ESTIMATION OF VARIANCE COMPONENTS FOR INDIVIDUAL PIGLET WEIGHTS AT BIRTH AND 14 DAYS OF AGE

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SUMMARY
Individual piglet weights were recorded at birth (IPWB) and at 14 days (IPW14) in three maternal lines over a time period of two years. The data included 24329 IPWB and 13640 IPW14 records from 2297 litters, 1797 dams and 180 sires. The piglet data included two generations only which may have limited the reliable simultaneous estimation of direct and maternal heritabilities and the litter effect. Consequently, a number of different models were employed to estimate these effects. Heritabilities were 0.03 for IPWB and 0.04 for both, IPW14 and growth rate from birth to 14 days (ADG14). The maternal genetic effect was larger for IPWB (m^2: 0.22) than for IPW14 (m^2: 0.13) and ADG14 (m^2: 0.09). In contrast, litter effect estimates were lower for IPWB (c^2: 0.10) than for IPW14 (c^2: 0.22) and ADG14 (c^2: 0.22). Overall, these results agree well with estimates presented in previous studies. Individual piglet birth weight is labour intensive to record, has a low heritability and low genetic relationship with post-natal growth limiting its use for genetic improvement of piglet performance.
Keywords: Pigs, variance components, piglet birth weight, pre-weaning piglet growth.

INTRODUCTION
Piglets with high birth weight have a greater chance of pre-weaning survival (Rydhmer 1992; Roehe 1999). In addition, litter mortality has a negative genetic correlation with average piglet weight per litter showing that more piglets die in litters with a low average piglet birth weight (Hermesch *et al*. 2001). These relationships indicate two avenues for genetic improvement in birth weight. Firstly, direct selection for individual piglet weights as a trait of the piglet or secondly, selection for larger average piglet weights per litter, a trait of the sow. Roehe (1999) recommended individual piglet birth weight for selection since the estimated heritability for litter birth weight was lower than the maternal heritability for individual piglet birth weight. Both parameters are describing genetic potential of the sow to birth large piglets. Genetic parameters for litter weight traits of the sow from the same study have been published in these proceedings (Hermesch *et al*. 2001). This paper presents variance components for individual piglet weights at birth and 14 days under different random effect models.

MATERIAL AND METHODS
Individual piglet weights were measured in three maternal lines at Bunge Meat Industries from November 1998 to November 2000. Individual piglet birth weight (IPWB) was recorded for every piglet of each litter, including stillbirths, within 12 hours at birth. A second piglet weight was taken at 14 days (IPW14). Piglets were raised under commercial conditions and cross fostering was practiced. Only piglets which stayed on their natural mother or which were cross fostered to a sow participating

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in the project were recorded at 14 days. A further piglet trait analysed was average daily gain from birth to 14 days (ADG14). These piglet weight and growth traits were available for 2297 litters from 1797 sows and 180 sires. These piglet data covered two generations with 205 recorded animals, 178 sows and 27 sires, being parents themselves.

The fixed effect models were developed using the SAS procedure GLM (SAS 1988) and included the farrowing week, the sex of the animal, the line and parity of the sow as well as the interaction between line and parity. These fixed effects were fitted for all traits. For traits recorded at 14 days a further fixed effect fitted was whether or not a piglet had been cross fostered. The total number of piglets born per litter was fitted as a linear covariable for all piglet traits. Mixed models were analysed using ASREML (Gilmour *et al.* 1999). The random effects included in the model were the additive genetic effect of the piglet, the permanent environment of the litter the piglet was born in and the maternal genetic effect.

RESULTS

Piglet traits analysed had relatively large coefficients of variation ranging from 21 to 27% (Table 1). The full fixed effect model accounted for 13 to 19% of the total variation. Fitting total number of piglets born as a linear covariable had the largest effect on the coefficient of determination for IPWB.

Table 1. Number of records, coefficient of variation (CV%) and coefficient of determination (R^2) variation for two fixed effects for piglet weight and growth traits

Trait	Unit	N	CV%	R^2 full model	R^2 not adjusted for litter size
IPWB*	kg	24329	23.7	0.19	0.09
IPW14	kg	13640	20.9	0.18	0.15
ADG14	g/day	13611	27.2	0.13	0.12

* IPWB: Individual piglet weight at birth, IPW14: Individual piglet weight at 14 days, ADG14: growth rate from birth to 14 days.

Piglet weights at birth and at 14 days are influenced by the piglet's own genetic growth potential, its litter environment and the maternal genetic effect. A number of random effects models were employed to estimate these effects, including a series of models fitting only two random effects and one model fitting all three random effects (Table 2). By definition, the log likelihood increases with the inclusion of more random effects in the model and models fitting only two random effects were compared with the model fitting all three random effects. The model with the second highest log likelihood included the litter effect and the maternal effect (Model M4). Estimates of the litter effect and maternal genetic effect were 0.10 and 0.23 for IPWB, 0.22 and 0.13 for IPW14 and 0.22 and 0.10 for ADG14. The adjustment for litter size influenced the litter effect for IPWB. The litter effect increased to 0.20 (model M5) when IPWB was not adjusted for litter size (not shown in Table 2).

The direct additive genetic effect of the piglet on its own weight was low with heritabilities being 0.03 for IPWB and 0.04 for IPW14 and ADG14 (M4). The data structure limits the reliable simultaneous estimation of all three random effects. While it is not possible to disentangle the litter and maternal genetic effect, the additive direct effect was estimated by fitting sire as a random effect and linking sire with the full genetic relationship matrix. Comparison of direct and maternal heritabilities between the full animal model (M4) and a model fitting sire as a random effect along with litter and maternal genetic effect showed no significant differences in parameters (not shown in Table 2). The animal model showed higher heritability estimates when the maternal genetic effect was not fitted (M1) since the direct additive genetic effect accounted for parts of the maternal genetic effect (Table 2). In contrast, the heritability did not increase significantly in comparison to the full animal model (M4) when the maternal genetic effect was omitted from the sire model (M5).

