

REALIZED HERITABILITIES FOR FIRST PARITY LITTER SIZE IN MICE,
EFFECTS OF MATERNAL ENVIRONMENTS AND RESPONSE IN LIFETIME PERFORMANCE

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INTRODUCTION

After 40 generations of divergent selection for litter size in mice, the three high lines that had plateaued (Joakimsen & Baker, 1977; Vangen, 1990) were randomly mated for two generations to form the base population for 22 new generations of selection for high first parity litter size in different maternal environments. The lines H4, H8, H12 and HI were selected from litters standardized to 4, 8 and 12 pups at day one in the first three lines and from unstandardized litter size in the HI-line. A control line HK was formed from the same base. The old control line K was also maintained (gen. 42 + 22 gen.). In a line that had been selected for low litter size (L) and where realized heritability was zero from generations 20-40, selection was reversed and the selection criterion became the same as in the high lines H4, H8, H12 and HI. In the lines HK, K and L litter size was standardized to 8 pups at day one. After generation 16 standardization level was changed to 8 pups in all high lines as well.

To measure lifetime fertility of the lines, all females from all lines except HI were given the chance to produce four litters, and litter size in these 4 successive litters was the measure of lifetime performance used.

Selection was based on mother's performance for litter size, total number born (TB). Realized selection differentials were calculated by averaging the males' and females' deviation from the average litter size in the same generation. As selection was based on female performance, the selection differential in one generation was the average of female selection differential in the same generation and male selection differential from the previous generation.

Realized heritabilities were estimated as twice the regression of cumulative selection differentials on cumulative selection responses. Standard deviations of the estimates were calculated according to Hill (1972).

RESULTS

Population parameters averaged over generations 1-22 are presented for the different lines in Table 1. In each line, except the L-line, 50 females were put to mating. The phenotypic standard deviations were 3.01 pups as an average for the high lines, somewhat lower in the K- and L-line. Selection differentials were app. equal in the high lines. Even in the control lines there were small positive selection differentials.

Table 2 shows the selection response as deviation from the HK-line for the high lines and as deviation from the K-line in the L-line. Except for the H4-line, the response is much higher in the last part of the experiment compared to the first 16 generations. The response is negative in H8 (first part of experiment) and H4 (last part of experiment).

Table 3 shows regression coefficients of cumulative selection differentials on cumulative selection response, and Table 4 the corresponding realized heritabilities. Except for two estimates, all are positive and express heritability estimates for litter size from 3 to 22 percent.

There is no pattern in the effect of standardization level on realized heritability even if this was very clearly expressed from the preliminary analysis of generations 1-10, where realized heritability was high at low standardization level and zero in unstandardized litter size line (Vangen, 1986). Averaged over the high lines, the heritability increased from the first to the second part of the experiment. Measuring response in the high lines as deviation from the K-line instead of the HK-line gave no great difference in results in the first 16 generations, but for the total experimental period realized heritability was 3 times higher when response was measured as difference from the K-line. The L-line, which had plateaued for low litter size prior to this reversed selection, showed a substantial high response throughout all generations with a realized heritability of 18 percent. As the inbreeding level was the same in this line as in the K-line, response was only measured as deviation from the K-line.

In Table 5 is shown the litter size traits total born (TB) and litter size per exposed female (LIEX) for the different parities of generation 22, and in Table 6 is the parity trend expressed as regression coefficients of parity number on the litter size traits.

Both tables express the decline in TB over parity in all high lines. Only the L-line shows an increase in actual litter size over parity. The decline is largest in the H4, H8 and H12 lines, lines selected for high litter size from a high genetic level.

For LIEX, the decline over parity is much greater. This trait declined already from parity one in all lines, expressing the higher proportion of empty females in the later parities. Summarized over the three high selection lines, TB was 2.76 pups higher in lifetime performance compared to the HK line and 8.93 pups higher than the K-line. For LIEX, the corresponding numbers were 4.78 and 6.72 pups.

