RESULTS OF LONG TERM SELECTION FOR GROWTH TRAITS IN LABORATORY MICE

L. Bünger, G. Herrendörfer and U. Renne
Research Centre for Animal Production Dummerstorf-Rostock
of the Academy of Agricultural Sciences of the GDR,
Dummerstorf 2551-GDR.

SUMMARY

A modified exponential model was used to analyse the direct response of long term selection among full-sib-families (2♂/litter), 80 pairs per line, selection proportion 50%, selection for body weight and protein amount at 42 days (BW 42 2♂, PA 42 2♂) in outbred laboratory mice and to estimate realized h^2 functions for the BW42 1♂and PA 42 2♂. In the BW-line the BW 42 1♂was increased after 50 generations by 26.5g, 11.5s_p, 21s_g or to 196% of the start value (27.7g). A selection limit can be expected at 61.2g. Realized h^2 at the start was 0.299 and at the end of selection 0.04. The half-life was about 20 generations or 0.17Ne. The PA 1♂increased from 3.14g by 2.2g (70%; 8.6s_p; 23s_g). The half-life was about 33 generations. Realized h^2 decreased from 0.15 to 0.05. The selection for PA was accompanied by a strong increase in BW in the absence of any directed change of protein %, averaging 18.03%.

INTRODUCTION

(1) Extensive data are available on the genetic architecture of postweaning body weight or growth rate (for reviews see: Roberts, 1965a, b; Eisen, 1974, 1980; McCarthy, 1982; Bünger et al., 1982) and on correlated responses in body composition resulting from selection for growth (for reviews see: Roberts, 1979; Malik, 1984; Bünger, 1987). But only a few studies have involved direct selection for components related to body composition in rats or mice (for literature see Eisen, 1989).

(2) Exponential models are more appropriate than linear or polynomial models for fitting the selection response (Robertson, 1960; Bohren, 1975; Eisen, 1980). The application of similar non-linear models is usual in studies of growth of animals (e.g. Eisen, 1976; Taylor, 1980; Parks, 1982), but only a few studies have used them for analysis of long-term selection experiments (James, 1965; Frahm and Kojima, 1966; Eisen, 1972, 1975; Harris, 1982; Bünger et al., 1988).

The objective of this paper is to analyse the direct response of long term single trait selection for body weight and protein amount at 42 (BW 42, PA 42) by use of a modified exponential model proposed by Herrendörfer and Bünger (1988).

MATERIALS AND METHODS

The selection experiment has been described in detail by Bünger (1987) and is briefly reviewed here in tabular form (see Table 1, Experimental design).

RESULTS

Selection for body weight: The response of male body weight at 42 days (BW 42 1♂) plotted against generation number (Figure 1) shows that this selection trait increased from 27.67g (=C) to 54.2g in generation 50. That is an increase by 26.5g, 11.5s_p, 21s_g or to 196% of the start value. At a body

weight of 61.2g (33.5g, 120%, $15s_p$, $27s_g$ over start value) a selection limit can be expected presuming no mutation occurs. The relation between cumulated selection response (cum.SR) and realized cum. selection differential (cum.SD) is the basis for the estimation of the h^2-function using the first derivative of the exponential function. Because the selection criterion was the sum of 2 male full-sibs the h^2- and s^2-values were converted to an individual basis. Realized h^2 at the start was 0.299 and decreased to 0.044. Whereas s^2_p increased from 5.3 to 21.3, s^2_g fell from 1.6 to 0.9. The half-life was about 20 generations, that means after about 0.17 realized Ne (= 120), half of the total response is reached.

Table 1 Experimental design

Reference: Bünger (1987)	Animal model: Laboratory mice

Base population: randombred strain Fzt:DU
cross of 4 randombred and 4 inbred strains (Schüler, 1985)

Line designation	Sel.-duration	Sel.-trait
DU-6	0 - 50	Body weight (BW 42 2♂)
DU-6P	0 - 50	Protein amount (PA 42 2♂)
DU-Ks	8/9 - 50	Randomly selected control population

Population size: 80 pairs/gen./line Ne = 160
Sel.-procedure: Selection for the sum of full-sib performance (2♂/litter) at 42 days

Mating:	ratio	age (d)	duration (d)
	1♂:1♀	63 ± 4	14

	DU-6	DU-6P	DU-Ks
Sel.percentage; $\bar{p}$ =	49.6 ± 10	49.5 ± 6	46.1 ± 2
stand. SD; ds =	0.798 ± 0.2	0.796 ± 0.13	0.066 ± 0.13

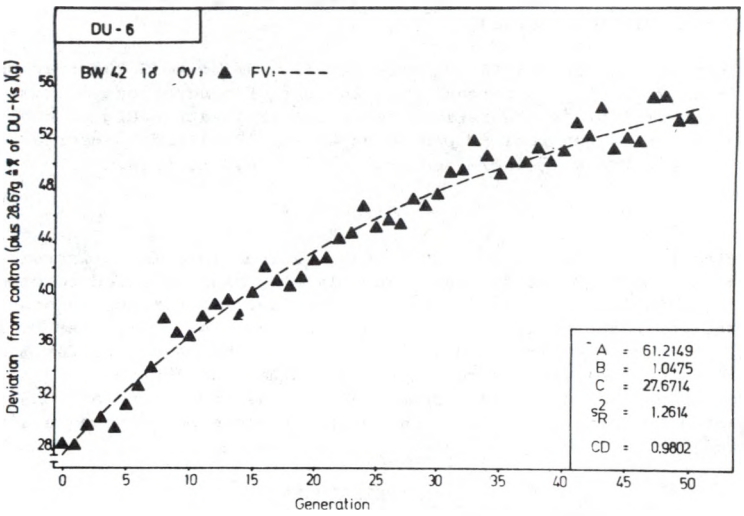
Litter size standardization: at birth (day 0) to 8 (gen. 0-15) and 9 (since gen. 16) and elimination of all litters with LS < 7

