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PIGLET TRAITS AT BIRTH ARE ASSOCIATED WITH THEIR SURVIVAL UNTIL WEANING

P. Tabuaciri, K.L. Bunter and H-U. Graser

Animal Genetics and Breeding Unit*, University of New England, Armidale, NSW, 2351

SUMMARY

Data collected on individual piglets born to primi- and multiparous sows from maternal and terminal lines were averaged by litter and analysed as a trait of the sow. Heritability (h^2) estimates of all scored traits were generally low (h^2<0.10), with the exception of the incidence for incisor I_1 eruption (h^2: 0.24). Moderate to high heritabilities were evident for average birth weight and crown to rump length (0.30 and 0.37) but ponderal index was less heritable (h^2: 0.07). Phenotypic correlations show that piglets which are heavier, bigger and had incisor eruption (indicating physiological maturity) are less likely to have difficulties in respiration or thermoregulation at birth, and are more likely to survive until weaning. Whilst, incisor eruption shows some potential as a possible selection criterion for breeding programs, more data is required to improve the accuracy of parameter estimates.

INTRODUCTION

Pig breeding programs have been successful in achieving genetic progress in economically important traits, especially lean growth, feed efficiency and more recently, litter size (Canario *et al*. 2007). However, selection for some of these desired traits can have negative implications on the quality of piglet at birth, influencing its ability to survive until weaning. In particular, selection to improve finisher pig performance and litter size at birth has consequences for both body weight and composition of piglets at birth (Hogberg and Rydhmer 2000). Piglets from larger litters are characteristically smaller, lighter and are less vigorous at birth (Quesnel *et al*. 2008). Further, physiological maturity at birth may be affected (Canario *et al*. 2007). Genetic selection to improve piglet survival should engage a range of factors relating not only to litter size and other traits of the sow (e.g. mothering ability), but potentially also to piglet traits that contribute to their survival. The aim of this study was to investigate the associations between some practical (non-invasive and inexpensive) piglet traits and survival until weaning, treated in this study as sow traits.

MATERIALS AND METHODS

Within a single herd, data were collected on purebred piglets from primi- and multiparous sows representing maternal and terminal lines. Piglets were processed within 12 hours after farrowing and individual piglets were tagged and weighed (BWT, kg) prior to any cross-fostering. Additional data recorded on individual piglets included:

- Crown to rump length (CRU, cm): from the base of the piglet's skull to the base of its tail
- Ponderal index (PIN, kg/m^3): $PIN=BWT/(CRU/100)^3$ as reported by Baxter *et al*. (2009)
- Rectal temperature (TEM, ^0C): taken with a digital thermometer
- The absence or presence (0/1) of meconium staining (MST), shivering (SHI), abnormally pale skin colour (SCO) and bloodshot eyes (EYE) were scored, along with the absence or eruption of the I_1 incisor tooth (INC)
- Respiration rate (RES), muscle tone (MTO), body condition (CON), and hydration status (HYD) were scored in three classes: 0 = normal, 1 = moderate and 2 = poor

The number of the sow's own piglets which survived until weaning (SUR) for each litter was then calculated, regardless if fostering occurred or not.

Data analyses. A total of 9135 piglets from 122 service sires were recorded. The final data averaged by litter and analysed at the sow level represented 847 litters from 704 sows, which were daughters of 267 sires and 580 dams. Four generations of additional pedigree were obtained for each sow; the total number of animals in the pedigree was 4893. Univariate analyses were used to develop models for systematic effects and to obtain initial estimates of genetic parameters under an animal model using ASREML (Gilmour *et al*. 2006). Approximate F-tests were used to assess the significance of systematic effects and/or their interactions; only effects significant at $P<0.05$ were retained. Systematic effects (Table 1) included sow transfer date (17 levels), sow line (4 levels), parity group (4 levels), and TB as a linear covariate. Correlations between specific traits were estimated in a series of bivariate analyses using the univariate model for each trait.

RESULTS AND DISCUSSION

Not all litters had complete recording for all traits (Table 1). The incidence of bloodshot eyes was relatively high but mostly observed to be mild (not reported). Meconium staining and pale skin colour were rarely observed, while the average incidence of shivering and incisor eruption was ~30%. Relatively low litter averages for CON, RES, MTO, and HYD support generally high percentages of normal piglets recorded at birth. All scored traits had high coefficients of variation (CV), whereas CV for continuous traits varied from very low (TEM) to moderate (PIN and BWT) and high (CRU). Low CV for TEM is expected as body temperature is closely controlled physiologically. On average, approximately 8.6 of the sow's own piglets survived until weaning across diverse lines and fostering patterns.

