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Evaluation of the Impact of Pig Birth Weight on Grow-Finish Performance, Backfat Depth, and Loin Depth

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ABSTRACT

The effect of birth BW on pig growth was studied in 1,932 barrows and gilts. The pigs were weighed at birth, weaning, and exiting the nursery. The pigs were weighed and measured ultrasonically at approximately 28-d intervals from 74 to 158 d of age. Daily feed intake data were recorded via an electronic feeder from 38 kg BW to the end of test. The relationships of the pig growth variables, carcass predicted percentage lean, and predicted days to achieve 125 kg BW to birth BW were evaluated via regression analyses. Equations fitting ultrasonic loin depths at 46.7, 64.6, 83.5, and 102.5 kg BW included significant ($P < 0.05$) linear, quadratic, and cubic birth BW variables. At market BW, pigs with birth BW of 1.0 kg had 1% less predicted lean than pigs with birth BW of 2.0 kg. Pig ADG had linear-quadratic relationships ($P < 0.001$) to birth BW in the gilts and linear-quadratic-cubic relationships ($P < 0.02$) to birth BW in the barrows. Regression equations predicted that increasing the birth BW of pigs with below-average birth BW had a greater impact on increasing the ADG than increasing the birth BW of pigs with average or above-average birth BW. No relationships ($P > 0.60$) were found between daily feed intakes and birth BW. Feed conversion (feed:gain) had linear or linear-quadratic relationships ($P < 0.05$) to birth BW. Pigs with birth BW less than 1.1 kg had greater feed:gain, more days to achieve 125 kg, and decreased predicted percentage lean than pigs with birth BW greater than 1.1 kg.

Key words: pig, growth, birth weight, percentage lean, feed conversion

INTRODUCTION

Variability in the growth rate of pigs is important to economic costs and returns for both the pork producer and processor (Patience and Beaulieu, 2006; Boys et al., 2007). Pork processors have the objective of marketing lean pork products that are uniform in weight and composition (Boland et al., 1993; King, 1999). The optimization of pork production systems, including the evaluation of alternative management and marketing strategies, requires knowledge of the between-pig variation in BW and carcass composition (Le Dividich, 1999; Li, 2003).

Some of the variation in postweaning pig growth is due to variation in birth BW (Le Dividich, 1999; Wolter and Ellis, 2001; Klindt, 2003). Pigs with light birth BW have decreased growth rates (Rehfeldt and Kuhn, 2006; Schinckel et al., 2007b,c). Little research has been conducted on the impact of pig birth BW on daily feed intake (**DFI**) and feed conversion (Mroz et al., 1987; Poore and Fowden, 2004). In past trials, pigs were sorted into 2 or 3 groups based on pig birth BW (Mroz et al., 1987; Gondret et al., 2005; Rehfeldt et al., 2008). Pig growth rates have curvilinear relationships with birth BW (Schinckel et al., 2004, 2007b,c). Thus, estimation of the true relationship of birth BW to postweaning pig performance and composition may require data on pigs with a wide distribution of birth BW. The objective of this research was to evaluate the effects of pig birth BW on grow-finish pig performance and measures of backfat and loin depth.

MATERIALS AND METHODS

The BW data are from a study (Schinckel et al., 2009a,b,c) to evaluate the growth and carcass composition of 3 terminal sire lines (lines 35,

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47, and 71) mated to 2 dam lines (lines 850 and 1950). Sows were bred continuously between August 2003 and March 2004. 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. During the course of the trial, the finishing facility was filled twice (2 replicates), with pigs from each farrowing-nursery group filling a room. Barrows and gilts of each sire-dam line were allocated to pens (18 pigs/pen, 0.683 m^2/pig). 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 was randomly assigned to either a 113-, 127-, or 141-kg slaughter BW 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 started on test at a mean age of 74 d and a mean BW of 38.3 kg. Live animal measurements of backfat depth and loin depth were collected at each weigh day from the day on test to the assigned market BW of each pig. The ultrasonic equipment used for these measurements consisted of an Aloka 500V instrument (Aloka, Wallingford, CT) equipped with a 3.5-MHz transducer. Measurements were made with a 16.5-cm transducer placed longitudinally between the 10th and last ribs approximately 7.0 cm off the midline of the pig. Feed intake data were collected by feed intake recording equipment (FIRE, Osborne Industries Inc., Osborne, KS). After editing, 1,932 pigs had complete DFI records from the day on test to their target market BW.

