Genetic parameters of feed intake patterns of Duroc sows during gestation and lactation

M. Helal[2], M. Ragab[1,3] & J.P. Sánchez[1]

[1]*Genetica i Millora Animal, IRTA, Torre Marimon, Caldes de Montbui, 08140 Barcelona, Spain.*
[2]*Animal Production Department, Fac. Agriculture, Cairo Univ., Giza, 12613, Egypt.*
Mostafa.helal@agr.cu.edu.eg (Corresponding Author)
[3]*Poultry Production Department, Kafer El-Sheikh Univ., Kafer El-Sheikh, 33516, Egypt.*

Abstract

This study aimed at elucidating the genetic parameters of feed intake traits of 663 Duroc sows during 2 gestation and lactation periods and their relationship with number of piglets born alive (NBA) using tri-variate analyses. FI was calculated for lactation period (FI_{lac}), early gestation (FI_{1-40}), and late gestation (FI_{41-105}) which thereafter was separated to FI_{41-80} and FI_{81-105}. High variability was noticed for FI_{1-40} and FI_{81-105}, very low variability was observed for FI_{41-80}. Heritability estimates were generally low and ranged from 0.025 to 0.069 for daily FI during gestation. For daily lactation FI it was 0.117 and 0.211 for NBA. Positive genetic correlations were obtained between FI during middle-late gestation and FI_{lac}. Positive genetic correlations were obtained between early-middle gestation FI (0.99-0.64) traits and NBA. Nearly null genetic correlation between NBA and FI_{lac} was obtained (0.09).

Keywords: gestation, lactation, sow feed intake, heritability, correlation

Introduction

Feed intake is a key factor in the economic and sustainable pig industry. However, feed intake of sows during gestation and lactation periods did not received much research attention perhaps because it represents only 15-17% of the total feeding costs which are estimated by 68% the total variable production costs (Solà-Oriol & Gasa, 2016). During gestation and lactation periods, adequate FI levels prevent excessive mobilization of nutrients from body stores (Yoder *et al.*, 2014) which increases sow longevity. FI during gestation is changing according to the stage of gestation which supports the theory of multi-phase feeding strategy during that period (Jackson, 2009, McPherson *et al.*, 2004). Studies have demonstrated considerable genetic variation for FI traits during lactation (Bergsma *et al.*, 2008, Hermesch, 2007). However, little is known about the genetic parameters of FI of pregnant sows. Therefore, there is a lack of knowledge about the genetic relationships between FI during gestation and lactation periods. Accordingly, the aim of this study is to estimate the genetic parameters of feed intake patterns during gestation and lactation periods and their relationship with prolificacy traits.

Material and methods

Animals and dataset

Animals used in this study come from a Duroc line (Tibau *et al.*, 1999), which was subjected to selection since 1991 using an index including weight at off test, approximately 180 days (W180), backfat thickness at off test (BF180), number born alive (NBA) and number of functional teats (NT). In this study, a total number of 663 sows belonged to different parity orders were used. Individual feed intake (FI), body weight (BW) and backfat (BF) were recorded during gestation and lactation periods, and the obtained number of born alive (NBA) was also recorded for each sow. Changes in BF (ΔBF) was calculated as the difference (mm) between BF just before parturition and BF just after AI.

FI data at early gestation (until approximately 40 days of gestation) and during lactation were manually recorded 3-4 times per weeks. For middle and late lactation FI records were retrieved from the feeding devices used to provide feed to the sows housed in groups. FI data were edited by keeping records during gestation and lactation periods, daily FI records lower than 1.6 kg (about 1% of the data) and outliers were treated as missing values. Also, data recorded after 105 days of gestation were eliminated to avoid the high FI variability resulted by pre-parturition time. Daily FI records until 28 days of lactation were only considered. Daily FI was predicted for days without record during lactation (FI_{lac}) and early gestation (FI_{1-40}) using 3rd degree Legendre Polynomial function. Late gestation daily FI missing records (FI_{41-105}) were predicted using 6th degree Legendre Polynomial function. Thereafter this period was divided to calculate two separated daily FI traits: FI_{41-80} and FI_{81-105}. In addition, a single gestation daily FI trait (FI_{1-105}) was defined combining FI throughout all the gestation.

