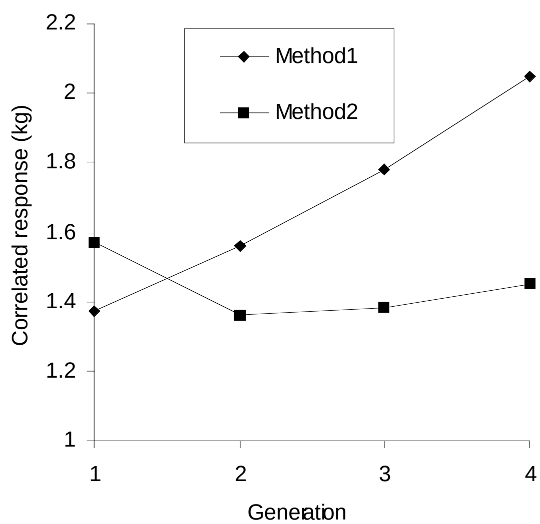

Figure 10. Correlated response for piglet weight at 21 days (P21WT) from two methods.

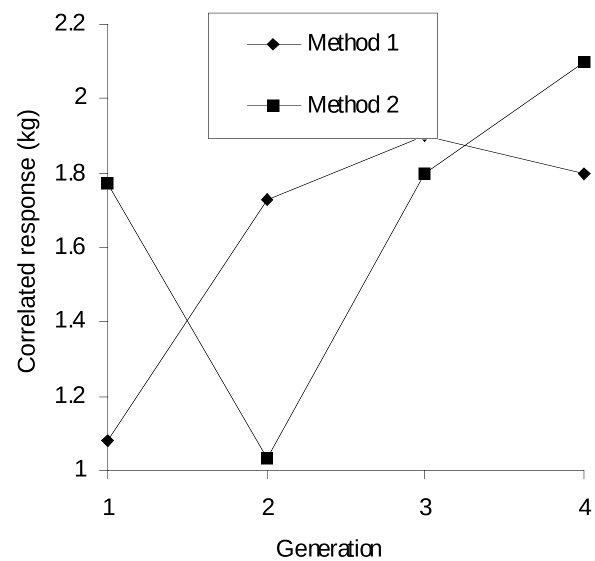

Figure 11. Correlated response for piglet weight at 42d (P42WT) from two methods.

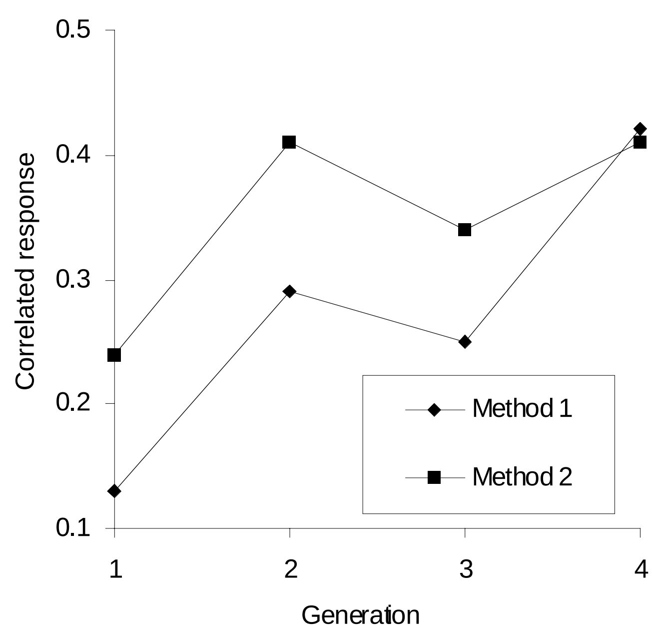

Figure 12. Correlated responses for nipple number (NN) from two methods

Table 1. Distribution of parents and offspring by line and generation.

	Select line				Control line			
			Offspring				Offspring	
Generation	Sires	Dams	Boars	Gilts	Sires	Dams	Boars	Gilts
0	-	-	-	-	6	9	40	50
1	7	16	48	75	5	14	50	62
2	7	17	51	74	6	13	49	58
3	7	18	60	70	6	14	48	60
4	8	18	75	81	6	14	50	56
Totals	29	69	234	300	29	64	237	286

Table 2. Regressions of correlated traits on generation and weighted cumulative selection differential.

	Generation		Selection differential	
Trait[a]	Method 1	Method 2	Method 1	Method 2
TNB	-.17 ± .30	.06 ± .13	-.005 ± .007	.001 ± .003
NBA	-.24 ± .08	-.14 ± .08	-.006 ± .002	-.003 ± .002
N21	-.21 ± .14	-.11 ± .27	-.005 ± .004	-.002 ± .007
N42	-.16 ± .24	-.18 ± .21	-.005 ± .005	-.005 ± .005
LBWT	.05 ± .14	.14 ± .13	.001 ± .003	.003 ± .003
LAWT	.30 ± .73	.13 ± .17	.006 ± .02	.003 ± .004
L21WT	.25 ± 1.37	.36 ± .37	.006 ± .03	.008 ± .009
L42WT	1.2 ± .20*	.96 ± .14*	.03 ± .006*	.02 ± .005*
PBWT	.04 ± .04	.11 ± .08	.001 ± .0009	.003 ± .002
P21WT	.23 ± .003*	-.03 ± .05	.006 ± .003*	-.0008 ± .001
P42WT	.23 ± .12	.86 ±.22	.005 ± .003	.003 ± .005
NN	.08 ± .03	.04 ± .03	.002 ± .0006	.001 ± .0008

[a]TNB=total number born; NBA=number born alive; N21=number of piglets nursed at 21 days; N42=number of piglets weaned at 42 days; LBWT=litter birth weight; LAWT=litter live weight at birth; L21WT=21-day litter weight; L42WT=42-day litter weight; PBWT=piglet birth weight; P21WT=21-day piglet weight; P42WT=42-day piglet weight; NN=nipple number.

