

# Analysis of lactation feed intakes for sows with extended lactation lengths<sup>1</sup>

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**ABSTRACT:** The objectives of this research were to quantify and model daily feed intakes to 28 d of lactation in modern sows. A total of 4,512 daily feed intake (DFI) records were collected for 156 Hypor sows from February 2015 to March 2016. The mean lactation length was  $27.9 \pm 2.0$  d. The data included 9 parity 1, 33 parity 2 and 114 parity 3+ sows. Data were collected using a computerized feeding system (Gestal Solo, JYGA Technologies, Quebec, Canada). The feeding system was used to set an upper limit to DFI for the first 7 d of lactation. Overall, the least-squares means of a model including the random effect of sow indicated that DFI continued to slowly increase to 28 d of lactation. The DFI data were fitted to Generalized Michaelis-Menten (GMM) and polynomial functions of d of lactation (t). The GMM function  $\{DFI_{i,t} \text{ (kg/d)} = DFIO + (DFIA - DFIO)(t/K)C/[1 + (t/K)C]\}$  was fitted with 2 random effects for DFI ( $dfiA_i$ ) and intercept ( $dfi0_i$ ) using the NLMIXED procedure in SAS. The polynomial function  $DFI_{i,t} \text{ (kg/d)} = [B0 + B1 t + B2 t^2 + B3 t^3 + B4 t^4]$  was fitted with 3 random effects

for B0, B1, and B2 using the MIXED procedure in SAS. Fixed effects models of the 2 functions had similar Akaike's Information Criteria (AIC) values and mean predicted DFI. The polynomial function with 3 random effects provided a better fit to the data based on R2 (0.81 versus 0.79), AIC (14,709 versus 15,158) and RSD (1.204 versus 1.321) values than the GMM function with 2 random effects. The random effect for B2 in the polynomial function allowed for the fitting of the function to lactation records that had decreased DFI after 15 d of lactation. The random effects for the polynomial function were used to sort the lactation records into 3 groups based on the derivative of the function at 21 d of lactation. Lactation records of the 3 groups had similar DFI the first 2 wk of lactation ( $P > 0.40$ ). The 3 groups of sows had substantially different DFI after 18 d of lactation ( $P < 0.028$ ). The differences in both actual and predicted DFI between the 3 groups increased with each d of lactation to d 28 ( $P < 0.001$ ). Mixed model polynomial functions can be used to identify sows with different patterns of DFI after 15 d of lactation.

**Key words:** feed intake, lactation, nonlinear functions, sow

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## INTRODUCTION

Genetic selection for increased sow productivity including litter weaning weight and number of pigs weaned has increased the demand for milk production (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). The required dietary content of digestible amino acids and other nutrients is based on the sow's daily feed intakes (DFI). Currently there is limited data on the DFI of sows to 28 d of lactation; most recent studies with DFI records had 21 d lactation lengths (Schinckel et al., 2010; Cabezón et al., 2016). The objectives of this research were to quantify and model daily lactation feed intakes to 28 d of lactation in modern sows.

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## MATERIALS AND METHODS

Animal procedures were consistent with the Guide for the Care and Use of Animals in Agricultural Research and Teaching (FASS, 2010).

### *Animals and Housing*

Daily lactation feed intake records were collected in a commercial research farm in Quebec, Canada. Sows were housed in an environmentally controlled building with farrowing crates. A total of 4,512 DFI records were collected for 156 Hypor sows from February 2015 to March 2016. The mean lactation length of sows was  $27.9 \pm 2.0$  d. The data included 9 parity 1 (P1), 33 parity 2 (P2) and 114 parity 3+ sows (P3+). Data were collected using a computerized feeding system (Gestal Solo, JYGA Technologies, Quebec, Canada). The feeding system was used to set an upper limit at 1.20 times the past mean *ad-libitum* DFI for sows of each parity for each of the first 7 d of lactation. After d 7 of lactation, DFI was not restricted by an upper limit. The feeders are volumetrically based and calibrated to the gram for each farrowing group.