Statistical Analysis Models

Tri-variate animal repeatability models were used to analyse the indicated traits, in these models FI_{lac} and NBA were always considered in the analysis and in addition one daily gestation FI trait was fitted. The model used for NBA and gestation daily FI was:

$$y_{ijklm} = P_i + B_j + S_k + \beta_1 \mathrm{BW} + \beta_2 BF + \beta_3 \Delta BF + \beta_4 \, Age + a_l + p_l + e_{ijklm}$$

where Y_{ijklm} denotes the value of the trait during the reproductive cycle i^{th} of animal l^{th}, in batch j^{th} and season k^{th}. The fixed effects were: reproductive cycle (P_i, 5 levels: 1st, 2nd, 3rd, 4th-6th and > 6th); batch (B_j, 25 levels); season (S_k, 3 levels) and partial regressions on BW, age, BF and ΔBF (β_1, β_2, $\beta_3$and β_4, respectively). The random part of the model includes the additive genetic and permanent environmental effects of the sow l (a_l, p_l) .The term e_{ijklm} is the residual of the model. The model for lactation daily FI was the same as that previously described but in addition it included the effect of the lactation length. Random effects were assumed to be independent, but the same random effect was assumed correlated between traits. The prior distribution of the additive genetic values and permanent effects were $\boldsymbol{a}|\boldsymbol{G} \sim MVN(\boldsymbol{0}, \boldsymbol{A} \otimes \boldsymbol{G})$ and $\boldsymbol{p}|\boldsymbol{P} \sim MVN(\boldsymbol{0}, \boldsymbol{I} \otimes \boldsymbol{P})$ where $\boldsymbol{A}$ is the matrix of coefficients of relatedness between individuals, ⊗ denotes the Kronecker product, $\boldsymbol{G}$ is the 3x3 additive genetic covariance matrix, $\boldsymbol{P}$ is the corresponding 3x3 covariance matrix and $\boldsymbol{I}$ is the appropriate identity matrix. For all analyses, statistics of the marginal posterior distributions of all unknown parameters were obtained using the Gibbs Sampling algorithm. The software used for Gibbs Sampling was gibbs2f90 (Misztal *et al.*, 2002). Chains of 200,000 samples were run and the first 20,000 iterations were discarded, one out 100 iterations was retained.

Results and discussion

Descriptive statistics are presented in Table 1. During gestation period the variability of FI was high during early gestation, decreased to nearly null values in mid gestation, and increased again in late gestation. The same trend was also observed for FI averages as it was 2.29 kg/d/sow in FI_{1-40}, then decreased about 20% during FI_{41-80}, and reached 2.73 kg/d/sow in FI_{81-105} period. These patterns are compatible with the feed restriction the sows are subject to. The average daily lactation FI was 5.87 kg/d/sow.

Table 1. Mean, SD, minimum, maximum and number of records (N) for traits and covariates.

Trait/Covari	Mean	SD	Minimum	Maximum	N
FI_{1-40}	2.29	0.24	1.62	2.91	1094
FI_{41-80}	1.84	0.04	1.6	1.94	1062
FI_{81-105}	2.73	0.11	1.81	3	1062
FI_{41-105}	2.18	0.06	1.69	2.35	1062
FI_{1-105}	2.23	0.12	1.77	2.51	1097
FI_{lac}	5.87	0.52	3.55	7.21	948
NBA	11.34	3.06	1	19	1092
BW	222.3	23.7	148.5	358.5	1081
Age	652	254	251	1433	1097
BF	16.36	3.71	7	31	1098
ΔBF	3.07	2.92	-12	18	992

Heritability estimates for all traits are presented in Table 2. Heritability estimates for daily FI during gestation are nearly null. Lactation daily FI was also low but slight higher (0.117). Low lactation FI heritability (0.14) was also reported in pigs (Bergsma *et al.*, 2008). Hermesch (2007) reported similar h^2 estimates, and they also observed an increasing trend with the lactation time. Moderate heritability (0.21) was estimated for NBA, similar h^2 (0.15) was reported by Abell *et al.* (2012). Low positive genetic correlation (0.09) was found between NBA and daily lactation FI (not reported in tables). Hermesch *et al.* (2008) reported positive genetic correlation between daily lactation FI and NBA.

Table 2. Posterior means (SD) of genetic parameters for the different traits.

Trait	h^2 (SD)	P^2 (SD)	Residual (SD)
FI_{1-40}	0.025 (0.019)	0.024 (0.022)	0.0269 (0.0001)
FI_{41-80}	0.054 (0.030)	0.031 (0.033)	0.0004 (0.00002)
FI_{81-105}	0.069 (0.036)	0.064 (0.053)	0.0051 (0.0004)
FI_{41-105}	0.061 (0.032)	0.056 (0.056)	0.0015 (0.0001)
FI_{1-105}	0.040 (0.024)	0.040 (0.025)	0.0045 (0.0002)
FI_{lac}	0.117 (0.046)	0.196 (0.058)	0.1091 (0.0083)
NBA	0.211 (0.050)	0.093 (0.042)	6.1608 (0.3949)

