Selection of Piglets with a Reduced Placental Size Does Not Hinder Production Traits

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Summary and Implications

Using a purebred population of Yorkshire (Y) females, our laboratory recently reported that the ratio of a piglet's weight to that of its placenta (RATIO) varies ≈threefold within a litter. This variation in RATIO is due predominantly to variations in placental weight that are known to be a limiting factor in litter size. It was further determined that selection of boars and gilts with a higher than average RATIO for breeding resulted in an increased litter size and reduced placental weights. The objective of this experiment was to examine the effects of RATIO on economically important production traits (21- day weight, days to 105 kg and backfat and loin area at 105 kg) in a purebred breeding stock herd of Y and Landrace pigs. Sows were monitored throughout farrowing, and as each piglet appeared its umbilical cord was clamped close to the dam's vulva and again near the neonates body then cut between the clamps. A number designating birth order was then tied around the exposed umbilical cord with surgical silk and the tagged umbilical cord was allowed to retract back into the birth canal. Each piglet was then notched to match its numbered placenta. Following expulsion, placentae were separated, piglets and placentae weighed, and RATIO determined for each. Piglets were individually weighed at 21 days and scanned by ultrasound at 105 kg for backfat thickness and loin area. Placental weight exhibited a significant ($P<.0001$) negative correlation with RATIO ($r=-.73$), whereas birth weight did not ($r=.09$, $P>.25$). Further, neither 21-day weight nor days to 105 kg were associated with RATIO. Additionally, carcass quality was not associated with RATIO. These data indicate that piglet selection based on a high RATIO (increased placental efficiency) is not detrimental to economically important production traits. Data will continue to be compiled on the tagged gilts as they reach breeding age to determine if their selection for increased placental efficiency results in increased litter size.

Introduction

Litter size in commercial pig breeds has remained relatively constant at ≈10 piglets for the last 80 years. Classical methods of genetic selection for this trait have proven unfruitful as estimates of heritability for the number of live born piglets per litter has been low and highly variable. As an alternative approach for increasing litter size, the prolific Chinese Meishan pig was imported into the United States in 1989. The Meishan gilt farrows three to five more live piglets per litter than commercial pig breeds even though ovulation rate and uterine size are similar across breeds.

Preimplantation Meishan conceptuses elongate to a decreased length and develop a smaller placenta than conceptuses of U.S. pig breeds. Due to its decreased placental size, the Meishan conceptus stimulates increases in the density of placental and adjacent endometrial blood vessels, thereby increasing nutrient flux per unit placental area over other breeds. This is especially pertinent in that uterine size becomes limiting to litter size during mid- and late gestation. Due to greater than 7,000 years of selection on litter size, the Chinese may have indirectly selected conceptuses with smaller more vascular placentae. This is supported by the observation that markedly less variation is observed in both Meishan placental sizes and piglet birth weights than that of commercial pig breeds.

Recently, we reported a threefold variation in placental weights that was not related to differences in piglet weights at farrowing within litters of purebred Yorkshire pigs. We then proposed an index of placental efficiency by determining the piglet weight:placental weight ratio (RATIO) for each conceptus. Litter size was increased by three live born piglets when high RATIO Yorkshire gilts and boars were mated compared with the litter size resulting from the mating of low RATIO Yorkshire gilts and boars, averaging 12.5 and 9.5 piglets, respectively.

The objective of this study was to determine if selection for RATIO in a larger seedstock herd of straight-bred Finnish Yorkshire and Landrace sows had any detrimental impact on economically important production traits such as 21-day weight, days to 105 kg and backfat depth and loin muscle area at 105 kg.

Materials and Methods

Purebred Finnish Yorkshire and Finnish Landrace females at a seedstock operation were observed continually throughout farrowing. As each piglet was farrowed, its umbilical cord was clamped closest to the piglet's body (Umbilical clamp, Hollister, Libertyville, Ill.) and again close to the sow's vulva (uterine forceps, Milltex, Lake Syracuse, NY) and then cut between the clamps. A number matching the piglet's birth order was ligated to the umbilical cord protruding from the sow's vulva, and the uterine forceps released, allowing the tagged end of the umbilical cord to retract back through the birth canal. Each piglet was then ear notched with birth order, its sex determined, and individually weighed. After placental expulsion, placentae were separated, identified and weighed individually. A RATIO was calculated for each piglet. Not all piglets were tagged due to premature detachment of the umbilical cord from the placenta during delivery. Therefore, only records for the 15 sows where ≥75% of the piglets were tagged were used when analysis required RATIO. Piglets were weighed individually again at 21 days of age. The number of days each piglet required to reach 105 kg was determined. Backfat depth and loin muscle areas were determined by real time ultrasound scanning when all piglets weighed ≈105 kg. No breed effect was observed on birth weights, placental weights, RATIO, 21-day weight, days to 105 kg, backfat depth or loin muscle area. Therefore, all data was pooled for analysis.