### *Statistical Methods*

A preliminary analysis was conducted to evaluate means, variances and the relationships among DFI and 4 periods (1 to 7, 8 to 14, 15 to 21 and 22 to 28 d) using the correlation (CORR) procedure of SAS (SAS Inst. Inc., Cary, NC.). Least square means of DFI for each d of lactation were obtained using repeated measures with a compound symmetry covariance structure and sow as a repeated random effect with the MIXED procedure of SAS. The DFI data were fitted to alternative forms of a Generalized Michaelis-Menten (GMM) function using the nonlinear mixed (NLMIXED) procedure of SAS (López 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 DFI,  $DFI_0$  is predicted DFI at  $d = 0$ ,  $t$  is d of lactation,  $K$  is a parameter equal to the d of lactation at which one-half of the increase from  $DFI_0$  to  $DFI_A$  is achieved  $\{DFI_{1,k} = [(DFI_A + DFI_0)/2]\}$  and  $C$  is a unit less parameter related to changes in the rate in which DFI increases with d of lactation (López et al., 2000). This function has an inflection point (IP, d) =  $K [(C - 1)/(C + 1)]^{(1/C)}$  and the DFI 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  $DFI_A$  ( $dfi_{iA}$ ) in the GMM function 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 mean DFI at each d of lactation. The inclusion of a second random effect for  $DFI_0$  ( $dfi_{0i}$ ) accounts for different DFI early in each sow's lactation. The addition of a random effect for C or K allows increased flexibility in fitting the between sow variance in the shape of the lactation curves. An alternative is to estimate the value for a random effect such as  $c_i$  or  $k_i$  as linear function of the random effect for  $DFI_A$  or  $DFI_0$  ( $dfi_{0i}$  or  $dfi_{Ai}$ ; Cabezón et al., 2016). For example, the value for  $k_i$  could be estimated based on its overall linear relationship with another random effect such as  $k_i = b_1 dfi_{Ai}$  or  $k_i = b_2 dfi_{0i}$ . Alternative mixed models of GMM function were evaluated based on residual standard deviation (RSD) and Akaike's Information Criteria (AIC) values. The inclusion of K or C as a linear function of  $dfi_{0i}$  or  $dfi_{Ai}$  in the 2 random effects model was also evaluated.

A polynomial function was fitted to the data with the form  $DFI_{i,t} = B_0 + B_1 t + B_2 t^2 + B_3 t^3 + B_4 t^4$ , using the MIXED procedure in SAS with an unrestricted covariance structure. Initially a fixed effect model of the polynomial function was fitted to the data. Then random effects were added to the model for the intercept ( $B_0$ ), linear regression coefficient ( $B_1$ ) and quadratic regression coefficient ( $B_2$ ) based on AIC values.

It should be noted when the random effect is multiplied by a quadratic variable, or more complex high ordered variables, the mean value for a group of records is not obtained by using the parameter estimates ( $B_0$  to  $B_4$  in the polynomial function). Instead, the predicted value for each record using the function parameters and the random effects for each record must be calculated. The mean of the predicted values is the value that represents the group mean. The predicted values of the mixed model polynomial function were outputted from the SAS MIXED procedure.

The coefficient of determination ( $R^2$ ) values for each model were calculated using the standard deviation of the actual and the error variance of the predicted observations. Both the MIXED and NLMIXED procedures provided predicted values for the random effect of each lactation record, variance estimates for each random effect and the residual variance.

Further investigation was done based on the solutions of the  $b_{1i}$  and  $b_{2i}$  random effects for the polynomial function. The derivative of the polynomial function was calculated for 21 d of lactation for each lactation record. Lactation records were sorted into 3 groups, records with a derivative less than  $-0.10$  kg/d<sup>2</sup> indicating a decrease in DFI (DECREASE), those with a derivative greater than  $0.10$  kg/d<sup>2</sup> indicating an

**Table 1.** Weekly daily feed intake means (kg/d) of lactating sows and correlations among the weekly means

Wk	Mean	SD	Pearson correlation coefficients		
			Wk 1	Wk 2	Wk 3
Wk 1	4.47	1.05			
Wk 2	7.26	1.52	0.62		
Wk 3	8.32	1.89	0.33	0.72	
Wk 4	8.77	2.14	0.34	0.64	0.79

increase in DFI (INCREASE) and those with intermediate values (greater than  $-0.10$  kg/d<sup>2</sup> and less than  $0.10$  kg/d<sup>2</sup>) indicating a small change in DFI after 21 d of lactation (SMALL CHANGE).

