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Analysis of lactation feed intakes for sows including data on environmental temperatures and humidity

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ABSTRACT

Daily feed intakes (DFI) of 565 lactation records were evaluated for sows of 2 genetic lines, PIC C-22 and L-42. Sows were fed ad libitum during the entire 21-d lactation period with a diet supplemented with either 0 or 0.3% betaine-HCl. Sows were fed corn–soybean based diets (3.32 Mcal of ME/kg). The DFI data were fitted to generalized Michaelis-Menten functions of day of lactation. The generalized Michaelis-Menten function $\{DFI_{i,t}\ (kg/d) = DFI_0 + (DFI_A - DFI_0)(t/K)^C/[1 + (t/K)^C]\}$ *with 2 random effects for DFI* (dfi_{Ai}) *and intercept* (dfi_{0i}) *with K as a linear function of* dfi_{0i} *provided the best fit to the DFI data* ($R^2 = 0.474$)*. The addition of a single covariate including daily degree-hours above 24°C (DGH24), daily maximum temperature (MaxT), or daily mean temperature (MeanT) of the current day were considerable* ($P < 0.001$)*. Furthermore, the addition of either a second covariate as the prior day DGH24 or MaxT to the single covariate models with current day DGH24 or MaxT was significant* ($P < 0.001$)*. No genetic line differences were found for the random effects* dfi_{0i} *and* dfi_{Ai}*. Betaine-supplemented sows had a 0.27 kg/d greater mean for* dfi_{Ai} ($P = 0.004$)*. Substantially greater DFI was found at the end of lactation in betaine-supplemented parity 1 and parity 2 sows* ($P = 0.012$ *and 0.005, respectively). Parity was important for both random effects* ($P < 0.001$)*. Parity × treatment and genetic × parity interactions were found for* dfi_{Ai} ($P = 0.006$ *and 0.049, respectively).*

Key words: sow, lactation, feed intake, betaine, temperature

INTRODUCTION

Genetic selection for increased sow productivity including litter weaning weight and number weaned has increased demand for milk production (Shurson and Irvin, 1992; Bergsma et al., 2008). Selection experiments and predicted genetic relationships indicate that selection for increased sow productivity will result in increased sow BW loss during lactation (Shurson and Irvin, 1992; Bergsma et al., 2008). Sow lactation feed intakes have not increased to the same extent as the increased demand for milk production (Kim and Easter, 2001; Trottier and Johnston, 2001). Increasing sow lactation feed intakes could reduce BW losses and allow maintenance of body condition (Auldist and King, 1995; Revell et al., 1998; Kim and Easter, 2001).

Sows are increasingly susceptible to heat stress if the ambient temperature in the farrowing room rises above 25°C (Prunier et al., 1997; Quiniou and Noblet, 1999). The average daily lactation ME intakes are reduced by 1.6% as temperatures increase each Celsius degree greater than 22°C and decreased by 3.67% for each Celsius degree increase greater than 25°C (NRC, 2012).

Greater than 60% of the United States sow farm operations have reported decreased fertility during the hot summer months of July and August (Knox et al., 2013). Betaine

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supplementation in sows has been shown to enhance reproductive performance (Ramis et al., 2011; van Wettere et al., 2012). Betaine supplementation may be more effective when feed intake is restricted or the animal is under stressful conditions (Casarin et al., 1997).

The objectives of this research were to quantify and model daily lactation feed intakes and to evaluate the effects of environmental temperatures, humidity, and betaine supplementation on lactation feed intakes.

MATERIALS AND METHODS

Animals, Housing, and Treatment Groups

Animal procedures were consistent with the *Guide for the Care and Use of Animals in Agricultural Research and Teaching* (FASS, 2010). The study was conducted at a commercial, naturally ventilated farrowing facility located in Rancagua, Chile. The trial was performed during the summer over 14 wk from December 15, 2014, to March 24, 2015, in a Mediterranean climate region, classified as Csb (Köppen, 1948). The farm was located in the foothills region of the Andes Mountains at 641 m altitude.

