Selection for Food Intake, Percentage Fat and Lean Mass in the Mouse

by

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I declare that this thesis is my own composition and that the research described in it is my own work, except where otherwise stated.

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SUMMARY

The aim of this experiment was to establish and examine lines of mice that differed in food intake, percentage lean and total lean mass. To achieve this, mice were selected for four to six week food intake, adjusted for four week weight, for the ratio of gonadal fat pad weight to body weight, and for the index (body weight - 8 x gonadal fat pad weight). For each selection treatment there were three replicates, each consisting of a High, a Low and an unselected Control line.

The realised heritability of four to six week food intake, adjusted for four week weight, was 14 $\pm$ 2.7% from the High-Low divergence. Selection for increased food intake led to an increase in litter size and in body weight at six and ten weeks, a slight increase in four week weight and in four to six week gross efficiency, and a decrease in percentage fat. Selection for decreased food intake led to a decrease in litter size and in six and ten week weight, a slight decrease in four week weight and in four to six week gross efficiency, and no change in percentage fat.

The realised heritability of the ratio of gonadal fat pad weight to body weight was 43 $\pm$ 5.9% from the High-Low divergence. Selection for an increase in the ratio led to an increase in percentage total fat, but little change in four to six week food intake and gross efficiency, and in body weight at four, six and ten weeks. Selection for a decrease in the ratio led to a decrease in percentage total fat, in four to six week food intake and gross efficiency, and in body weight at four, six and ten weeks. There was no change in percentage protein or in litter size as a result of

selection in either direction.

The realised heritability of the index (body weight - 8 x gonadal fat pad weight) was 54 $\pm$ 1.2% from the High-Low divergence. Selection for an increase in the value of the index led to an increase in four to six week food intake and in gross efficiency, and in body weight at four, six and ten weeks. Selection for a decrease in the value of the index led to a decrease in food intake, in gross efficiency and in body weight. There was no difference in percentage fat between the High and Low selected lines, and only a small difference in litter size.

CONTENTS

INTRODUCTION

Three reasons can be suggested for studying body composition and its relationship with growth and food intake.

Firstly, farmers and animal breeders would like to produce animals that will grow quickly, not consume too much food and contain a high proportion of lean in their carcasses. It is known to be more energetically efficient to lay down lean than fat (Pullar and Webster, 1977), and in these days of concern about dietary fat, customers prefer lean meat.

Secondly, it would be interesting to know more about the factors that contribute to human obesity. Is it entirely caused by diet or is it partly genetically determined? Could obesity be significantly reduced by greater exercise? These and other questions have yet to be fully answered.

Thirdly, as scientists, we wish to know more about how animals "work" - what happens to the energy that goes in as food and how does it contribute to growth and maintenance?

A. Body Composition

The body of an animal consists of four main components - water, protein, ash (bone) and fat. Fat is by far the most variable of these components in adult animals. Indeed, it seems that after a certain age, the relative proportions of protein, water and ash are fixed, and only the proportion of fat varies. Moulton (1923) called the age after which the relative proportions of water, ash and

protein are constant the point of "chemical maturity", and estimated this to be about 4.5 per cent of the total life expectancy of an animal. It is not now thought that this figure is correct for every species, but the concept of a point in an animal's life after which the relative proportions of protein, water and ash no longer change, still holds.

However, this is not to say that the amount of fat in the body is not under precise control. Larson and Anderson (1978) removed both epididymal fat pads and the right inguinal fat pad from a group of 50 Sprague Dawley rats. After 13 weeks, chemical analysis revealed that both treated and untreated rats had the same amount and the same proportion of total body lipid. Dissection revealed that compensatory growth had occurred in the inguinal, perineal and mesenteric depots of the lipectomized rats. This growth had occurred by cellular hypertrophy (cell growth) in the perineal and mesenteric depots and by an increase in cell number in the inguinal depots.

B. Genetic Relationship between Body Composition, Growth Rate, Efficiency and Food Intake.

Body composition is related to growth rate, food intake and efficiency of growth. There are various ways of examining these relationships.

Firstly, one can study genetically obese animals, either single gene mutants or polygenically obese animals. The cause(s) of their obesity can be determined, and the ways in which they differ from lean animals in growth rate, food intake and efficiency can be examined.

Secondly, one can study the relationships between growth rate, food intake, efficiency and body composition in genetically lean animals, either by taking measurements of these characters in a population or by selecting for one of these characters and seeing the effects on others.

1. Study of Genetically Obese Animals

Several strains of genetically obese animals have been discovered. In some cases the obesity is caused by a single gene mutation, for example ob in the obese mouse and fa in the Zucker fatty rat. In other strains the obesity is polygenic, for example the Ossabaw stain of pigs and the NZO strain of mice.

Obese (ob/ob) mice have a number of defects, but it has not yet been established which is the primary lesion. They seem to have a defective thyroid gland (York et al, 1978). They are hyperthyroid and their adipose tissue is less sensitive to thyroid hormones than that of normal mice. Some of these defects were corrected by adrenalectomy - there seems to be a hypersecretion of adrenal steroids in the obese mouse, but it is believed that the thyroid defects start earlier than the adrenal malfunction. It was suggested that both defects might result from a primary defect in the hypothalamus.

Both the obese (ob/ob) mouse and the Zucker fatty (fa/fa) rat eat more than their lean litter-mates. This increased appetite (hyperphagia) is not, however, the primary cause of their obesity. When obese (ob/ob) mice and Zucker fatty (fa/fa) rats are pair-fed to their lean litter mates (fed the same amount of food as their lean litter mates have eaten the previous day), they still become

obese, although to a lesser extent than if they are fed ad libitum.

Two studies have been carried out to discover whether the obesity of the Zucker fatty rat is caused by a decrease in protein deposition as compared with lean control rats. Bell and Stern (1976) looked at the change in the various carcass components of lean and obese Zucker rats from 13 to 31 days of age. It was found that at 31 days of age, although the fatty rats had considerably more fat than the controls, water, ash and protein formed the same proportions of fat-free mass, suggesting that the rate of protein deposition is the same in both genotypes.

Radcliffe and Webster (1976) fed Zucker fatty (fa/fa) rats and lean rats diets of varying protein level. In some cases the fatty rats were pair-fed to lean rats. When the rats were fed ad libitum both genotypes gained the same amount of protein on all diets. When pair-fed to lean rats, fatty rats gained less protein than the controls. It was suggested that rats eat as much food as is necessary to achieve a certain level of protein deposition. Fatty rats have an abnormal balance between protein and fat deposition, therefore they have to eat more than lean rats to achieve the same level of protein deposition.

The Ossabaw pig is an obese feral strain. Cote and Wangness (1978) compared the obese Ossabaw pig to a lean Yorkshire strain. They measured growth rate, food intake and gross efficiency (weight gain / weight of food eaten) from 3 to 8 weeks of age, and compared the composition and gross efficiency of gain. The lean pigs ate more and gained more weight, but the gross efficiency of the two types of pig was the same. The lean pigs had greater water, ash and protein gains, but the fat and energy gains were the same for lean and obese

pigs. The similar energy gains reflect the higher calorific value of fat. The obese pigs were more energetically efficient (energetic efficiency = energy retained in carcass / energy intake). It was concluded that, compared to the domestic pig, the Ossabaw pig is characterised by a decreased capacity for growth of fat-free mass rather than by an increased capacity for fat deposition. This is obviously a different type of obesity from that exhibited by the Zucker fatty rat.

Recently there has been much speculation about the role of temperature regulation in obesity. James and Trayhurn (1979) suggested that genetically obese animals and humans are defective in a thermogenic response to cold temperatures (non-shivering thermogenesis). It was discovered that obese (ob/ob) mice and Zucker fatty (fa/fa) rats undergo an extreme drop in body temperature and eventually die at 4°C, despite their insulating layer of fat. Furthermore, when 10 day old obese mice are exposed to cold they showed a marked drop in rectal temperature, unlike lean mice. At 10 days old the obese syndrome is not apparent, so the themogenic defect precedes obesity in the obese mouse.