The DFI of groups by weeks and by days were tested using repeated measures with compound symmetry covariance structure and sow as the repeated random effect with the MIXED procedure in SAS. The model included group, weeks or days, parity and their interactions as fixed effects. The slice option in SAS was used to evaluate group effect in each wk or d, after a two-way interaction involving the group and wk or d effect was found significant. Rate of change in DFI at 21 d (kg/d<sup>2</sup>) and the mean difference on DFI between wk 4 and 3 (kg) were tested for significant differences among the 3 lactation groups using the MIXED procedure in SAS. The model included groups of sows as a fixed effect.

## RESULTS AND DISCUSSION

The average lactation length was  $27.9 \pm 2.0$  d. Mean DFI averaged  $7.18 \pm 2.75$  kg/d. The mean and SD for DFI progressively increased with each wk of lactation (Table 1). Feed intake increased rapidly the first wk, increased at a decreased rate to d 17 of lactation and then very gradually increased to 28 d of lactation. Similar patterns of increasing DFI during lactation were found for gilts restricted fed during gestation (Revell et al., 1998; Weldon et al., 1994a). Shurson and Irvin (1992) found DFI of 2.23, 3.41, 3.72, and 3.92 kg/d for Duroc sows and DFI of 3.37, 4.83, 5.09 and 4.67 kg/d for Landrace sows from wk 1 to 4. Cabezón et al. (2016) reported mean DFI of 5.24, 6.50, 7.12 and 7.39 kg for d 1 to 5, 6 to 11, 12 to 16 and 16 to 21 of lactation. The DFI in this trial with genetically improved crossbred sows was substantially greater than the purebred sows of Shurson and Irvin (1992). Current genetically improved crossbred sows have greater milk production, lactation feed intakes, overall metabolic rates and heat production than past sows (Cabezón et al., 2017a). The mean results of Cabezón et al. (2016) were taken in the summer months in Chile. The DFI of the sows of Cabezón et al. (2016) for the coolest days of the summer were similar to the first 21 d in this trial.

The DFI achieved from d 2 to d 7 of lactation were approximately at 74 to 76% of the upper DFI allowed by the electronic feeding system. The upper limit allowed by the feeding system had minimal impact to reduce the mean or variation in DFI the first 7 d of lactation.

The coefficients of variation (CV) were similar for the 4 weekly means ranging from 20.9 to 24.4%. Cabezón et al. (2016) found CV's of 16.4 to 23.0% for the mean DFI of 4 5-d periods of 21 d lactation records. The correlation between the mean DFI of the first and second wk of lactation was greater ( $r = 0.62$ ) than the correlations of the first wk to mean DFI on wk 3 and 4 ( $r = 0.33$  and  $r = 0.34$ , respectively). The correlations of the mean DFI between the second, third and fourth wk ranged from 0.64 to 0.79. These correlations are an indicator of the repeatability of the DFI and variation between sows during the early and late d of lactation (Cabezón et al., 2016). The current DFI data suggest that 2 sources of variation are present, one at the beginning and one at the end of lactation, and the two sources of variation are only weakly related.

