

**Increasing Sperm Production in Mature Boars via Manipulation of their Neonatal Environment**  
**North Carolina Pork Council Matching Grants Program**  
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## **Introduction**

Boar studs are analogous to feed mills on most swine operations. Both are cost centers and supply vital inputs to profit centers. In the case of boar studs, the inputs are insemination doses and the profit centers are sow farms. Consequently, increasing the number of sperm cells per ejaculate is one of the most effective ways to increase the efficiency of the boar stud, provided fertility isn't compromised. Most management strategies for increasing spermatozoa per ejaculate in boars have focused on adult boars and have not been very successful (Flowers, 1997). One reason for this is that the biological framework for sperm production in adults probably is established early in a boar's life. The cells in the testicles and secondary sex glands responsible for the production of sperm and seminal fluids undergo two periods of rapid development. The first occurs during the first 3 weeks after birth and is thought to be the most critical. The second occurs between 40 and 60 days of age and there is some debate as to its contribution to adult function. Consequently, a boar's potential for sperm production probably is fixed by the time he leaves the nursery. As a result, strategies to increase it need to be applied early in life.

Recently, we ranked our adult boars (n=20) from highest to lowest in terms of their average number of spermatozoa per ejaculate and began to investigate possible reasons why some boars consistently produce significantly more than others. We were not able to identify differences in the way they were managed as adults, nor genetics, as we have several pairs of littermates that are on opposite ends of our ranking. In our study, one of the factors that was highly correlated ( $r = 0.9$ ) with adult sperm production was the boar's weaning weight, which, in turn, exhibited a strong inverse relationship ( $r = - 0.95$ ) with the size of the litter from which the boar was weaned. These relationships seem logical since boars weaned in small litters would experience less competition and have the opportunity to consume larger quantities of milk than their counterparts in large litters. The additional nutrition that they received during lactation would coincide with a key developmental period for the testicles and secondary sex glands. In addition, we also noticed that boars weaned from small litters tended to have higher amounts of two seminal plasma proteins associated with fertility (Flowers, NCPC grant, 1998 - 2001) and learned to mount dummy sows for collection with fewer training sessions than their counterparts reared in larger litters. Thus, it seems physiologically plausible that manipulation of the litter size in which boars nurse may be a way to enhance their sperm production and other aspects of adult reproductive function. The objective of the experiment is to determine the effect of litter size during lactation on sexual maturation, libido, sperm production, semen quality, and fertility in adult boars.

## Experimental Procedures

Forty boars were used in the study. One day after birth, boars were crossfostered such that littermates were raised in litters of 6 pigs ( $n=20$ ) or in litters of greater than or equal to 9 pigs ( $n=20$ ). Litters contained equivalent numbers of gilts and boars as possible, based on their sex ratios at birth. Crossfostering was done in such a way to minimize potential milk production differences among sows. For example, if a sow gave birth to 5 gilts and 5 boars and was selected to nurse a litter of 10 or greater, then 4 of her sons were fostered off (to 4 different sows) and she received 4 boars (from 4 different sows). Thus, she nursed boars with 4 different genotypes, one of those being hers.

Litters were weaned between 18 and 22 days of age and boars were managed according to normal industry practices through the nursery and finishing phases of production. In addition, after weaning and through finishing, boars were housed such that individuals from the two treatment groups, boars from small (6 pigs) or large litters ( $\geq 10$  pigs), were in the same pens. This was important so that pen effects that might bias the results were eliminated. At 5 months of age, boars were moved from finishing and housed in individual crates. At 5.5 months of age boars were trained for collection with a dummy sow and be collected once per week until they are at least two years of age.

Body weight and testicular sizes were measured at birth, weaning, and every three weeks thereafter until the boars are two years old. The length of time and the number of training session required to train boars for collection was recorded. Total number of spermatozoa and semen quality estimates including computer-assisted motility analyses, head/tail morphology, acrosome morphology, and acrosin activity will be recorded for each ejaculate. Seminal plasma protein profiles will be measured in one ejaculate per month for each boar. Finally, when boars are 10 months of age, equal numbers of spermatozoa from two boars, one each from a small and large litter, will be pooled to make heterospermic insemination doses. The pooled semen will be used to breed sows ( $\sim n=10$  per week per combination) and the paternity of the offspring will be determined with DNA fingerprinting techniques. If boars weaned from small litters have enhanced fertility, then they should consistently sire the majority of pigs in each of the litters that result from the heterospermic inseminations. At the end of the two year study, it is estimated that we will have a minimum of 750 litters upon which to base the fertility analyses. Analysis of variance procedures for repeated measures will be used to analyze both categorical (Rosner, 1989) and continuous (Snedecor and Cochran, 1989) variables. The statistical model consisted of treatment (small or large litter), time, and all appropriate interactions.