Cold-adapted animals show non-shivering thermogenesis (NST) in which increased heat production is mediated by the sympathetic nervous system. The capacity for NST is related to the presence of brown adipose tissue, which is found in cold-adapted animals. A study by Rothwell and Stock (1979a) suggested another role for brown adipose tissue. Rats were encouraged to overeat by being fed a "cafeteria" diet - a diet consisting of rich and varied foodstuffs. Some of the rats became obese and some did not. The rats consumed an average of 80 per cent more energy, but only gained an average of 27

per cent more weight. It was calculated that the total energy expenditure of the "cafeteria"-fed rats was 100 per cent greater than that of normally fed controls, even greater when corrected for body weight. When the brown adipose tissue was dissected out, the weight found in the "cafeteria"-fed rats was similar to that found in animals adapted to 5°C, more than twice that found in the controls. This increase consisted of active tissue, there was no increase in lipid deposition. It was concluded that, by various criteria, there is an association between changes in brown adipose tissue and dietary-induced thermogenesis, resembling changes found in cold-adapted animals.

Trayhurn et al (1982) put young lean and obese (ob/ob) mice on a "cafeteria" and a normal diet. The "cafeteria"-fed lean mice ate 69 per cent more digestible energy, but retained only 19 per cent more energy than the normally fed controls. The "cafeteria"-fed obese mice consumed 49 per cent more energy and retained 88 per cent more energy than the normally fed obese mice. The energetic efficiency of lean mice was lower on the "cafeteria" diet, whereas the obese mice were more energetically efficient on the "cafeteria" diet. The brown adipose tissue (BAT) from the four groups of mice was examined. The "cafeteria"-fed lean mice had 26 per cent more brown fat than their controls, but the protein content was the same. The cytochrome oxidase activity of the "cafeteria"-fed lean mice was 53 per cent higher than that of the controls, so the oxidative capacity of BAT had been increased by overfeeding in the lean mice. The "cafeteria"-fed obese mice showed no increase in the weight of brown adipose tissue, protein content or cytochrome oxidase activity over their normally fed controls. Trayhurn et al explain that one of the

primary mechanisms for thermogenesis in BAT is a proton conductance pathway across the inner mitochondrial membrane, which can be inhibited by GDP. GDP binding can serve as a measure of activity of this proton conductance pathway. There was a 50 per cent increase in GDP binding in "cafeteria"-fed animals in both groups, but the binding was less for the obese mice on both diets. So the proton conductance pathway had increased in activity in both groups, but not the total oxidative capacity of the brown adipose tissue.

It was concluded that the results were consistent with the view that regulatory dietary-induced thermogenesis (DIT) mediated by BAT plays an important part in energy balance, also that a reduced capacity for DIT is important in the development of obesity. The obesity in ob/ob mice might be viewed as a consequence of reduced NST and DIT in BAT. The reduction in NST leads to a low maintenance requirement and excessive energy gain on a normal intake, and the reduction in capacity for DIT leads to an impairment in the ability to dissipate excess energy when hyperphagia starts.

There is now some evidence that brown adipose tissue exists in adult man (it was previously thought that it was present only in infancy). It might be a possibility that some obese humans suffer from underactive brown fat, but much work remains to be done before the role of brown adipose tissue is fully understood.

Although the study of genetically obese animals can yield much useful information, it must always be remembered that genetically obese animals (especially single gene mutants) differ from normal animals in extreme ways. Caution should therefore be used in extrapolating from the results of studying animals such as the ob/ob mouse to obese animals or humans that are merely at the top end of a

normal distribution for fatness.

2. Selection Experiments

a. Selection for Body Weight in the Mouse

When mice are selected for high body weight at a given age or for high weight gain, an increase in percentage fat in the selected mice is commonly observed, when they are compared with unselected controls at the same age. This is not always true when the selected and unselected mice are compared at the same weight. Robinson and Bradford (1969) selected for high 3 to 6 week weight gain in one line of mice. After 17 generations of selection the selected mice had an average of 18.3 per cent fat at 9 weeks of age and 20.3 per cent fat at 12 weeks, compared with 10.5 per cent and 14.7 per cent in the unselected control line. After 31 generations of selection 10 week old selected females had 23.4 per cent fat, compared with 9.4 per cent fat in the controls (Meyer and Bradford, 1974).

McPhee and Neill (1976) selected two lines of mice for high and low 8 week weight for 25 generations. Although the high line mice had a lower percentage of fat at early weights, they had a higher proportion of fat than the control line mice at body weights over 21.6g.

Eisen et al (1977) compared two lines of mice, one which had been selected for high 6 week weight for 73 generations (H6) and one that had been selected for high 4 to 6 week gain for 37 generations (M16). The H6 mice showed no increase in percentage fat, whereas the M16 mice showed a large increase in percentage fat, both relative to their unselected control lines. The M16 line did show a larger response in weight gain compared with its control, however. Various

reasons were suggested for the different responses in percentage fat - different selection criteria (but 6 week weight and 4 to 6 week gain are highly correlated), genetic drift or different gene frequencies in the base population.

Stainer and Mount (1972) examined a strain of mice which consisted of a line selected for high 6 week weight, a line selected for low 6 week weight and an unselected control line (Falconer, 1953). There were no differences in the body composition of mice in the high and low lines, despite large differences in growth rate. However, their conclusions were based on measurements of very few animals - between 3 and 14 mice per line were examined at different ages.

Is it possible to select for high body weight or weight gain and to deliberately keep percentage fat from increasing? The results of an experiment by Hull (1960) suggests that the age of selection plays an important part in the resulting degree of fatness. Mice were selected for high 3, 4.5 and 6 week body weight. When the amount of fat at 6 weeks of age in the selected lines was measured, it was found that the earlier the age of selection, the fatter the mice were at 6 weeks, both in amount and percentage of fat.

Hayes and McCarthy (1976) selected mice for high and low 5 week weight (H5 and L5) and for high and low 10 week weight (H10 and L10) for 15 generations. The lines were examined and compared with an unselected control line at 5, 10 and 21 weeks of age. The growth curves of H5 and H10 mice, and of L5 and L10 mice were found to be very similar. The percentage of fat was found to be higher in H5 than in H10 mice at all ages, and lower in L5 mice than in L10 mice at all ages. Although both H5 and H10 mice were fatter than control

line mice at 10 and 21 weeks, the H5 mice were much more so.

A model was suggested to explain this difference, based on the assumption that there are two main things that affect growth rate - food consumption and the partitioning of food energy available for growth between protein and fat. Protein contains 23kJ per gram whereas fat contains 39 kJ per gram. The efficiency of protein deposition is 0.45 and the efficiency of fat deposition is 0.75, so it takes about the same amount of energy to deposit 1g of protein or fat (Pullar and Webster, 1977). However, protein is laid down with 4-5 times its weight in water, so the energy cost of depositing 1g of lean is less than a quarter than that of depositing 1g of fat.

If one selects for high growth rate at 5 weeks of age, one selects almost entirely for increased appetite. Such mice continue to eat more as they grow older and, as protein deposition ceases, the excess food intake is laid down as fat. If one selects for high growth rate at 10 weeks of age, one selects animals that are more energetically efficient - those that lay down a relatively higher proportion of their food intake as lean. These animals will be leaner at later ages than mice selected at 5 weeks of age.

A study which suggests another possible method of selecting for increased growth without a large increase in fatness is that of Falconer (1960a). For 14 generations, mice were selected for high and low 3 to 6 week weight gain on a "high" and "low" plane of nutrition - a normal diet fed ad libitum and the same diet diluted with indigestible fibre. After several generations of selection, mice from each line were reared on both diets to see the correlated responses to selection on each diet. It was discovered that on the "high" plane of nutrition, mice selected for high growth rate on

either dietary regime grew at the same rate, but those selected on the "low" plane of nutrition were less fat.

Hetzel (1968) selected mice for high and low 3 to 6 week gain on an ad libitum and a restricted diet. It was discovered that on the ad libitum diet, those mice selected for high growth rate on the restricted diet grew more slowly, but were much less fat than those selected on the ad libitum diet.

McPhee and Neill (1980) selected two lines of mice for high 5 to 9 week gain, corrected for 5 week weight, on a fixed level of food intake, for 6 generations. The selected lines were compared with the control line on an ad libitum and a restricted diet. Both selected lines grew faster and were fatter than the controls on each diet. Unfortunately, no mice were selected on an ad libitum diet in this experiment, so it is impossible to know whether the mice similarly selected on an ad libitum diet would have been even fatter than the mice selected on the restricted diet.

