A STUDY OF THE GENETIC BEHAVIOUR OF SOME QUANTITATIVE TRAITS IN MICE

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The results of this work provide a basis for the behaviour of the same process, more or less, when applied to larger species of livestock. This procedure is followed by passing the obstacle of prolonged generation intervals confronting the breeder of large animals.

and inactive than the small one, had comparatively shorter ears, feet and tail and have a higher ovulation rate. Colour gene differences had also appeared between the lines and MacArthur accepted random genetic drift as a probable explanation here.

Butler (1952) crossed the large and small strains of MacArthur together and to two other inbred strains and analysed the crosses. In all cases he found the F_1, F_2 means to be intermediate between the parents, while the backcrosses were intermediate between the F_1 and the respective parental strain. Thus the mean weight showed proportionality to the percentage of genes for the large size in the genotype. The F_2 variance was no greater than that of the F_1. Warwick and Lewis (1954 a) obtained results that were in agreement with the preceding ones when they crossed their small and large strains.

Results essentially similar to Butler's were reported by Chai (1956 b), though he found some increase in the variance of the F_2 over that of the F_1.

A second study involving MacArthur's strains was that of Lewis and Warwick (1953). They crossed the large and the small strains to an unselected random-bred strain from the same base as the selected strains. Then they backcrossed to the large strain and continued selection for high 60 day weight, similarly a backcross to the small strain was selected for low weight, in each case they selected with both outbreeding and inbreeding mating systems. They observed responses over a further five generations in both directions and the results were essentially similar in both inbred and outbred populations.

The quantitative nature of the genetic variation in body weight of the mouse was thus firmly established from some of the early work. MacArthur (1944 a) found animals which he described as "runts" in his small strain. Lewis and Warwick (1953) also found them in the small strain, and noted that they greatly increased the variance.

However King (1950, 1955) who was also working with MacArthur's small strain showed that these runts resulted from action of a single recessive gene which King labelled Pygmy. Homozygous Pygmies at six weeks old are approximately half the size of normal litter was radically different from that practiced by Goodale or MacArthurs, in that animals were selected on the basis of their deviation from the litter mean for their own sex. Each family as far as possible contributed one male and one female as parents in the succeeding generation (within family selection).

Falconer found that his high and low lines diverged regularly over the eleven generations, which he first reported. However this response was markedly asymmetrical whereas his high line gained a total of 4 grams in mean weight, the low line decreased in weight by 7 gram nearly twice as much. This asymmetry was reflected in the heritability estimates of (0.2) for upward selection and 0.5 for downward.

A more detailed analysis of the asymmetry with further results was given in a later paper (Falconer 1955). Six week weight can be regarded as consisting of two parts - the weaning weight at 3 weeks which is largely a characteristic of the mother, and the growth from three to six weeks (more or less depending on the individual's potential). When Falconer examined these 2 components separately, he found that the asymmetry of response was entirely attributable to weaning weight and not at all to post weaning growth. Falconer also found that his stocks exhibited directional dominance in favour of large size, inbreeding depression would operate adversely in the high line while in the low line it would assist the selection for small size.

Taylor (1954) working with Falconer's stocks found that this directional dominance was similarly a feature of the three week weight, which reflects maternal performance.

Falconer and Robertson (1956) took body weight as a metric character and opposite extremes (large and small) were selected as parents in the "extreme" line. Individuals closest to the mean were selected as parents in the "central" line. No change of variability was detected in the extreme line. The males of the central line showed a small decline of variability. The 2 lines diverged in body weight in both sexes, the extreme line being the heavier.

They showed that selection of extreme phynotypic devients did not materially change the sensitivity to the environmental influences. An increase in environmental variance from this cause is therefore unlike[illegible] to be an important consequence of unidirectional selection.

Korkmaan (1957) used the selection in two ways in the first he increased the weight of males and decreased the weight of females, and in the second he made the opposite. He used within litters selection in the first 5 generations and within and between litters selection from 5-10 generations. He found that the sex difference in body weight seems to be manifested mainly at 30-60 days, the time when the animals reach sexual maturity.
Fowler (1958) studied the growth of strains of mice selected for large and small body size and found that the genes present in the foundation population and the criteria of selection may affect the nature of the response of selection for large and small body size in the 2 unrelated strains under study.

