Genetic Parameters for Lean Growth Rate and Its Components in U.S. Landrace Pigs

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Summary and Implications

Records on 65,536 Landrace pigs collected between 1985 and 1999 in herds on the National Swine Registry STAGES program were used to estimate additive genetic (animal), common environmental (litter), and residual variances and covariances for days to 250 lb, backfat, loin eye area, and lean growth rate. Analysis was by the REMLf90 program of I. Misztal using a multiple-trait animal model with fixed effects of contemporary group and sex and random effects of animal, litter, and residual error. Heritability estimates were 0.54, 0.39, 0.49, and 0.48 for days to 250 lb, backfat, loin eye area, and lean growth rate, respectively. Genetic correlations for lean growth rate with days to 250, backfat, and loin eye area were -0.83, -0.38, and 0.40, respectively. Phenotypic correlations for lean growth rate with days to 250 lb, backfat, and loin eye area were -0.80, -0.40, and 0.56, respectively. Litter effects were large only for days to 250 lb. Lean growth rate should be used as an important selection criteria in genetic improvement in pigs.

Introduction

Increased participation in merit buying programs by producers has increased the emphasis given to leanness. However, the future competitiveness of pork depends on genetic improvement in the efficiency of quality lean production. The biological index of lean growth rate (LGR) has been proposed as the most appropriate expression of the industry's objective for this phase of production. Selection for lean growth rate has been practiced for many years in swine production, and the effectiveness of selection for this trait has been demonstrated by many researchers. However, the degree of the effectiveness of selection is variable, primarily due to different selection criteria applied.

(2) reported the effectiveness of selection for LGR in a synthetic line of Yorkshire-Meishan pigs based on the lean prediction equation recommended by National Pork Producers Council (12). Although estimates of genetic parameters for the components of LGR have been widely reported (7, 9, 10, 11) parameter estimates for LGR in the literature are variable and from relatively small samples of the population (2, 11, 13). The objective of this study was to obtain genetic parameter estimates for LGR and its components in a large data set of purebred Landrace pigs in the United States.

Material and Methods

Data source

Data were obtained from the National Swine Registry on Landrace pigs born between 1985 and 1999. Numbers of records, animals, litters, contemporary groups, and litters represented are shown in Table 1, along with means for days to 250 lb (Days250), backfat (BF), loin eye area (LEA), and lean growth rate. Data on boars, gilts, and barrows were included in the data set. BF and LEA were measured ultrasonically at the 10th rib. BF, LEA, and Days250 were adjusted using recommendations in Guidelines for Uniform Swine Improvement Programs (15). LGR was calculated using the lean prediction equation recommended by National Pork Producers Council (14).

Table 1. Numbers of records and means for days to 250 lb, backfat, loin eye area, and lean growth rate.

Item	Landrace
Records	65,536
Animals	68,437
Contemporary group	1,202
Litters	14,791
Days to 250, d	174.4 ± 16.46
Backfat, in.	0.68 ± 0.21
Loin eye area, in.^{2}	6.71 ± 0.87
Lean growth rate, lb/d	0.57 ± 0.068

Statistical analysis

The data were analyzed according to the following multiple-trait model:

$Y_{ijkm} = u + cg_i + sex(herd)_j + litter_k + a_{ijkm} + e_{ijkl}$

where cg_i is the fixed effect of comtenorary group, $sex(herd)_j$ is the fixed effect of sex within herd, $litter_k$ is the random effect of litter of birth, a_{ijkl} is the random effect of animal, and e_{ijkl} is the random residual error. Estimation of variances and convariances was made using the REMLf90 program provided by I. Misztal (Univ. of Georgia, Athens).

Results

Estimates of genetic, litter, and residual variances are shown in Table 2. Heritabilities for Days250, BF, LEA, and LGR were 0.54, 0.39, 0.49, and 0.48, respectively. The estimate of Days250 was consistent with the result of 0.57 in the National Genetic Evaluation Program (13). It was higher, however, than the average literature estimates of 0.47 reported by (5) and 0.25 by (16). (3) reported an estimate of 0.32 for days to 100 kg. (9) also reported estimates of heritabilities for days to 100 kg ranging from 0.26 to 0.32 based on Yorkshire, Landrace, Duroc, and Hampshire data from the Canadian Swine Improvement Program.

The estimate of heritability for BF in this study was in the range of previous estimates. (8) reported heritabilities for backfat at 90 kg ranging from 0.40 to 0.44 for different breeds of performance tested pigs. (10) found an estimate of 0.54 for real-time ultrasonic backfat thickness. (1) used Yorkshire records from U.S. central test stations and reported a heritability estimate for backfat of 0.56. (4) used data from herds of Landrace and Large White pigs and estimated heritabilities of 0.39 and 0.50 for backfat. (11) reported an estimate of 0.59 for backfat by using pen averages for Yorkshire, Landrace, and Duroc boars. (9) measured backfat thickness ultrasonically at the midback and on both sides of the loin 5 cm from the midline. Average backfat was adjusted to 100 kg and the average heritability for four breeds was 0.52. (6) reported a heritability estimate of 0.36 for backfat.

The estimate of heritability for LEA was consistent with previous estimates of 0.46 by (16), 0.46 by (10), and 0.48 in the National Genetic Evaluation Program (13). It was higher, however, than the estimate of 0.24 reported by (6). The estimate of heritability for LGR was 0.52. This is similar to the estimate of 0.50 in the National Genetic Evaluation Program (13), but higher than the values of 0.39 estimated by (11) and 0.30 by (2).

