Differential Prepartum and Postpartum Growth Patterns of Yorkshire and Meishan Piglets Gestated in the Same Uterine Environment

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Summary and Implications

While Yorkshire fetal growth appears to depend on increasing placental size, more extensive vascularization of a smaller placenta appears to support Meishan fetal growth. Further studies are needed to extend our knowledge of the mechanisms controlling placental growth and vascularization. The ability to manipulate conceptus size may allow producers the opportunity to increase litter size in domestic pigs. More piglets farrowed per sow per year combined with the effects of fetal genotype on postpartum growth rate, as confirmed by the current study, would allow more efficient pork production.

Introduction

Profitability for pork producers continues to hinge on the number of piglets raised per sow per year. As ovulation rate averages 15 to 16 and prenatal mortality ranges between 30 and 40 percent in U.S. pig breeds, the resulting litter size averages 9.7 piglet farrowed (Iowa Livestock Enterprise Summaries: 1995 Swine Enterprise Record). In contrast, the prolific Chinese Meishan pig which exhibits the same ovulation rate as U.S. pig breeds, farrows three to five more piglets per litter (i.e., 13 to 15 piglets) due to a reduction in embryonic mortality (Ford and Youngs, 1993). However, the mechanism(s) used by the Meishan female to prevent embryo loss is not well understood.

We have previously demonstrated that the Meishan uterus exerts a powerful inhibitory effect on conceptus (fetus and placenta) size. Both Meishan and Yorkshire conceptuses transferred to Meishan uteri were markedly smaller ($\leq$ 60 percent) on day 90 of gestation than either genotype gestated in Yorkshire uteri. Uterine capacity, not ovulation rate, is considered the greatest limitation on litter size. Because uterine size is similar between the Meishan and U.S. pig breeds, this reduction in conceptus size induced by the Meishan uterine environment may allow an increased number of fetuses to be accommodated.

Litter size has been shown repeatedly to be inversely related to piglet birth weight across a variety of pig breeds. Svendsen *et al*. (1986) reported that piglets weighing less than .9 kg. from European breeds of swine exhibited reduced viability as well as depressed postpartum growth rates. In contrast, straightbred Meishans which have litters of 13 to 15 piglets which weigh $\geq$ .8 kg. experience no decrease in viability or survival when compared to the 1.4 kg. piglets comprising a litter (i.e., eight to 10 piglets) farrowed by straightbred Yorkshire females.

It has been known for many years that the uterine environment can exert powerful effects on conceptus growth within a variety of mammalian species. If a conceptus from a larger breed is transferred to the uterus of a smaller breed its growth rate will be slowed. In contrast, if a conceptus from a smaller breed is transferred to the uterus of a larger breed its growth rate is accelerated. Interestingly, uterine-induced alterations (i.e., increases or decreases) in birth weights are negated quickly by differences in piglet genotype. Postpartum growth rates of rabbits, lambs or foals with similar genotypes were not affected by gestation in restrictive (smaller breed) or permissive (larger breed) uterine environments even though their birth weights differed markedly (Venge, 1950; Hunter, 1958; Walton and Hammond, 1938).

Accordingly, transferring Yorkshire conceptuses into Meishan uteri should produce "miniaturized" Yorkshire piglets at birth that exhibit genetically determined postpartum growth rates. The understanding and utilization of the mechanism(s) by which Meishans reduce conceptus size and maintain fetal viability may offer pork producers the opportunity to increase their net profit.

Therefore, it was the objective of this experiment to confirm the individual effects of the uterine environment and fetal genotype on piglet birth weight and placental size of Meishan and Yorkshire conceptuses co-transferred to either Meishan or Yorkshire females. Additionally, we were interested in the postpartum growth patterns exhibited by Meishan and Yorkshire piglets from both uterine environments.