### Nonlinear Functions and Random Effects

The fixed effects models for the GMM and the polynomial functions had similar AIC and RSD values (Table 2). The polynomial function included the linear, quadratic, cubic and quartic effects of d of lactation. The final mixed model for the GMM function included 2 random effects. The random effect for DFI<sub>A</sub> ( $dfi_{Ai}$ ) was the first random effect added to the GMM function. The addition of the 2 random effects,  $dfi_{Ai}$  and  $dfi_{0i}$  significantly improved the fit of the GMM function to the data. No solution for a 3 random effect or 2 random effect models with a third parameter (C or K) as a linear function of a random effect ( $dfi_{Ai}$  and  $dfi_{0i}$ ) was achieved. Without a random effect for C or K, the DFI curves for each lactation record had similar shape. It should be noted with a value of C less than 1.0, there is no inflection point and the rate in which DFI increased each d of lactation was always decreasing (first derivative always negative and decreasing with d of lactation, (López et al., 2000). Past research have reported values of C of approximately 1.6 and inflection points at d 2 of lactation (Schinckel et al., 2010; Cabezón et al., 2016).

The final model for the polynomial function included the linear, quadratic, cubic and quartic effects of d of lactation and three random effects;  $b_{0i}$ ,  $b_{1i}$ , and  $b_{2i}$  based on AIC values. The random effects account for variation in the intercept, linear regression coefficient and quadratic regression coefficient. The polynomial function with 3 random effects provided a better fit to the data based on  $R^2$  values, AIC values and RSDs than the GMM function with 2 random effects. The mean

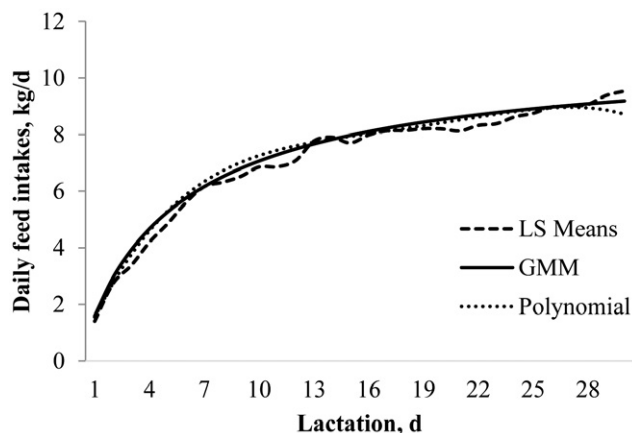
**Table 2.** Parameter estimates and statistics for the generalized Michaelis-Menten (GMM) and polynomial functions

Item <sup>1,2</sup>	Estimate	SE	P-value	R <sup>2</sup>	RSD <sup>3</sup>	AIC
GMM, fixed effects						
DFI <sub>A</sub>	10.174	0.415	< 0.001	0.46	2.006	17,941
DFI <sub>0</sub>	-0.690	0.850	0.4174			
C	1.045	0.147	< 0.001			
K	4.011	0.466	< 0.001			
GMM, 2 general random effects (dfi <sub>Ai</sub> and dfi <sub>0i</sub> )						
DFI <sub>A</sub>	11.013	0.473	< 0.001	0.79	1.321	15,158
DFI <sub>0</sub>	-0.547	0.623	0.381			
C	0.928	0.099	< 0.001			
K	4.934	0.353	< 0.001			
Var (dfi <sub>Ai</sub> )	6.246	1.023	< 0.001			
Var (dfi <sub>0i</sub> )	3.741	0.900	< 0.001			
Cov (dfi <sub>Ai</sub> , dfi <sub>0i</sub> )	-3.114	0.890	< 0.001			
Var (e)	1.746	0.039	< 0.001			
Polynomial function, fixed effects						
B <sub>0</sub>	0.3099	0.197	< 0.001	0.46	2.008	17,953
B <sub>1</sub>	1.4397	0.085	< 0.001			
B <sub>2</sub>	-0.1064	0.0112	< 0.001			
B <sub>3</sub>	0.00366	0.00055	< 0.001			
B <sub>4</sub>	-0.00005	0.00001	< 0.001			
Polynomial function, 3 general random effects (b <sub>0i</sub> , b <sub>1i</sub> and b <sub>2i</sub> )						
B <sub>0</sub>	0.1483	0.158	0.3487	0.81	1.204	14,709
B <sub>1</sub>	1.5212	0.0560	< 0.0001			
B <sub>2</sub>	-0.1181	0.00695	< 0.0001			
B <sub>3</sub>	0.00428	0.00035	< 0.0001			
B <sub>4</sub>	-0.00006	0.0000058	< 0.0001			
Var (b <sub>0i</sub> )	1.6024					
Var (b <sub>1i</sub> )	0.05599					
Var (b <sub>2i</sub> )	0.000056					
Cov (b <sub>0i</sub> , b <sub>1i</sub> )	-0.1921					
Cov (b <sub>0i</sub> , b <sub>2i</sub> )	0.005118					
Cov (b <sub>1i</sub> , b <sub>2i</sub> )	-0.00162					

