SELECTION FOR COMPONENTS OF FEMALE REPRODUCTIVE EFFICIENCY

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SUMMARY

Three lines of mice consisting of 20 pairs of mice were selected for seven generations on performance in the first litter as follows: Line A- Total weight of litter weaned per gram of dam body weight at nine weeks of age; Line B- Number of young born alive per gram of dam body weight at nine weeks of age; Line C- random selection. Realized heritability estimates for NB/D9W were 0.16±0.07, while for TWW/D9W the estimate was 0.02±0.02.
The correlated selection responses for NB and D9W were in the desired directions with selection for NB/D9W. However selection for TWW/D9W resulted in correlated responses both in the positive direction. Possible explanation for these direct and indirect responses are discussed in the paper.

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INTRODUCTION

Female reproductive performance has a significant effect on the efficiency of most animal production systems. Measurements of the trait can become more complicated as selection objectives are refined, e.g. with respect to the time interval the trait is measured over i.e. one parity or over a lifetime. A further complication can arise if imputs e.g. maintenance requirements, as well as output are considered. In general the genetic relationship between size and reproductive performance at least in the first parity of the mouse has been found to be positive (McCarthy 1982).

The mouse has been used as an experimental model for farm species with numerous selection studies on various components of reproductive efficiency. These studies with the possible exception of those involving total weight weaned (Eisen, 1981), have been successful in improving the respective traits. What is less certain has been their success in improving the selection objective. The goal of this study was to evaluate the selection response for two components of reproductive efficiency, total number born and total weight weaned per gram of female body weight measured in the first parity.

MATERIALS AND METHODS

Mice: Three lines of random bred mice, each consisting of 20 breeding pairs were selected for seven generations on the basis of performance in the first litter, as follows: Line A- total weight of litter at weaning (3 weeks) divided by the dam's nine week weight; Line B- total number of live young born divided by the dam's nine week weight; Line C- at random. In each case two males and two females from the progeny of the ten pairs highest in the selection criterion (or in random order) were chosen to breed the next generation.

Throughout the experiment a commercial pellet feed and tap water were supplied ad libitum. The temperature in the mouse room ranged from 21 to 25oC. Mice were mated at between nine to ten weeks of age.

Measurement: Number of young born (NB), Number of young weaned (NW) and total litter weight at weaning (TWW) were taken routinely for all litters. Individual weights for the dams were also recorded at nine weeks of age (D9W). Average weaning weight (AWW), number born alive per gram of dam's nine week weight (NB/D9W) and total weight weaned per gram of dam's nine week weight (TWW/D9W) were also determined.

Analysis: Realized heritabilities were calculated as twice the regression of deviation from control on cumulated selection differential. Correlated responses were estimated for component traits as the regression of deviation from control on generation means. All data was pooled and heritability estimates for the various traits were calculated using daughter dam regression. Genetic correlations were estimated using the following formula - $r_g = \frac{cov_{xy}}{\sqrt{cov_{x\,x}\ cov_{yy}}}$ (Falconer 1981). These analyses were carried out within generation and line.

RESULTS

Generation means for the selected traits in the respective selection and control lines are shown in Figures 1 and 2.

The regression means on generation for all traits in the three lines are presented in Table 1. Although most of the estimates were not significantly different from zero, many of the values especially in the control line tended to be negative. This is likely to be the result of inbreeding depression, an adverse environmental trend or a combination of both.

In Table 2 realized heritability estimates and daughter-dam regression estimates are shown. Although the heritability estimates calculated using daughter dam regression were similar for both traits, selection was far more successful for NB/D9W.

Regression of deviations from the control on generation mean for component traits in the two selected lines are given in Table 3. All estimates were not significantly different from zero. Correlated responses were comparatively higher for the principal components of selection, i.e. TWW in Line A and NB in Line B, D9W also behaved differently in the two lines.

Estimates of heritability, genetic and phenotypic correlations for NB, NW, TWW, AWW and D9W are shown in Table 4. All heritability estimates except for NB were moderate and significantly different from zero. Genetic and phenotypic correlations were high between NB, NW and TWW, and were negative between NB and NW with AWW. A number of the genetic correlations involving D9W were greater than 1 and less than -1. This was possibly due to environmental correlations.

DISCUSSION

Estimates of heritability, genetic and phenotypic correlations for and between NB, NW, TWW and AWW obtained in the daughter-dam regression analysis were in general agreement in both sign and magnitude to those obtained by Steane and Roberts (1981). The one exception was the lower heritability estimate obtained in this analysis for number born which is possibly due to the presence of negative maternal environmental effects in this analysis. Like Steane and Roberts we also found negative genetic and phenotypic correlations between number born and weaned with average weaning weight which are contrary to the positive realized responses between NB and AWW reported by Eisen (1978) and Joakimsen and Baker (1978). In both of the latter studies litters were standardized at birth which could explain the difference in results.