Materials and Methods

Meishan and Yorkshire gilts of similar reproductive age (i.e., two to five postpubertal estrous cycles) were checked for estrus twice daily. When a Meishan and a Yorkshire gilt were in estrus at the same time, these gilts were handmated at that time to boars of their own breed and again 12 hours later. Embryos were collected from the Meishan and Yorkshire donor gilts 48 hours after the onset of estrus from the Meishan and Yorkshire donor gilts and transferred to a non-mated recipient gilt (Meishan or Yorkshire) which had been in estrus at the same time as the donor gilts. Ten embryos (five Meishan and five Yorkshire) were transferred into each oviduct of the recipient gilt for a total of 20 embryos per recipient female.

The recipient gilts were fed a ration which exceeded the NRC guidelines during gestation. At day 107 of gestation, gilts were moved from their outside pens into farrowing crates and checked daily for signs of impending parturition by the ability to express milk from a teat. From the time a stream of milk could be expressed, gilts were monitored continuously until farrowing was complete. Immediately after each piglet's birth, breed, birth weight and crown rump length were recorded. Each piglet was then ear notched so individual growth rate could be tracked weekly until day 56 postpartum.

At each piglet's birth, the exposed umbilical cord was tagged to match the piglet's number, cut and allowed to retract so each piglet could be matched with the appropriate placenta at delivery. At expulsion, each placenta was identified, then weighed and its length determined. Circular discs from each placenta were cut from the chorioallantoic membrane on both sides of the amnion after clamping the tissue between two stainless steel rings which held the tissue firmly in place. Each placental disc was fixed, paraffin embedded, and later sectioned (5 μM.), and the resulting sections were adhered to a microscope slide.

Micrographs of randomly selected stained placental sections were taken with a photomicroscope. Each micrograph enlarged the placental tissue 125 times. The total placental area, number of villi (the area of nutrient exchange) and sizes of blood vessels, blood vessel area and vascular density (blood vessel area/placental area) were quantified from each micrograph using an image analysis system.

Results and Discussion

Two visually distinct types of placentae were observed during the farrowing of each recipient female. Relatively large and blanched placentae were exclusively matched to Yorkshire fetuses while smaller, redder placentae were matched to Meishan fetuses (fig. 1).

Although Meishan placentae weighed markedly less and were shorter ($P < .01$) than Yorkshire placentae, regardless of recipient breed (fig. 2 and fig. 3), placentae matched to either Meishan and Yorkshire piglets farrowed by Yorkshire recipients were heavier and longer than those from Meishan recipients.

Regardless of a reduced placental size, Meishan piglets gestated in a Yorkshire uterine environment exhibited birth weights similar to those of their Yorkshire littermates (fig. 3). However, in a Meishan uterine environment genetically-determined size differences were maintained as Meishan piglets weighed markedly less at birth ($P < .05$) than their Yorkshire littermates (fig. 2).

Figure 1. A large Yorkshire placenta (left) and a small Meishan placenta (right) recovered from a Yorkshire recipient female. The Yorkshire and Meishan fetuses attached to these placentae were born at similar weights.

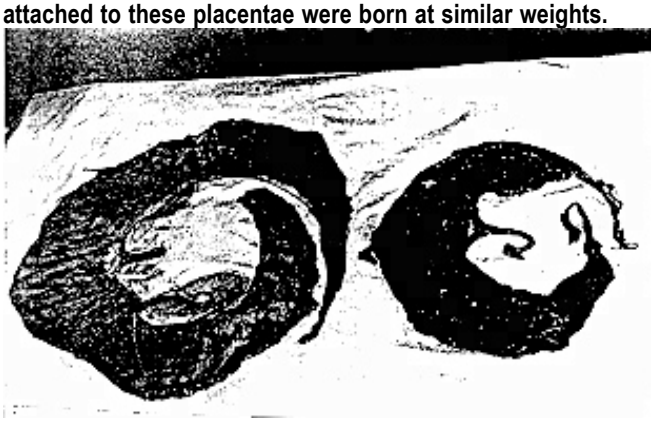


Figure 2. Meishan uterine environmental influence on the prepartum growth of both Meishan and Yorkshire conceptuses.

