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GENETIC CORRELATIONS BETWEEN LITTER SIZE AND UTERINE CAPACITY

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ABSTRACT

The objective of this experiment was to study the genetic relationships of litter size (LS), ovulation rate (OR), and number of implanted embryos (IE) among does having normal uterine conditions (intact does) and does having crowded uterine conditions (ULO does). LS in ULO does is an estimate of uterine capacity (UC). Data from 929 ULO and 683 intact does were analysed. Intact does were contemporary of ULO does. Laparoscopy was performed on all does during their second gestation 12 d after mating and the number of corpora lutea and number of implantation embryos were counted. Genetic parameters were estimated by residual maximum likelihood. Heritabilities of UC and LS were low (0.07 vs. 0.13, respectively). Heritabilities of OR in ULO and intact does were moderate (0.30 vs. 0.20, respectively). Heritabilities of IE in ULO and intact does were moderate (0.32 vs. 0.16, respectively). Genetic correlations of LS, OR and IE between ULO and intact does were high (near 1). These correlations suggest that litter size is controlled by similar genetic mechanisms in ULO does and intact does, and the same can be said for ovulation rate and number of implanted embryos. As the heritability of UC is not higher than the heritability for LS, selection for UC should not be more efficient for improving LS than selection for LS itself.

Key Words: Rabbits, litter size, ovulation rate, implanted embryos, genetic parameters

INTRODUCTION

Blasco et al. (1994) and Bolet et al. (1994) suggested litter size of unilaterally ovariectomized does (ULO) as a measure of uterine capacity. A divergent selection experiment on uterine capacity has been performed, and its results published by Blasco et al. (2000) and Santacreu et al. (2000) in this Congress. As there is no foetal migration, only one uterine horn remains functional, and uterine capacity is expressed only in one horn. We do not know the genetic relationship between uterine capacity and litter size in does with both uterine horns being functional. As both traits are not necessarily the same trait, the objective of this paper is to estimate the genetic correlation between uterine capacity and litter size; i.e. between litter size of ULO and intact does.

MATERIAL AND METHODS

Animals

Rabbits came from a divergent selection experiment for uterine capacity, measured as litter size in unilaterally ovariectomized does (ULO). Both lines were derived from a synthetic breed previously selected for litter size during 12 generations (line V). Each divergent line had approximately 40 females and 12 male per generation, each female had up to four parities, and data from ten generations of selection were analysed. Data of contemporary intact does of both lines were collected from the 6th generation of selection. A

total of 929 ULO and 683 intact does were used in this experiment.

Surgical Techniques

Left ovary was removed before puberty in ULO does. A laparoscopy was performed on all does at day 12 of their second gestation, and corpora lutea and implanted embryos were counted. The description of the unilateral ovariectomy technique can be found in Blasco et al. (1994). The laparoscopy technique was described in detail by Santacreu et al. (1990).

Traits

OR: total ovulation rate estimated as number of corpora lutea on both ovaries in intact does, and only in the right ovary in ULO does. ROR: ovulation rate on the right ovary in intact does. LOR: ovulation rate on the left ovary in intact does. IE: total number of implanted embryos estimated as number of implantation sites on both uterine horns in intact does, and only in the right uterine horn in ULO does. RIE: number of implanted embryos on the right uterine horn in intact does. LIE: number of implanted embryos on the left uterine horn in intact does. LS: total number of rabbits born (this trait estimates uterine capacity in ULO does and it is litter size in intact does). All the traits were measured in the second parity with the exception of LS, which was measured up to four parities.

Statistical Analysis

Least squares analyses were performed on all traits using the following model:

$$Y_{ijklm} = \mu + G_i + YS_j + L_k + LCT_l + e_{ijklm}$$

Where G is the fixed effect of group (ULO or intact doe), YS is the year-season fixed effect (with 35 levels), L is the line fixed effect (does of base generation, does of high uterine capacity line or does of low uterine capacity line), LCT is the lactation fixed effect (nulliparous does, multiparous does lactating at birth, and multiparous does not lactating at birth). GLM of the SAS statistical package was used (SAS, 1996).

Genetic parameters were estimated by multivariate residual maximum likelihood (REML). LS was analysed with a repeatability animal model, with year-season, line and lactation fixed effects. OR and IE were analysed with animal models including year-season, line and lactation effects. LS, OR and IE were considered to be different traits in ULO and intact does. Genetic correlation between ULO and intact does for LS was estimated by a bivariate REML. The other genetic correlations were estimated by trivariate REML including LS of ULO does in the analyses. Genetic correlations between LS, OR and IE within groups (ULO or intact does) were estimated by multivariate REML and LS of ULO does was included in the analysis, in order to avoid possible biases due to selection. VCE statistical package was used for all REML analyses (Groeneveld, 1994).

RESULTS AND DISCUSSION

Table 1 shows the means of the analysed traits. Although total ovulation rate was a 6% lower in ULO does, it was enough to overcrowd the corresponding uterine horn. ULO does had a litter size a 22% lower than intact does. This difference is closely related to the number of implanted embryos more than to differences in postimplantation survival. These results agree with previously published reports of the first generations of selection of these lines (Blasco et al., 1994; Argente et al., 1996).

Table 2 shows the effect of selection on uterine capacity in components of litter size of intact does. The difference between ROR and LOL is 0.92 ova. Estimates of components of litter size in the base generation can be found in Blasco et al. (1993a). It seems that selection on uterine capacity increased the right-side ovulation rate, since the base generation had a difference between ovaries of only 0.36 ova. The difference between RIE and LIE was lower (0.56). These results agreed with the results found in a line of mice selected for uterine capacity (Gion et al., 1990).