In general, mice selected for high weight gain or high body weight at a given age show an increase in percentage fat, especially as they get older. If mice are selected at later ages or on a restricted diet, they may not become as fat, but mice selected on a restricted diet may have a poorer response in growth rate.

As food intake forms the greatest proportion of the cost of raising meat animals, farmers and animal breeders are interested in producing animals that are efficient, that is animals that gain a large amount of weight per unit food intake. The ratio of weight gain to food intake is known as gross or food efficiency; its reciprocal, food intake / weight gain, is known as food conversion

ratio.

Three physiological parameters might affect gross efficiency. Firstly, digestibility, the ability of an animal to extract nutrients from food. Secondly, maintenance requirements, the energy required to maintain body weight. The maintenance requirements of an animal are proportional to its metabolically active body weight, normally taken to be (body weight) to the power of 0.75 or 0.73. Thirdly, animals may differ in the efficiency with which they use the energy gained from food to deposit new fat or lean in growth.

When mice have been selected for high growth rate, increases in gross efficiency have usually been found. Various workers have tried to determine the underlying changes responsible for such increases. Fowler (1962) studied a strain of mice which had been selected for high and low 6 week weight (Falconer, 1953). The large mice ate more and had a higher gross efficiency, and the small mice ate less and were less efficient than the unselected control line mice. There were no differences between the lines in digestibility.

Timon and Eisen (1970) compared the 9th generation of a line of mice selected for high postweaning gain with a control line on restricted and ad libitum diets. The selected mice were more efficient on both feeding regimes. When differences in maintenance were taken into account, there were no differences between the lines in the energetic efficiency of protein or fat deposition. They concluded that selection had caused an increase in appetite, which led to an increase in the amount of energy available for growth. Gross efficiency had therefore increased, but not energetic efficiency.

Roberts (1981) looked at three replicates of the 'Q' strain

(Falconer, 1973) which consisted of six lines selected for high 6 week weight, six lines selected for low 6 week weight, and six unselected control lines. Looking at mice from generation 17, it was found that high line mice ate more, and low line mice ate less, than control line mice, at the same age or weight. High line mice had a higher gross efficiency, and low line mice were less efficient, than the controls. When the mice were fully grown, the low line mice ate more per unit body weight than mice from the high line. It seemed that the low line mice had a higher maintenance requirement per unit body weight than the high line mice.

The only study in which mice selected for high growth rate have shown an increase in energetic efficiency is one carried out by Canolty and Koong (1975). They examined the 41st generation of a line of mice selected for high 3 to 6 week gain and an unselected control line (Robinson and Bradford, 1969). They concluded that the selected mice had the same maintenance requirements per unit metabolic body size as the controls, but the net efficiency of food utilisation was higher in the selected lines. This result is surprising in view of the results of previous studies. It might be possible that the underlying causes of changes in gross efficiency are not the same in different selected lines, but more work must be done in this area before the question of which physiological changes are responsible for changes in gross efficiency is resolved.

b. Selection for Efficiency in Mice

A number of lines of mice have been selected for gross efficiency and the correlated responses studied. Sutherland *et al* (1970) selected 3 lines of mice for high rate of gain from 4 to 11 weeks

for 10 generations. Then for 11 generations one line was selected for high food intake, one for high efficiency and one for high rate of gain. Food intake, weight gain and efficiency increased in all 3 lines in both periods of selection, although efficiency increased only slightly in the line selected for increased food intake. After the second selection period, the line selected for efficiency had the largest response in both gain and efficiency, and the largest response in food intake was found in the line selected for that character. Realised genetic correlations of 0.91 between gain and efficiency, 0.71 between gain and food intake, and 0.34 between food intake and efficiency were calculated. In a further study, Biondini et al (1968) examined the changes in carcass composition in the 3 lines. The weights of all carcass components had increased in all lines in both periods of selection. The percentage of fat had increased in all 3 lines in the first period of selection, but only in the lines selected for increased food intake and weight gain in the second period of selection.

Parker and Bhatti (1982) selected for low food conversion ratio in mice under ad libitum and restricted feeding terminated by fixed time or quantity of food. Six generations of selection were carried out. The realised heritabilities obtained were higher for the lines selected on the restricted diet. They concluded that, although the genetic correlation of gain and food conversion ratio is very highly negative, which had previously been used as an argument for selecting for gain to improve efficiency (or to decrease food conversion ratio), the results suggested that where animals are restricted in feed and taken off test after a fixed amount of food, they should be directly selected for food conversion ratio to get

the greatest increase in efficiency.

Yuksel et al (1981) selected for efficiency on both ad libitum and restricted feeding. Selection was carried out on high 3 to 5 week efficiency for 8 generations, and high 5 to 7 week efficiency for 7 generations. All selected lines showed a response in efficiency. The lines selected at later ages showed a larger response, although the realised heritability estimates were about the same for all selected lines (0.13). When the lines were tested on both diets, all lines ate more and were more efficient when fed ad libitum. On both feeding regimes, the lines selected on that regime were no more efficient than those selected on the other. When carcass analyses were performed on animals fed ad libitum, all selected lines showed an increase in percentage fat compared with the controls at both the start and finish of test.

In mice, selection for efficiency on either a restricted or an ad libitum diet seems to lead to an increase in weight gain and usually to an increase in percentage fat. It seems surprising that selection on a restricted diet should increase fatness, as it might be expected that the more efficient animals under such circumstances would be those that laid down more lean and less fat.

A few general results can be summarised from selection experiments in mice. If high weight gain or body weight is selected for, animals show an increase in food intake, gross efficiency and usually in percentage fat. Changes in energetic efficiency are not commonly seen. Mice selected at later ages or on a restricted diet may show less increase in fatness than those seected at an early age or on an ad libitum diet.

Mice selected for increased efficiency show an increase in body weight, usually an increase in fatness and sometimes an increase in food intake. Mice selected for efficiency on a restricted diet show an increase in weight gain and fatness. Mice selected for high food intake show an increase in weight gain, fatn ess and a slight increase in efficiency.

c. Selection Experiments in Other Species

Mice are often used in selection experiments because they are relatively cheap to feed and have a comparatively short generation cycle. It is important, however, to compare the results of selection experiments on mice with those on other species, to see if general conclusions can be drawn.

Baker et al (1975) selected rats for high and low 3 to 9 week gain. Two lines were selected in each direction for 15 generations. The high line rats increased in 9 week weight, and the low line rats decreased in 9 week weight, compared with unselected control line rats. None of the selected lines showed a change in 3 week weight. In generation 11, carcass analyses were performed on 20 rats from each line (Baker and Chapman, 1975). Both the high and low selected line rats were found to be less fat than the control line rats, which is a surprising result in view of the increase in fatness commonly observed in mice selected for increased growth rate.

Dickerson and Grimes (1947) selected for efficiency of gain in Duroc pigs. The selected line showed a decrease in food conversion ratio, an increase in daily gain and a reduction in food intake. The genetic correlation between food conversion ratio and daily gain was calculated and found to be highly negative. It was concluded that

selection for increased daily gain should produce more efficient pigs.

Ollivier (1979) selected boars for 11 years on an index 0.01 ADG -0.5 BF, where ADG is the average daily gain (g) from 30 to 80kg liveweight, and BF is the average of 6 backfat measurements (mm) at 80kg liveweight. Increases in average daily gain, daily food intake and weight of loin and ham, and a decrease in backfat weight were observed.

Standal and Vangen (1979) selected pigs on an index which combined average daily gain and backfat thickness for 8 generations. One line was selected for an increase in the value of the index, and one line for a decrease in the value of the index. The high line pigs had a greater daily gain and percentage lean than the low line pigs. The low line pigs had a higher food conversion ratio, backfat thickness and percentage fat than the high line pigs.

Whittemore *et al* (1982) selected pigs for an increase in the value of an index which combined average daily gain and backfat thickness. After 12 generations of selection, selected pigs and unselected control line pigs were tested on five different feeding levels. The selected pigs had lower rates of fat growth and higher rates of lean growth on all feeding levels. On the *ad libitum* diet, the selected pigs ate less, and had a slightly higher growth rate than the controls.