## Results and Discussion

The effect of neonatal litter size on body weight and testes size are shown in Figures 1 and 2. For these two variables, there was a season by treatment interaction. In essence, boars raised in small litters weighed more and have larger testicles than boars reared in large litters. However, the difference between the two treatments is much greater in the spring-born than the fall-born replicate. Our interpretation of this is that under less than ideal conditions, as is the case for boars that mature during the summer environment (litters born in the spring), the advantage of being raised in a small litter increased exponentially.

Training for semen collection began when boars were 24 weeks of age ( $\sim 155$  days of age). There were no differences in the number of boars successfully being collected by the end of the training period (Figure 3). However, the overall training period was significantly reduced for boars from small (10 days) than large litters (30 days). These data indicate that boars allowed to nurse in litters of 6 pigs

or less have larger testicles and greater libido than boars nursing in litters of 10 or more pigs. The two observations probably are related. Boars raised in small litters had increased testicular size at relatively young ages compared with boars raised in large litters. One interpretation of these data is that testicular maturation and thus testosterone production began earlier. This, in turn, should result in attainment of puberty at a younger age as measured by their desire to mount a dummy sow and be collected. It is particularly impressive that all 20 boars that nursed in small litters mounted and were collected during the first 5 days of the training period. In contrast, only 5 of the 20 boars that nursed in large litters were trained for semen collection during the first 5 days of the training period.

Numbers of spermatozoa per ejaculate are also greater in boars raised in small versus large litters. It is important to remember that there is a 6 month difference in age between the fall-born and spring-born replicates, so these data have been analyzed and presented separately (Figure 3). In the spring-born replicate, boars raised in small litters produced about 10 billion more spermatozoa per ejaculate about 75% of the time (61 weeks) between 42 and 112 weeks of age. In contrast, for those born in the fall, boars raised in small litters consistently had 20 billion more spermatozoa per ejaculate than their counterpart raised in large litters beginning at 39 weeks of age until the end of the study ended when they were 2 years of age. ***From a practical perspective, the collective advantage of being raised in a small litter was an additional 200 insemination doses (600 billion spermatozoa) for boars born in the Spring and an extra 567 insemination doses (1700 billion spermatozoa) for boars born in the Fall.*** No significant differences among treatments in motility, morphology, acrosome morphology, acrosin activity, or capacitation status were observed (Table 1).

Finally, boars raised in small litters sired, on average, around 65% of the piglets resulting from heterospermic inseminations. Consequently, they appear to be more fertile than boars raised in large litters (Table 1). It is difficult to translate this relative advantage into differences in farrowing rate and numbers of pigs born alive at the present time. This is due to the fact that use of heterospermic inseminations and paternity testing of the resulting offspring is a relative assessment of fertility. In other words, it can be used to rank boars from most to least fertile. However, this technique cannot really establish whether the most fertile boar produces farrowing rates of 95% or 85%. Nevertheless, these data do indicate that regardless of what the actual fertility level, boars raised in small litters would be higher than those reared in large litters.

