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# Use of a Stochastic Model to Evaluate the Growth Performance and Profitability of Pigs from Different Litter Sizes and Parities of Dams

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## ABSTRACT

*A stochastic model was developed to evaluate the effects of total number of pigs born and dam parity on pig compositional growth and postweaning profitability. The survival of pigs was modeled as a function of parity and of birth weight. Two management strategies were simulated, either with or without cross-fostering. Without cross-fostering, litter sizes of 6 to 14 total pigs born were simulated. Litter sizes of 6 to 20 total pigs born were simulated to be cross-fostered to obtain a constant of 11 pigs nursed. Pigs from parity 1 dams were predicted to be slower growing and have reduced survival compared with pigs from dams of other parities. Increasing total pigs born from 6 to 14 without cross-fostering reduced 150-d BW by 8.0 kg and carcass weight at marketing from 5.8 to 6.2 kg. Differences in carcass value from 6 to 14 total pigs born ranged from \$9.50 to \$11.10 per pig and profitability of pigs (\$/weaned pig) ranged from \$6.17 (parity 6) to \$7.37 (parity 1). Without cross-fostering, weaning pigs from parity 1 dams were \$5.82 to \$7.68 less valuable than pigs from dams of other parities at the same total number born. Pigs born and reared in cross-fostered litters by parity 1 dams had \$9.72 and \$10.09 less carcass value and were \$6.70 and \$7.06 less profitable than weaning pigs of parity 2 and parity $\geq$3 dams. Pigs born in larger litters, with or without cross-fostering, were less profitable postweaning than pigs from smaller litters.*

**Key words:** birth weight, growth rate, pig, stochastic model, weaning weight

## INTRODUCTION

Both the mean growth rate and the variation in growth rate of pigs are important to the economic returns of pork producers (Patience and Beaulieu, 2006; Boys et al., 2007). The optimization of pork production systems, including evaluation of alternative management strategies, requires knowledge of the between-pig variation in BW and carcass composition (Li, 2003; Boys et al., 2007).

Some of the variation in postweaning pig growth and composition is due to variation in birth and weaning weights (Wolter and Ellis, 2001; Rehfeldt and Kuhn, 2006). Pig birth and weaning weights are affected by parity of the sow, total pigs born, and number of pigs nursed (Le Dividich, 1999; Milligan et al., 2002). Selection for increased litter size can result in decreased mean pig birth and weaning weights (King, 1999; LeDividich, 1999). This in turn may result in pigs with reduced growth rates and reduced preweaning and nursery survival (Knol et al., 2002; Quiniou et al., 2002; Schinckel et al., 2007b, 2010).

Pig growth rates, survival rates, and carcass composition measurements have primarily nonlinear relationships with pig birth and weaning weights (Knol et al., 2002; Schinckel et al., 2007a, 2009d). Stochastic models produce a distribution of pigs that better reflects the curvilinear responses of population performance and profit-

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ability to changes in pig birth and weaning weights (Pomar et al., 2003; Schinckel et al., 2003, 2009d). The objective of this research was to evaluate the growth performance and profitability of pigs with different litter sizes and parities by using a stochastic pig compositional growth model.

# MATERIALS AND METHODS

The BW, feed intake, and carcass data are from a study (Schinckel et al., 2009a,b,c, 2010) evaluating the growth, feed intake, and carcass composition of 3 terminal sire lines. Pigs were treated humanely and according to FASS (2010) guidelines. Pigs were weaned at 19 d of age and placed into a nursery for 36 d. During the nursery stage, the pigs were fed a series of commercial starter diets. Pigs were placed into a finisher facility that had 8 identical rooms. The barrows and gilts were fed a series of corn- and soybean meal-based diets to achieve approximately 95% of their maximum predicted protein deposition rates based on previous studies (Schinckel et al., 2009a). A minimum of 1 barrow and 1 gilt from each litter were randomly assigned to a 113-, 127-, or 141-kg slaughter weight at 5 to 6 wk of age. Each pig was weighed at birth, weaning, 36 d in the nursery, and 28- to 29-d intervals until target BW was achieved. Pigs were begun on test at a mean age of 74 d and mean BW of 38.3 kg. Individual daily feed intake (**DFI**) data were collected by Feed Intake Recording Equipment (FIRE, Osborne Industries Inc., Osborne, KS). When the pigs reached their assigned target market weight, they were delivered to a commercial pork processor. The hot carcass weight of each pig was recorded. Backfat depth (**BFD**) and loin depth (**LD**) were measured with an optical probe (Fat-O-Meat'er, SFK Technology A/S, Herlev, Denmark) at 7 cm off midline at the third and fourth to the last ribs.

