SELECTION FOR OVULATION RATE IN RABBITS: CORRELATED RESPONSE ON LITTER SIZE AND ITS COMPONENTS

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ABSTRACT

The aim of this work was to evaluate the response to six generations of selection for ovulation rate. The line was derived from a line selected for litter size during 12 generations and then for uterine capacity for 10 generations. Selection was relaxed during 6 generations and then animals were selected for ovulation rate during 6 generations. Selection was based on phenotypic value for ovulation rate and pressure of selection for does was close to 30%. To avoid increase of inbreeding, males were selected within sire families. Line size was approximately 20 males and 80 females per generation. Does were mated for the first time at 18-20 weeks of age and 11-12 days after each parturition thereafter. Laparoscopies were performed on all does at day 12 of their second gestation. Traits recorded in second parity were: ovulation rate (OR), estimated as number of corpora lutea; number of implanted embryos (IE) estimated as number of implantation sites; litter size (LS) estimated as total number of born rabbits, and prenatal survival (PS=LS/OR). All the traits were recorded only in the second parity with the exception of LS which was recorded over four parities. Data from 524 laparoscopies and 1874 parities were analyzed using Bayesian methods. Heritabilities of OR, IE, LS and PS were 0.27, 0.18, 0.06 and 0.07. Selection increased OR in 1.5 oocytes but correlated response on LS was lower (0.4 kits). Correlated response on IE and PS were 1.25 and -0.04, respectively.

Key words: Selection, Ovulation rate, Prenatal survival, Litter size.

INTRODUCTION

Breeding programs in rabbits always include litter size as an objective of selection due to its importance in the economy of the farms. However, direct selection for litter size has had little success and the response has been lower than expected due to its low heritability (reviewed by Blasco *et al.*, 1993a).

In rabbits, the increase in litter size is basically associated to an increase in ovulation rate (García and Baselga, 2002; Brun *et al.*, 1992). This phenomenon, in addition to the fact that ovulation rate presents a higher heritability than litter size (Blasco *et al.*, 1993b), led to propose selection for ovulation rate as an indirect way of selection for litter size.

In pigs and mice some authors observed that response on ovulation rate was high, but the correlated response in litter size was not significantly different from zero (in mice, Bradford, 1969; Land and Falconer, 1969; in pigs, Cunningham *et al.*, 1979; Lamberson *et al.*, 1991; Rosendo *et al.*, 2007).

The aim of this work is to evaluate the response to six generations of selection for ovulation rate.

MATERIALS AND METHODS

Animals and experimental design

The selected line was derived from a line selected for litter size during 12 generations (García and Baselga, 2002) and then for uterine capacity for 10 generations (Argente *et al.*, 1997). Selection was relaxed during 6 generations and then animals were selected for ovulation rate during 6 generations. Selection was based on phenotypic value for ovulation rate and pressure of selection for does was close to 30%. To avoid increase of inbreeding, males were selected within sire families. A male per family was selected at each generation. Males were selected from litters of does which presented the highest ovulation rate. The female-male composition for the base generation and the six generations of selection were: 86-19, 75-27, 93-19, 88-16, 91-19, 60-15 and 107-20. Does were mated for the first time when they were 18-20 weeks old and 11-12 days after each parturition thereafter. Laparoscopies were performed on all does at day 12 of their second gestation, corpora lutea and implanted embryos were counted. Details of the technique are given by Santacreu *et al.* (1990). Animals were kept under controlled 16L:8D photoperiod and housed at the experimental farm of the Polytechnic University of Valencia in individual metal cages.

Traits

Traits analyzed in second parity were: ovulation rate (OR), estimated as number of corpora lutea; number of implanted embryos (IE) estimated as number of implantation sites; litter size (LS) estimated as total number of rabbits born, and prenatal survival (PS=LS/OR). All the traits were recorded only in the second parity with the exception of LS which was recorded over four parities. Data from 524 laparoscopies and 1874 parities were analyzed.

Statistical Analysis

Bayesian analyses were carried out. The model used to analyse litter size included season-year with 19 levels, parity-lactation state with 3 levels (nulliparous does, lactating multiparous does and non-lactating multiparous does), the breeding value of the animal and the permanent environmental effects for litter size (596 levels).

The model used to analyze the traits of the second parity included the effects of generation with 7 levels, lactation state with two levels (lactating and non-lactating does) and the breeding value of the animal.
Bivariate analyses including ovulation rate were performed. To analyse litter size, data augmentation was used. After some exploratory analyses, we used a single long chain of 3,000,000 samples, with a burn-in period of 200,000. Only one sample from each 100 was saved for inferences. Convergence was tested using the Z criterion of Geweke. Monte Carlo sampling errors were computed using time-series procedures described in Geyer (1992). Bounded uniform priors were used for all unknowns with the exception of breeding value of the animal and the permanent environmental effects for litter size. Prior knowledge about additive and permanent effects was represented by assuming that these were normally distributed.

RESULTS AND DISCUSSION

Table 1 shows raw means and standard deviations for the traits recorded in each generation. Phenotypic trends were not clear for any of the traits studied, however the mean value obtained for ovulation rate in the sixth generation of selection was high compared to mean values reported by other authors who also worked with maternal rabbit lines. For example, Santacreu *et al.* (2005) reported a mean value for ovulation rate of 14.8 oocytes with a standard deviation of 2.9 and García and Baselga (2002) reported a mean value of 14.98 oocytes. Mean values obtained for prenatal survival were lower than values reported by Blasco *et al.* (1993b) and García and Baselga (2002) who obtained a mean value close to 0.70.

