Feeding behaviour traits recorded during gestation are heritable even though feed intake itself is restricted

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Summary

Data obtained from electronic sow feeders during the gestation period were used to investigate feed intake and feeding behaviour traits from 3785 predominantly (89.9%) F1 sows. Estimates of heritability, permanent environmental effect of the sow and phenotypic variance were obtained for seven distinct time periods during gestation for average feed intake (AFI), daily time spent eating (AFT), rate of feed consumption (AFR), the number of feeding events (AFE) and total born (TB) piglets. As expected, heritability estimates for feed intake traits such as AFI1-AFI7 were not different from zero, which can be explained by the restricted feed allocation (rather than *ad libitum* feeding). In the same time periods, heritabilities for the amount of time sows spent eating were low to moderate: lowest at the beginning (0.12±0.03) and at the end of gestation (0.16±0.04) and highest in the middle of gestation (range: 0.16 to 0.27). The same pattern was found for the rate of feed consumption. Further investigation of these feeding behaviour traits is warranted with respect to their associations with reproductive performance outcomes, given that they represent potential limitations to sows' ability to consistently meet their nutritional requirements over time.

Keywords: gestation, ESF, feed intake, feeding behaviour, sows, heritability

Introduction

Traits that reflect feeding behaviour patterns include the number of visits within a day, feed intake per visit or per day, time spent for each feeding event, total eating time per day as well as the rate of feed consumption (Cassady *et al.*; Labroue *et al.*, 1997). With the development of electronic sow feeders (ESF) in the 1980s, it became possible to record feed intake of sows on an individual level (Chapinal *et al.*, 2008). Recording and evaluating feed intake of sows, and possible deviations from a given feeding curve could, for example, be the first indicator on an individual level of compromised health status (Cornou *et al.*, 2008). In this study we examined genetic parameters for feed intake and feeding behaviour traits recorded during the gestation period for sows housed in a large dynamic groups fed using ESF.

Material and methods

The data were part of routine feed intake recording by Rivalea Australia Pty Ltd during the period of one year (January-December 2015) from a gestation housing system with large dynamic groups. Sows with feed intake records were predominantly (89.9%) F1 (Large White x Landrace, PrimeGro™ Genetics, Corowa, NSW) females. The majority of sows (91.7%)

had known parentage. In total, there were 3785 sows from 251 sires and 2268 dams recorded over 6132 mating events. Sow feed was delivered using ESF manufactured by Rivalea Australia. Sows were trained to use ESF as gilts prior to their first entry into the gestation groups. The amount of feed delivered to individual sows was based on standard feeding curves, which were constructed separately for first vs higher parity sows. These feeding curves were not altered seasonally, but the feeding curve could be adjusted for individual sows, if required. Intake for individual sows was controlled through recognition of individual sow identification tags using RFID by the ESF. Non-feed delivery events were not recorded by these feeders.

Data from all individual feeding events (about 1 million records) were used to construct a range of traits for individual sows. Preparation of the data included eliminating duplicates, combining adjacent events (within 60 seconds) into one feeding event, adding in missed events (a zero daily intake) if a one day gap occurred between two feeding events, and accumulating all daily feeding events into a single daily record per sow. From originally 4106 sows, 3785 sows with known outcomes from 6132 mating events were included in analysis (92% of sows). Sows with unknown outcomes were generally due to the loss of identification tag.

The gestation period was arbitrarily divided into seven groups, based on days of gestation: 1-7 (Group 1), 8-14 (Group 2), 15-35 (Group 3), 36-90 (Group 4), 91-100 (Group 5), 101-105 (Group 6) and more than 105 days of gestation (Group 7). Groups were arbitrarily constructed to align them with both specific periods of interest and changes to the feed delivery curve on days 35 and 90 of gestation. Data in this study included average daily feed intake recorded for each stage of gestation (AFI1-AFI7), time spent feeding (AFT1-AFT7), rate of feed consumption (FR1-FR7), calculated as AFI/AFT within each observed period, average feed intake for all of the observed sows per mating event (AFIALL), along with average feed intake (AFI), average feeding time (AFT), average number of feeding events per day (AFE) and average rate of feed consumption (AFR) for sows with more than 90 days of records. The counts of missed feeding events (MISSF), daily feeding intake below 1 kg (BELOW1), and feeding events above 30 minutes (ABOVE30) over all records, along with total born piglets (TB) were also obtained.