Results and Discussion

A threefold difference in RATIO was observed within individual litters (Fig. 1). Due to this littermate variation, the average RATIO of a litter was not associated with litter size. The distribution of RATIOs for individual piglets averaged 5.7±.1 and ranged from 2.8 to 11.4, a fourfold difference in placental efficiency (Fig. 2). Although piglet birth weights ranged from 694 to 2,500 g, these differences in piglet birth weights could not explain the variations observed in individual RATIOs (Fig. 3). In contrast, placental weights, which ranged from 80 to 554 g, were observed to exhibit a high negative correlation with individual RATIOs (Fig.4). No significant association was found between RATIO and the 21-day weight of piglets (Table 1). Additionally, RATIO was not associated with the days it took piglets to reach 105 kg, backfat depth or loin muscle area at 105 kg (Table 1). In contrast to RATIO's lack of association with economically important production traits, the birth weight of piglets was significantly correlated with both 21-day weight and the days to 105 kg (Table 1). The correlation between piglet birth weight and 21-day weight was positive as heavier piglets at birth were heavier at 21 days of age. Piglets that weighed more at birth and were heavier at 21 days of age also reached 105 kg sooner, resulting in a negative correlation (Table 1). Adjusted backfat depth and loin muscle area measured 1.02±.03 cm and 47.8±.5 cm^2, respectively. Piglet birth weight, placental weight, 21-day weight, and days to 105 kg were not associated with backfat depth. In contrast, the piglet 21-day weight was positively associated with loin muscle area while piglet birth weight was not (Table 1).

It has been a widespread misconception that large piglets are supported by placentae that are proportional to their bodyweight. The variation in individual piglet RATIOs observed in this study indicates otherwise as emphasized by Yorkshire boar 30-1 (highlighted box in Fig. 3). This piglet weighed 2,500 g at birth yet was supported during late gestation by a placenta that weighed 282 g, resulting in a RATIO of 8.9. The widely varying RATIOs demonstrate that fetuses, even within litters, have diverse genotypes. The failure to associate RATIO with any of the economically important production traits in the current study, however, is an indication that the genes contributing to litter size and those regulating production are not pleotrophic or closely linked. Commercial pork producers have continually selected for heavier piglets at birth. Although piglet birth weight was significantly correlated with both 21-day weight and days to 105, this measurement only accounted for 16% of the variation in both the 21-day weight and days to 105 kg. These data illustrate that birth weight is a poor indicator of future growth performances. Additionally, only 25% of the variation in days to 105 kg was accounted for by 21-day weight. It appears that as the pigs aged, the variances in postpartum gains for the individual piglets can be attributed to differences in genotype.

We plan to follow the reproductive efficiency of tagged gilts from this study as they reach breeding age to determine if their selection for increased placental efficiency results in increased litter size and placental efficiency of their offspring. The apparent diversity of fetal genotypes observed within each litter may help explain the inability of researchers to increase litter size by simply selecting individuals from larger litters. The low-tech process of placental tagging used in the current study, however, would allow commercial pork producers the opportunity to identify high-RATIO females within their herd that would have the genetics to produce larger litters. Additionally, this above-average RATIO, indicative of a smaller, more efficient placenta, appears to have no detrimental effects on postpartum growth efficiency.

Increasing litter size by within herd selection could allow commercial pork producers the opportunity to decrease their sow herds and still keep existing finishing facilities operating at full capacity, thus increasing profits through decreasing the cost of production.