As pigs are expensive animals to use for selection experiments, genetic parameters have often been calculated from observations on populations and the utilisation of family data. Biswas *et al* (1966) examined food intake, weight gain, backfat thickness and per cent lean cuts in Durocs, Yorkshires and crossbred pigs. They calculated

genetic correlations of 0.9 between gain and food intake, 0.63 between gain and efficiency, and -0.20 between food intake and efficiency. There were positive genetic correlations between backfat thickness and gain, and between backfat thickness and food intake. Other correlations were non-significant.

Robinson and Berruecos (1973) calculated similar genetic correlations when they measured food intake, gain, per cent lean cuts and backfat thickness (live and carcass) in pigs. Genetic correlations were calculated to be -0.41 for food conversion ratio and average daily gain, and 0.86 for gross efficiency and average daily gain. Average daily gain had a small negative genetic correlation with carcass backfat thickness and a small positive genetic correlation with live backfat thickness. Live backfat thickness was positively correlated with gross efficiency, and negatively correlated with food conversion ratio. Per cent lean cuts and average daily gain were both positively correlated with gross efficiency, the correlation being lower for average daily gain. It was concluded that an index using average daily gain and backfat thickness should be used to select for efficiency.

Broiler chickens have been selected for increased growth rate by commercial companies for a long time. The amount of fat in the carcasses of chickens seems to be increasing and is becoming a problem. Proudman et al (1970) found an increase in percentage fat when chickens were selected for high growth rate. Pym and Solvyns (1979) studied the body composition of lines of chickens which had been selected for increased food intake, efficiency and body weight gain. Only the line selected for food intake had an increase in fatness, the high gain line showed no change in carcass composition

and the high efficiency line had a reduced percentage of fat. Pym (1982) mentions other studies on the selected lines, in which it was found that the line selected for food intake had an increased maintenance requirement, the line selected for efficiency had a decreased maintenance requirement, and the line selected for weight gain had no change in maintenance requirement. It was concluded that selection for weight gain had improved efficiency because of an increase in food intake, whereas selection for efficiency had led to a decrease in maintenance requirement and a higher percentage of lean.

The lack of an increase in fatness in the high gain line is surprising in view of the reported increase in fatness in commercial broilers. Pym (1979) argues that this increase may not be entirely genetic - nutritional and management factors may play a part. A replicated selection experiment might provide a clearer picture - if a number of lines were selected for increased gain and all had similar changes (or no changes) in body composition, then the results would be more convincing.

It does seem likely that selection for efficiency in broilers leads to a decrease in fat percentage. Pigs also show a decrease in percentage fat when selected for increased efficiency. Why do mice differ from larger animals in this respect? Mice are very inefficient animals, compared with pigs and chickens. For example, Standal and Vangen (1979) give an average figure of 3.26 for the food conversion ratio of pigs from weaning to 80kg weight. The food conversion ratio of an unselected strain of mice (Sutherland _et al_, 1970) between 4 and 11 weeks of age varies between 15 and 20. Because of their large surface area to volume ratio, a large part of

their energy expenditure is required to maintain body temperature. Fat mice will be better insulated than leaner ones, and may therefore have to expend less energy on heat maintenance. Fatter mice could therefore be as, or more, efficient than leaner mice. Larger animals have to expend relatively less energy on thermoregulation, so the partitioning of food energy between protein and fat in the body will be more important in determining the efficiency of an animal.

d. Selection for One Component of the Body

Comparatively few studies have been carried out on selection for one component of the body, although a few studies provide some information.

McLellan and Frahm (1973) selected for high and low hindleg muscle weight in 12 week old male mice. Positive correlated responses were observed in body weights from 3 to 12 weeks of age, and in average daily gain. The ratio of hindleg muscle weight to total body weight decreased in the low line, but was unchanged in the high line.

Leymaster et al (1979a,b) selected pigs for an increase in per cent lean cuts at 81.6kg and for an increase in the weight of lean cuts at 160 days. Selection for the weight of lean cuts increased both the weight and the percentage of lean cuts. Selection for per cent lean cuts increased the percentage of lean cuts, but the weight of lean cuts was unchanged.

Notter et al (1976) selected for increased rate and efficiency of lean growth in rats for 6 generations. Wang et al continued the selection for a further 9 generations. Both selected lines increased

in 3 to 9 week gain, although the increase was greater in the lines selected for rate of lean growth. The lines selected for rate of lean growth got fatter, whereas the lines selected for efficiency of lean growth got less fat than the controls.

Hetzer and Harvey (1967), Hetzer and Miller (1972) selected for high and low backfat thickness in Duroc and Yorkshire pigs. All lines responded to selection, but the correlated responses were different from those expected from genetic correlations calculated in the base population. In the Duroc swine, pre- and post-weaning weights decreased in the high fatness line, and increased in the low fatness line. In the Yorkshires, both selected lines showed a decrease in pre- and post-weaning weights. Daily gain increased in both Duroc selected lines and in the Yorkshire high fatness line, and decreased in the Yorkshire low fatness line. From an offspring-parent analysis, both body weights and average daily gain were calculated to have negative genetic correlations with backfat thickness. It was suggested that, in Yorkshire pigs, backfat thickness is at an optimum with respect to its effect on growth rate. Any change in backfat thickness will decrease growth rate, regardless of the genetic correlation in the base population.

The results of these four very different selection experiments lead to no general conclusions. Selection for an increase in the weight of a muscle in mice led to no increase in the proportion of that muscle. On the other hand, selection for an increase in the weight of lean cuts in pigs led to an increase in the per cent of lean cuts.

Selection for increased protein gain in rats led to an increase

in body weight and in the percentage of fat. Selection for increased efficiency of protein gain led to a smaller increase in weight gain and a decrease in percentage fat.

Selection for high and low fatness in Durocs and Yorkshire swine did not produce the changes in weight and daily gain expected from base population estimates of genetic correlations.

Many more selection experiments have to be carried out on selection for an increase in fatness or leanness in different species to provide an understanding of the effect of such selection on other characters such as growth and efficiency.

C. Aims of this Experiment

One way to investigate the genetic relationships between growth rate, efficiency, food intake and body composition is to select for one or more of these characters and to observe the correlated responses in the other characters. If more than one line is selected for each trait, it becomes possible to decide whether correlated responses are a result of genetic drift, or whether they result from genetic correlations between characters.

Many lines of mice have been selected for increased rate of gain (McPhee and Neill, 1980; Rahnefeld et al, 1963; Robinson and Bradford, 1969; Sutherland et al, 1970; and others) and for increased body weight at a given age, (Falconer, 1953; Hull, 1960; Falconer, 1973; Hayes and McCarthy, 1976; McPhee and Neill, 1976; and others). It is generally found that such selected mice show increases in food intake, gross efficiency and percentage fat.

A number of lines of mice have been selected for an increase in

gross efficiency (Sutherland et al, 1970; Parker and Bhatti, 1982; Yuksel et al, 1981; and others), and increases in body weight and sometimes in food intake and fatness have been observed.

To provide a fuller understanding of the genetic relationships between growth rate, efficiency, food intake and body composition, selection for food intake and body composition should also be carried out. Only one line of mice has been selected for increased food intake. Sutherland et al (1970) selected for high 4 to 11 week food intake. Selection was carried out in one replicate, and the line had previously been selected for increased growth rate for 10 generations. The selected mice showed an increase in growth rate and in fatness, and a slight increase in gross efficiency.

Notter et al (1976) selected rats for increased rate or efficiency of lean growth from 3 to 9 weeks of age for 5 generations. Two lines were selected for each character, and both sets of selected lines showed increases in growth rate and 9 week weight, although the increases were greater in the line selected for rate of lean growth. Wang et al (1980) extended the selection for a further 9 generations, and measured the carcass composition and food intake of all lines. The lines selected for increased rate of lean growth had increased in food intake, gross efficiency and fatness. The lines selected for increased efficiency of lean growth had an increase in gross efficiency, no change in food intake, and a decrease in fatness.

In this experiment, to provide more information on the effect of selecting for food intake or body composition, mice were selected for food intake, total lean mass and percentage lean. Selection was two-way - for an increase and a decrease in each character. Each

selection treatment consisted of three replicates (three high lines, three low lines, and three unselected control lines).