Sows from 10 farrowing rooms (18.75 × 8.15 × 2.15 m), each with 20 farrowing crates (2.2 × 1.66 m), were used during 3 cycles per room. Daily lactation feed intake (**DFI**) records were collected under commercial research conditions. A total of 11,108 DFI records were collected for 565 sows with mean lactation length of approximately 21 d. The data included 120 sows that were parity 1, 120 that were parity 2, 261 that were parity 3 to 5, and 64 that were parity 6+, and sows from 2 genetic lines: 282 PIC C-22 and 283 L-42. Dietary treatments were randomly allotted to concurrent farrowing rooms of sows (with 15 replicate rooms per treatment). Sows were fed diets with either 0% (279 sows) or 0.3% (286 sows) of betaine product (93% betaine-HCl, 70.7% betaine, Excential Beta-Key, Excentials, Wenkerdam, the Netherlands) inclusion in their diets (approximately 13.8 g/d betaine) from 2 d before farrowing due date until weaning. Sows were fed corn–soybean based diets (Table 1). Betaine was included in the diet at the expense of corn and was added and mixed into the diet at the feed mill.

Sows were fed 2.1 kg/d with a diet containing 16.2% NDF during gestation. Daily feed intake was increased 0.5 kg/d during the last third of gestation only in sows with body condition scores of 3 or less. Sows were fed twice per day (3 kg each) the 2 d before farrowing. After farrowing, sows were fed to achieve ad libitum feed intake 3 times per day. Feed was weighted with a scale, and the amount of feed given in each feeding was based on the amount of feed remaining in the feeder.

Temperature, relative humidity, and dew point measurements were recorded every 5 min with a logger device (EL-USB-2, DATAQ Instruments Inc., Akron, OH) in each farrowing room to develop daily 24-h environmental profiles. Ten loggers, one in each room, were placed at 0.9 m from the floor at the level of sows, away from water sources and air currents. The loggers were activated when sows were moved to the farrowing room and were deactivated at weaning.

Table 1. Calculated nutrient composition of the basal corn–soybean meal based lactation diet[1]

Component	Basal lactation diet
ME, Mcal/kg	3.32
NE, Mcal/kg	2.43
Moisture, %	10.96
Ash, %	2.98
CP, %	20.04
Crude fiber, %	2.37
Ether extract, %	6.68
Nitrogen free extract, %	53.04
NDF, %	9.44
SID Lys, %	1.10
SID Met + Cys:Lys	0.55
Choline, mg/kg	750.00

[1]For the betaine diet, the basal lactation diet was supplemented with betaine-HCl (3 g/kg) by adding 3 kg/t of Beta Key (70.7% pure betaine; Beta-Key, Excentials, Werkendam, the Netherlands) to replace an equal quantity of corn. SID = standardized ileal digestible.

Statistical Analysis

A preliminary analysis was conducted to evaluate means, variances, and the relationships among the daily feed intakes and 4 periods (1–5, 6–11, 12–16, and 17–21 d) using the correlation (CORR) procedure of SAS (SAS Institute Inc., Cary, NC). The sow DFI data were fitted to alternative forms of a generalized Michaelis-Menten function using the nonlinear mixed (NLMIXED) procedure of SAS (**GMM**, Lopez et al., 2000; Schinckel and Craig, 2002; Schinckel et al., 2010). The default maximum likelihood was used in the estimation and solution procedures. The GMM function has the form $DFI_{i,\,t}$ (kg/d) $= [DFI_0 + (DFI_A - DFI_0)(t/K)^C]/[1 + (t/K)^C]$, where DFI_A is asymptotic daily feed intake, DFI_0 is predicted daily feed intake at day = 0, i is lactation record, t is days of lactation, K is a parameter equal to the day of lactation at which one-half of the increase from DFI_0 to DFI_A is achieved $\{DFI_{i,\,k} = [(DFI_A + DFI_0)/2]\}$, and C is a unitless parameter related to changes in the rate in which daily feed intake increases with days of lactation (Lopez et al., 2000). This function has an inflection point: (IP, d) $= k[(C - 1)/(C + 1)]^{(1/C)}$, and the daily feed intake at the IP $= \{[1 + (1/C)]DFI_0\} + \{[1 - (1/C)]DFI_A\}$. In this function, the parameters DFI_A, DFI_0, K, and C can be considered as random effects.

The inclusion of a single random effect for DFI_A (dfi_{iA}) produces a series of feed intake curves in which each sow lactation record has an approximate constant percent (dfi_{iA}/DFI_A) greater or lesser DFI than the