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INHERITANCE OF TEAT NUMBER AND ITS RELATIONSHIP TO MATERNAL TRAITS IN SWINE[1]

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Summary

The relationship of teat number to seven measures of female reproduction was evaluated in the University of Nebraska Gene Pool population. Teat number was recorded for 7,513 pigs, ovulation rate for 2,794 gilts and litter size and weight at birth and weaning (42 days) for 789 gilts. Paternal half-sib and full-sib analyses were used to estimate heritabilities for each trait and to estimate the genetic and phenotypic correlations of teat number with the measures of reproduction. The direct response to selection for ovulation rate and the correlated response in teat number were also evaluated from the regressions of line differences (Select-Control) on generation number (10 generations of selection) and cumulative selection differential for ovulation rate. The paternal half-sib heritability for teat number was .32, and the paternal half-sib heritabilities for ovulation rate and the litter traits were similar to previous estimates from this population. Most of the genetic and phenotypic correlations with teat number were negative and all were nonsignificant. The realized heritability for ovulation rate was .46 ± .10. The regression of response in teat number on generation number was .08 ± .03 ($P<.10$). An estimate of .44 was obtained for the realized genetic correlation of teat number with ovulation rate.

(Key Words: Swine, Teat Number, Heritability, Correlations, Litter Traits.)

Introduction

The swine industry has traditionally applied selection pressure to teat number in order to maintain what is considered an adequate number of teats. Limited information is available about the inheritance of teat number and its relationship to other economically important traits. Before any knowledgeable selection decision can be made, sufficient estimates of the relevant phenotypic and genetic parameters must be available to establish a sound basis for judgment. With this in mind, analyses were undertaken to estimate the heritability of teat number and its genetic and phenotypic correlations with some measures of female reproduction. Both paternal half-sib and full-sib estimates of the genetic parameters were obtained so that maternal effects might be evaluated. In addition, the effect on teat number of selection for ovulation rate was investigated to evaluate further the genetic relationship between these two traits.

Materials and Methods

Ten generations of selection for ovulation rate have been completed in the University of Nebraska Gene Pool herd. The project was initiated in 1967 with the formation of the base generation, and in the spring of 1977 the final selected generation was farrowed. An unselected control line has been a part of the project throughout the study. The population, management procedures, selection procedures and other pertinent details have been described previously by Zimmerman and Cunningham (1975).

Traits Measured. Traits included in these analyses were teat number, ovulation rate and six litter traits. Teat number was recorded for 7,513 pigs of both sexes within 24 hr of birth and included all visible teats. Ovulation rate was measured at second estrus on 2,794 gilts.

Litter traits were evaluated on the 789 gilts which farrowed. Litter size traits were (1) number farrowed, which included all fully formed pigs; (2) number farrowed alive (NA), and (3) number weaned (NW) at 42 days. Survival rate was the proportion NW/NA. Litter weight traits included (1) litter birth weight, the sum weight of all fully formed pigs, and (2)

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litter weaning weight, the sum weight of all pigs alive at 42 days.

Analyses of Variance. Heritabilities and genetic and phenotypic correlations were estimated from components of variance and covariance. The model used included effects for line-generation, sires within line-generation, dams within sires and progeny within dams. Initially, separate heritability estimates for teat number were obtained for each sex, but they were not significantly different. The heritability for teat number was then estimated with a model which included sex as a fixed effect.

Heritabilities were estimated as 4X [paternal half-sib correlation] and 2X [full-sib correlation]. Paternal half-sib and full-sib genetic correlations were obtained from the sire and sire plus dam components of variance and covariance. Standard errors for the genetic parameters were calculated with the formulas given by Dickerson (1969). Phenotypic correlations were estimated from the within line-generation components of variance and covariance.