The litter size, weaning rate and 6 week weights of all mice were recorded, as well as the characters required to select the mice. After 7 generations of selection, the body composition of mice from all lines was determined by chemical carcass analysis. The food intake of all lines was measured after 8 generations of selection.

METHODS

A. Measurement of Body Composition and Food Intake.

To carry out the selection experiment, it was necessary to find some way of measuring body composition. The first method to be investigated was the tritiated water technique which had been used in rats (Rothwell and Stock, 1979b) and other species (Foy and Schneiden, 1960). This technique involves injecting a mouse with a fixed volume of tritiated water. After about two hours, when the tritiated water has dispersed in the blood, a blood sample is taken from the tail and centrifuged. A sample of plasma and a sample of the original tritiated water are put in a liquid scintillation counter. By comparing the c.p.m. of the two samples, it is possible to calculate the volume of water in the mouse. If the mouse has been weighed, the percentage water in the mouse can also be calculated. As lean tissue is laid down with a large amount of water, this method can give a measure of the lean tissue mass and percentage lean of a mouse. Unfortunately, although the technique seems to work with larger animals, it proved to be too inaccurate for use with mice, because of the small volume of blood that can be obtained from a live mouse, and the small differences between mice that had to be measured.

The next method to be investigated was that of removing and weighing the gonadal fat pads. These fat pads are discrete deposits and are easy to remove accurately. They can be dissected out quickly, making it possible to examine a large number of mice within a given time. The correlation between percentage gonadal fat pad

weight and percentage total fat is high (r = 0.9, Jagot et al, 1980; Rogers and Webb, 1980).

As percentage fat and percentage lean are negatively correlated (r = -0.73, Lang and Legates, 1980), it is clear that selection for low per cent gonadal fat pad weight will select mice with a high percentage of lean. Conversely, selection for high per cent gonadal fat pad weight will select mice with a low percentage of lean.

To enable an index of body weight and gonadal fat pad weight to be constructed that would predict total lean mass, twelve samples of ten mice were sent for a chemical analysis of carcass composition. These mice had had their body weight and gonadal fat pad weight recorded, and had been sorted into groups for high and low body weight, and high and low gonadal fat pad weight.

The first generation of selection had to be carried out before the results of the carcass analysis were available, so an index was constructed. (Body weight - 8 x gonadal fat pad weight) will predict fat-free mass, as the gonadal fat pads represent about one eighth of the total fat in mice at the age at which it was intended to select them.

The results of the carcass analysis showed that the best predictor of lean mass was an index which effectively ignored gonadal fat pad weight (body weight - 0.64 x gonadal fat pad weight). We did not wish to use this index for two reasons. Firstly, selection for body weight alone has been carried out many times in the past and did not seem worth repeating. Secondly, as mentioned previously, selection for body weight usually leads to an increase in percentage fat, and it is lean mass we wish to increase. It was decided to retain the index used in the first generation of

selection, which should increase lean mass while preventing a large increase in percentage fat.

Gonadal fat pad weight was therefore used in the above ways to provide measures of percentage lean and of total lean mass.

Preliminary studies in the lines selected for food intake, indicated that 4 week weight and 4 to 6 week food intake are significantly correlated ($r = 0.46 \pm 0.069$ for females, 0.67 ± 0.048 for males (from generation 0, replicate 1 of the lines selected for food intake)). It was decided that, to avoid selecting largely for increased or decreased 4 week weight, that food intake would be adjusted for 4 week weight by a regression. In generations 0 to 2, a regression coefficient of 2.34 (calculated from generation 0 of replicate 1) was used to correct for 4 week weight in both sexes. However, as the diet of the mice was changed during generation 1, and the new diet seemed to be more energetically dense than the old, new values were calculated for the value of the regression coefficients in generation 2. The new regression coefficients were 1.65 for females and 2.21 for males, and these values were used from generation 3 onwards. Throughout the selection experiment, the adjustment for 4 week weight was carried out assuming a mean 4 week weight of 16.1g for females and 17.8g for males.

B. Mice Used, Mating Structure and Management.

A new strain of mice was established for the selection experiment, the 'G' strain. Two inbred lines, JU and CBA, and an outbred strain, CFLP, were used. The CFLP mice were obtained from Carworth Laboratory about three years before the start of the

selection experiment. They are a large albino strain of mice which had been developed for embryo transfer work, and had been maintained at Edinburgh with eight pair-matings per generation with minimal inbreeding. The two inbred lines were crossed, and the F1 was crossed to CFLP mice. One generation of random mating followed the second cross, the next generation being designated generation 0 of the selection experiment.

It had originally been intended that within-litter selection should be practised for all selection criteria. However, the removal of gonadal fat pads involves sacrificing mice, so another selection procedure had to be adopted. Two alternative methods were considered - family selection and within-family retrospective selection of males. Family selection involves sacrificing most of the members of a sibship and selecting the remaining members of the families with the highest and lowest values of the character being selected. The latter method of selection involves mating a set of brothers to a set of sisters from another litter, then killing the males when the females are pregnant. The offspring of the male with the highest or lowest value of the character in each litter are kept for the next generation. The two methods both have advantages and disadvantages. The first method would make it possible to select in both sexes and at any age. However, family selection decreases the effective population size (Falconer, 1960b) and there are thought to be strong maternal effects on body weight and gonadal fat pad weight at 6 weeks of age (Eisen and Roberts, 1981), which is the age at which this type of selection would probably have been carried out if used. It would be necessary to standardize litter size to try to reduce maternal effects. The second method of selection would negate

maternal effects and increase effective population size, making it possible to have a lower rate of inbreeding with the same number of mice. This method would only make it possible to select in males, and at a later age than the first method would allow. It was decided that the second method of selection offered more advantages, so it was employed in the lines selected for percentage lean and total lean mass.

Within-family selection was also carried out in the lines selected for appetite, although in this case selection could be carried out before mating and in both sexes.

For all three selection criteria, three replicates (1-3) were set up. Each replicate consisted of a High (H) line, a Low (L) line and an unselected Control (C) line. All lines consisted of 16 pair-matings per generation until generation 8, when they were cut to 8 pair-matings per generation to release facilities for examining correlated responses. The mating scheme was that used by Falconer (1973). It keeps the theoretical rate of inbreeding per generation constant, and has the advantage that the mating schedule is the same in each generation.

If a mating was infertile, offspring were used from the reciprocal mating, or failing that, from the mating of closest relationship to the one that failed.

Mating structure from generation 1 to 8

Family of Origin		Mating	Family of Origin		Mating
Female	Male	Number	Female	Male	Number
1	2	1	2	1	9
3	4	2	4	3	10
5	6	3	6	5	11
7	8	4	8	7	12
9	10	5	10	9	13
11	12	6	12	11	14
13	14	7	14	13	15
15	16	8	16	15	16

Mating structure from generation 9 onwards

Family of Origin		Mating	Family of origin		Mating
Female	Male	Number	Female	Male	Number
1	2	1	2	1	5
3	4	2	4	3	6
5	6	3	6	5	7
7	8	4	8	7	8

To spread the technical work involved in the experiment, the replicates were set up in every generation as follows -

Week	Replicate	Week	Replicate
1	F1	7	P2
2	A1	8	
3	P1	9	F3
4		10	A3
5	F2	11	P3
6	A2	12	F1

Throughout the experiment, litter size was standardized to between 6 and 12 pups. Litters larger than 12 had the extra pups removed, and litters smaller than 6 were augmented with spare pups from other litters, when possible. Extra pups were toe-clipped for identification and discarded at weaning. Litters were weaned at 21 days of age, unless the mice were very small, in which case they were left with their dam for a few extra days. On weaning, males and females were separated and housed in cages of six. All mice were group-fed except the mice used for measurement of individual food intake. Males which had been individually fed were caged separately afterwards until mating.

In generation 0 and for part of generation 1, the mice were fed on McGregor's Rat and Mouse Diet. This food seemed to be of poor quality and no specifications were given for protein content, so the diet was changed to B.P.'s Rat and Mouse No. 1 Expanded Maintenance Diet, which has a crude protein content of 14.8% (details of the formulation of this diet are given in Appendix I). The mice were

changed to the new diet as follows - GF1, GA1, GP1 at birth (generation 2); GF2, GA2, GP2 at mating (generation 1); GF3, GA3, GP3 at weaning (generation 1).

