

## **Controls of Litter Size—Do Conclusions Drawn from Institutional Research Herds Always Have Relevance to Commercial Swine Production?**

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#### **Summary and Implications**

Increasing litter size in pigs has been an ongoing concern of many producers because it has the greatest impact on profitability of the swine enterprise. To study the biology of conceptus growth and survival, many models have been used by researchers. It was determined that a major component in limiting litter size results from the impacts of limitations in uterine space (i.e. uterine capacity). Placental efficiency, which is the ratio of a fetus's weight compared with that of its placenta, has been shown to impact litter size, and is heritable. Selection for breeding animals having a high placental efficiency at term, has been shown to increase litter size. Furthermore, although piglet weight was only slightly decreased in offspring of boars and gilts selected for increased placental efficiency, placental size was profoundly reduced. This reduction in placental size was coupled with an increase in vascularity, thus nutrient and oxygen uptake by the conceptus could be accomplished over a decreased surface area of attachment to the uterine wall. Reproductive data obtained to date have been gathered largely from university swine herds that may have little relevance to commercially used US pig breeds. In contrast to the constant evaluations of physiological changes associated with increased litter size at universities, swine seed stock producers have selected for many generations simply on increased litter size and have not bothered to evaluate the resulting physiological changes associated with increased fecundity. Therefore, it was the objective of this study to investigate the reproductive characteristics of a commercially relevant swine herd in Iowa (PIC Camborough Line) at selected gestational ages. Multiparous sows (ranging from 1 to 14 parities) were slaughtered on

days 25, 36, and 44 of gestation, time periods corresponding to intervals which are before, during, and after the time when uterine capacity becomes limiting. At the laboratory, the uterine horns were measured and ovulation rate was determined. Conceptuses were removed and fetal and placental weights were determined. Uterine horn length and ovulation rate did not differ between the three gestational groups. Conceptus number decreased from  $15.8 \pm 0.6$  on day 25 to  $12.9 \pm 0.5$  and  $12.1 \pm 0.4$  on day 36 and day 44 (litter size in this population averages  $\sim 11.5$  liveborn piglets/litter). Conceptus survival to day 25 was  $60.2 \pm 0.1\%$ , which then decreased to  $50.1 \pm 0.1\%$  on day 36 and  $46.3 \pm 0.1\%$  on day 44. There was a positive correlation between conceptus number and ovulation rate on day 25 but by day 36 this association was lost. Conceptus number was not associated with uterine length on day 25, but by day 36 there was a positive association that remained through day 44. On all three gestation days there was a negative association between conceptus number and placental weight, but no association between conceptus number and fetal weight was observed, indicating that larger litters are comprised of conceptuses having small placentae, but the same sized fetuses. These data indicate that, compared with commonly reported values for university herds (16-18 ovulations), ovulation rate in these mixed parity production animals is extremely high, whereas conceptus survival as estimated from the number of conceptuses divided by the number of ovulations was very low. Additionally, although conceptus number was related to the ovulation rate on day 25, by day 36 the limitations of uterine size began to reduce conceptus number irrespective of ovulation rate. These data suggest that ovulation rate is not a limiting factor in litter size in this line of commercially relevant pigs. In contrast, the higher than expected ovulation rate observed in these pigs resulted in significant embryo losses and early uterine crowding. The consequences of this early conceptus crowding may have detrimental impacts on prenatal and postnatal growth rate and survival.

#### **Introduction**

Historically, efforts to increase reproductive efficiency in swine have focused on increasing litter size. Increasing litter size by just one piglet has been estimated to save American pork producers \$50 million per year in feed costs alone. In our attempts to understand the reproductive biology of litter size, there have been three main hypotheses generated at three different institutions: 1) litter size may be controlled by placental size and vascularity (Iowa State University); 2) uterine length may be a limitation to litter

size (USDA-MARC); and 3) ovulation rate may be limiting the number of potential piglets (University of Nebraska). In our initial research at ISU, we have observed that the prolific Meishan pigs has a 3- to 4-piglet increase in litter size over U.S. pig breeds due to a smaller, more vascular placenta, while uterine size and ovulation rate remain similar to other less prolific pig breeds. We were able to use this observation and apply it to U.S. pig breeds. When breeding animals were selected at birth for a high placental efficiency (piglet weight divided by the weight of its placenta), they had three more piglets per litter than breeding animals selected for a low placental efficiency. In these selections, piglet weight in the high placental efficiency and low placental efficiency group were similar ( $\geq 1,300$  g), whereas placental weights were markedly different. Although university efforts have focused on gaining an understanding of the physiological basis for litter size differences, companies selling breeding animals to producers have selected for highly prolific lines, but have not investigated the physiological basis from their selections. Therefore, we set out to characterize the reproductive characteristics of a line of commercially relevant U.S. swine.