*P<.05.

References

1. Boldman, K. D., L. A. Kriese, L. D. Van Vleck, and S. D. Kachman. 1993. A Manual for Use of MTDFREML. A set of program to obtain estimates of variances and covariances [Draft]. U. S. Department of Agricultural Research Service.
2. Burlot, T., S. Zhang, J. Naveau, C. legault, and J. P Bidanel. 1998. Genetic parameters and genetic trends in the Sino-European Tiameslan composite line. In: Proc. 6th World Congr. Genet. Appl. Liverst. Prod. V:599.
3. Cameron, N. D. 1994. Selection for components of efficient lean growth rate in pigs. 1. Selection pressure applied and direct responses in a Large White herd. Anim. Prod. 59:251.
4. Cameron, N. D., and M. K. Curren. 1994. Selection for components of efficient lean growth rate in pigs. 1. Selection pressure applied and direct responses in a Large White herd. Anim. Prod. 46:263.
5. Chen, P., T. J. Baas, and J. C. M Dekkers. 1999. Selection for lean growth rate in a synthetic line of Yorkshire-Meishan pigs. 1. Selection pessure applied and direct response. ISU Swine Research Report. ASL-1670.
6. Cleveland, E. R., D. J. Cunningham, and E. R. Peo. 1982. Selection for lean growth in swine. J. Anim. Sci. 54:719.
7. Cleveland, E. R., R. K. Johnson, and P. J. Cunningham. 1988. Correlated responses of carcass and reproductive traits to selection for rate of lean growth in swine. J. Anim. Sci. 66:1371.
8. DeNise, R. S., K. M. Kersey, L. A. Swiger, and R. F. Plimpton. 1983. Selection for increased leanness of Yorkshire swine. IV. Indirect responses of the carcass, breeding efficiency and preweaning litter traits. J. Anim. Sci. 56:551.
9. Fredeen, H. T., and H. Mikami. 1986a. Mass selection in a pig population: Experimental design and responses to direct selection for rapid growth and minimum fat. J. Anim. Sci. 62:1492.
10. Fredeen, H. T., and H. Mikami. 1986b. Mass selection in a pig population: Correlated responses in reproductive performance. J. Anim. Sci. 62:1523.
11. Kerr, J. C. and N. D. Camerson. 1996. Responses in gilt post-farrowing traits and pre-weaning piglet growth to divergent selection for components of efficient lean growth rate. Anim. Prod. 63:523
12. Leymaster, K. A., L. A. Swiger, and W. R. Harvey. 1979a. Selection for increased leanness of Yorkshire swine. I. Experimental procedures and selection applied. J. Anim. Sci. 48:789.
13. Leymaster, K. A., L. A. Swiger, and W. R. Harvey. 1979b. Selection for increased leanness of Yorkshire swine. II. Population parameters, inbreeding effects and response to selection. J. Anim. Sci. 48:800.
14. McPhee, C. P. 1981. Selection for efficient lean growth in a pig herd. Australian Journal of Agricultural Research 32:681.
15. McPhee, C. P., G. A. Rathmell, L. J. Daniels, and N. D. Cameron. 1989. Selection in pigs for increased lean growth rate on a time-based feeding scale. Anim. Prod. 47:149.
16. Moeller, S. J. 1994. Evaluation of genetic parameters for fat and muscle deposition in swine utilizing serial real-time ultrasonic measurements. Ph. D. Thesis. Iowa State Univ. Ames, IA
17. NSIF. 1997. Guidelines for Uniform Swine Improvement Programs. National Pork Producers Council. Des Moines, IA.
18. Stern, S., K. Johansson, L. Rydhmer, and K. Andersson. 1994. Performance testing of pigs for lean tissue growth rate in a selection experiment with low and high protein. I. Experimental design and efficiency of selection. Acta Agric. Scand. Section A, Anim. Sci. 43:136.
19. Tess, M. W., G. L. Bennett and G. E. Dickerson. 1983. Simulation of genetic changes in life cycle efficiency of pork production. II. Effect of components on efficiency. J. Anim. Sci. 56:354
20. Vangen, O. 1977. Studies on a two trait selection experiment in pigs. I. Growth, feed consumption and feed conversion ratio after 10 years of selection for growth rate and backfat thickness. Acta Agric. Scand. 27:331.
21. Vangen, O. 1980. Studies on a two trait selection experiment in pigs. V. Correlated responses in reproductive performance. Acta Agric. Scand. 30:309.