Direct Response. Direct response to selection for ovulation rate was evaluated by the regression of line means on generation number, the regression of line difference (Select-Control) on generation number and the regression of line difference on unweighted cumulative selection differential. Standard errors of the regression coefficients included error due to drift as formulated by Hill (1972).

Correlated Response. Correlated response in teat number to selection for ovulation rate was evaluated in the same manner as was the direct response, including the addition of drift error to the standard errors of the regression coefficients. In addition, a realized genetic correlation (r_g) was estimated with the regressions of direct and correlated response on cumulative selection differential (Rutledge *et al.*, 1973):

$$r_g = \frac{CR_{TN}\ h_{OR}\ \sigma P_{OR}}{DR_{OR}\ h_{TN}\ \sigma P_{TN}}$$

where:

CR_{TN} = regression of correlated response on cumulative selection differential,

DR_{OR} = regression of direct response on cumulative selection differential,

h = square root of heritability (PHS) and

σp = pooled within line-generation phenotypic standard deviation.

Statistical significance for the realized genetic correlation was evaluated from the regression of line difference in teat number on cumulative selection differential, since the correlated response can be significant only if r_g is significant.

Results and Discussion

Heritabilities. Standard deviations, heritability estimates and standard errors are presented in table 1. The full-sib estimate of heritability of teat number was greater (P<.01) than the paternal-half-sib estimate, indicating a significant maternal effect on teat number. Skjervold (1963) observed a similar relationship in heritabilities estimated from sib analysis of purebred and crossbred progeny of Large White and Landrace parents. The absence of heterosis for teat number in Skjervold's study minimized the possibility that the observed relationship was due to nonadditive genetic effects. Literature estimates of heritability range from .10 to .42 and average approximately .30 (Allen *et al.*, 1959; Enfield and Rempel, 1961; Skjervold, 1963).

The two heritability estimates for ovulation rate were nearly identical (.49 and .51) and are similar to sib correlation estimates reported earlier for this project (Pumfrey *et al.*, 1975; Young *et al.*, 1978). The paternal half-sib estimates for the six litter traits were higher than would be expected, except for number weaned, which is again similar to the estimate reported by Young *et al.* (1978). For five of the litter traits, the dam component of variance was negative, causing the respective full-sib esti-

TABLE 1. HERITABILITY ESTIMATES AND STANDARD ERRORS

Trait[a]	SD	h^2 PHS[b] ± SE	h^2 FS[c] ± SE
TN	1.14	.32 ± .04	.44 ± .03
OR	2.60	.49 ± .10	.51 ± .06
NF	2.75	.47 ± .21	.17 ± .14
NA	2.66	.44 ± .21	.16 ± .14
NW	2.60	.13 ± .22	.22 ± .14
SR	.17	.40 ± .19	–.08 ± .15
LBW	3.51	.26 ± .20	–.00 ± .15
LWW	30.78	.34 ± .21	.16 ± .14

[a]Tn = teat number, OR = ovulation rate, NF = number farrowed, NA = number farrowed alive, NW = number weaned, SR = survival rate, LBW = litter birth weight and LWW = litter weaning weight.

[b]PHS = paternal half-sib.

[c]FS = full-sib.

mates of heritability to be lower than the paternal half-sib estimates.

Correlations. Estimates of genetic and phenotypic correlation with teat number are presented in table 2. None of the correlations was significant and no significant differences existed for method of estimation of the genetic correlations. The phenotypic correlation of teat number with ovulation rate did approach significance (P<.10). The means for teat number and number farrowed alive (13.1 and 9.1, respectively), the proportion of litters in which number farrowed alive exceeded the dam's teat number (about 5%) and the fact that cross-fostering was practiced in each generation are all reasons why teat number was not a critical factor for pig survival and growth in this population.

