Title: Litter size produced by gilts divergently selected on reproductive components. - **NPB #98-238.**

Investigator: Dr. Timothy J. Safranski.

Institution: University of Missouri-Columbia.

Co-Investigator: Dr. William R. Lamberson.

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I. Abstract:

One of the factors that influences litter size in swine is the ability of the mother to gestate to term the major possible proportion of viable embryos. This ability has been termed uterine capacity and is considered dependent on the physical capacity of the uterus, fetal demand of nutrients, and the efficiency of the placenta to supply them. The weight ratio between the fetus and its placenta at birth was used as a measurement of placental efficiency in two experiments directed to investigate the effect of this trait on litter size. In the first experiment, a selection index including litter size, birth weight and placental weight was used. Divergent selection was practiced with two replicates per line. After one generation of selection the numerical trends in the index values behaved accordingly with the expectations.

In the second experiment, carried out in collaboration with the University of Nebraska, gilts from two lines previously selected for either an index of components of litter size or at random were evaluated for correlated responses in placental efficiency. Placental efficiency was measured as the ratio of piglet weight to placental weight at birth. An increase of three fully formed piglets in the selected line was accompanied by a decrease in both piglet and placenta weight at birth. The reduction in placenta weight was smaller, resulting the selected line having a smaller placental efficiency than the control line. These results suggest that physiological mechanisms other than increased placental efficiency are responsible for the higher litter size in the selected line.

II. Introduction:

Genetic selection for litter size in swine is hampered by low heritability, and low selection differential because it is expressed in the dam and not in the individual being selected. Current strategies to minimize these problems are difficult to apply by the average pork producer since they require either big centralized sets of performance records or complicated surgical procedures to measure components of litter size such as ovulation rate, embryo survival, and uterine capacity. An understanding of the physiological components of litter size is needed if this trait is going to be modified through selection directed to the most critical and malleable components. Factors that influence litter size in pigs are ovulation rate, fertilization rate, embryonic survival and fetal survival. Fetal survival is affected by, among other things, uterine capacity defined as the maximum number of fetuses a female can carry to term. Uterine size, fetal demand for nutrients and the efficiency of the placenta in providing nutrients are factors that affect uterine capacity.

During studies with prolific breeds (Ford, 1997) it was found that part of their advantage in litter size could be explained by the presence of smaller fetuses with lower nutrient demands, better supplied by smaller and more efficient placentas. Based on this concept a selection strategy was conceived (Wilson, et al 1998) in which individuals were ranked based on the ratio of birth weight to placenta weight as an indicator of placental efficiency. From a practical point of view, selection based on this ratio could lead to smaller piglets, and all the negative consequences this can have in production. One way to avoid this possible complication is through use of a selection index that allows the selection of individuals carried by efficient placentas while keeping constant the piglet weight.

III. Objectives:

The primary objective of this study was to determine response in litter size to combined selection on litter size and placental efficiency. A secondary objective was to measure response in placental efficiency to previous selection carried out at the University of Nebraska on components of reproduction.

IV. Procedures:

In both experiments, the estimation of placental efficiency involved determining the weight of the piglet at birth and the weight of its respective placenta. To this end, the umbilical cord of each piglet was double tagged with identically numbered mouse ear tags at birth. One tag was placed approximately 5 cm and the other 10 cm from the piglet. The cord was severed between the tags and the piglets weighed. All placentas were collected and weighed at delivery.

<u>Experiment one:</u> A selection index was developed which included litter size, birth weight and placental weight, adjusted for differences in gestation length and parity number. The index was calculated as:

$$\text{Index} = (0.25 * \text{Litter size})/\sigma_{ls} + \text{Birth weight}/\sigma_{bw} - \text{Placenta weight}/\sigma_{pw}$$

Measurements were taken on litters of 24 sows in each of two farrowing groups (replicates). Within each group the 24 highest and lowest indexing females and the seven highest and lowest indexing males were chosen to create divergent lines with either high or low placental efficiency. Selected piglets were grown at the Swine Research Complex of the University of Missouri and then transferred to the Swine Pasture Farm for finishing. For detection of estrus gilts were exposed to a mature boar for 10 minutes daily beginning at 150 days of age. After the second estrus, females were artificially mated to males in the same line and replicate, avoiding half- and full-sibling mating. At 107 days of pregnancy females were transferred to the Animal Sciences Research Center farrowing room where birth was attended 24 hours a day in order to collect placental efficiency information as described above.

<u>Experiment two:</u> Sixty gilts each from a control and a high litter size line, developed by selection on an index of components of litter size during fourteen generations at the University of Nebraska (Johnson and Cassady, 1998) were observed at farrowing. The index included ovulation rate and survival of conceptuses to day 50 of gestation. This index was designed to increase ovulation rate while holding conceptus mortality constant, thus increasing litter size.

Information on birth weight and placental weight was collected as described. Additional information collected included litter size, placental vascularity scored 1-5, dam pre-farrowing weight, and maternal grand sire identification.

Statistical analyses were performed using the GLM procedure of SAS. Models included the effect of line on birth weight (n=607), placental weight (n=563), placental efficiency (n=406), and placental vascularity (n=182), each with and without litter size as covariate. Independent variables in the models were dam pre-farrowing weight, and line, with maternal grand sire used to test line effects and a covariate of dam pre-farrowing weight.

V: Results:

Experiment one: After one generation of divergent selection the numerical trend in the index value behaved accordingly with expectations. The values for each line and the base population (generation 0 of selection) averaged over replicates are shown in Table 1. The selection differentials averaged across replicates for the first generation are shown in Table 2.

Table 1. Trait averages after one generation of divergent selection.

	Base Population*	High Line*	Low Line*
Litter Size (piglets)	12.7 ± 2.8	12.5 ± 2.0	12.1 ± 2.9
Birth Weight (g)	1441.4 ± 305.9	1454.4 ± 277.6	1455.5 ± 286.9
Placenta Weight (g)	299.5 ± 116.3	302.9 ± 89.2	314.3 ± 119.3
Index	2.00 ± 1.42	2.05 ± 0.94	1.70 ± 1.43

***average of two replicates**

Table 2. Selection differentials for generation one.

	High Line*	Low Line*
Males	1.60	-1.45
Females	1.06	-1.19

***average of two replicates**

Experiment two: Litter size was higher (p<.01) in the selected than the control line. Line effect for placental vascularity was not significant (p=.34). Birth weight was higher in control than selected line (p<.01). Placental weight was higher (p=.10) in control than selected. Placental efficiency was higher (p=.09) in control than selected. Trait averages with their standard deviations are shown in Table 3.

Table 3. Trait averages and standard deviations in the selected and control lines.

	Selected Line	Control Line
Litter Size (piglets)	11.5 ± .5	8.5 ± .5
Birth Weight (g)	1012.0 ± 24.8	1218.6 ± 34.9
Placenta Weight (g)	202.2 ± 5.9	222.1 ± 8.1
Placental efficiency (ratio)	5.33 ± .10	5.76 ± .10

Data obtained with the present research show that litter size can be modified by manipulating one or several physiological components of this complex trait. The observed response in the index values show that index selection based on placental efficiency may prove to be a useful tool to improve litter size in swine herds of any size using technology and procedures that are relatively simple and inexpensive. Additional generations of selection on this index will be necessary to confirm results of the first generation.

VI. References:

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