Table 1: Raw means, standard deviation (SD) and number of data (N) for ovulation rate (OR), number of implanted embryos (IE), prenatal survival (PS) and litter size (LS) in each generation of selection

		Generation						
		Base	1	2	3	4	5	6
	Mean	15.33	15.45	15.53	16.21	15.53	15.14	16.62
OR	SD	2.14	2.43	2.52	2.43	2.94	2.22	2.15
	N	73	73	86	77	57	56	100
	Mean	12.51	12.47	12.38	12.01	11.22	11.66	13.15
IE	SD	3.17	3.37	3.33	3.55	3.84	3.60	3.57
	N	72	70	86	74	55	56	97
	Mean	0.58	0.56	0.62	0.50	0.53	0.53	0.59
PS	SD	0.21	0.20	0.20	0.24	0.24	0.22	0.18
	N	70	64	81	70	53	55	93
	Mean	8.13	8.52	9.07	9.12	8.60	8.55	9.32
LS	SD	2.99	2.54	2.87	2.96	2.89	3.07	2.99
	N	352	159	240	248	255	219	388

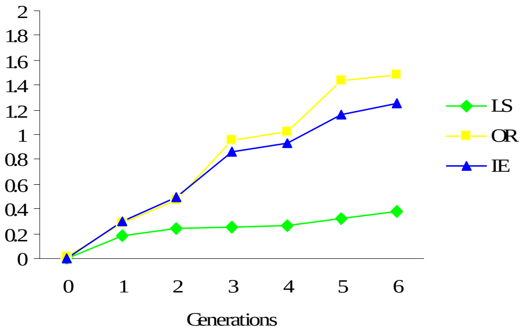
Features of the marginal posterior distributions of the heritabilities are summarized in Table 2. Monte Carlo standard errors were small and the Geweke test did not detect lack of convergence in any case. The heritability of prenatal survival and litter size were much lower than that of ovulation rate (0.27 versus 0.07 and 0.06, respectively). The heritability of ovulation rate was similar to that obtained by Blasco *et al.* (1993b) but lower than the values reported by Ibáñez *et al.* (2006). The estimates for litter size and number of implanted embryos were similar to the values reported by other authors (Blasco *et al.*, 1993b; García and Baselga, 2002; Piles *et al.*, 2006), but the heritability of prenatal survival was lower than the values observed in other works (Blasco *et al.*, 1993b; García and Baselga, 2002; Ibáñez *et al.*, 2006; Piles *et al.*, 2006).

Table 2: Features of the estimated marginal posterior distributions of the heritabilities for ovulation rate (OR), number of implanted embryos (IE), prenatal survival (PS) and litter size (LS)

	Mean	Median	SD	HPD (95%)	k	MC_{se}	Z
OR	0.27	0.26	0.10	0.06-0.47	0.10	0.002	-1.33
IE	0.18	0.17	0.07	0.04-0.34	0.07	0.001	-1.53
PS	0.07	0.07	0.04	0.01-0.16	0.02	0.001	-0.92
LS	0.06	0.05	0.03	0.00-0.11	0.01	0.0009	1.44

SD: standard deviation, HPD: highest posterior density region at 95%, k: limit of the interval [k, ∞) containing a probability of 95%, MCse: Monte Carlo standard error, Z: Z-score of Geweke test.

Figure 1 shows genetic trends for the traits analysed. Selection increased ovulation rate in 1.5 oocytes but correlated response on litter size was lower (0.4 kids). These results corroborate the observations reported in the experiments that have been carried out in mice and pigs (Bradford, 1969; Land and Falconer, 1969 in mice and Cunningham *et al.*, 1979; Lamberson *et al.*, 1991; Rosendo *et al.*, 2007 in pigs). Correlated response on number of implanted embryos was high, but from the third to the sixth generation this response seems to be lower than the response observed for ovulation rate. Moreover, prenatal survival decreased in 4%. In pigs, selection for ovulation rate was accompanied by a decrease in embryo/fetal survival rate of 1.6% per generation, therefore, the increase in litter size was only 20-30% of the increase in ovulation rate (Johnson *et al.*, 1985).



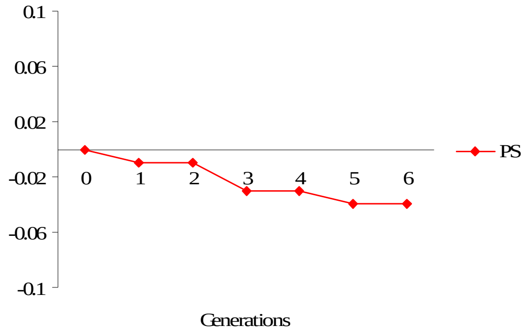


Figure 1: Genetic trends for ovulation rate (OR), number of implanted embryos (IE), prenatal survival (PS) and litter size (LS)

CONCLUSIONS

Selection for ovulation rate increased ovulation rate (1.5 oocytes) but correlated response on litter size was lower (0.4) and similar to response obtained when direct selection for litter size is carried out.

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