Korkman (1947) reported no significant correlation between number of teats and number of pigs born but did observe significant correlations for litter size and weight at 3 weeks. Allen *et al.* (1959) examined pig numbers, pig weights and litter weights at birth, 21 days and 56 days and found that only pigs per litter at birth had a significant within-breed correlation with teat number. Enfield and Rempel (1961) used the regression of maternal trait on total teat number to examine the relationship with number of pigs alive, average pig weight at birth and weaning and total litter weight at weaning. No significant relationships were observed. However, when functional teat number, measured as number of teats with milk at farrowing, was substituted as the independent variable and the effect of number of pigs born alive was removed, a significant relationship was observed with number of pigs weaned and weight of litter weaned. Skjervold (1963) observed no significant correlation of teat number with number of pigs born alive or average birth weight but did report a significant correlation with number of pigs at 3 weeks of age.

TABLE 2. GENETIC AND PHENOTYPIC CORRELATIONS WITH TEAT NUMBER

Trait[a]	$r_{G_{PHS}}$[b] ± SE	$r_{G_{FS}}$[c] ± SE	r_p
OR	−.04 ± .25	.06 ± .08	.06†
NF	−.31 ± .36	−.31 ± .33	−.03
NA	−.15 ± .36	−.12 ± .33	−.02
NW	.14 ± .70	−.10 ± .28	−.04
SR	.27 ± .40	–[d]	−.06
LBW	−.77 ± .60	–[d]	−.06
LWW	−.41 ± .43	−.01 ± .32	−.02

[a]TN = teat number, OR = ovulation rate, NF = number farrowed, NA = number farrowed alive, NW = number weaned, SR = survival rate, LBW = litter birth weight and LWW = litter weaning weight.

[b]PHS = paternal half-sib.

[c]FS = full-sib.

[d]Summed sire and dam components of variance were negative. Sign indicates sign of summed covariance components.

†P<.10.

Direct Response. Results of the evaluation of direct response to selection for ovulation rate are presented in table 3. The regression of response on unweighted cumulative selection differential provided an estimate of realized heritability of .46 ± .10, which agreed closely with sib correlation estimates. Similar estimates, tested on both weighted and unweighted selection differentials, have been reported in

TABLE 3. DIRECT AND CORRELATED RESPONSE TO SELECTION FOR OVULATION RATE

Trait	b^a_{Select}	$b^a_{Control}$	$b^b_{R \cdot G}$	$b^c_{R \cdot CSD}$
Ovulation rate	.38 ± .08**	−.12 ± .07	.49 ± .10***	.46 ± .10**
Teat number	.07 ± .03*	−.01 ± .02	.08 ± .03†	.07 ± .03†

[a]Regression of line means on generation number.

[b]Regression of line difference (Select-Control) on generation number.

[c]Regression of line difference (Select-Control) on cumulative selection differential.

†P<.10.

*P<.05.

**P<.01.

***P<.001.

earlier studies (Zimmerman and Cunningham, 1975; Newton *et al.*, 1977; England *et al.*, 1977; Cunningham *et al.*, 1979) conducted as part of this project. In generation 10, the final selected generation, the line difference (Select-Control) in ovulation rate was 5.1 corpora lutea.

Correlated Response. The correlated response in teat number was evaluated in the same manner as the direct response to selection (table 3). The regression of Select line means on generation number was significant, but the regressions involving response (Select-Control) only approached significance ($P<.10$). The line difference in teat number in generation 10 was .38 teats in favor of the Select line, down from the high of .84 teats in the previous generation.

The realized genetic correlation of teat number with ovulation rate was .44. Statistical significance of this estimate depends on the significance of the correlated response presented in table 3. The correlated response approached significance ($P<.10$).

In retrospect, these data indicate that teat number is moderately heritable and may be subject to significant maternal effects. On the basis of variance-covariance analysis, no significant genetic or phenotypic relationships exist between teat number and the various measures of female reproduction studied. In this population, teat number does not appear to be a critical factor for pig survival and growth. Direct selection for ovulation rate has been effective and has resulted in what appears to be a small positive correlated response in teat number.

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