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PRE-WEANING GROWTH IN RABBITS: THE MATERNAL EFFECTS

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INTRODUCTION

In rabbit production, the kits are with her mother during a month, and rabbit is fattening during one month more. Ferguson *et al.* (1997) indicated that pre-weaning traits with the greatest effect on market trait performance were the individual kit body weight at birth, milk intake and season of weaning.

Kits from large litters have lower individual weights (Argente *et al.,* 1999) and individual survival was related to individual birth weight, since the kits with lower birth weight also had a lower probability of survival (Argente *et al.*, 1999; Vicente *et al.,* 1995).

In this context, it should be interesting to estimate the variance and covariance components for growth traits during the lactation in rabbits.

MATERIAL AND METHODS

Animals

A total of 3809 young rabbits (Table 1) of a F_2 population obtained by crossing the High and the Low line of a population selected for uterine capacity were used in the experiment (see details of the population in Peiró *et al.,* 2008.).

The animals were kept at the farm of the Universidad Miguel Hernández de Elche. The farm had controlled ventilation and 16 hours of light per day.

The females had their first mating at 18 weeks of age. Does were mated again 10 days after delivery. Young rabbits were weaned at 28 days of age and adoptions were not allowed. The female and her offspring were allocated in individual cages. All animals had free access to water and pelleted.

The offspring of all the does was individually identified and weighed at birth, at 7, 10, 14, 21 and 28 days of age. The young rabbits were weighed within 24 hours after birth, so some kits had suckled before they were weighed. The intake of milk was verified by a white mark in the abdominal area.

Traits

The following traits were analysed: individual weight at birth (IWB, g.); individual weight at 7 days (IW7, g.); individual weight at 10 days (IW10, g.); individual weight at 14 days (IW14, g.); individual weight at 21 days (IW21, g.); individual weight at 28 days (IW28, g.) and daily gain during lactation (DG, g./day).

Statistical Analysis

The traits were analysed using the following model:

$$\mathbf{y = Xb + W_c c + Z_a a + Z_m m + e},$$

where **y** is the vector of observations, **b** is the vector of fixed effects including the parity order (1st, 2nd or more), the intake of milk before being weighed at birth (whether the kit suckled or not), and the season (4 levels), and the litter size at birth as covariate, **c** is the vector of the common litter effects, **a** is the vector of direct additive genetic effects, **m** is the vector of maternal additive genetic effects, e is the vector of residuals, and **X**, $\mathbf{W_c}$, $\mathbf{Z_a}$ **and** $\mathbf{Z_m}$ are known incidences matrices that relate the fixed and random effects to the traits. All Random effects are assumed to be normally distributed. Thus,

$$c \sim N\left(0, I \otimes \acute{o}_c^2\right)$$

$$\begin{bmatrix} a \\ m \end{bmatrix} \sim N\left(0, A \otimes G_0\right)$$

where G_0 include variance and convariance for direct and maternal additive effect for each trait.

The analysis was carried out using Bayesian approach with Gibbs sampling using the program TM. The Gibbs sampler was run as a single chain with length of 100000 samples. The first 30000 samples were used as bur-in and discarded. Every 10th sample of the remaining 70000 was saved to estimate the features of the realised posterior distribution. Convergence was tested using Z criterion of Geweke (Sorensen and Gianola, 2002) and Monte Carlo sampling errors were computed using time-series procedures described by Geyer (1992).

Following Willham (1972), the phenotypic variance was defined as $\sigma^2_p = \sigma^2_c + \sigma^2_a + \sigma^2_m + \sigma_{am} + \sigma^2_{e,}$ where, σ^2_c is the variance of common litter effects, σ^2_a is the variance of additive genetic effects, σ^2_m is the variance of maternal additive genetic effects, σ_{am} is the covariance between direct and maternal additive genetic effects, and σ^2_e is the residual variance. The total heritability is defined as

$$h^2_t = (\sigma^2_a + 0.5\ \sigma^2_m + 1.5\sigma_{am})/\ \sigma^2_{p.}$$

RESULTS AND DISCUSSION

Means, range and coefficients of variations for the weekly weight and daily gain of the rabbit during the lactation periods are shown in Table 1. The means were slightly higher than other maternal rabbit populations. Argente *et al*. (1999) obtained 50 g. for individual weight at birth and 547 g. for individual weight at weaning and Krogmeier *et al.* (1994) presented 17.6 g/day for individual pre-weaning weight gain. The coefficients of variation ranged from 0.23 to 0.31.

Features of estimated marginal posterior distributions of the direct and maternal heritabilities, the proportion of the phenotypic variance attributable to common litter effects, the total heritabilities and the genetic correlation between direct and maternal effects are presented in Tables 2 and 3. They exhibited small Monte Carlo error, and the Geweke test did not detect any lack of convergence (data not shown in Tables).

Table 1. Number of records, mean, minimum, maximum and coefficient of variation (CV) for weight and daily gain during the lactation period.

	Records	Mean	Minimum	Maximum	CV
IWB	3809	59	19	161	0.23
IW7	2633	137	33	372	0.28
IW10	2978	176	36	461	0.27
IW14	2560	236	70	650	0.29
IW21	2206	325	107	931	0.32
IW28	2701	578	136	1220	0.30
DG	2682	18.6	3.2	39.6	0.31

IWB: individual weight at birth (g.); IW7: individual weight at 7 days (g.); IW10: individual weight at 10 days (g.); IW14: individual weight at 14 days (g.); IW21: individual weight at 21 days (g.); IW28: individual weight at 28 days (g.); DG: daily gain during lactation (g./day).