<sup>1</sup>Function has the form  $DFI_{i,t} = DFI_0 + (DFI_A - DFI_0)(t/K)^C / [1 + (t/K)^C]$  where  $DFI_{i,t}$  is daily feed intake (kg/d) *i*th lactation at *t* d of lactation,  $DFI_A$  is asymptotic daily feed intake (kg/d),  $DFI_0$  is daily feed intake at  $d = 0$ ,  $t = d$  of lactation,  $K$  is parameter related to  $d$  of lactation than one half of the increase from  $DFI_0$  to  $DFI_A$  is achieved,  $C$  is a unitless parameter,  $dfi_{Ai}$  is a random effect for  $DFI_A$  and  $dfi_{0i}$  is a random effect for  $DFI_0$ .

<sup>2</sup>Function has the form  $DFI_{i,t} = B_0 + B_1 t + B_2 t^2 + B_3 t^3 + B_4 t^4$  where  $DFI_{i,t}$  is daily feed intake (kg/d) *i*th lactation record at *t* d of lactation.

<sup>3</sup>RSD is the residual standard deviation, AIC is the Akaike's Information Criteria.

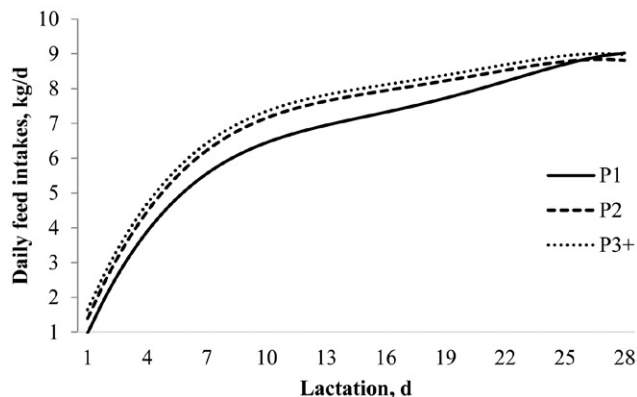


**Figure 1.** Daily feed intake (kg/d) least squares means and mean predicted values for the Generalized Michaelis-Menten (GMM) and Polynomial mixed model equations.

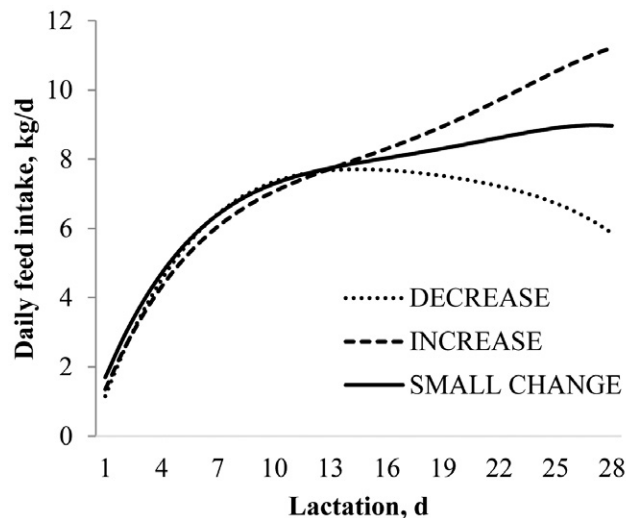
predicted values for the polynomial and GMM mixed model are shown in Fig. 1. Overall the mean predicted values for the 2 functions are nearly identical.

