Hyper-Prolificacy and Acceptable Post-Natal Development - A Possible Contradiction

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▪ Introduction

Although the components of litter size (ovulation rate, embryonic survival and uterine capacity) responsive to genetic selection are well established. However, the reality in existing "hyper-prolific" sows is that increased selection pressure for numbers born has led to indirect negative effects of intra-uterine crowding, reprogramming of fetal development, less efficient post-natal growth performance and adverse effects on carcass quality at slaughter. Therefore, a considerable amount of the variation in growth performance after birth may be pre-programmed during fetal development in the uterus (see Foxcroft and Town, 2004). The effects of prenatal programming on postnatal performance are not limited to effects on muscle development and growth. Harding et al. (2006) showed that the organs most notably affected by pre-natal programming in stillborn pigs with low birth weight were the heart, liver and spleen, with obvious implications for post-natal health outcomes generally.

Both birth weight of the individual pig and between litter variation in birth weight are of considerable economic interest for pork production, as post-natal growth in the pre-weaning, nursery and grow-finish stages of production is impaired in low, compared with high, birth weight pigs (see review of Foxcroft et al., 2007). Available results indicate that pigs of low birth weight have poorer carcass and meat quality. Unfortunately, although selection for improved prolificacy has resulted in an increase of litter size at birth in most breeding populations, this has been associated with increased within-litter variation in piglet birth weight, as well as an overall decrease in average birth weight of the litter. The proportion of live-born vs. dead-born pigs within the litters of one population of hyper-prolific French sows (**Table 1**) suggests that the growth potential of the live-born pigs that survive to weaning will be seriously affected by intra-uterine competition with the increasing number of fetuses born dead.

A better appreciation of the characteristics of prolific dam-lines is clearly needed. This information, and an increasing focus on the need to maximize total net revenues per sow in terms of the value of saleable pork products relative to the input costs involved per kg of pork sold, should drive the management of appropriate terminal dam-lines in the future. Ultimately, selection of sows with increased uterine capacity offers the best opportunity for increasing the number of pigs born per litter, without compromising the post-natal growth performance of these pigs.

Table 1. Production data recorded for individual hyperprolific, white-type, sows from commercial units in Brittany, France.[a]

Sow parity	Total pigs born	Pigs born dead	Pigs born live	Adjusted litter size 48 h after farrowing
7	***20***	***6***	***14***	***12***
2	15	2	13	13
5	***19***	***5***	***14***	***11***
2	15	1	14	11
9	***14***	***1***	***13***	***12***
5	***13***	***0***	***13***	***12***
4	19	1	18	13
2	12	0	12	12
5	***13***	***1***	***12***	***10***
5	***18***	***0***	***18***	***11***
4	16	1	15	12
1	10	2	8	12
4	16	0	16	12
5	***18***	***3***	***15***	***11***
8	***22***	***5***	***17***	***11***
5	***13***	***7***	***6***	***12***

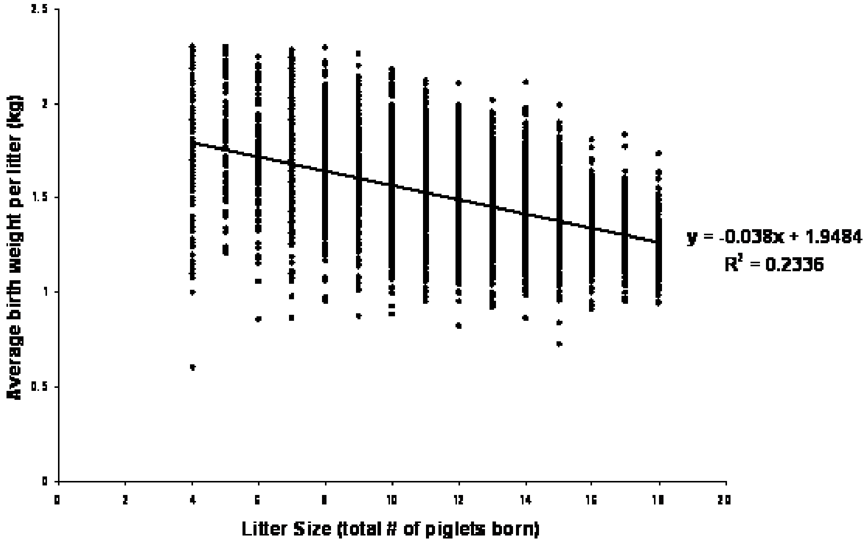
[a]Individual higher parity sows (***data shown in bolded italics***) with high ovulation rates tend to show both an increase in total and dead born pigs per litter. Data are from personal communication (Leveneau, P.).