Table 1. Data characteristics and estimates of heritability (h^2) and permanent environmental effects (pe^2) (all×100), with phenotypic variance (σ^2_p) from single trait models, with model R^2

Traits	N	Mean (SD)	Model effects	h^2 ±se	pe^2	σ^2_p	R^2 (%)
BWT (kg)	840	1.59 (0.26)	D, L, PG,TB	30±12	36±12	0.04	30
CRU (cm)	847	22.9 (1.52)	D, L, PG,TB	37±12	19±12	1.48	36
PIN (kg/m^3)	840	132 (19.2)	D, PG	7±8	3±10	183	57
CON (0-2)	847	0.34 (0.34)	D, L, PG,TB	2±8	31±10	0.07	37
TEM (^{0}C)	847	38.0 (0.52)	D, TB	5±7	10±9	0.26	16
MST (0/1)	847	0.002 (0.02)	D, PG	4±5	B	0.0004	3
SHI (0/1)	847	0.29 (0.34)	D, PG	8±8	1±10	0.09	29
EYE (0/1)	847	0.74 (0.27)	D,TB	6±5	B	0.05	32
INC (0/1)	847	0.34 (0.31)	D, L,TB	24±11	18±12	0.08	13
SCO (0/1)	847	0.01 (0.06)	D, L,TB	B	B	0.003	4
RES (0-2)	847	0.10 (0.16)	D, L, PG,TB	13±9	14±10	0.02	17
MTO (0-2)	847	0.14 (0.21)	D, L, PG,TB	5±8	11±10	0.03	29
HYD (0-2)	847	0.24 (0.31)	D, L, PG,TB	3±5	B	0.06	41
SUR	847	8.62 (2.92)	D, L, PG,TB	14±10	22±11	7.53	8

See text for trait abbreviations. Model effects are D: sow transfer date; L: sow line; PG: parity group; and TB: total born. B: estimate fixed on boundary (zero).

Estimates of heritabilities. Heritability (h^2) estimates were very low (<0.10) for TEM, MST, SHI, EYE, MTO, and HYD, indicating that the variability observed was not genetic in origin. Further, variance due to the permanent environmental effect of the sow (pe^2) was also negligible for these traits, implying low repeatability. In contrast, moderate heritability or repeatability estimates were evident for BWT, CRU, CON, and INC, but not PIN, which is a composite measure intended to identify light for size pigs. A large proportion of the variation in PIN was explained by transfer date and seasonal differences in piglet development traits were evident (not shown). Repeatabilities for BWT, CRU and INC were much larger (range: 0.43 to 0.65) than their heritabilities (range: 0.24 to 0.37), supporting a significant permanent environmental effect of the sow on these piglet attributes. The heritability estimates for BWT was lower than that reported by Damgaard *et al*. (2003), but consistent with previous estimates from this population (Bunter *et al*. 2010). The lower estimates of h^2 and pe^2 for RES suggests that respiratory difficulties are less repeatable between litters. The low h^2 for SUR is consistent with other literature values (Hellbrugge *et al*. 2008).

Due to the data structure, it was difficult to accurately separate additive genetic from permanent environmental effects. Therefore, more data is needed to achieve this. However, some traits that have been shown in other studies to be good indicators of piglet survival were found in this study to have a very low genetic component and low repeatability, supporting low h^2 overall.

Correlations between traits. Strong genetic and/or phenotypic correlations between BWT, CRU and CON demonstrated the strong relationships between weight, size and piglet condition at birth. Phenotypic correlations between these, or PIN, and other traits indicated that heavier and bigger piglets were better able to thermoregulate, with increased body temperature and reduced shivering, and were less likely to exhibit respiration difficulties or poor muscle tone; consistent with the review of (Alonso-Spilsbury *et al*. 2005).

Table 2. Estimates of genetic correlations below diagonal and phenotypic correlations above diagonal, with standard error in brackets