The solution of the random effect for  $B_2$  allows the polynomial function to fit sows with different shaped DFI curves during lactation. The solution of the random effect for  $B_2$  in the polynomial function allowed for the fitting of the function to data for sows that had decreased DFI after 21 d of lactation and for the P1 that had an initially slower increase in DFI from d 1 to 12 of lactation (Fig. 2).

The derivative of the polynomial function was calculated for 21 d of lactation to sort the records into 3 groups (DECREASE, INCREASE and SMALL CHANGE). This resulted in 22 records with decreased DFI, 29 with increased DFI and 105 records with de-



**Figure 2.** Predicted daily feed intakes (kg/d) for parity 1 (P1), parity 2 (P2) and parities 3 and greater (P3+) sows from the mixed model Polynomial function.



**Figure 3.** Mean predicted daily feed intakes for sows sorted into groups based on their predicted change in daily feed intake at 21 d of lactation. DECREASE records have derivative for the polynomial function of less than  $-0.1 \text{ kg/d}^2$ , INCREASE have a derivative of greater than  $0.1 \text{ kg/d}^2$  and SMALL CHANGE a derivative intermediate to the other 2 groups.

derivatives close to zero (Table 3). Lactation records of the three groups had similar DFI the first 2 wk of lactation ( $P > 0.40$ ). The three groups of records had different DFI on wk 3 and wk 4 of lactation. ( $P = 0.009$  and  $P < 0.001$ , respectively). The differences among the 3 groups for wk 4; 6.86, 9.06 and 10.73 kg/d for DECREASE, SMALL CHANGE and INCREASE groups of lactation records, respectively, were substantial ( $P < 0.001$ ). An analysis of the DFI indicated that the DFI of the 3 groups of lactation records started to separate at d 15 of lactation and were different after d 18 of lactation ( $P < 0.028$ , Fig. 3). The differences in both actual and predicted DFI between the 3 groups increased with each d of lactation to d 28. Both the rate of change in DFI at 21 d and the mean difference on DFI between wk 4 and 3 were significantly different among the 3 groups of sows ( $P < 0.001$ ). The overall mean for the estimated change in feed intake per d at d 21 of lactation was  $0.0008 \pm 0.1240 \text{ kg/d}^2$ . The overall mean difference on DFI between wk 4 and 3 was  $0.45 \pm 1.32 \text{ kg/d}$ . The mean overall correlation between the rate of change in DFI at 21 d and the mean difference on DFI between wk 4 and 3 was 0.77.

It is possible that some of the variation in DFI may be due to differences in body composition of the sows at the time of farrowing. Sows with greater body fatness at farrowing have decreased lactation DFI with substantially reduced DFI the first wk of lactation (Dourmad, 1991; Revell et al., 1998; Weldon et al., 1994a; b). After the first wk of lactation the DFI of the sows with greater body fatness increases with each d of lactation with a consistent reduction in DFI relative to leaner sows.

The required dietary content of digestible amino-acids and other nutrients for lactating sows is based on the sow's estimated milk production and the sow's DFI each d of lactation (NRC, 2012). Also, the dietary requirements must also consider the body composition of the sow at farrowing and the change in body composition during lactation. These results indicate that substantial variation exists between sows for DFI as the weekly means had CV over 20%. The DFI are

**Table 3.** Least-squares means for the lactation records grouped by their predicted rate of change in DFI at 21 d of lactation