▪ Sources of Variance in Postnatal Growth Performance

A comparison between the largest and smallest pigs within a litter has most frequently been used to study impacts of birth weight on postnatal growth performance. However, limitations in functional uterine capacity in hyper-prolific sows are predicted to result in prenatal programming effects on entire litters (Foxcroft et al., 2007). If this assumption is correct, then the origins of increasing variance in postnatal growth performance needs to be clarified as the basis for developing selection and production strategies that effectively address the problem.

As an initial approach to determining the origins of increased variation in litter birth weight and postnatal growth performance, a retrospective study of production data from a large breeding nucleus population was conducted (Smit, 2007). One of the goals of this study was to characterize litters that had been subjected to prenatal programming in a data set with information on litter phenotype after birth, but no information about ovulation rates. As shown in **Figure 1**, both the mean and the variance in birth weight decreased in bigger litters. Irrespective of their litter of origin, the birth weight of most pigs born in litters >15 is low, because uterine capacity is at its limits and most litters trend towards the lower limits of possible birth weight (around 1.0 kg).

Figure 1. Correlation between the total number of pigs born and average birth weight of the litter (N = 5,290). (From Smit, 2007)



At the other extreme, in litters of <10, factors other than uterine capacity must explain the large variance in birth weights. Therefore, the greatest likelihood of finding variation in average litter birth weight that might be associated with different patterns of prenatal survival appeared to be in litters between 10 and 15 total born. The characteristics of litters of between 10 and 15 pigs total born, with low and high average birth weight were, therefore, compared.

For each litter size in this range, the average birth weight was calculated and litters within an average birth weight plus or minus 0.2 kg of the average were excluded from the analysis. This resulted in a new dataset involving 1,094 litters, which were classified as having "High" or "Low" average birth weight, as shown in **Figure 2**. The relationships between High or Low birth weight class with the total number of piglets born per litter, number of piglets born alive and dead, and the number of piglets weaned were then determined (**Table 2**).

Figure 2. Litters classified as having a "High" (average litter birth weight > mean birth weight + 0.2 kg for a particular litter size born) or "Low" (average litter birth weight < mean birth weight - 0.2 kg for a particular litter size born) average birth weight within the litter size range from 10 to 15 total pig born. (N = 1,094) (After Smit, 2007).