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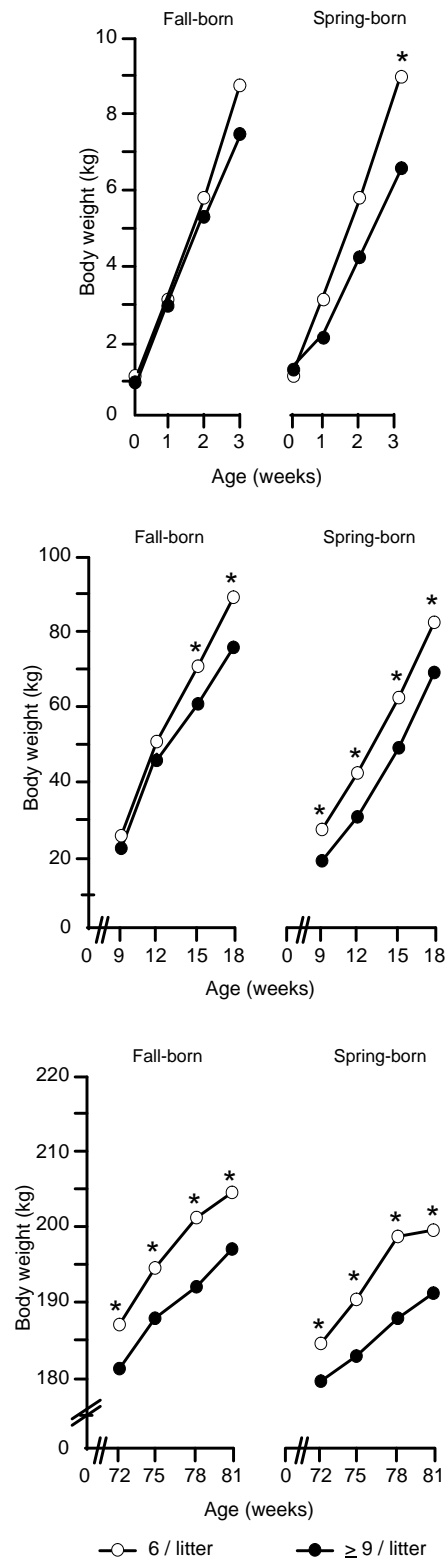


Figure 1. Effect of neonatal litter size on body weight. \* Boars raised in litters of  $\leq 6$  weighed more compared with boars raised in litters of  $\geq 9$  ( $P < 0.05$ ).

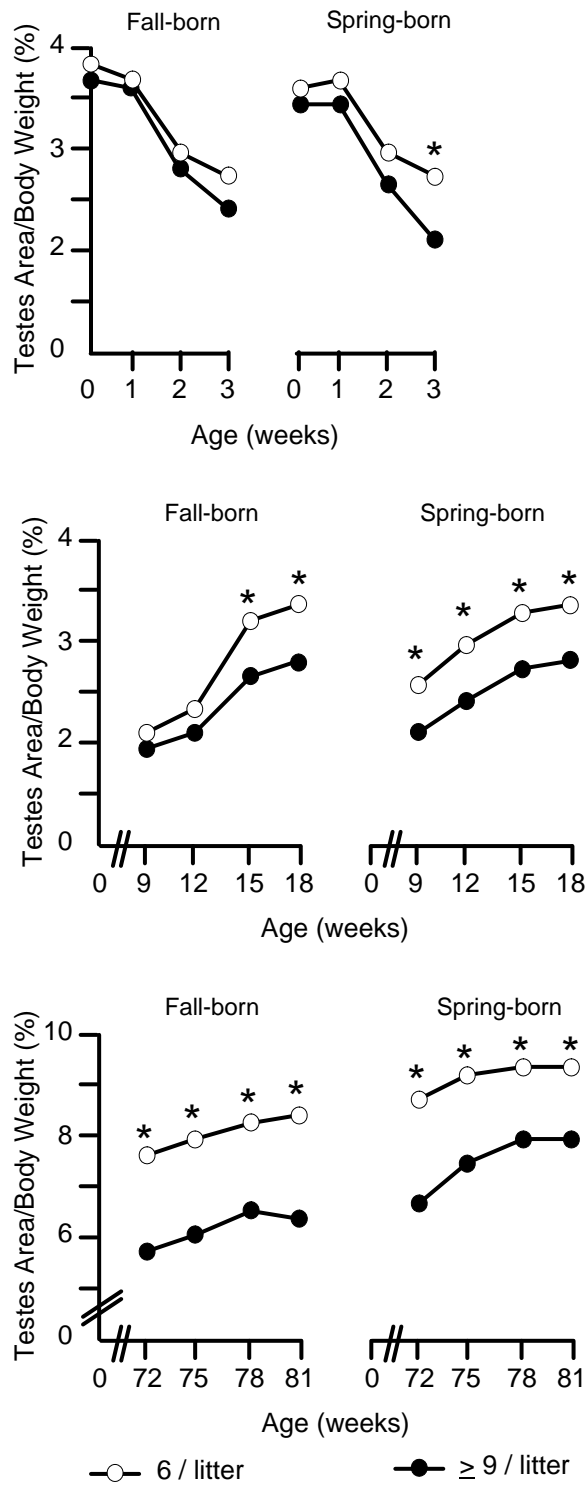


Figure 2. Effect of neonatal litter size on testes size. \* Boars raised in litters of  $\leq 6$  had larger testes relative to body size compared with boars raised in litters of  $\geq 9$  ( $P < 0.05$ ).