Because of high mortality among nursing mothers, all matings were put on B.P.'s Rat and Mouse No. 3 Expanded Breeder Diet, which has a crude protein content of 21.0% (details of the formulation of this diet are given in Appendix 1.). The mice were left on this diet from mating until their litter was weaned, and the diet was introduced in matings from GP1 (generation 4) onwards. In a further attempt to improve the general health of the mice, all mothers of generations 4 and 9 were put on Terramycin for a week after the birth of their litter.

Throughout the experiment, litter size, adjusted litter size, number weaned and six week weights were recorded in all lines.

C. Selection Procedures

In the lines selected for food intake (the 'appetite' or 'A' lines) individual food intake from 4 to 6 weeks of age, adjusted for 4 week weight by a within-family (within-sex) regression, was calculated.

In each replicate in generation 0, four males and four females from each of sixteen litters had their 4 to 6 week food intake measured in individual feeding cages. The mice with the highest adjusted food intake were used as parents of generation 1 of the High line. The mice with the lowest adjusted food intake were used as the parents of generation 1 of the Low line. One of the two remaining mice of each sex from each litter were used as parents of

generation 1 of the Control line. In subsequent generations, four males and four females from each litter (when available) were tested in the High and Low lines. If, for example, there were less than 4 females in a litter, 4 males and all the females were tested. Two mice of each sex from each litter were tested in the Control lines.

In the lines selected for percentage protein (the 'F' lines) and for total protein (the 'P' lines), body weight and gonadal fat pad weight were measured in 10 week old males. In each replicate in generation 0, four males from each of sixteen litters were pair-mated to four females from another of those litters. After about two weeks, when the males were 10 weeks old, the males were removed, killed and weighed. The gonadal fat pads were dissected out and weighed.

In the percentage protein ('F') lines the ratio of gonadal fat pad weight to body weight was calculated. The offspring of the males with the lowest ratio of fat pad weight to body weight formed generation 1 of the High line. The offspring of the males with the highest ratio formed generation 1 of the Low line, and the offspring of one of the other two males from each litter formed generation 1 of the Control line.

In the total protein ('P') lines body weight and gonadal fat pad weight were combined in the index (body weight - 8 x gonadal fat pad weight). The offspring of males with the highest value of the index formed generation 1 of the High line, and the offspring of males with the lowest value of the index formed generation 1 of the Low line. The offspring of one of the remaining two males from each litter formed generation 1 of the Control line.

In subsequent generations, in both the P and F lines, four males

were mated from each litter and dissected at 10 weeks in the High and Low lines. In the Control lines one male was mated from each litter and another was kept, so two males were dissected at 10 weeks of age.

D. Measurement of Correlated Responses.

1. Carcass Composition

To see what effect selection had had on the body composition of the mice, and to see if the selection criteria used in the F and P lines had produced differences in percentage lean and in total lean mass, carcass analyses were performed. In generation 7, sixteen 10 week old males from each line (one per litter when possible) were sacrificed. The contents of the stomach and intestines were removed, and the mice were frozen in batches of eight (two batches per line). The Rowett Research Institute allowed the use of their facilities for the freeze-drying and mincing of the mice. Subsequently, carcass analyses were kindly performed by staff at the Rowett. A sample of each minced batch of eight mice was taken and heated to 100°C to determine dry matter content. The samples were further heated to 800°C to determine ash content. Another sample was taken from each batch to estimate fat content, using the chloroform-methanol method (Atkinson et al, 1972). Fat estimation was performed at least twice for each batch of mice.

2. Measurement of Food Intake, Ten Week Weight and Gonadal Fat Pad Weight.

In generation 8 and 9, mice from each selection treatment were

measured for the traits for which the other groups had been selected, in order to examine the correlated responses to selection. Mice from the P and F lines had their 4 to 6 week food intake measured, and males from the A lines had their 10 week body weight and gonadal fat pad weight examined.

In the A lines, in generation 8, one male from each odd-numbered litter was mated to a female from an even-numbered litter. When the males were 10 weeks old they, along with three other males from each odd-numbered litter in the High and Low lines, and another one male per litter in the Control lines, were killed. Their fat pads were dissected out and weighed, and their body weights were recorded. From the offspring of these matings, four males per litter in the High and Low lines, and two males per litter in the Control lines, were kept for dissection. To continue the selection lines, males from even-numbered litters and females from odd-numbered litters, in generation 8, had their food intake measured in the usual way, with only 8 matings per line being set up to provide the next generation.

In both the P and F lines, in generation 8, females from even-numbered litters and males from odd-numbered litters were individually fed from 4 to 6 weeks of age, and their food intake and weights at the start and finish of test recorded. This was carried out for four mice per litter in the High and Low lines, and two mice per litter in the Control lines. From these mice, 8 matings per line were set up, and the progeny had their food intake measured, four mice of each sex per litter in the High and Low lines and two mice of each sex per litter in the Control lines. To continue the selection lines, in generation 8, even-numbered males were mated to odd-numbered females and killed, dissected and their progeny

selected as usual. Therefore, only 8 matings per line produced generation 9.

3. Body Weights at Later Ages

In generation 9, eight females per line were kept until 16 weeks of age. Body weights were measured at 10, 13 and 16 weeks of age, to see the effect that the different selection treatments had had on later weights and growth curves.

E. Data Analysis

1. Realised heritabilities

Responses in the selected characters were calculated from the overall means of each line. For each replicate, High-Control, Low-Control, and High-Low differences were used. Selection differentials were calculated by taking the average difference of each selected mouse from its litter-sex mean, each difference being weighted by the number of its progeny measured for the selected character in the next generation. As selection was carried out in only one sex in the P and F lines, the selection differentials calculated in these lines were halved to take account of this fact. Realised heritabilities were calculated for generation 0 - 11 from the regression of response on cumulated selection differential. Selection differentials in the Control lines were calculated, but were assumed to be zero for this analysis.

2. Inbreeding Coefficients

The inbreeding coefficient in each replicate in each generation was calculated from the formula

$$F_t = 1/2N_E + (1 - 1/2N_E)F_{t-1}$$

where F_t is the inbreeding coefficient in generation t, F_{t-1} is the inbreeding coefficient in the previous generation, and N_E is the effective population size. Effective population size was calculated from the formula

$$N_E = 4N/(2 + \sigma_K^2)$$

where N_E is the effective population size, N is the actual population size (twice the number of breeding pairs), and σ_K^2 is the variance in the number of individuals from each family that survive to breed.

3. Carcass Composition - Differences Between Lines

Within each selection treatment, differences in carcass components (amount and per cent) between lines (High, Low and Control) and replicates were examined by an analysis of variance. A simple hierarchical model was used.

$$Y_{ijk} = \mu + L_i + R_{ij} + e_{ijk}$$

where Y_{ijk} is the observation on the kth batch of the jth replicate of the ith line, μ is the overall mean, L_i is the fixed effect of the ith line, R_{ij} is the random effect of the jth replicate in the ith line, and e_{ijk} is random error.

RESULTS

More detailed results than those presented in this chapter are given in Appendix 2.

A. Direct Responses to Selection and Realised Heritabilities

1. GA Lines - Selection for Four to Six Week Food Intake

The results of eleven generations of selection for 4 to 6 week food intake, adjusted for 4 week weight, are shown in Figs. 1-4. In Fig. 1, the mean of the three replicates is shown and Figs. 2-4 show the responses of the three replicates separately. In all cases the adjusted food intakes of the two sexes are averaged.

Looking first at the mean of all replicates, there appears to have been a large drop in adjusted food intake between generations 0 and 2. This can be explained by the fact that the diet of the mice was changed during this period, and the new diet is more energetically dense than the old.

Taking the mean of the Control lines, from generation 2 to 11, adjusted food intake has remained fairly constant, with a slight drop at generation 11.

The responses to selection in the two directions were proportionately very similar. At generation 11 the High lines had increased by about 8.0%, and the Low lines had decreased by about 8.6% of the Controls.