Feed intake variable	Group of lactation records <sup>1</sup>						P-value
	DECREASE		SMALL CHANGE		INCREASE		
	LS Means	SE	LS Means	SE	LS Means	SE	
# Lactation records	22		105		29		
Wk 1, kg/d	4.17	0.33	4.39	0.19	4.02	0.30	0.40
Wk 2, kg/d	7.52	0.33	7.52	0.19	7.38	0.30	0.89
Wk 3, kg/d	7.76	0.33	8.41	0.19	8.96	0.30	0.009
Wk 4, kg/d	6.86	0.33	9.06	0.19	10.73	0.30	< 0.001
Overall, kg/d	6.58	0.32	7.34	0.19	7.77	0.29	0.006
(Wk 4 to Wk 3), kg/d	-1.47	0.22	0.57	0.10	1.47	0.19	< 0.001
Slope at 21 d, kg/d <sup>2</sup>	-0.210	0.014	0.002	0.007	0.158	0.012	< 0.001

<sup>1</sup>DECREASE lactation records had a derivative for the mixed model polynomial function of less than  $-0.1 \text{ kg/d}^2$ , INCREASE lactation records had derivative of greater than  $0.1 \text{ kg/d}^2$  and SMALL CHANGE records being intermediate to the other 2 groups.

moderately repeatable after the second wk of lactation. In this data, the sows were sorted into 3 groups with drastically different DFI the last 2 wk of lactation. If the 3 groups of sows have similar milk production levels, the estimated dietary concentration of amino acids requirements for the 3 groups are substantially different. Most models of sow lactation requirements estimate the mean nutrient requirements for a group of sows and have not considered the variation in milk production and DFI between sows (NRC, 2012). Larger datasets with more complete records are needed to estimate the relationship between litter growth rates and estimated milk production with the variation in the lactation DFI curves and subsequent variation in estimated SID amino acid requirements during different phases of lactation. With substantial variation in litter weight gain and DFI, a stochastic model used with a system of daily updating could result in more precise feeding of individual sows during lactation. Also, the DFI records could be fitted to a polynomial function in real time and identify sows that from d 15 to 18 whose DFI are beginning to decrease. A reduction in DFI could be related with lameness, health issues and result in impaired subsequent reproductive performance.

It should be noted that the fixed effects model of the 2 functions and the predicted values for the mixed model GMM and polynomial functions had nearly identical mean predicted DFI. Based on analyses of lactation DFI, the GMM function fits the overall mean DFI data (Schinckel et al., 2010; Cabezón et al., 2016). The simultaneous solution of the random effects for  $B_1$  and  $B_2$  allow the polynomial function to fit the DFI data for subpopulations of sows that have either decreased or substantially increased DFI after 15 to 18 d of lactation than the overall population of sows.

Selection for increased litter size and improved milk production has increased the heat production of modern sows (Stinn and Xin, 2014). Heat production is a function of both milk production and the heat increment of feeding (NRC, 2012; Cabezón et al., 2017a). A model of heat production has estimated that greater than 90% of the variation in heat production among sows in late lactation is due to variation in DFI (Cabezón et al., 2017a). The variation in DFI from 14 to 28 d of lactation indicates substantial variation in the sows' heat production during late lactation. New technologies to remove the excess heat production of lactating sows in high environmental temperatures should account for the substantial variation in heat production among sows (Cabezón et al., 2017a; b).

Continued selection for increased litter weight gain and improved milk production may result in sows with greater mobilization of body tissues, both protein and lipid, during lactation (Sauber et al., 1998; Eissen et al.,

2003; Bergsma et al., 2008). Alternatives strategies for genetic selection could include: 1) selection for increase lactation DFI or shape of the DFI curve, 2) measurement and selection of sows with decreased lactation protein loss, and 3) selection of sows which are more able to cope with numerous stressors of farrowing (Mosnier et al., 2009). The random effects of the polynomial function could be used as a possible criteria for selection.

Overall DFI increased with each d of lactation to 28 d. Both the GMM and polynomial function provided good fit to the population mean DFI. A mixed polynomial model provided the best fit to the lactation DFI data as some sows had decreased DFI after 15 d of lactation. The analyses indicated 3 groups of sows that had substantially different DFI after approximately 15 d of lactation. The substantial differences in DFI suggest high variation in the individual sow's nutrient requirements and heat production. In combination with estimates of sow BW and body composition, the collection and analysis of DFI records by recently developed electronic feeders could be used to improve lactation management and genetic selection.

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