The direct heritability was 0.16, 0.22, 0.14, 0.13, 0.18, 0.16 and 0.17 for weight at birth, at 7, 10, 14, 21 and 28 days of age and daily gain. The maternal heritability for these traits was 0.11, 0.13, 0.17, 0.10, 0.09, 0.14 and 0.13, respectively. Krogmeier *et al.* (1994), using DFREML, reported estimates of direct and maternal heritabilities equal to 0.15 and 0.01, respectively, for individual weight at birth. And, both direct and maternal heritabilities were 0.28 (Krogmeier *et al.* 1994) for the individual weight at weaning.

In our experiment, the estimates of the direct heritability were higher than the maternal heritability, except for individual weight at 10 days of age. In pigs, Su *et al.* (2008) reported higher maternal heritability (0.158 and 0.160, Landrace and Yorkshire, respectively) than direct heritability (0.069 and 0.09) for birth weight.

The proportion of phenotypic variance attributable to the common litter effect ranged from 0.33 for weight at 10 days to 0.54 for weight at 21 days. The common environmental effects of litter explained a greater part of phenotypic variance for all the traits and were higher than their additive variances. This tendency agrees with the results reported by García and Baselga (2002) for the individual weight at weaning.

The posterior mean of genetic correlations between direct and maternal effects were always negative and there was a tendency to increase with kit age (-0.09 for weight at birth and -0.51 for weight at 28 days, Table 3), These results should be taken with caution due to the estimations had low precision. In pigs, this correlation of weight at birth was -0.124±0.113 for Landrace and -0.106±0.362 for Yorksire (Su *et al.,* 2008).

The estimates of total heritability were 0.16, 0.18, 0.15, 0.11, 0.16, 0.10 and 0.10 for weight at birth, at 7, 10, 14, 21, 28 days and daily gain. The negative correlation between direct and maternal additive effects led to a low total heritability (defined by Willham, 1972) for all the traits. The estimates were higher than those obtained by Su *et al*. (2008) for birth at weight in piglets (0.147 and 0.115).

CONCLUSIONS

These results suggest that genetic improvement in rabbit weight before weaning by selection should be based on both direct and maternal additive genetics effects.

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Table 2. Posterior mean and standard deviation (sd) of direct heritability (h^2_a), maternal heritability (h^2_m) and the proportion of the phenotypic variance attributable to common litter effects (c^2).

Trait[1]	h^2_a			h^2_m			c^2		
	Mean (sd)	$HPD_{95\%}$	MC_{se}	Mean (sd)	$HPD_{95\%}$	MC_{se}	Mean (sd)	$HPD_{95\%}$	MC_{se}
IWB	0.16(0.09)	0.02,0.35	0.0026	0.11(0.07)	0.00,0.25	0.0032	0.31 (0.03)	0.25,0.38	0.0005
IW7	0.22(0.14)	0.00,0.50	0.0060	0.13(0.11)	0.00,0.35	0.0059	0.43(0.05)	0.33,0.52	0.0010
IW10	0.14(0.09)	0.01,0.33	0.0035	0.17(0.10)	0.00,0.37	0.0054	0.33(0.04)	0.25,0.41	0.0007
IW14	0.13(0.10)	0.00,0.32	0.0035	0.10(0.07)	0.00,0.24	0.0030	0.50(0.04)	0.41,0.58	0.0014
IW21	0.18(0.11)	0.01,0.39	0.0085	0.09(0.07)	0.00,0.23	0.0061	0.54(0.06)	0.42,0.64	0.0038
IW28	0.16(0.09)	0.01.0.35	0.0032	0.14(0.09)	0.00,0.31	0.0040	0.45(0.05)	0.36,0.54	0.0012
DG	0.17(0.09)	0.01,0.35	0.0033	0.13(0.09)	0.00,0.31	0.0039	0.47(0.05)	0.37,0.55	0.0012

[1]IWB: individual weight at birth (g.); IW7: individual weight at 7 days (g.); IW10: individual weight at 10 days (g.); IW14: individual weight at 14 days (g.); IW21: individual weight at 21 days (g.); IW28: individual weight at 28 days (g.); DG: daily gain during lactation (g./day).
[2] $HPD_{95\%}$: highest posterior density interval (95%); MC_{se}: Monte Carlo error

Table 3. Posterior mean and standard deviation (sd) of total heritability (h^2_t) and correlation between direct and maternal additive genetic effects ($r_{(a,m)}$).

Trait[1]	h^2_t [2]			$r_{(a,m)}$		
	Mean (sd)	$HPD_{95\%}$	MC_{se}	Mean (sd)	$HPD_{95\%}$	MC_{se}
IWB	0.16(0.08)	0.01,0.31	0.0030	-0.09(0.15)	-0.85,0.99	0.0261
IW7	0.18(0.12)	-0.02,0.39	0.0045	-0.25(0.58)	-1.00,0.90	0.0320
IW10	0.15(0.10)	-0.02,0.34	0.0048	-0.17(0.60)	-1.00,0.93	0.0317
IW14	0.11(0.08)	-0.01,0.27	0.0030	-0.27(0.59)	-1.00,0.86	0.0287
IW21	0.16(0.10)	0.00,0.34	0.0081	-0.43(0.53)	-1.00,0.70	0.0266
IW28	0.10(0.09)	-0.02.0.26	0.0035	-0.51(0.49)	-1.00,0.55	0.0238
DG	0.10(0.09)	-0.02,0.27	0.0033	-0.51(0.48)	-1.00,0.54	0.0233

[1]IWB: individual weight at birth (g.); IW7: individual weight at 7 days (g.); IW10: individual weight at 10 days (g.); IW14: individual weight at 14 days (g.); IW21: individual weight at 21 days (g.); IW28: individual weight at 28 days (g.); DG: daily gain during lactation (g./day).
[2] $HPD_{95\%}$: highest posterior density interval (95%); MC_{se}: Monte Carlo error

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