	BWT	CRU	PIN	CON	TEM	SHI	EYE	INC	RES	MTO	SUR
BWT		**0.76**	**0.14**	**-0.55**	**0.24**	**-0.13**	**0.13**	**0.33**	**-0.43**	**-0.41**	**0.16**
		(0.02)	**(0.04)**	**(0.03)**	**(0.03)**	**(0.04)**	**(0.04)**	**(0.03)**	**(0.03)**	**(0.03)**	**(0.04)**
CRU	**0.95**		**-0.51**	**-0.37**	**0.17**	**-0.08**	0.07	**0.30**	**-0.37**	**-0.34**	0.01
	(0.07)		**(0.03)**	**(0.03)**	**(0.04)**	**(0.04)**	(0.04)	**(0.03)**	**(0.03)**	**(0.03)**	(0.04)
PIN	-0.56	**-0.85**		**-0.19**	**0.10**	**-0.07**	0.06	-0.02	**-0.08**	**-0.08**	**0.08**
	(0.61)	**(0.35)**		**(0.03)**	**(0.04)**	**(0.03)**	(0.04)	(0.04)	**(0.04)**	**(0.04)**	**(0.04)**
CON	nr	-0.51	nr		**-0.15**	0.06	-0.04	**-0.14**	**0.45**	**0.40**	**-0.23**
		(0.89)			**(0.04)**	(0.04)	(0.04)	**(0.04)**	**(0.03)**	**(0.03)**	**(0.04)**
TEM	-0.31	-0.38	nr	nr		**-0.33**	0.04	**0.18**	**-0.31**	**-0.36**	**0.18**
	(0.56)	(0.50)				**(0.03)**	(0.03)	**(0.03)**	**(0.03)**	**(0.03)**	**(0.04)**
SHI	-0.07	0.19	ns	nr	0.22		0.04	-0.06	**0.15**	**0.23**	-0.005
	(0.48)	(0.42)			(0.76)		(0.04)	(0.04)	**(0.03)**	**(0.03)**	(0.04)
EYE	0.20	0.33	-0.26	nr	-0.09	-0.12		**0.09**	-0.02	-0.04	**0.16**
	(0.40)	(0.37)	(0.68)		(0.72)	(0.62)		**(0.04)**	(0.04)	(0.04)	**(0.04)**
INC	0.10	0.29	nr	nr	0.07	0.43	-0.14		**-0.21**	**-0.18**	**0.09**
	(0.33)	(0.23)			(0.60)	(0.55)	(0.45)		**(0.03)**	**(0.03)**	**(0.04)**
RES	**-0.88**	**-0.81**	0.25	0.31	0.02	-0.03	-0.43	-0.52		**0.69**	**-0.19**
	(0.25)	**(0.29)**	(0.69)	(0.85)	(0.65)	(0.60)	(0.57)	(0.33)		**(0.02)**	**(0.04)**
MTO	ns	-1.06	nr	nr	nr	nr	nr	-0.37	nr		**-0.22**
		(0.62)						(0.56)			**(0.04)**
SUR	0.43	0.40	0.003	nr	nr	-0.41	0.33	-0.24	-0.54	-1.45	
	(0.36)	(0.36)	(0.66)			(0.63)	(0.56)	(0.43)	(0.44)	(0.66)	

See text for trait abbreviations; nr: not supplied as se of estimate >0.9; ns: not significant.

Ponderal index was recommended by Baxter *et al*. (2008) as a good indicator trait for pre-natal survival of outdoor reared piglets. However, genetic parameters and phenotypic correlations reported here suggest PIN is less informative than BWT for piglet survival in this data. Phenotypic correlations demonstrated that piglets were more likely to survive until weaning if they were heavier, had good body condition, and higher rectal temperature at birth. Heavier piglets were also more likely to have erupted incisors, suggesting increased physiological maturity at birth. Correlations between INC and TEM, RES, MTO, CON and SUR were consistent with the above. On the other hand, correlations between RES and MTO scores with SHI indicated that piglets with poor respiration or muscle tone were also more likely to be shivering. Correlations between SUR and these traits supported the concept that piglets which survived were less likely to show shivering or poor respiration and muscle tone scores at birth. Correlations between EYE and the other traits suggest that blood shot eyes could be an indicator of parturition difficulty associated with larger piglet size, accompanied by reduced MTO. However, the high incidence for EYE suggests better discrimination for the extent of bleeding might provide a more informative measure.

Relatively limited data and low heritabilities led to genetic correlations with high standard errors. Genetic correlations among traits were consistent in direction with estimates of phenotypic correlations for most trait combinations. Further analyses at the piglet level are intended.

CONCLUSIONS

While traits such as PIN, RES, and TEM provide some indication of physiological maturity at birth and farrowing outcomes, and subsequently piglet survival, heritability estimates were low. Traits with moderate heritabilities, such as BWT, CRU and INC, which are also correlated with the number of piglets that survived until weaning, are more promising from the breeding perspective. Incisor eruption can be easily measured and potentially provides a new selection criterion for pig breeding programs targeting improved piglet survival at weaning. However, more data is required to improve the accuracy of genetic parameter estimates, which will facilitate evaluation of additional measures such as INC in the breeding context.

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