

DIVERGENT SELECTION FOR UTERINE EFFICIENCY IN UNILATERALLY OVARIECTOMIZED RABBITS. II. RESPONSE TO SELECTION.

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SUMMARY

Two experiments of divergent selection on uterine efficiency were performed. Rabbit does were unilaterally ovariectomized and a laparoscopy was made at mid gestation to count the number of corpora lutea and implanted embryos. Selection was on the number of dead fetuses (ND) between implantation and birth in the second gestation in the first experiment, and on litter size in the second one. Selection on ND was not effective in experiment 1, although an indirect response was observed in number of corpora lutea and implanted embryos. No changes in fetal survival were found. Selection on litter size was effective in experiment 2, but due to an increase in the number of implanted embryos. The genetic variability of uterine efficiency seems to depend more on embryo survival and implantation sites than on fetal survival.

INTRODUCTION

Selection on uterine efficiency (Christenson et al., 1987) may provide an indirect way to improve litter size. Only results from one experiment in mice have been hitherto published (Kirby and Nielsen, 1993), showing that uterine efficiency was not more effective than selection on litter size. However, although selection on litter size has been effective in several experiments with mice, little success has been found in closed populations of rabbits or pigs (see review by Blasco et al., 1993). In a former paper (Bolet et al., 1994) we have described two experiments of divergent selection on uterine efficiency in rabbits, and genetic parameters of traits related with uterine efficiency have been estimated. In this paper we examine the results of the selection.

MATERIALS AND METHODS

Two divergent selection experiments, described in Bolet et al. (1994), have been performed. Selection was for number of dead rabbits from implantation to birth in experiment 1 (to decrease them in the high line and to increase them in the low line) and for litter size in experiment 2, in both cases on unilaterally ovariectomized females. The evolution of the phenotypic means has been analyzed separately in both experiments. Least square means were calculated from a model with generation and line (within generation) effects. When data from several parities were analyzed, parity effect was also included. In the experiment 1, a fixed effect of type of female (ovariectomized or intact) was included.

Least square means were calculated on number of corpora lutea (CL), number of implanted embryos (IE), litter size at birth (LS), number of dead fetuses after implantation ($ND=IE-LS$), and on embryonic ($ES=NI/CL$), fetal ($FS=LS/IE$) and prenatal ($PS=LS/CL$) survival. We use the word 'embryo' from ovulation to implantation, and the word 'fetus' from implantation to birth.

RESULTS

Figure 1 shows the evolution of the differences between high and low lines in experiment 1 for CL, IE, ND and LS (figure 1a), and for the survival rates (figure 1b). Figure 2 shows the same for experiment 2. Results of the 4th generation of selection (G4) of experiment 2 are still provisional, since at the moment of writing the paper only half of the does of this generation have been measured. Differences on ND were not significant in any experiment. Differences in LS and IE were significant in all the generations of experiment 2, in experiment 1 IE goes from positive significant differences in G1 and G2 to negative in G4.

LS differences of experiment 1 were significant only in the last generation. Differences in CL were significantly negative from G2 to G4 in experiment 1, but the pattern was not clear in the other experiment. FS was not significant in any experiment. ES and PS did not show a clear pattern of significance.

DISCUSSION

Selection on ND was not effective in experiment 1, and no changes in fetal survival were found. Selection on litter size was effective in experiment 2, but due to an increase in the number of implanted embryos. Fetal survival and number of dead rabbits did not change, although it has been suggested that competence among embryos could produce differences in fetal survival when the rate of implanted embryos would be high (Adams, 1962; Hafez, 1964). As a consequence of this, the evolution of prenatal survival followed the same pattern as the evolution of embryo survival. Uterine capacity, measured as number of pups born to unilaterally ovariectomized females, has also been effective in changing litter size in mice (Kirby and Nielsen, 1993). The average response in litter size of three replicates of the selected line was 0.09 ± 0.01 on generation 21.

The results showed in fig. 1 and 2 are consistent with the heritabilities estimated on the same data by Bolet et al. (1994a). Selection in experiment 1 was on ND, whose heritability was zero, and it was not successful. Selection of experiment 2 was on LS, whose heritability was 0.18, and it was successful.