Table 2. Differences in log likelihood, heritabilities (h^2), litter effects and maternal genetic effects (m^2) along with standard errors (se) and phenotypic variance for piglet traits

Trait	Model (M)	Diff. LogL[a]	h^2 (se)	c^2 (se)	m^2 (se)	σ^2_p
IPWB*	M1: $\sigma^2_a + \sigma^2_c$	-94	0.45 (0.04)	0.15 (0.01)	-	0.114
	M2: $\sigma^2_a + \sigma^2_m$	-111	0.08 (0.02)	-	0.33 (0.01)	0.113
	M3: $\sigma^2_c + \sigma^2_m$	-6.5	-	0.10 (0.02)	0.23 (0.02)	0.103
	M4: $\sigma^2_a + \sigma^2_c + \sigma^2_m$	0	0.03 (0.01)	0.10 (0.01)	0.22 (0.02)	0.103
	M5: Sire + σ^2_c	-170	0.04 (0.02)	0.31 (0.01)	-	0.103
IPW14	M1: $\sigma^2_a + \sigma^2_c$	-27	0.15 (0.03)	0.29 (0.01)	-	0.755
	M2: $\sigma^2_a + \sigma^2_m$	-172	0.15 (0.03)	-	0.33 (0.02)	0.858
	M3: $\sigma^2_c + \sigma^2_m$	-2.2	-	0.23 (0.02)	0.13 (0.02)	0.763
	M4: $\sigma^2_a + \sigma^2_c + \sigma^2_m$	0	0.04 (0.02)	0.22 (0.02)	0.13 (0.02)	0.752
	M5: Sire + σ^2_c	-35	0.04 (0.02)	0.34 (0.01)	-	0.741
ADG14	M1: $\sigma^2_a + \sigma^2_c$	-15	0.11 (0.03)	0.28 (0.01)	-	2864
	M2: $\sigma^2_a + \sigma^2_m$	-163	0.14 (0.03)	-	0.32 (0.02)	3267
	M3: $\sigma^2_c + \sigma^2_m$	-4.0		0.23 (0.02)	0.10 (0.02)	2861
	M4: $\sigma^2_a + \sigma^2_c + \sigma^2_m$	0	0.04 (0.02)	0.22 (0.02)	0.09 (0.02)	2872
	M5: Sire + σ^2_c	-20	0.01 (0.01)	0.31 (0.01)	-	2834

* for abbreviations see Table 1. a: Difference in Log Likelihood in comparison to model fitting σ^2_a , σ^2_c and σ^2_m

The individual piglet weights at birth and at 14 days were genetically a different trait (r_g: 0.60±0.19). Further, IPWB had a low genetic correlation of 0.37±0.26 with ADG14 (Table 3). Both traits recorded at 14 days were genetically the same trait (r_g 0.95±0.03). Correlations between maternal genetic effects were similar to genetic correlations.

DISCUSSION

Piglet birth weights are influenced by the direct additive genetic, litter and maternal genetic effects. Reliable estimation of these random effects requires a data set covering multiple generations. The data structures available in this project may have limited the reliable estimation of these three effects simultaneously. Several models showed that the maternal and litter effects were the main random effects for the piglet traits analysed. The direct additive effect was of minor importance. These estimates agree with results presented by Kaufmann *et al*. (2000) and Roehe (1999) who reported direct heritabilities of 0.02 and 0.08, maternal heritabilities of 0.21 and 0.22 and litter effect estimates of 0.11 and 0.09 for piglet birth weight. An increase in the litter effect and a decrease in the maternal genetic effect from birth to 14 days were also found by Kaufmann *et al*. (2000). In the study by Kaufmann *et al*. (2000) the data structure covered seven generations recorded over seven years. The number of generations was not mentioned explicitly in the study by Roehe (1999) but records were collected over a time period of six years.

Table 3. Genetic (r_g), litter effect (r_c), maternal genetic (r_m), environmental (r_e) and phenotypic correlations (r_p) (with standard errors) between piglet traits

Trait1	Trait 2	r_g	r_c	r_m	r_e	r_p
IPWB*	**IPW14**	0.60 (0.19)	0.54 (0.05)	0.72 (0.05)	0.64 (0.01)	0.63 (0.01)
IPWB	**ADG14**	0.37 (0.26)	0.32 (0.06)	0.34 (0.09)	0.36 (0.01)	0.34 (0.01)
IPW14	**ADG14**	0.95 (0.03)	0.97 (0.004)	0.89 (0.02)	0.96(0.001)	0.96 (0.001)

* for abbreviations see Table 1

Litter size accounted for a large proportion of the phenotypic variation for piglet birth weight. Adjustment for this effect reduced the litter effect estimate for piglet birth weight while it did not affect the direct and maternal heritabilities. These findings correspond to results by Roehe (1999) showing that the number of embryos/foetuses in the uterus influences the ability of the individual piglet to grow.

Roehe (1999) found that the maternal heritability for piglet weight was larger than the heritability for total litter weight but lower than the heritability for average piglet weight of the litter. The heritability estimate for average piglet weight of the litter (Hermesch *et al*. 2001) was also larger than the maternal heritability for IPWB. It is labour intensive to record individual piglet weights and it would take years to obtain data structures sufficient for accurate genetic analysis. Further, piglet weight at birth was lowly heritable, had no significant genetic relationship with post-natal growth. Therefore, it is recommended not to use individual piglet weights for genetic improvement of piglet growth.

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