Data preparation and analysis were performed using R (R Core Team, 2016). F-tests were used to assess the significance of systematic effects and/or their interaction; effects that were significant at $P<0.05$ were retained in models for analyses. Systematic effects evaluated included sow line (5 levels), mating year-month (16 levels), parity group (4 levels), diet (2 levels) and shed-pen (12 levels). For all the feed related traits, significant systematic effects included parity group, diet, mating year-month and pen-shed. Sow line was added to this model for AFI4 and AFT3, MISSF, BELOW1, and AFIALL. Mating year-month, parity group and shed-pen were significant for TB. Random effect models were developed and parameter estimates were obtained using ASReml (Gilmour *et al.*, 2014). Estimates of variance components were performed under a linear mixed animal model by residual maximum likelihood procedures. Univariate analyses were performed for estimation of genetic parameters. Inclusion of the permanent environmental effect of the sow to accommodate repeated records per sow was tested using the likelihood ratio test (Mrode, 2005).

Results and discussion

Not all sows had complete intake data in all time periods during gestation because the data commenced with groups of mixed gestational age, or because sows were removed from the group if they were unsuited to the ESF system (i.e. failed to eat), or because sows could not complete their gestation within the time period examined.

Raw data characteristics

Overall means are presented in Tables 1 and 2. The average daily feed intake, amount of time sows spent eating and the rate of feed consumption were the highest at the beginning of gestation (2.63±0.27, 16.0±4.86 and 180±63.3), and the lowest in the middle of gestation (2.09±0.13, 14.1±3.95 and 158±42.1), mirroring changes in feeding curves. Feed intakes were lower than the allocated feeding curve predominantly in periods 1 (-0.13 kg/day) and 4 (-0.15 kg/day). The average number of feeding events over all sow-mating events was 1.16±0.13, reflecting that most sows ate only once per day. The average count of missing feeding events during the gestation period was 3.45±3.41. However, this did not always represent a reduction in feed intake below the sow's allocation because sows could eat twice in one calendar day (typically close to midnight), consuming allocations from 2 days within 1 day, resulting in them missing the following day.

Based on calculated coefficients of variation (CV), variability in average daily feed intake was lower than variability in time spent eating or the rate of feed consumption within all time periods. Variability in the time spent eating or rate of feed intake was the highest at the beginning and at the end of the gestation and lowest in mid-gestation (Table 1). High variability at the start of gestation probably reflects disruption in feeding activity due to group construction, while at the end of gestation could represent increasing variability between sows in their physical capacity to eat or access the feeders.

The model R^2 was the lowest for the amount of time sows spent eating per day, 3.0-9.5% (Table 1) and rate of feed consumption, showing a low accuracy of the model for predicting time spent eating. Model R^2 were also relatively low for the average number of feeding events (5.3%), missing feeding events (18.4%) or feeding events below 1 kg (24.2%) (Table 2). In contrast, the model almost perfectly explained average feed intakes for sows which had a lot of feed intake data (R^2 90.2%, Table 2), demonstrating that most sows eat their allocation of feed averaged over days.

Parameter estimates

Currently, there is limited literature regarding genetic parameters for feed intake and feed intake behaviour traits of group housed gestating sows. Heritability estimates for average daily feed intake under restricted feeding were negligible and not different to zero (Table 1). Heritability estimates of daily feed intake obtained for growing pigs, which typically express their appetite under *ad-libitum* feeding, are around 0.20 (Huisman & Van Arendonk, 2004; Shirali *et al.*, 2017). Heritabilities for the average time sows spent eating were moderate: lowest at the beginning (0.12±0.03) and at the end (0.16±0.04) of the gestation period, while in the middle estimates had a range from 0.16-0.27 (Table 1). These estimates were also lower than heritabilities previously reported for growing pigs, 0.36±0.05 (Labroue *et al.*, 1997). Heritabilities for the rate of feed consumption followed a similar pattern over the gestation, with an estimate of 0.18±0.03 for AFR (Table 1). For comparison, heritability of the rate of feed consumption for growing pigs was 0.49±0.05 (Labroue *et al.*, 1997) and 0.26 (Shirali *et al.*, 2017). Heritability for average number of feeding events observed was 0.03±0.02, which was much lower than for growing pigs (0.43±0.05) (Labroue *et al.*, 1997).

This outcome might reflect the fact that visits without a feed delivery were not recorded by the feeders. Average feed intake for sows that had more than 90 days of records had heritability not different from zero. Heritability for total born piglets was 0.16±0.03, which is similar to the previous findings (Bunter *et al.*, 2009).

Conclusions

Results presented in this paper show that heritability for the traits connected with the daily amount of feed consumed is not different from zero, which was expected, as sows were restricted in the amount of feed delivered throughout gestation. However, sows were still able to express heritable variation in feeding behaviour traits, such as the time spent feeding, and the number of missed feeding events or small feeds. Further investigation of these feeding behaviour traits is warranted with respect to their associations with reproductive performance outcomes, given they represent potential limitations to a sow's ability to consistently meet their nutritional requirements during gestation.