Upon reaching their assigned target BW, pigs were delivered to a commercial pork processor. The warm carcass weight of each pig was recorded. Fat and loin depth were measured with an optical probe (Fat-O-Meater, SFK Technology A/S, Herlev, Denmark) between the third and fourth ribs anterior to the last rib. The pork processor used a proprietary equation to predict carcass lean percentage from the optical probe measurements.

Previously Fitted Body Weight, Daily Feed Intake Functions, and Ultrasonic Measure

The Generalized Michaelis-Menten (**GMM**) function (Schinckel et al., 2009a) was fitted to the BW data using the nonlinear mixed (NLMIXED) procedure of SAS (SAS Institute Inc., Cary, NC). The GMM equation has 2 alternative forms: $WT_{i,t} = [(WT_0 K^C) + (WF\ t^C)]/(K^C + t^C)$ or $WT_{i,t} = WT_0 + [(WF - WT_0)(t/K)^C]/[1 + (t/K)^C]$, where WF is mean mature BW, WT_0 is the mean birth BW, t is days of age, K is a parameter equal to the days of age at which one-half the WF is achieved, and C is a unitless parameter related to changes in proportional growth and shape of the growth curves (Lopez et al., 2000). The solution of the GMM included random effects for WF (wf_i) and K (k_i) and a random effect for C predicted as a linear function of wf_i ($c_i = B\ wf_i$). By including the random effects of each pig into its sex-specific GMM equation, pig BW at each day of age, ADG at any specific BW or age, and days to achieve a specific target BW can be predicted. The number of days to achieve 125 kg BW was predicted for each pig.

The DFI data of the barrows and gilts were fitted to a Bridges function (Bridges et al., 1986; Schinckel et al., 2009b): $DFI_{i,t} = C[1 - \exp(-Mt^A)] + e_{i,t}$, where C is the mean mature DFI (kg/d), M is the exponential growth decay constant, t is the age (d) or BW (kg) of the ith animal, and A is the kinetic order constant. Because the exponential decay parameter was close to zero, the model was reparameterized ($M' = \log_e M$) with the form: $DFI_{i,t} = C\{1 - \exp[-\exp(M')\ t^A]\}$.

Alternative random effects models were evaluated based on the Akaike's information criterion (**AIC**) for each function. The Bridges function fitted to the DFI data of each sex included 2 pig-specific random effects, m_i' and c_i. An alternative analysis predicted a random effect for a_i as a linear function of c_i ($a_i = b\ c_i$). In these analyses, the fixed parameter A was replaced by $A + a_i$, which is $A + b\ c_i$.

Daily feed conversion (feed:gain, kg/kg) was predicted for each pig as the ratio of predicted DFI (kg/d) divided by the ADG (kg/d) previously predicted for each pig (Schinckel et al., 2009b). The DFI and feed:gain were predicted for each pig at 4 ages (84, 105, 126, and 147 d). The DFI and feed:gain were then predicted for each pig at the mean BW (46.7, 64.6, 83.5, and 102.5 kg) for each of the 4 ages.

The serial ultrasonic backfat and loin depth measurements of each sex were fitted to alternative functions of BW using the NLMIXED procedure of SAS (Schinckel et al., 2009c). Based on AIC values, the mixed model exponential function with the form $Y = \exp(b_0 + b_1BW + b_2BW^2) + a_i[\exp(b_0 + b_1BW + b_2BW^2)]^D$ was fitted separately for each sex-replicate group of pigs (Schinckel et al., 2009c). Ultrasonic backfat and loin depths were predicted for each pig at 4 BW (46.7, 64.6, 83.5, and 102.5 kg BW) by inclusion of the random effect (a_i) of each pig in the sex-specific exponential function.

Fitting the Growth Variables to Functions of Birth BW

The variables collected at the target BW of each pig (ultrasonic backfat depth, ultrasonic loin depth, carcass weight, optical probe fat depth, optical probe loin depth, and predicted percentage lean) were fitted to a model including the fixed effects of replicate, sire line, dam line, and their 2-way interactions; the random effect of room within replicate; and the allometric function of BW. To evaluate the impact of birth BW, the regressions of birth BW, $(\text{birth BW})^2$, and $(\text{birth BW})^3$ were included in the model.

The impact of birth BW on several pig growth performance variables was evaluated by regression analyses. The