Genetic, permanent and residual correlations between gestation daily FI traits are presented in Table 3. High positive genetic correlations were observed between gestation daily FI traits and NBA, particularly when considering FI at early gestation, or the whole gestation period. Positive genetic correlations were obtained between FI_{lac} and daily middle (FI_{41-80}) or late (FI_{81-105}) gestation FI, this correlation with early gestation daily FI was null. When the whole gestation was considered (FI_{1-105}), the correlation with FI_{lac} cannot be discarded to actually be positive, although the posterior mean is negative. Weldon *et al.* (1994) reported a negative phenotypic relationship between daily FI during gestation and lactation. Permanent correlations had large errors and the only ones that can be said to be different from zero are FI_{lac} -FI_{1-40} and FI_{lac} -FI_{1-105}, in both cases negative. In spite of these results it has to be noted that given the low variability and heritability of gestation daily FI traits the aforementioned estimates of genetic correlations do not have much relevance. In fact our major conclusion is that gestation FI data are of limited interest to genetically modify efficiency of the sows, being much more promising to consider lactation FI data as well as backfat thickness and body weight evolution.

Table 3. Posterior means (SD) of genetic, permanent and residual correlations.

	Genetic		Permanent		Residual	
	FI_{lac}	NBA	FI_{lac}	NBA	FI_{lac}	NBA
FI_{1-40}	0.14(0.27)	0.99(0.0.1)*	-0.78(0.27)*	0.37(0.49)	-0.03(0.05)	-0.02(0.04)
FI_{41-80}	0.63(0.31)*	0.64(0.31)*	-0.26(0.59)	0.11(0.61)	-0.02(0.06)	-0.04(0.05)
FI_{81-105}	0.82(0.25)*	0.45(0.30)	-0.31(0.51)	0.39(0.58)	-0.01(0.06)	-0.06(0.05)
FI_{41-105}	0.81(0.27)*	0.45(0.31)	-0.10(0.42)	0.50(0.63)	-0.02(0.06)	-0.06(0.05)
FI_{1-105}	-0.35(0.54)	0.68(0.26)*	-0.74(0.31)*	0.27(053)	0.04(0.05)	0.01(0.04)

* Probability of being greater that 0 > 0.95 or <0.05.

Acknowledgements

This study has been funded by the Spanish research project RTA2014-00015-C02-01 and by Feed-a-Gene Project, funded from the European Union's H2020 Programme under grant agreement no 633531.

List of References

Abell, C.E., J.W. Mabry, J.C.M. Dekkers & K.J. Stalder, 2012. Genetic and phenotypic relationships among reproductive and post-weaning traits from a commercial swine breeding company. Livest Sci. 145(1): 183-188.

Bergsma R., E. Kanis, M. Verstegen & E. Knol, 2008. Genetic parameters and predicted selection results for maternal traits related to lactation efficiency in sows. J Anim Sci. 86: 1067-1080.

Hermesch S., 2007. Genetic analysis of feed intake in lactating sows. In: *Association for the Advancement of Animal Breeding and Genetics*, pp. 61-64.

Hermesch, S., R.M. Jones & K.L. Bunter, 2008. Feed intake of sows during lactation has genetic relationships with growth and lifetime performance of sows. In *Pig Genetics Workshop Notes*, pp. 55-65.

Jackson A.S., 2009. Practical control of sow feed costs. Adv Pork Prod. 20: 75-80.

McPherson R., F. Ji, G. Wu, J. Blanton & S. Kim, 2004. Growth and compositional changes of fetal tissues in pigs. J Animl Sci. 82: 2534-2540.

Misztal I., S. Tsuruta, T. Strabel, B. Auvray, T. Druet & D. Lee, 2002. BLUPF90 and related programs (BGF90). In: *Proceedings of the 7th world congress on genetics applied to livestock production.* Montpellier, Communication No. 28–27.

Solà-Oriol D. & J. Gasa, 2016. Feeding strategies in pig production: Sows and their piglets. Anim Feed Sci Technol. (*In Press*).

Tibau, J., J. Reixach, & M.T. Batallé, 1999. Tendencias geneticas en lineas maternales de raza Duroc. ITEA.

Weldon, W.C., A.J. Lewis, G.F. Louis, J.L. Kovar, M.A. Giesemann & P.S. Miller, 1994. Postpartum hypophagia in primiparous sows: I. Effects of gestation feeding level on feed intake, feeding behavior, and plasma metabolite concentrations during lactation. J Anim Sci. 72(2): 387-394.

Yoder, C.L., V.M. Duttlinger & T.J. Baas, 2014. Estimates of genetic parameters associated with lactation feed intake and reproductive performance in purebred and F1 sows. J Anim Breed Genet. 131(4): 294-304.