CONCLUSIONS

- * Realized heritability estimates for no. total born ranges from 3 to 22 percent in different lines and generation periods.
- * Standardization level, that had great impact on realized parameters in the first 10 generations, showed no clear effects on the total response till generation 15. It was concluded that maternal effects, important for the immediate response to selection, were of little importance for the long term response.
- * It was a tendency that the H4 line, standardized to a low litter size at day one, did not show the same superiority in the later part of the experiment as in the first.
- * Lifetime performance, measured as litter size in four subsequent parities, was higher in the high lines than in the control and low lines, but the differences were smaller in lifetime performance than in first parity litter size.
- * The decline over parities in litter size and litter size per exposed female was greater in the high lines than in the low and control lines. However, all lines showed decline in fertility from parity 1 to parity 4.

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Table 1. Population parameters averaged over generations 1-22 in the different lines.

LINE	Per generation		
	No. litters	σ_D for litter size within gen.	Average sel. diff per gen (1-21)
H4	44.2	3.00	1.81
H8	46.8	2.96	1.94
H12	45.6	3.01	1.81
HI	46.0	3.11	1.85
HK	44.5	2.96	0.18
K	55.0	2.09	0.49
L	44.5	2.20	1.81

Table 2. Regression coefficients of generation number on cumulative selection response.

LINE	Gen. 2-16	Gen. 17-22	Gen. 2-22
	Deviation from HK		
H4	.117 ± .036**	-.045 ± .216	.034 ± .027
H8	-.017 ± .028	.237 ± .140	.032 ± .020
H12	.152 ± .020**	.194 ± .139	.113 ± .016**
HI	.066 ± .038	.198 ± .237	.083 ± .025**
Deviation from K			
L	-	-	.091 ± .010**

Table 3. Regression coefficients of cumulative selection differentials on cumulative selection response.

LINE	Gen. 2-16	Gen. 17-22	Gen. 2-22
	Deviation from HK		
H4	.059 ± .019**	-.007 ± .122	.019 ± .015
H8	-.008 ± .013	.112 ± .062	.016 ± .010
H12	.082 ± .011**	.092 ± .065	.060 ± .008**
HI	.032 ± .021	.087 ± .097	.044 ± .013**
Deviation from K			
L	-	-	.091 ± .10**

Table 4. Realized heritabilities for the selection criterion total no. born.

Line	Gen. 2-16	Gen. 17-22	Gen. 2-22
H4	0.12 ± 0.06	[-0.01]	0.04 ± 0.03
H8	[-0.02]	0.22 ± 0.09	0.03 ± 0.03
H12	0.16 ± 0.06	0.18 ± 0.09	0.12 ± 0.04
HI	0.08 ± 0.05	0.17 ± 0.09	0.09 ± 0.04
L	-	-	0.18 ± 0.05
Average for high lines	[0.09]	[0.14]	[0.07]
Average for high lines when deviation from K instead of HK	[0.09]	[0.16]	[0.21]

Table 5. Litter size and number of litters in the different parities of generation 22.

Line	Parity							
	1		2		3		4	
n	\bar{x}	n	\bar{x}	n	\bar{x}	n	\bar{x}	
Litter size, total born (TB)								
H4	42	20.00	35	20.25	29	18.20	11	13.90
H8	47	19.64	39	18.10	23	17.00	10	8.10
H12	45	19.89	37	20.86	27	18.40	23	16.26
HK	39	16.79	30	17.23	12	12.16	6	11.00
K	53	10.23	36	10.17	32	9.63	17	7.53
L	57	11.09	52	11.85	44	12.27	26	11.03
Litter size per exposed female (LIEF)								
H4	50	16.80	49	14.46	46	11.48	45	3.40
H8	50	18.42	47	15.02	44	8.89	42	1.93
H12	50	17.91	49	15.75	42	11.83	36	10.38
HK	50	13.10	49	10.55	46	3.17	44	1.50
K	58	9.32	56	6.54	56	5.50	55	2.33
L	60	10.55	60	10.27	60	9.00	60	11.03

Table 6. Regression coefficients of parity number (1-4) on fertility.

Line	Litter size, total born	Litter size per exposed female
H4	-1.556 ± .097**	-4.282 ± .098**
H8	-2.709 ± .153**	-5.519 ± .061**
H12	-1.197 ± .074**	-2.673 ± .034**
HK	-1.195 ± .146**	-4.228 ± .078**
K	-.678 ± .039**	-2.200 ± .026**
L	.145 ± .035**	-1.858 ± .059**