Legates et al. (1958) selected for 6-weeks weight and 12 day litter weight in mice. Divergences of 24.1 and 13% of the performence in the base population resulted from intralitter selection for 6 weeks individual weight and 12-day litter weight respectively correlated responses were 16.7 and 10.5% respectively.

Falconer (1960 b) selected mice for growth on high and low planes of nutrition and he enumerated the manifold causes that may result in asymmetrical responses. Falconer's main conclusions, the asymmetrical response may be summarised as follows :

i- A large number of loci of approximately equal effects control the genetic variation in body weight.

ii- Dominance is predominantly in the direction of large size.

iii- The response ceased in both lines after about 20 generations.

iv- The large and small lines (about 28 and 12 g. respectively) eventually diverged by sixteen times the original genetic standard deviation.

v- The realized heritability remained unchanged in both lines until the limit was reached.

vi- Realized differentials equals the expected differentials in the high line, but fell short in the low indicating that natural selection impedes progress when selecting for small size.

vii- When selection was suspended, the small line reverted towards the original level, corroborating the finding with respect to natural selection, the large line did not revert.

viii- Compared with the small line, the large line had longer tails, had higher twelve day and three week weights, and had a larger litter size. The number of fertile mating and postnatal viability fell in both lines.

Zucker (1960) reported that after 10 generations of two ways of within litter selection for body size in rats with observations on simultaneous changes in coat colour pattern and hood size there is a nearly 80 % differences in mean body size, with rate of progress in the two directions about the same. So far there is no evidence of correlation between any coat colour character and body size.

Korkman (1961) selected two strains derived from a single population for body weight at 40 days of age. Weight increased in the population on a high plane of nutrition, the average increase corresponded to a heritability of 0.22. No significant weight response to selection was observed on low plane of nutrition. Selection for body weight on a high plane of nutrition seemed to favour long bodied and long tailed animals.

Bowman (1962) showed that recurrent selection for large size in mice from a non-inbred population and subsequent crossing with an inbred tester produced a response could be fairly accurately predicted by methods based on additive genetic variance alone. There was no evidence of overdominance.

A report by Rahnefeld, Boylan, Comstock and Singh (1963) supports many of these conclusions. Their experimental procedures differed in several important respects from Falconer's. Firstly, their base population was derived from a reciprocal cross of only two inbred strains. Secondly they selected for growth between three and six weeks. Thirdly they conducted a mass selection procedure based entirely on the growth of the individual mouse. Selection for increased growth for 17 generations changed the mean growth by 4 or 5 grams depending on how the increase was estimated. This progress however represented only about 43% of the original mean growth and 6 times the additive genetic standard deviation. Their response was linear over the period of study and at the time of reporting, showed no indication of diminishing. They concluded that many genes were fluctuated both at birth and at weaning. The weaning litter sizes were smaller in generations 11 to 16 than before or after. There was a slight tendency in large toward decrease of litter size at birth but not at weaning.

Another work on selection in mice was done by Dalton (1967); he selected for high and low growth and reported that the indirect responses on either plan of nutrition (full and diluted diets) were equal to the direct responses on the same plane. Hence selection for growth could be well carried out in the environment in which the animals were to perform as in any other environment.

Elsen *et al*. (1970) selected for 12 day litter weight in mice for 10 generations (within family selection) in 4-replicate lines of mice. He reported that the average realized h^2 was 0.11 ± 0.02 and the observed genetic gain 0.25 ± 0.04 gram per generation. Direct additive genetic variance for genes controlling growth in the individual accounted for 22.2% of the total variation. Whereas postnatal maternal genetic variance accounted for only 6.1%. There was a positive covariance between direct environment and maternal environment accounting for 56.2 % of the phenotypic variance in individual 12-day weight with only 10.8% being due to genetic postnatal maternal influences. There was a slight positive correlated response in number born. The genetic correlation between litter size and 8-weeks weight was 0.69.

Hanrahan and Elsen (1970) also studied the effect of selection for increasing 12-day litter weight in mice on lactational performance and found that the correlation between the two traits studied was estimated to be 0.45.