There have been few selection experiments for criteria similar to NB/D9W and TWW/D9W reported in the literature. Eisen (1978) used an index which selected upwards for litter size and downwards for six week body weight. He obtained a realized heritability estimate of 0.14 which is similar to the estimate obtained in this experiment. The direct and indirect selection responses for TWW/D9W were somewhat surprising. Despite selection against D9W, the correlated response was positive which could account for the lack of response in the total trait. The correlated response in TWW (2.55gm/gen) approached significance (P 0.08) which was somewhat more successful when compared to other experiments where TWW was selected for directly (Dalton and Bywater (1963) and Steane and Roberts (1981)).

Division of TWW by D9W may have produced a similar effect to that of standardising the litter at birth in terms of partly counteracting the negative maternal environment effect which has been said to be the cause of lack of response in TWW (Eisen 1981).

These results can be best accommodated by the following set of hypotheses (see also Luxford and Beilharz, 1982; Beilharz, this conf.):

1) Postnatal maternal performance is limited by environmental constraints . In other words, in any environment, total resources available to the young are finite.

2) In the face of biological constraints, selection response will follow the path of least resistance. Selection for NB/D9W allows a response to occur because greater number and smaller size are compatible. Both AWW and D9W are measures of the same underlying trait, size.

3) Greater number and greater size of young are not compatible at weaning, which is the limiting stage of the reproductive process. Standardization of litters downwards, removes the constraint at weaning and explains the differences at the present results from others, as pointed out above.

4) In general, size of dam (D9W) is positively related to postnatal maternal performance. In the selection criterion TWW/;B9W, with the environmental constraint present, reduction in D9W is not compatible with a rise in TWW.

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TABLE 1: REGRESSION OF GENERATION MEANS ON GENERATION FOR ALL TRAITS

Line	Trait						
	D9W	NB	NW	TWW	AWW	NB/D9W	TWW/D9W
A	0.098	-0.075	-0.163	-1.675	-0.021	-0.006	-0.073
B	-0.494**	0.07	-0.230	-3.457	-0.419	-0.006	-0.097
C	-0.14	-0.207	-0.332	-5.475**	-0.241	-0.612	-0.148

** $P < 0.01$

TABLE 2: REALIZED AND DAUGHTER-DAM HERITABILITY ESTIMATES FOR NB/D9W AND TWW/D9W

Heritability	Trait	
	NB/D9W	TWW/D9W
Realized	0.16*	0.02
Regression	0.24	0.23

* $P < 0.05$

TABLE 3: REGRESSION OF DEVIATION FROM CONTROL ON GENERATION MEAN FOR COMPONENT TRAITS IN THE SELECTED LINES.

Line	Trait				
	NB	NW	TWW	AWW	D9W
A	0.132	0.169	2.55	0.219	0.241
B	0.279	0.102	0.763	-0.179	-0.351

TABLE 4: ESTIMATES OF HERITABILITY (ON THE DIAGONAL); GENETIC CORRELATIONS (ABOVE DIAGONAL) AND PHENOTYPIC CORRELATIONS (BELOW DIAGONAL)

	NB	NW	TWW	AWW	D9W
NB	0.10	0.92	0.82	-0.16	-1.6
NW	0.61	0.35	0.82	-0.38	-1.02
TWW	0.40	0.56	0.27	0.99	0.37
AWW	-0.56	-0.56	0.16	0.38	1.05
D9W	0.11	0.08	0.19	0.10	0.30

Figure 1: Selection Response for NB/D9W in Lines B and C

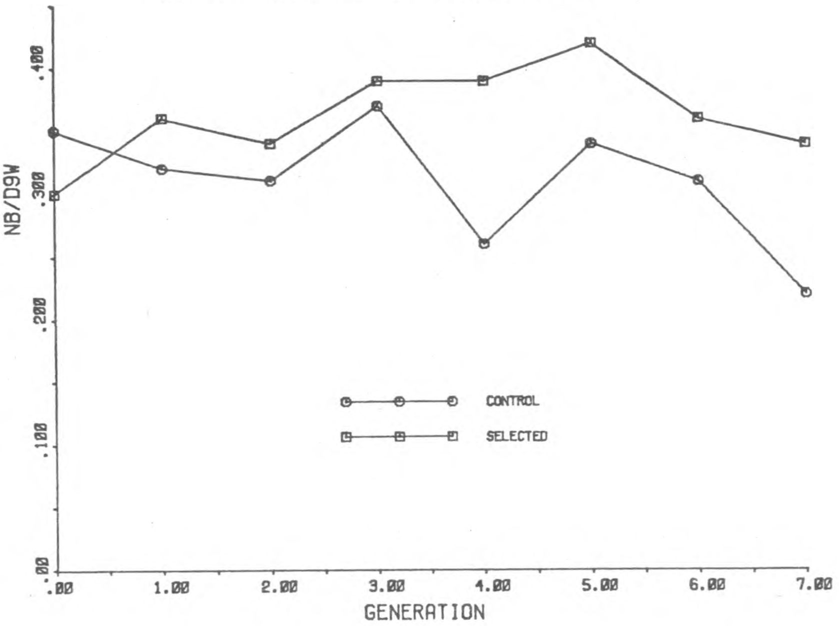

Figure 2: Selection Response for TWW/D9W in Lines A and C