Table 1. Least Square means (LSM), with their standard errors (SE) in unilaterally ovariectomized (ULO) and intact does.

	ULO does			intact does			
	N	LSM	SE	N	LSM	SE	Sig
LS	2996	7.42	0.14	1618	9.47	0.14	**
OR	735	14.59	0.63	367	15.48	0.65	**
IE	735	12.92	0.75	367	14.96	0.78	**

LS: total number of young rabbit born. OR: total ovulation rate. IE: total number of implanted embryos. N: data number. Sig: ** = P<0.01.

Table 2. Least Square means (LSM), with their standard error (SE) in intact does.

	LSM	SE		LSM	SE	Sig
LOR	7.16	0.39	ROR	8.08	0.39	**
LIE	6.81	0.38	RIE	7.37	0.38	**

LOR: ovulation rate of the left ovary in intact does. ROR: ovulation rate of the right ovary in intact does. LIE: number of implanted embryos in the left uterine horn of intact does. RIE: number of implanted embryos in the right uterine horn of intact does. Sig: ** = P<0.01.

Table 3 shows genetic correlations between LS, OR and IE within group (ULO and intact does). LS had a positive genetic correlation with OR. This correlation was higher in ULO does. Moreover, LS was closely correlated with IE in both groups. LS in ULO does seems to be related in the same measurement by OR and IE. However in the first four generations of this experiment of selection, Argente et al. (1997) found a lower genetic correlation between LS and OR (0.34) and similar genetic correlation between LS and IE (0.71). These previous estimates were more similar to the values detected in intact does.

Table 3. Genetic correlations in unilaterally ovariectomized (ULO) and intact does.

	LS	OR	IE
LS		0.72 $\pm$ 0.09	0.81 $\pm$ 0.06
OR	0.35 $\pm$ 0.13		0.95 $\pm$ 0.06
IE	0.95 $\pm$ 0.07	0.59 $\pm$ 0.15	

LS: litter size. OR: ovulation rate. IE: implanted embryo. Above of diagonal genetic correlations in ULO does. Below of diagonal genetic correlations in intact does.

Table 4 shows heritabilities and genetic correlations between groups (ULO and intact does) for LS, OR and IE. Heritability of LS in ULO does was similar to the values found in ULO does (0.05 Bolet et., 1994) and ULO mice (0.08, Kirby and Nielsen, 1993). It was expected a higher heritability for LS in ULO does, because OR was not a source of variation for LS in ULO females and OR was genetically scarcely related to LS. However, heritability of LS in ULO does was similar to heritability in intact does (0.07 vs. 0.13, respectively) and it was in the range of those obtained in intact pigs, rabbits (see Blasco et al., 1993b for a review) and mice (see Nielsen, 1994 for a review). Heritability of OR was also similar in both groups (ULO and intact). Heritability of IE in ULO does was similar to the one found in intact does. These estimates were larger than the ones reported by Bolet et al. (1994) in ULO does (0.04) but similar to the estimates found in intact does (0.26, Blasco et al., 1993a; 0.18, Bolet et al., 1994).

The higher genetic correlations of reproductive traits between ULO and intact does (near of 1) indicate that litter size, ovulation rate and number of implanted embryos were controlled by almost the same genes. Correlations of those traits between groups were not estimated in the other published experiment of selection on uterine capacity in rabbit (Bolet et al., 1994). In mice, Long et al. (1991) found also a high genetic correlation between ULO and intact females for ovulation rate (they give a value of 1.05), but a lower genetic correlation for litter size between ULO and intact mice (0.53). This and the fact that heritability was not higher for uterine capacity than for litter size explains why selection on uterine capacity has been effective to improve litter size in mice, but not as effective as selection on litter size itself (Kirby and Nielsen, 1993). The differences in uterine capacity found between ULO lines lead to differences in litter size in intact does (Santacreu et al., 2000). This agrees with the high correlation found in this experiment. Our results show that uterine capacity in rabbit seems to be a different trait that in mice or pig. The uterine space does not seem to limit the development of the embryos in ULO does as much as in pigs or mice (Knight et al., 1977). The high correlation between ovulation rate of ULO shows that genes controlling the number of corpora lutea are the same with or without ovariectomy.

In summary, selection for uterine capacity does not seem to be a more efficient way for improving litter size than selection for litter size itself.

Table 4. Genetic parameters in unilaterally ovariectomized (ULO) and intact does.

	h^2	Perm	r_g(ULO, intact)
LS_{ULO}	0.07±0.02	0.12 ±0.02	
			0.92 ± 0.16
LS_{intact}	0.13±0.03	0.12 ±0.03	
OR_{ULO}	0.30±0.06		
			0.94 ± 0.09
OR_{intact}	0.20±0.09		
IE_{ULO}	0.32+0.05		
			0.92 ± 0.05
IE_{intact}	0.16+0.06		

LS_{ULO}: total number of young rabbit born in ULO does. LS_{intact}: total number of young rabbit born in intact does. OR_{ULO}: total ovulation rate in ULO does. OR_{intact}: total ovulation rate in intact does. IE_{ULO}: total number of embryos implanted in ULO does. IE_{intact}: total number of embryos implanted in intact does. h^2: heritability. Perm: permanent effect. rg: genetic

correlation.

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