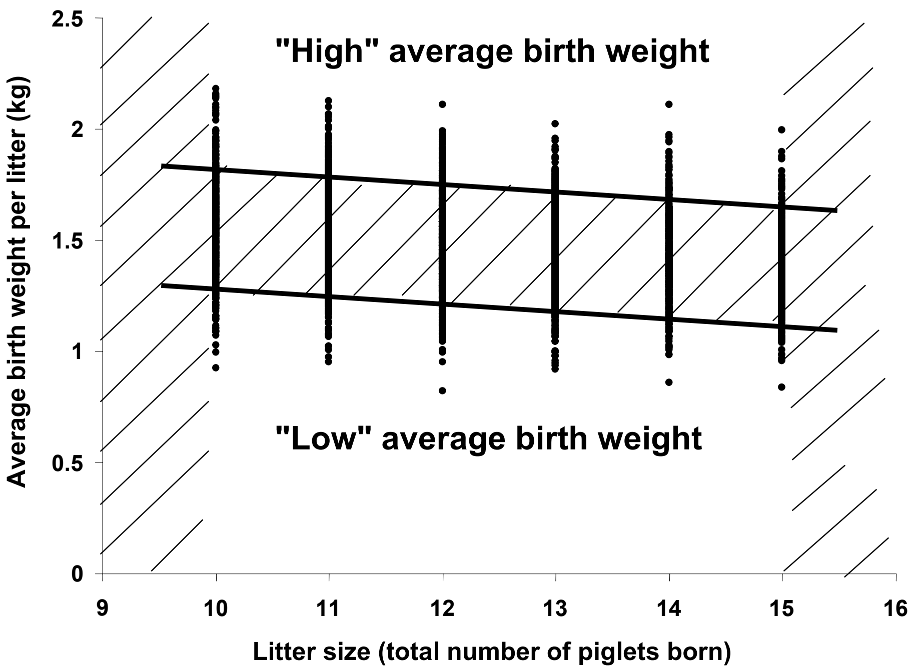


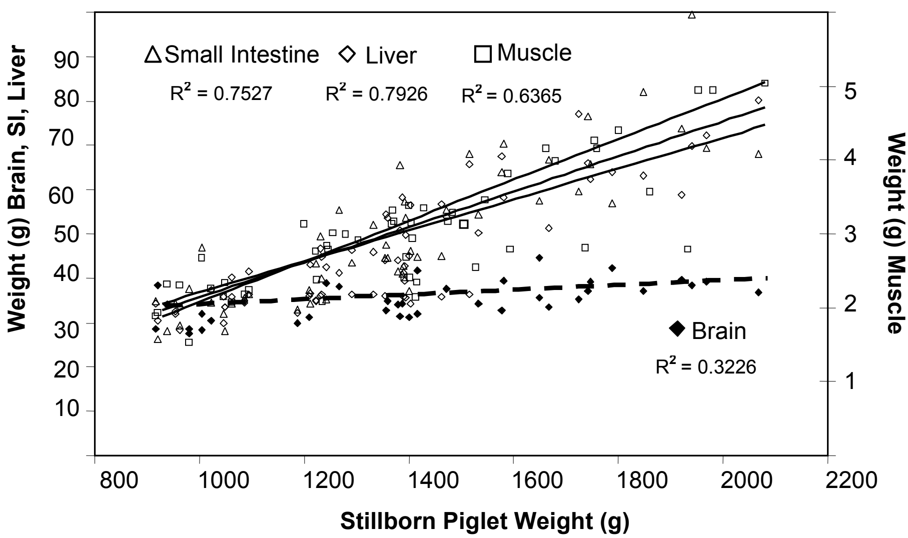
Table 2. Characteristics of litters classified as having a higher than average (High) and lower than average (Low) birth weight, and born in litter sizes of between 10 and 15 total pigs born. (After Smit, 2007).

	High	Low	*P*-Value
Average birth weight (kg)	1.8 ± 0.01	1.2 ± 0.01	< 0.001
Total born	12.3 ± 0.08	12.3 ± 0.07	0.91
Born alive	11.7 ± 0.09	11.0 ± 0.09	< 0.001
Born dead	0.6 ± 0.07	1.2 ± 0.06	< 0.001
Weaned	10.8 ± 0.10	9.4 ± 0.10	< 0.001

In litters with a High average birth weight, more pigs were born alive, fewer pigs were born dead, and more pigs survived to weaning, compared to the Low average birth weight litters. When only litters between 10 and 15 piglets born were considered in this way, the impact of numbers born on average litter birth weight is relatively small (<40g for each additional pig born between 10 and 15). In contrast, the difference in mean birth weight between High and Low birth weight litters in the 10 to 15 total born range was 590g, and each of these High and Low litter subsets represented about 15% of the total population of litters analyzed. Clearly, some factor other that total born per litter is driving these substantial differences in average litter birth weight. The observation that the Low average birth weight litters had more pigs born dead and less piglets weaned is consistent with the notion that these litters have been subjected to prenatal programming in utero.

This retrospective study of litter birth weight appears to identify between-litter variance in birth weight as the greatest potential contributor to variation in postnatal growth performance in a large population of litters born in commercial farms. However, the inference that low average birth weight is likely the result of intra-uterine crowding and would be associated with prenatal programming needed verification. In a subsequent study it was possible to use a population of sows in which the dynamics of prenatal loss had already been established and a trend towards high ovulation rates and increased prenatal loss in higher parity sows was evident Patterson et al. (2007). Phenotypic data were then collected from some 600 litters in this population, including parity of the sow, previous breeding history, records of total pigs born live and dead, individual birth weight of all pigs born, sex ratio of the litters and estimates of wet placental weight. In addition, necropsy was performed on a subset of still-born pigs that fell within the mid weight range for their respective litters, and data on organ weights were used to estimate the degree of prenatal programming. The variation in average litter birth weight in this study followed the same trends as in the study of Smit (2007). Having confirmed that the birth weight of the subset of still-born pigs necropsied fell within the mid weight range for their respective litters, it was then possible to demonstrate that Low average birth weight litters carried all the negative phenotypic characteristics associated with pre-natal programming (**Figure 3**). These data provide further support for the suggestion that one of the major causes of variation in postnatal growth performance is between-litter variation in average birth weight. Linking back to the extensive data on the impact of birth weight on postnatal growth performance earlier, the postnatal growth potential of these low birth weight litters should be a major concern for the pork industry.

Figure 3. Relationships between weight of still born pigs used for necropsy and the weight of the brain, liver, small intestine and semitendinosus muscle. (SRTC, unpublished data, 2007).



▪ Conclusions

Innovative approaches to addressing the problems, as well as the opportunities presented by pre-natal programming of post-natal performance, will likely be the benchmark of the most profitable pork production systems in the next decade. In particular, these approaches will need to address the possible conflict between continued selection for hyper-prolificacy and increased variance in post-natal growth performance. The following contributions to this Workshop explore such innovations in the management of modern prolific sows.

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