Acknowledgements

This research was funded by the Australian Pork CRC under the project 2A-116. First author is supported by UNE through International Postgraduate Research Award (UNE IPRA).

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Table 1: The number (N) of sows recorded for average feed intake (AFI), time spent feeding (AFT) and rate of feed consumption (AFR) defined by gestation phase (1-7), with the raw mean (SD) and estimates of heritability (h^2), permanent environmental effect (pe^2) and the phenotypic variance (σ_p^2)

	Gestation phase (days)							
	1-7	8-14	15-35	36-90	91-100	101-105	>105	
N	5723	5750	5682	5269	4064	3849	3016	6132
	Feed intake (kg/day)							
Trait	AFI1	AFI2	AFI3	AFI4	AFI5	AFI6	AFI7	AFIALL
R^2	33.7	33.2	65.2	61.2	43.3	19.8	10.9	45.8
mean (SD)	2.46 (0.44)	2.63 (0.27)	2.55 (0.17)	2.09 (0.13)	2.28 (0.16)	2.28 (0.23)	2.22 (0.31)	2.31 (0.23)
h^2 (se)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)	NA	0.02 (0.02)	0.0003 (0.01)	0.02 (0.02)	0.007 (0.01)
pe^2 (se)	0.02 (0.02)	NA	0.02 (0.02)	NA	NA	NA	NA	0.06 (0.02)
σ_p^2	0.13	0.05	0.01	0.007	0.01	0.04	0.09	0.03
	Daily time (minutes/day)							
Trait	AFT1	AFT2	AFT3	AFT4	AFT5	AFT6	AFT7	
R^2	3.0	9.5	8.3	4.5	4.6	4.3	5.1	
mean (SD)	14.7 (4.56)	16.0 (4.86)	15.4 (4.23)	14.1 (3.95)	15.0 (4.87)	15.0 (5.43)	14.7 (5.89)	
h^2 (se)	0.12 (0.03)	0.16 (0.03)	0.19 (0.04)	0.27 (0.04)	0.22 (0.04)	0.17 (0.04)	0.16 (0.04)	
pe^2 (se)	0.19 (0.03)	0.21 (0.03)	0.32 (0.04)	0.31 (0.04)	0.33 (0.04)	0.34 (0.04)	0.33 (0.05)	
σ_p^2	20.2	21.4	16.4	14.9	22.6	28.3	32.9	
	Rate of feed consumption (grams/minute)							
Trait	FR1	FR2	FR3	FR4	FR5	FR6	FR7	AFR
R^2	7.2	14.0	16.6	13.0	9.5	8.1	6.9	9.7
mean (SD)	183 (70.2)	180 (63.3)	178 (50.2)	158 (42.1)	167 (52.2)	169 (55.9)	171 (62.8)	168 (51)
h^2 (se)	0.09 (0.02)	0.10 (0.03)	0.26 (0.04)	0.34 (0.05)	0.19 (0.04)	0.20 (0.04)	0.13 (0.04)	0.18 (0.03)
pe^2 (se)	0.11 (0.03)	0.16 (0.03)	0.23 (0.04)	0.24 (0.04)	0.18 (0.04)	0.18 (0.05)	0.32 (0.05)	0.43 (0.03)
σ_p^2	4568	3447	2100	1544	2468	2875	3668	2315

[1] NA. Non applicable based on likelihood ratio test

Table 2: The number of sows recorded (N) for average feeding events per day (AFE), missing feeding events (MISSF), feeding events below 1 kg (BELOW1), feeding events longer than 30 minutes (ABOVE30), along with average feed intake/day (AFI) and time spent feeding (AFT) for sows with more 90 days recorded, total born piglets with the raw mean (SD), and estimates of heritability (h^2), permanent environmental effects (pe^2) and the phenotypic variance (σ_p^2)

	Feeding behaviour traits						
Trait	AFE	MISSF	BELOW1	ABOVE30	AFI	AFT	TB
N	6132	6132	6132	6132	3926	3926	4997
R^2	5.3	18.4	24.2	11.4	90.2	5.9	6.3
mean (SD)	1.16 (0.13)	3.45 (3.41)	5.25 (4.18)	4.33 (7.44)	2.27 (0.13)	14.7 (3.73)	12.4 (2.81)
h^2 (se)	0.03 (0.02)	0.12 (0.03)	0.10 (0.02)	0.13 (0.03)	0.005 (0.01)	0.33 (0.05)	0.16 (0.03)
pe^2 (se)	0.28 (0.02)	0.11 (0.03)	0.09 (0.03)	0.26 (0.03)	0.14 (0.03)	0.37 (0.05)	0.08 (0.03)
σ_p^2	0.02	9.47	13.2	49.0	0.002	13.1	7.39