#### Materials and Methods

Camborough line 6-02 (PIC) sows representing parities 1 to 14, were weaned once per week (Wednesdays) in groups of 30 and bred by AI at the subsequent estrus (Dayton Pork; Swine Graphics Enterprises, Webster City, IA). Sows (10/week) were assigned to be slaughtered on day 30, 40, or 50 post weaning (approximately day 25, 36, or 44 of gestation, respectively) and were slaughtered at a commercial packing plant in Des Moines, IA. At the laboratory, uterine horn length was determined. The number of corpora lutea was dissected to estimate ovulation rate. Conceptuses were removed from the uterus and individual fetal weight and placental weights were determined. Placental efficiency was calculated as the ratio of a fetus's weight to that of its placenta and used to estimate the function capacity of the placenta. Conceptus survival was calculated by dividing the number of viable conceptuses by number of corpora lutea.

#### Results and Discussion

A total of 190 pregnant tracts was collected on days 25 (n=63), 36 (n=60), and 44 (n=67) of gestation (Table 1). Uterine length and the estimated number of ovulations were not different between the three groups averaging  $434 \pm 5$  cm and  $26.6 \pm 0.4$ , respectively. Furthermore, there was no correlation between uterine length or ovulation rate with parity of the sow. Conceptus number decreased ( $P < 0.05$ ) from ~16 fetuses on day 25 to

~12 on day 44. Conceptus survival to day 25 was 60% which then decreased to less than 50% by day 44. On day 25, fetal weight was  $0.57 \pm 0.01$ g and, as expected, increased ( $P < 0.05$ ) to  $4.98 \pm 0.06$  on day 36 and to  $19.2 \pm 0.16$  g on day 44. Placental weight also increased ( $P < 0.05$ ) progressively, averaging  $6.1 \pm 0.2$ ,  $47.2 \pm 1.2$  and  $66.12 \pm 1.6$  g on day 25, 36 and 44, respectively. Placental efficiency was similar on day 25 and 36 ( $0.12 \pm 0.01$ ) and increased ( $P < 0.05$ ) on day 44 to  $0.33 \pm 0.01$ , a time of exponential growth of the fetus, whereas placental growth slows.

Table 2 depicts the associations of the reproductive parameters measured with the number of viable conceptuses on days 25, 36, and 44 of gestation. There was a positive correlation between conceptus number and ovulation rate on day 25 but by day 36 this association was lost. During the time when uterine capacity begins to limit conceptus number (after day 30), there was a positive association between uterine length and number of viable conceptuses on day 36, which remained on day 44. On all three gestation days there was a negative association between conceptus number and placental weight, but no association between conceptus number and fetal weight, indicating that conceptuses with small placentae had an increased chance of survival. This is consistent with previous studies in our laboratory which determined that during later gestation (day 70 to term), a smaller, more vascular placenta is associated with a larger litter size.

These data indicate that, compared with commonly reported values for university herds, ovulation rate in these mixed parity production animals is extremely high and is not apparently limiting on litter size. Additionally, although conceptus number present is related to the ovulation rate on day 25, by day 36 uterine capacity begins to decrease conceptus number irrespective of ovulation rate. Furthermore, it can be hypothesized that a very high ovulation rate may even be detrimental to conceptus growth and survival by increasing the competition for nutrients early in gestation. As we have previously demonstrated in our research Yorkshire herd at ISU during late gestation, a reduced placental size is associated with a larger litter size. This observation is consistent with the findings reported here, suggesting that in selecting for increased litter size in the Camborough line, placental size may have been decreased. Based on the data reported here, it is imperative that we define the reproductive phenotypes of commercially relevant breeds or lines of pigs to be sure that our university herds are physiologically relevant before investigating genetic differences.

**Table 1. Sow data from litters on day 25, 36, and 44 of gestation.**

	Day of gestation		
	25	36	44
Number of litters	63	60	67
Ovulation rate	26.5 ± 0.7 <sup>a</sup>	26.6 ± 0.6 <sup>a</sup>	26.9 ± 0.6 <sup>a</sup>
Numbers of conceptuses/litter	15.8 ± 0.6 <sup>a</sup>	12.9 ± 0.5 <sup>b</sup>	12.1 ± 0.5 <sup>b</sup>
Conceptus survival	60.2 ± 0.1% <sup>a</sup>	50.1 ± 0.1% <sup>b</sup>	46.3 ± 0.1% <sup>b</sup>

<sup>a,b</sup> Means SEM within a row with different superscripts differ ( $P < 0.05$ ).

**Table 2. Correlations of the reproductive parameters measured with the number of viable conceptuses on days 25, 36, and 44 of gestation.**

	Day of gestation		
	25	36	44
Ovulation rate	$r = +0.50$ $P < 0.001$	$r = +0.02$ NS	$r = +0.10$ NS
Uterine length (cm)	$r = -0.03$ NS	$r = +0.36$ $P < 0.001$	$r = +0.40$ $P < 0.001$
Placental weight (g)	$r = -0.36$ $P < 0.01$	$r = -0.28$ $P < 0.05$	$r = -0.33$ $P < 0.01$
Embryo weight (g)	$r = -0.04$ NS	$r = -0.07$ NS	$r = -0.09$ NS