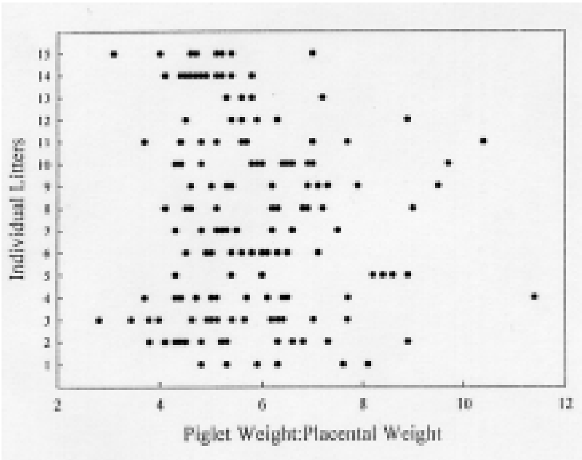

Figure 1. The distribution of individual piglet weight:placental weight ratios for the 15 different litters where ≥75% of the piglets were tagged. One-hundred percent of the piglets was tagged in 13 litters, 75% in litter #1, and 78% in litter #7.

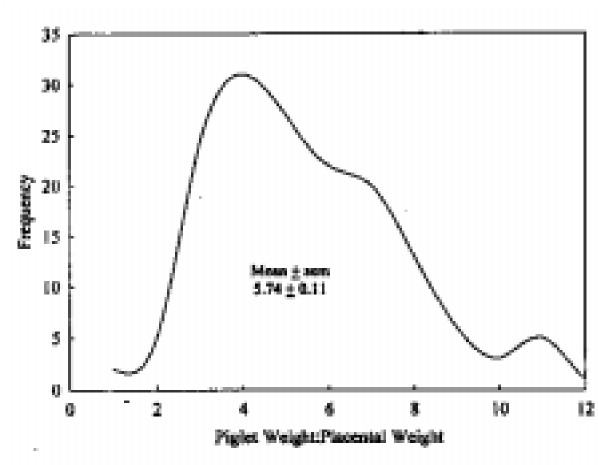

Figure 2. The frequency distribution of individual piglets weight:placental weight ratios depicted in Fig. 1.

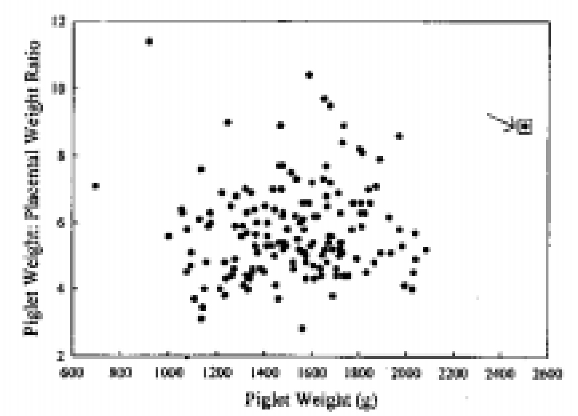

Figure 3. Individual piglet weights (n=161) versus their piglet weight:placental weight ratio. Highlighted box denotes boar 30-1.

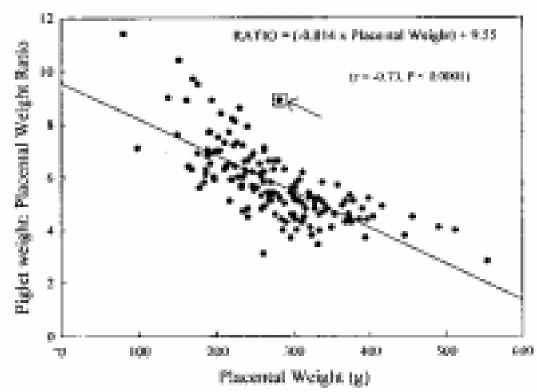

Figure 4. Individual placental weights (n=161) versus their corresponding piglet weight:placental weight ratio. Highlighted box denotes boar 30-1.

Table 1. Pearson's correlation coefficients.

	Birth wt (g)	Placental wt (g)	RATIO	21-day wt (g)	Days to 105 kg	Adjusted backfat (cm)	Adjusted area (cm^2)
Placental wt. (g)	.54 (.0001)*	_	_	_	_	_	_
RATIO	.09 (.26)	-.73 (.0001)*	_	_	_	_	_
21-day wt. (g)	.41 (.0001)*	.33 (.001)*	.11 (.29)	_	_	_	_
Days to 105 kg	-.40 (.0001)*	-.26 (.11)	-.08 (.51)	-.49 (.0001)*	_	_	_
Adusted backfat (cm)	-.11 (.26)	-.08 (.43)	.07 (.57)	.10 (.45)	.04 (.69)	_	_
Adjusted loin area (cm^2)	.16 (.11)	.21 (.12)	-.004 (.97)	.27 (.11)	-.26 (.12)	-.06 (.56)	_

Significance level enclosed by parenthesis.
*Indicates P<.001.