Litter size changed in both, experiment 1 and 2, due to changes in ovulation rate and embryo survival, but the pattern does not lead to clear conclusions. In both experiments it seems that the change in litter size is due to changes in number of implanted embryos, which are associated to changes in ovulation rate (CL) in experiment 1, but it is not so clear in experiment 2. In the experiment of selection for uterine capacity in mice, the response in litter size in intact females was due to an increase in prenatal survival (Gion et al., 1990). No significant differences were found between control and selected lines for ovulation rate.

The improvement in number of implanted embryos found in experiment 2 can be due to differences in rate of fecundation, embryo survival or factors related to the uterus. Fecundation rate seems to be very high in intact rabbits (95-98%, Adams, 1960), though varying between strains (82-93%, Bolet and Theau-Clement, 1994), but there are not studies in ovariectomized females, and perhaps immature ova could be responsible of the variations in embryo survival. Embryo survival depends on the embryo but it could also depend on the uterus environment, i.e. the amount and composition of uterine secretions (Bazer et al., 1990, in pigs). Whether differences of implantation are due to uterus environment and whether these differences will be conserved in females with both functional uterine horns, is a matter of further research.

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Figure 1: Evolution of the difference between high and low selection lines in litter size (LS), number of corpora lutea (CL), number of implanted embryos (IE), and number of dead fetuses between implantation and birth (ND), (figure 1a) and embryo, fetal and prenatal survival (ES, FS, PS), (figure 1b), from generation 0 (G0) to generation 4. Experiment 1. Selection to decrease (high line) and increase (low line) ND.

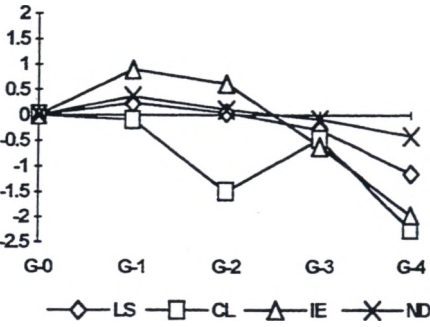


Figure 1a

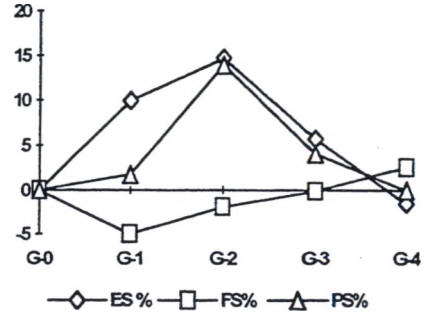


Figure 1b

Figure 2: Evolution of the difference between high and low selection lines in litter size (LS), number of corpora lutea (CL), number of implanted embryos (IE), and number of dead fetuses between implantation and birth (ND), (figure 2a) and embryo, fetal and prenatal survival (ES, FS, PS), (figure 2b), from generation 0 (G0) to generation 4. Experiment 2. Selection to increase (high line) and decrease (low line) LS.

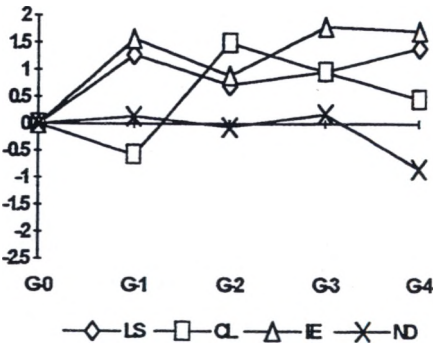


Figure 2a

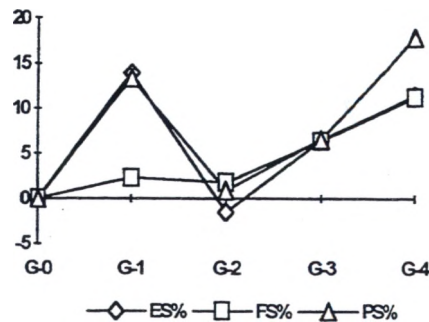


Figure 2b