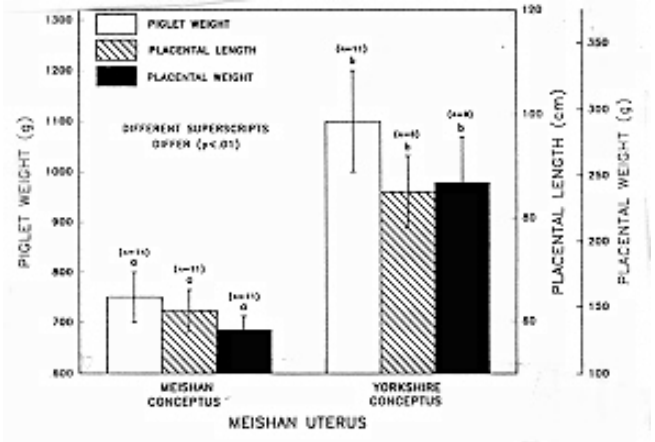
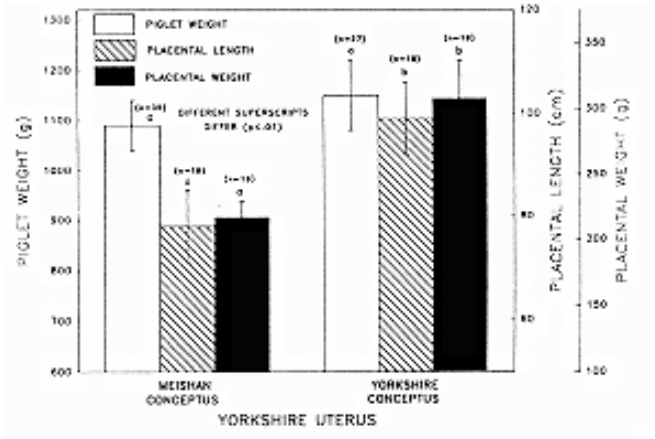


Figure 3. Yorkshire uterine environmental influence on the prepartum growth of both Meishan and Yorkshire conceptuses.



An explanation of these apparent differences in Meishan fetal growth in the uterus of the two recipient breeds may lie in the differences in placental vascularization. Interestingly, markedly increased placental vascular density (64 percent increase) was noted when Meishan conceptuses were gestated in Yorkshire vs. Meishan uteri. Additionally, Meishan placentae exhibited a consistently greater vascular density than Yorkshire placentae regardless of recipient breed.

The greater size of the Meishan placentae in Yorkshire uteri coupled with their markedly greater vascular density may have resulted in accelerated Meishan fetal growth due to increased nutrient uptake from maternal blood. Although the vascular density of Yorkshire placentae was markedly lower than Meishan placentae within the same uterine environment, Yorkshire placentae were always noticeably larger (i.e., heavier and longer). These data indicate that Yorkshire fetal growth may be predominantly dependent on increases in placental size due to a relatively constant placental vascularity.

After weaning and placement on full feed, fetal genotype began to dictate piglet growth rates, regardless of recipient breed. The picture on the front cover of the Swine Research Report shows four littermate barrows (two Meishan and two Yorkshire), farrowed by a single Yorkshire recipient on day 154 postpartum. The differences in fetal genotype are evident at this age with the faster growing Yorkshire barrows weighing 111.6 kg. while their smaller Meishan littermates weighed 60.3 kg. More importantly, Yorkshire and Meishan piglets born to Meishan females grew at rates equivalent to piglets of the same genotypes born to Yorkshire females from weaning to day 154. These data suggest that in this model, fetal genotype is far more important than piglet birth weight in dictating postpartum growth rates.

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