CHANGES IN OVULATION RATE AND UTERINE CAPACITY
IN SWINE SELECTED FOR LITTER SIZE

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SUMMARY

Data were collected in gilts of a line selected for litter size (LS) over 8 generations and a randomly selected line (RS). Both lines were derived from a line selected for ovulation rate for nine generations. Line differences (LS-RS) in ovulation rate were small at puberty, but reached .70 to 1.4 at the 2nd to 4th estrus, and uterine measurements (length, weight, volume and diameter) taken in cyclic gilts at 10-15 days of the second cycle were slightly higher in the RS line. Uterine capacity, estimated by unilateral hysterectomy-ovariectomy, was 1.4 fully formed pigs higher in LS gilts at 93-100 days of gestation. Line differences in ovulation rate and uterine capacity result in a litter size predicted difference of .90 pigs born, in good agreement with the 1.0 pigs observed difference.

INTRODUCTION

Reproductive efficiency is one of the major components of economic efficiency in swine. Tess et al. (1983) estimated that a 20% genetic improvement in number born alive in pigs would reduce costs of production by 5.3%.

The few experiments in which within-line selection for litter size was the major objective were not very successful (Rutledge, 1980, Bolet et al., 1989), even though the heritability of litter size in pigs is considered to be near .10 (Haley et al., 1988). Johnson et al. (1984) proposed the use of an index combining ovulation rate and embryonic survival as a way to improve genetic change in litter size. More recently, Bennett and Leymaster (1989) suggested a model integrating ovulation rate and uterine capacity as limiting factors to litter size in pigs.

The objective of this work was to investigate changes in ovulation rate (OV), uterine measurements and uterine capacity (UC) in a line of pigs selected 8 generations for litter size, after 9 previous generations of selection for ovulation rate.

MATERIALS AND METHODS

The Nebraska Gene Pool line is a 14-breed synthetic that was closed in 1965. Two lines, ovulation rate select (OR) and control (C) were established in 1967 (Zimmerman and Cunningham, 1975), and selection for ovulation rate maintained for nine generations. Line differences (OR-C) at generation nine were 3.7 eggs and 1.3 pigs/litter (Cunningham et al., 1979). In generation 10, three lines were derived from the OR line: one selected for litter size (LS), one for decreased age at puberty (AP) and one of relaxed selection (RS). Selection in these lines was maintained for eight generations, after which three additional generations of random selection took place for evaluation purposes. In these last three generations a sample of gilts from the RS and LS lines was mated by
boars from a line selected for an index of ovulation rate and embryo survival (Neal et al. 1989), and the first crosses backcrossed to boars of the maternal breed, to produce gilts that were either 1/2RS, 1/2LS, 3/4RS or 3/4LS.

In 1988, 103 gilts of the four genetic groups were slaughtered 10-15 days after the second estrus, and information collected on OV and uterine measurements (length, diameter, weight and volume). The least squares analysis of OV included the effects of line and slaughter weight. For uterine measurements, the model also included day of cycle and ovulation rate as covariates.

In 1989, a unilateral hysterectomy-ovariectomy (UHO) was performed by laparotomy at 3-10 days after the first estrus in 109 gilts of the four genetic groups. At this time, corpora lutea were counted to estimate OV, and one uterine horn and the ipsilateral ovary were surgically removed. The gilts were mated as soon as they were in estrus again, and then slaughtered at 93-100 days of gestation (91 gilts). Immediately after slaughter, number of corpora lutea was counted by ovarian dissection and number of pigs (fully formed and mummified) was counted. The least squares analysis of OV and number of pigs included the effects of line, side removed (left or right) and day of surgery. Estimates of genetic differences between lines were calculated from least squares means as $g_{LS} - g_{RS} = \overline{X}_{1/2LS} - \overline{X}_{1/2RS} + 2/3(\overline{X}_{3/4LS} - \overline{X}_{3/4RS})$.