## *Modeling the Effect of Dam Parity and Total Pigs Born on Pig Birth Weight*

Mean pig birth weight decreases as the total number born increases (Le Dividich, 1999; Quiniou et al., 2002). In addition, pig birth weights are skewed, with a greater percentage of lightweight pigs than expected based on a normal distribution (Milligan et al., 2002; Quiniou et al., 2002). In addition, the SD in birth weight increases as litter size increases (Quiniou et al., 2002).

To reproduce the skewness and increased SD of birth weight with increased litter size, 2 normal distributions were produced. Ten percent of the pigs were modeled as having a mean of 1.0 kg and SD of 0.10 kg. The remaining 90% of the pigs were sampled from a population with mean = 1.657 kg − 0.04725 (total number born − 9.0) and SD = 0.18 + 0.0162 (total number born − 9.0). The model reproduced the mean, SD, and percentage of pigs less than 1.0 kg of Quiniou et al. (2002) for litters sorted into different litter size categories.

Dam parity effects for mean pig birth weights of −0.10, +0.05, and +0.08 for parities 1, 2, and ≥3 were added based on data from Milligan et al. (2002). Weaning weight was predicted as a linear-quadratic function of birth weight (21-d BW = 2.56 + 3.36 birth weight − 0.3473(birth weight)$^2$ + 0.72 $z_1$, where $z_1$ is a value sampled from a standard normal distribution (Schinckel et al., 2009d). The value of 0.72 is the SD in 21-d BW of pigs from sows of the same parity, litter size, and birth weight.

## *Modeling 21-d Body Weight as Affected by Parity and Number After Transfer*

In addition, 21-d pig weight was adjusted for parity after accounting for parity differences in pig birth weight (National Swine Improvement Federation, 1996; Milligan et al., 2002). These adjustments were −0.10, +0.04, and +0.09 kg for parity 1, 2, and ≥3 litters.

Total 21-d litter weight was adjusted for the total number of pigs after transfer. The National Swine Improvement Federation (1996) adjustments were reparameterized to be proportional to the litter weights achieved with 50-kg litter weights with 10 pigs nursed. If the number after transfer (**NAT**) was less than 10 and ≥7, then adjustment for NAT = (10/NW)$^{0.291}$, where NW is the number weaned. If NAT was <7, then the adjustment was 1.11. The 21-d BW of pigs was multiplied by the adjustment for number of pigs nursed.

## *Modeling Pig Survival*

The survival of pigs during the birth process decreases as the parity of sows increases beyond 2 (Milligan et al., 2002). The birth survival data of Milligan et al. (2002) was modeled as 0.95 for parities 1 and 2, and as birth survival = 0.95 − 0.01125(parity 2) for parities ≥3. A value was sampled from a uniform distribution with 0.0 to 1.0. If the value of the pig for birth survival was greater than the value sampled, the pig survived the birth process. If the value for birth survival was less than the value sampled, the pig did not survive the birth process.

The data of Knol et al. (2002) were used to estimate a function relating the preweaning survival of pigs to pig birth weight. The generalized Michaelis-Menten (**GMM**) growth function provided the best fit to the data and had the following form: preweaning survival = −107.79 + {207.555 × (birth weight/0.487)$^{2.9156}$/[1 + (birth weight/0.487)$^{2.9156}$]}/100. Pigs were randomly assigned to either survive or not survive to weaning based on the comparison of their preweaning survival value and a value sampled from a uniform (0 to 1) distribution (as detailed above).

The nursery survival function was developed from unpublished data from PIC (PIC North America, Hendersonville, TN). The survival function was nursery survival = 1 − {exp [3.635 − 2.5135(birth weight) + 0.6426(birth weight)$^2$]/100}. Data from Larriestra et al. (2006) and