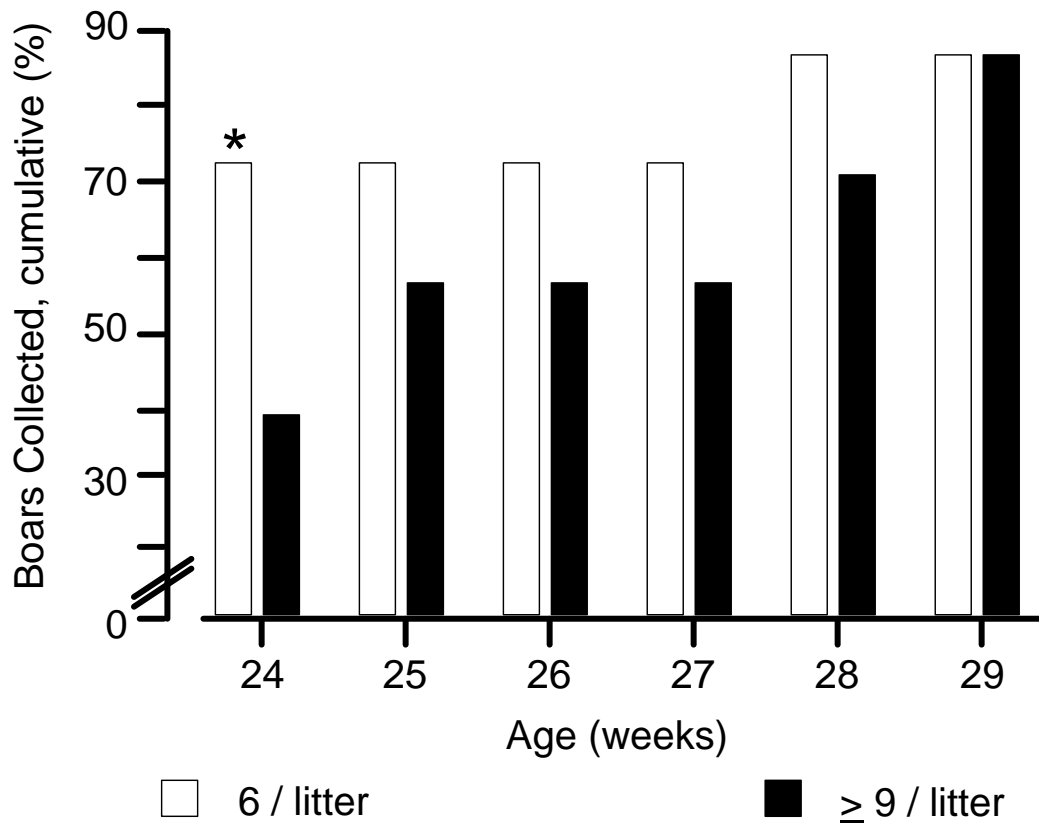


Figure 3. Effect of neonatal litter size on boars trained for semen collection on a dummy sow. \* More boars raised in litters of  $\leq 6$  were trained to collect from a dummy sow compared with boars raised in litters of  $\geq 9$  ( $P < 0.05$ ).