Litter effects were significant sources of variation only for LEA in this experiment (Table 2). (4) reported that 5% of the phenotypic variation in backfat of Landrace and Large White pigs was due to litter environmental effects. (9) reported average common environmental litter effects of 0.26 for days to 100 kg and 0.10 for backfat inYorkshire, Landrace, Duroc, and Hampshire pigs. (6) reported litter effects of 0.13 and 0.18 for BF and LEA, respectively.

LGR and its components are interrelated. Genetic and phenotypic correlations among traits are given in Table 3. Genetic correlations for Days250 with BF and LEA were estimated to be 0.04 and 0.10, respectively. (8) estimated the genetic correlation between BF and days to 230 lbs to be -0.11 for Durocs and -0.17 for Yorkshires. (1), using Yorkshire records from U.S. central test stations, reported a genetic correlation near zero (-0.05) for average daily gain and backfat. LEA was negatively associated with BF (r_g = -0.35) in this study. This is higher than the value of -0.27 reported by (11) and (6), but lower than the values of -0.66 in the NGEP (13) and -0.61 in (10). LGR had a negative genetic correlation with Days250 (-0.83) and with BF (-0.38), but a positive genetic correlation with LEA. Thus, selection for leanness in pigs based on LGR (higher values) can be accomplished without an adverse effect on Days250, BF, and LEA.

Results of this study indicate that LGR is highly heritable and should respond to selection. The National Pork Producers Council has developed a new lean prediction equation (14) that should be used when evaluating and selecting for a combination of leanness and growth in pigs.

References

1. Bryner, S. M., J. W. Mabry, J. K. Bertrand, L. L. Benyshek, and L. A. Kriese. 1992. Estimation of direct and maternal heritability and genetic correlation for backfat and growth rate in swine using data from centrally tested Yorkshire boars. J. Anim. Sci. 70:1755–1759.
2. Chen, P., T. J. Baas, and J. C. M. Dekkers. 2000. Selection for lean growth rate in a synthetic line of Yorkshire-Meishan pigs. I. Selection pressure applied and direct response. J. Anim. Sci. 78(suppl 2):28.
3. Ducos, A. J., P. Bidanel, V. Ducrocq, D. Boichard, and E. Groeneveld. 1993. Multivariate restricted maximum likelihood estimation of genetic parameters for growth, carcass and meat quality traits in French Large White and French Landrace pigs. Genet. Sel. Evol. 25:475.
4. Ferraz, J. B. S., and R. K. Johnson. 1993. Animal model estimation of genetic parameters and response to selection for litter size and weight, growth, and backfat in closed seedstock populations of Large White and Landrace swine. J. Anim. Sci. 71:850–858.
5. Hutchens, L. K., and R. L. Hintz. 1981. A summary of genetic and phenotypic statistics for pubertal and growth characteristics in swine. Oklahoma State Univ. Agr. Exp. Sta. Tech. Publ. T-155.
6. Johnson, Z. B., J. J. Chewning, and R. A. Nugent, III. 1999. Genetic parameters for production traits and measures of residual feed intake in Large White swine. J. Anim. Sci. 77:1679–1685.
7. Kaplon, M. J., M. F. Rothschild, P. J.Berger, and M. Healey. 1991. Population parameter estimates for performance and reproductive in Polish Large White nucleus herds. J. Anim.Sci. 69:91–98.
8. Kennedy, B. W., K. Johansson, and G. F. S. Hudson. 1985. Heritabilities and genetic correlations for backfat and age at 90 kg in performance-tested pigs. J. Anim. Sci. 61:78–82.
9. Li, X., and B. W. Kennedy. 1994. Genetic parameters for growth rate and backfat in Canadian Yorkshire, Landrace, Duroc, and Hampshire pigs. J. Anim. Sci. 72:1450–1454.
10. Lo, L. L., D. G. McLaren, F. K. McKeith, R. L. Fernando, and J. Novakofski. 1992. Genetic analyses of growth, real-time ultrasound, carcass, and pork quality traits in Duroc and Landrace pigs: II. Heritabilities and correlations. J. Anim. Sci. 70:2387–2396.
11. Mrode, R. A., and B. W. Kennedy. 1993. Genetic variation in measures of food efficiency in pigs and their genetic relationships with growth rate and backfat. Anim. Prod. 56:225–232.
12. NPPC. 1991. Procedures to Evaluate Market Hogs. 3th ed. National Pork Producer Council, Des Moines, IA.
13. NPPC. 1995. National Genetic Evaluation Program. National Pork Producer Council, Des Moines, IA.
14. NPPC. 2000. Composition and quality assessment procedures. National Pork Producer Council, Des Moines, IA.

15. NSIF. 1997. Guidelines for Uniform Swine Improvement Programs. p 12. USDA, Washington, DC.
16. Stewart, T. S. and A. P. Schinckel. 1990. Genetic parameters for swine growth and carcass traits. In: Genetics of Swine. L. D. Young [Ed]. USDA-ARS Nebraska.

Table 2. Estimates of genetic, litter, and error variances for days to 250 lb, backfat, loin eye area, and lean growth rate.

Component	Days to 250, days	Backfat, in.	Loin eye area, $in.^2$	Lean growth rate, lb/day
Genetic	109.27	0.015	0.23	0.0014
Litter	0.24	0.0013	0.053	0
Residual	89.98	0.022	0.24	0.0015
Heritability	0.54	0.39	0.49	0.48
Litter variance to phenotypic variance (c^2)	0	3.3	0.10	0

Table 3. Estimates of genetic (r_g) (above diagonal) and phenotypic (r_p) (below diagonal) correlations between traits.

Trait	Days to 250, days	Backfat, in.	Loin eye area, $in.^2$	Lean growth rate, lb/day
Days to 250		0.04	0.1	-0.83
Backfat	0.05		-0.35	-0.38
Loin eye area	-0.07	-0.38		0.40
Lean growth rate	-0.80	-0.40	0.56	