RESULTS

Line genetic differences ($g_{LS} - g_{RS}$) in 1988 for OV at second estrus, uterine length, uterine weight, uterine volume and uterine diameter were, respectively, $1.35 \pm 0.71$ eggs, $-8.21 \pm 18.61$ cm, $-93.0 \pm 37.9$ g, $-151.5 \pm 121.2$ ml and $-0.136 \pm 0.097$ cm. The only differences of statistical significance were those for uterine weight ($P < .05$) and OV ($P = .06$). Uterine measurements tended to be highly correlated with each other, but their correlation with OV was small and nonsignificant.

In the 1989 experiment, estimates of $g_{LS} - g_{RS}$ for OV at puberty, OV at mating (second to fourth estrus), number of fully formed pigs and number of fully formed plus mummified pigs was, respectively, $-0.33 \pm 0.90$ eggs, $0.67 \pm 0.88$ eggs, $0.71 \pm 0.73$ pigs and $-0.16 \pm 0.82$ pigs. None of these differences were of statistical significance ($P > .10$). Within line correlations among OV at puberty and at mating ranged from 0.09 to 0.42, and the correlation between OV at mating and number of pigs was 0.10.

DISCUSSION

The genetic difference in litter size between the LS and RS lines after eight generations of selection was about one pig born (Johnson, unpublished results). The purpose of this experiment was to investigate if this difference was due to changes in ovulation rate and/or uterine capacity. After the first nine generations of selection for OV (OR line) it was assumed that selection for litter size (LS line) would put most pressure on UC, because selection was taking place in a high OV line. The results do not provide clear evidence of which trait changed the most, probably because of the additional variation introduced by the UHO surgery. Nevertheless, they do indicate that line differences in OV at puberty are minor, but the LS line shows a clear superiority (.7 to 1.4) in OV in later cycles. The apparent superiority of the LS line in UC (as measured by the number of pigs in one horn challenged by a large number of potential
embryos) even though not statistically significant, was shown by the ability of one uterine horn to carry .7 more fully formed pigs in LS than in RS gilts. However, the advantage of the LS line was lost when the number of mummified pigs was considered, indicating that the limited UC of the RS line was a result of fetal mortality late in pregnancy.

Assuming that the ovary remaining after UHO had a compensatory response, ovulating about the same number of eggs as the two ovaries would (Fenton et al., 1970), $E_{LS}^S E_{RS}$ for OV can be estimated at 1.05 eggs, by averaging the ovulation rates at second cycle in 1988 and at mating in 1989. The $E_{LS}^S E_{RS}$ in UC for fully formed pigs can be estimated by doubling the difference in number of pigs in UHO gilts, leading to a $E_{LS}^S E_{RS}$ for UC near 1.4 pigs. Using these line differences for OV and UC, the Bennett and Leymaster (1989) model was used to predict litter size differences among lines. This model includes the linear, quadratic and cubic regression coefficients of litter size on mean OV and UC, as well as their interactions. Assuming the line differences above for OV and UC, predicted litter size difference between the two lines is .90 pigs, in good agreement with the 1.0 observed difference.

It was anticipated that most of the response in the LS line would be due to changes in UC rather than in OV. However, the results indicate that an increase occurred in both components. Koenig et al. (1986), working with these same lines of pigs, found that selection for OV resulted in increased evidence of abnormal eggs and embryos in early gestation. Therefore any increase in litter size in a high OV line may still require a simultaneous increase in OV, to compensate for the increased embryonic loss. Alternatively, the two components OV and UC may have reached an equilibrium, such that an increase in LS required joint changes in both traits.

In conclusion, response to selection for litter size was effective, resulting in an improvement of about one pig after eight generations of selection. This response was obtained by improvement of both uterine capacity and ovulation rate. Uterine dimensions and weights measured on nonpregnant gilts were not good indicators of uterine capacity for number of fully formed pigs late in gestation.

REFERENCES