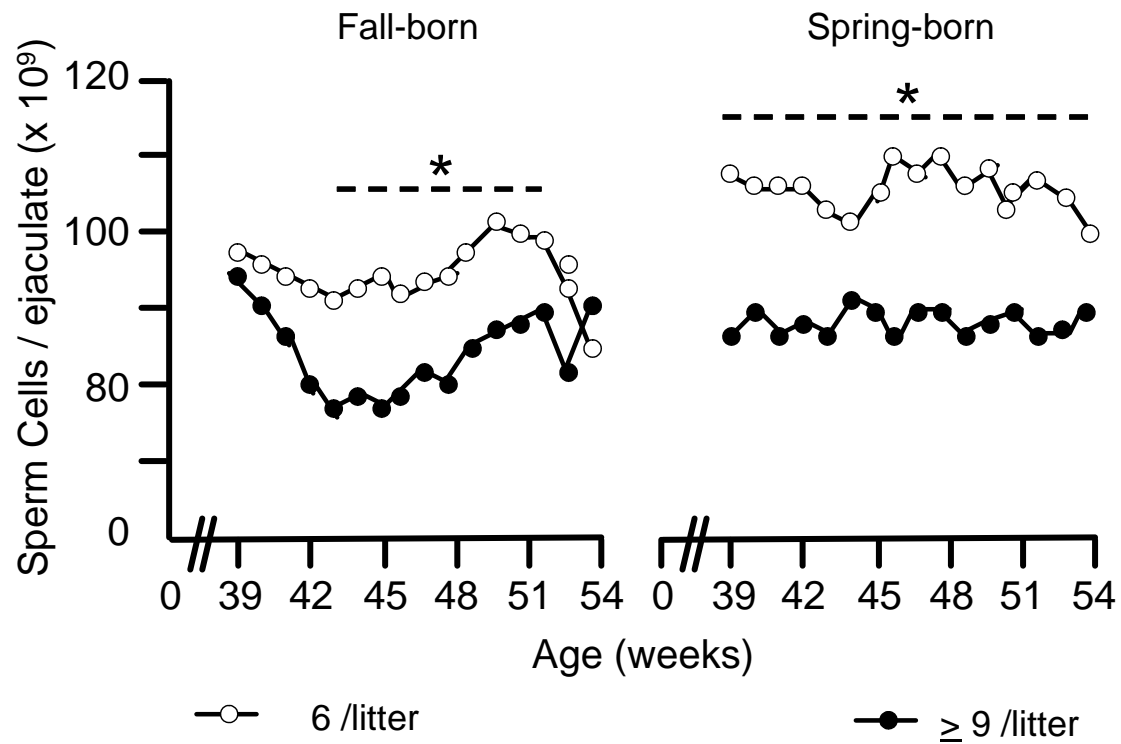


Figure 4. Effect of neonatal litter size on number of spermatozoa per ejaculate between 39 and 54 weeks of age. \* Boars raised in litters of  $\leq 6$  produced ejaculates with more spermatozoa compared with boars raised in litters of  $\geq 9$  ( $P < 0.05$ ).

Table 1. Semen Quality and Fertility Estimates from Boars raised in Small or Large Litters during Lactation (mean  $\pm$  s.e.).

Variable	Winter		Summer	
	$\leq 6$ / litter	$\geq 9$ / litter	$\leq 6$ / litter	$\geq 9$ / litter
Motile spermatozoa (%)	85.3 $\pm$ 5.7	86.8 $\pm$ 6.5	88.4 $\pm$ 4.3	80.8 $\pm$ 5.7
Normal morphology (%)	91.3 $\pm$ 3.4	84.6 $\pm$ 4.5	88.3 $\pm$ 5.1	82.1 $\pm$ 6.1
Normal acrosome morphology (%)	90.4 $\pm$ 4.7	83.2 $\pm$ 3.6	90.6 $\pm$ 6.1	80.3 $\pm$ 4.2
Acrosin activity (%)	95.3 $\pm$ 4.5	90.3 $\pm$ 3.2	92.8 $\pm$ 4.1	93.4 $\pm$ 4.6
Normal capacitation (%)	80.2 $\pm$ 7.8	70.3 $\pm$ 6.3	85.3 $\pm$ 6.9	79.7 $\pm$ 4.2
Seminal plasma proteins (relative units per ejaculate)	12.2 $\pm$ 2.4	10.1 $\pm$ 2.0	12.9 $\pm$ 2.1	10.7 $\pm$ 1.4
Proportion of piglets sired in heterospermic matings (%)*	67.3 $\pm$ 5.7	32.7 $\pm$ 5.4	63.5 $\pm$ 4.8	36.5 $\pm$ 4.3

\* Boars raised in litters of  $\leq 6$  sired more pigs than boars raised in litters of  $\geq 9$  (P = 0.02)