Remarks

- ad libitum feeding and housing in a semi-barrier-system
- establishment of generation 0 by division of full-sibs from 160 litters as parents into the 2 selection lines
- the protein amount in DU-Ks was not continuously determined
- elimination of the 2 test males after/by measurement of selection trait

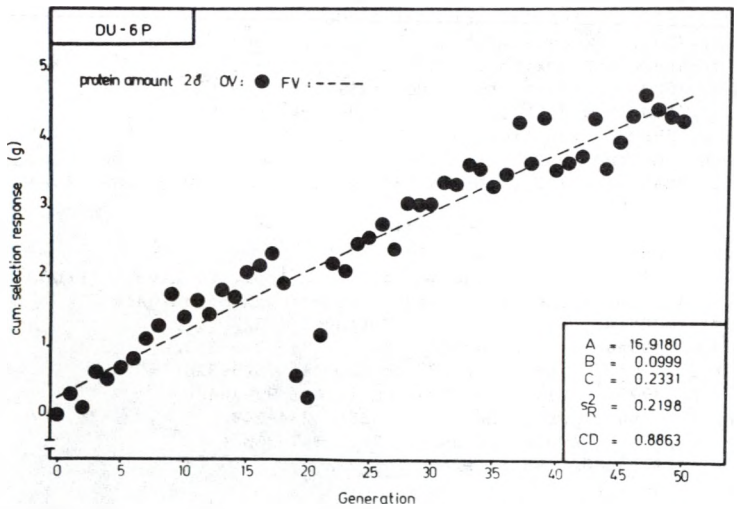
Selection for protein amount: The cum.SR for the selection trait (PA 2♂) plotted against generation number is shown in Figure 2. Despite the low values in generation 19, 20 and 21 a good fit was possible (CD = 0.886).

Figure 1. Generation means of male body weight at 42 days corrected by control data.



- OV, FV: observed value, function value
- CD, S^2_R: coefficient of determination, residual variance
- for further explanation see text

Figure 2. Cumulated selection response plotted against generation number.



Because control line data for PA were not continuously available the elimination of this negative environmental trend was not possible. The exclusion of these 3 values gave the parameters: A = 9.76, B = 0.107, C = 0 and a better fit (CD = 0.96).

After 50 generations PA 1σ increased from 3.14g to 5.20g that means by 2.06g (66%, $8s_p$, $21s_g$). Depending on the use of generations or cum. SD as independent variable a theoretical selection limit at 8.02g or 6.52g and half-lives of 63 or 34 generations can be expected. Realized h^2 decreased from 0.146 to 0.048 while s^2_p increased from about 0.066 to 0.24.

DISCUSSION

Selection for BW for 50 generations resulted in a large increase in mean body weights to 54.2g at 42 days. This is very high compared to other selection experiments, even for transgenic mice. So far as is known only obese mutants reach similar body weights but this is accompanied by a fat content of up to 50% (Bray and York, 1979). In the DU-6 line fat % at 42 days averaged 13.6%, whereas the corresponding values for the control and protein line were about 9.3 and 9.0% (Bünger 1987). The protein selection was accompanied by large increase in BW but the protein percentage remained unchanged.

REFERENCES

BOHREN, B.B. 1975. Genetics 80, 205-220.
BRAY, G.A. and YORK, D.A., 1979. Physiol. Rev. 59: 719-809.
BÜNGER, L. 1987. Genet. Probl. in der Tierzucht. Heft 13. AdL der DDR, Fzt Dummerstorf-Rostock.
BÜNGER, L., RENNE, U. and HERRENDÖRFER, G. 1988. Tag.-Bericht. Akad. der Landw.-wissenschaften DDR 268: 137-156.
EISEN, E.J. 1972. Genetics 72: 129-142.
EISEN, E.J. 1974. Proc. 1st World Congr. Genet. Appl. Livest. Prod. Madrid: 467-492.
EISEN, E.J. 1975. Genetics 79: 305-323.
EISEN, E.J. 1976. J. Anim. Sci. 42: 1008-1023.
EISEN, E.J. 1980. Z. Tierzüchtg. Züchtgsbiol. 97: 305-319.
EISEN, E.J. 1987. Theor. Appl. Genet. 74: 793-801.
EISEN, E.J. 1989. Livest. Prod. Sci. 23: 17-32.
FRAHM, R.R., KOJIMA and K.I. 1966. Genetics 54: 625-637.
HARRIS, D.L. 1982. Genetics 100: 511-532.
HERRENDÖRFER, G. and BÜNGER, L. 1988. Proc. Intern. Conf. Population Mathematics. In: Probl. d. angew. Statistik, Heft 26: 45-49. AdL der DDR.
JAMES, J.W. 1965. Heredity 20: 57-63.
MALIK, R.C. 1984. J. Anim. Sci. 58: 577.
McCARTHY, J.C. 1982. Proc. 2nd World Congr. Appl. to Livest. Prod.
PARKS, J.R. 1982. A theory of feeding and growth of animals. Berlin/Heidelberg/New York: Springer 1982.
ROBERTS, R.C. 1965a. Anim. Breed. Abstr. 33: 339-353.
ROBERTS, R.C. 1965b. Anim. Breed. Abstr. 33: 515-526.
ROBERTS, R.C. 1979. Livestock Prod. Sci. 6: 93-104.
ROBERTSON, A. 1960. Proc. R. Soc. B 153: 234-249.
SCHÜLER, L. 1985. Arch. Tierzucht. 28: 357-363.
TAYLOR, St. C.S. 1980. Anim. Prod. 31: 223-235.