Looking at the three replicates separately, it is apparent that there has been a much greater response to selection in replicate 1 than in replicates 2 and 3. If High-Low differences at generation

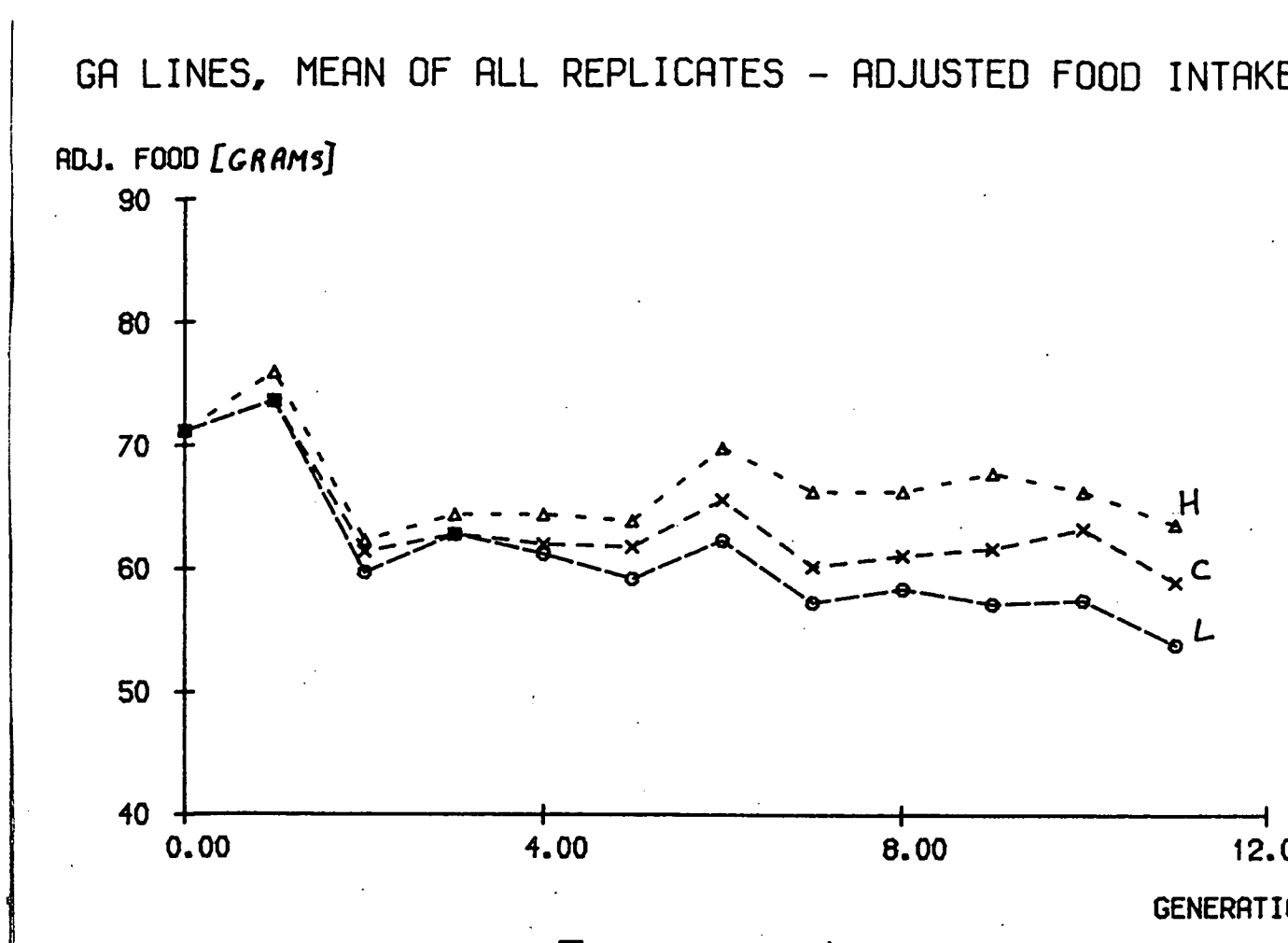


Figure 1

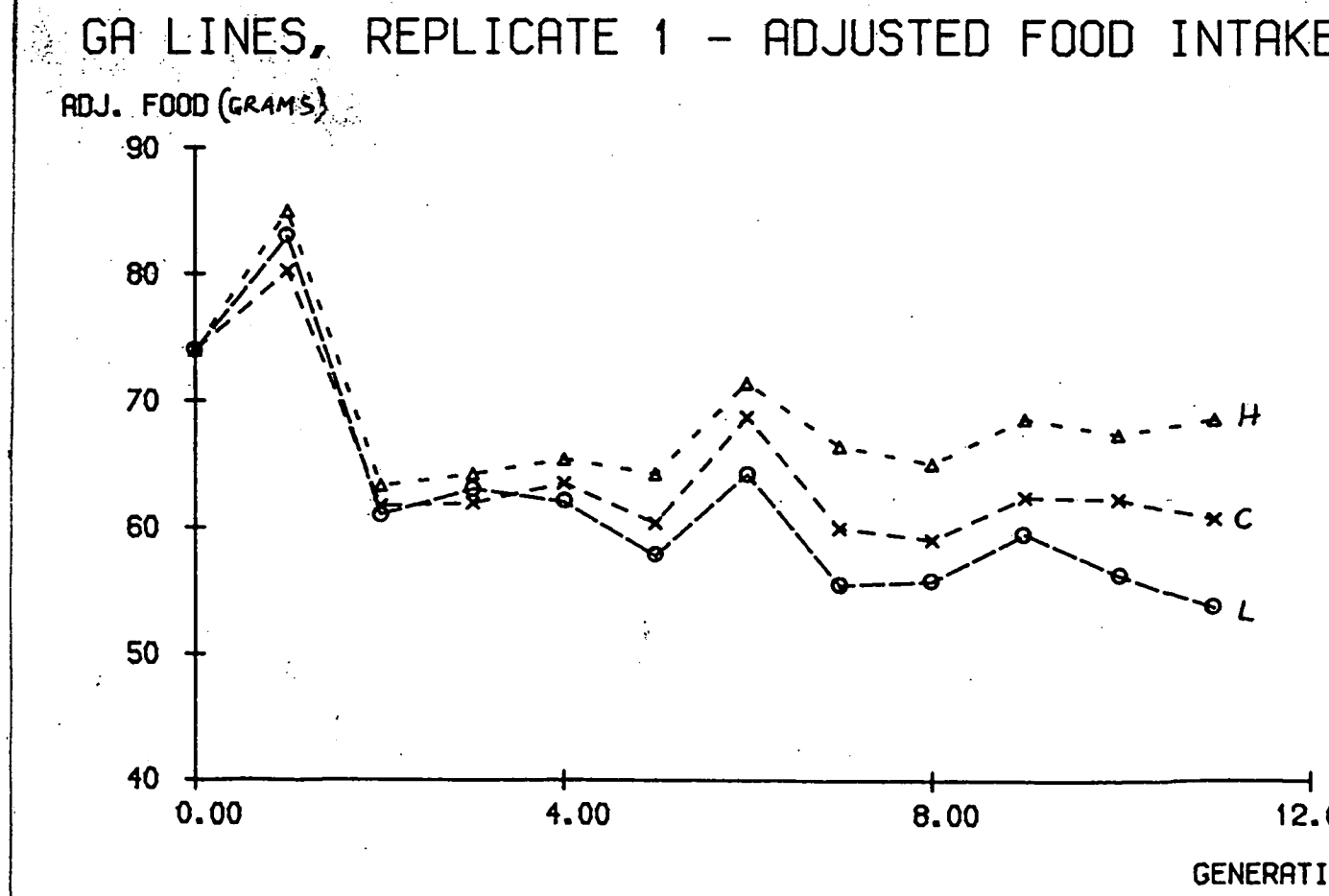


Figure 2

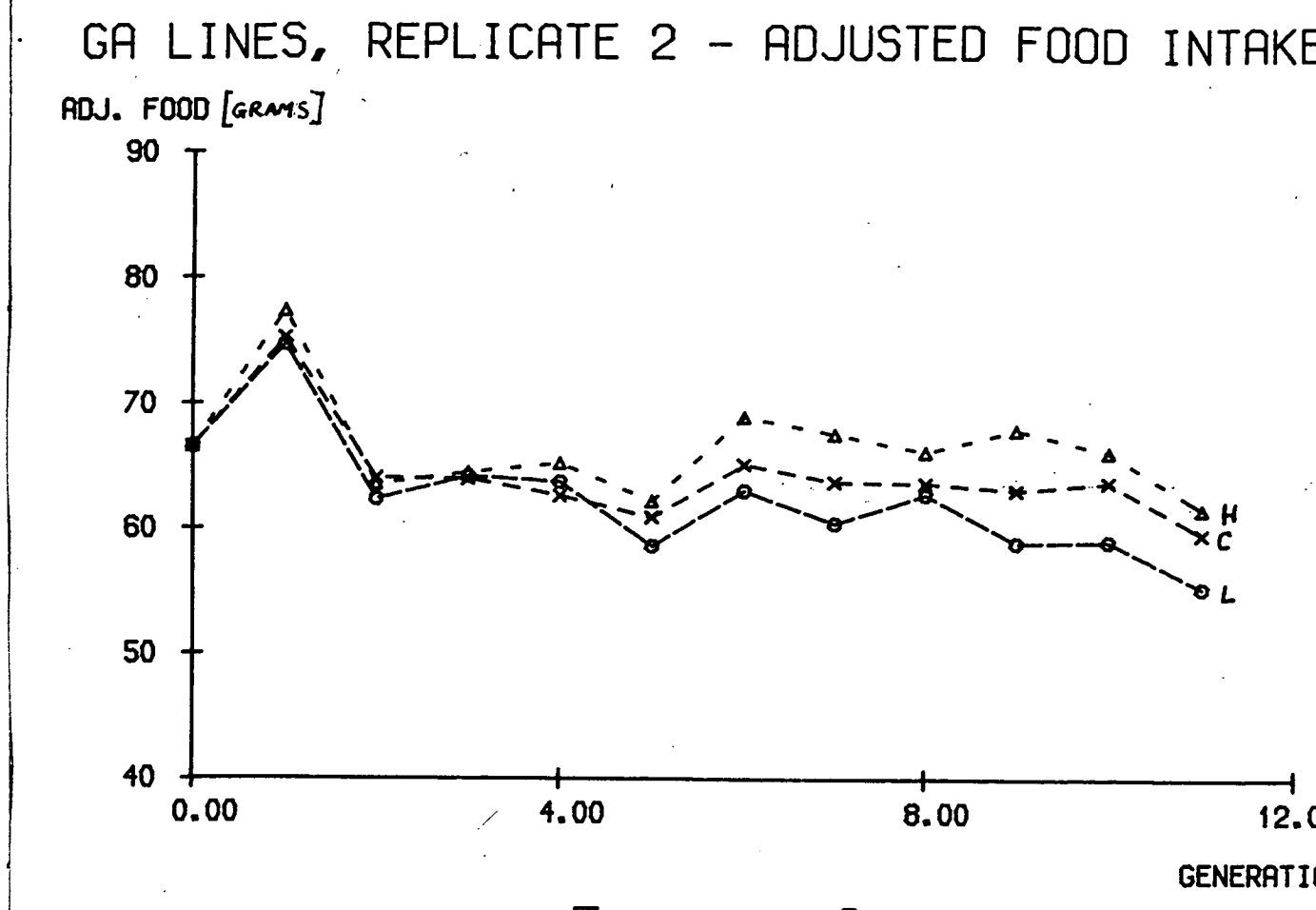


Figure 3

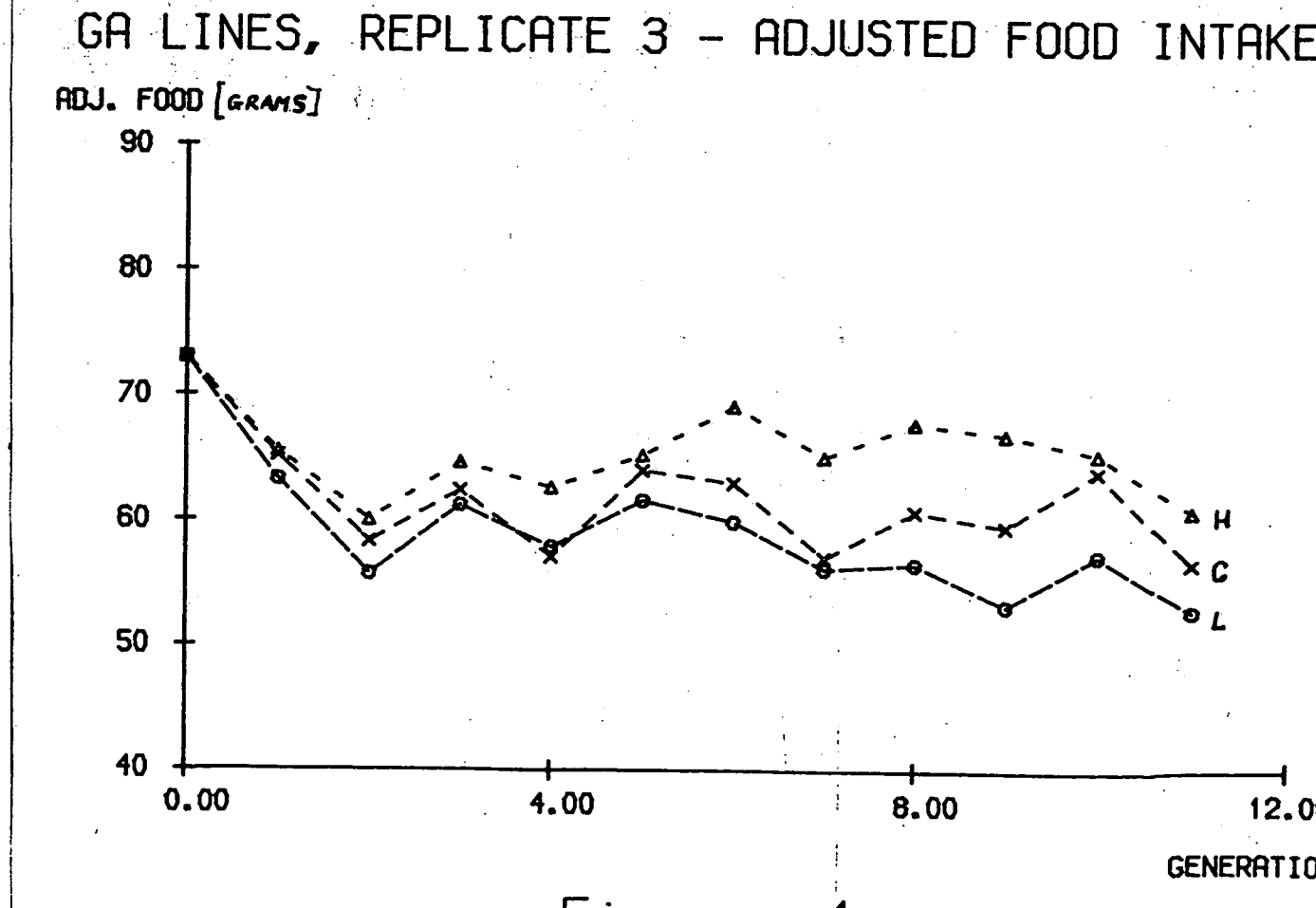


Figure 4

11 are taken as proportions of the Control means, the values obtained are 24.7% for replicate 1, 10.6% for replicate 2 and 14.1% for replicate 3. The responses to selection in the two directions appear symmetrical in replicates 1 and 3, but not in replicate 2, where there seems to be a larger change in the downward direction with respect to the Control line.

The means of all replicates for unadjusted 4 to 6 week food intake, with the sexes plotted separately, are shown in Fig. 5. It can be seen that males eat, on average, 3 to 4 grams more food during this period than do females. The changes in unadjusted food intake parallel those in adjusted food intake, although the High lines show a greater change with respect to the Controls than do the Low lines. When the sexes are averaged, the High lines have increased by 10.2 %, and the Low lines have decreased by 5.8% of the Controls.

Table 1 shows the total cumulated selection differentials in the three High, three Low and three Control lines. The total cumulated selection differentials are similar in magnitude in the High and Low lines, and are close to zero in the Control lines, except that of replicate 2, which has been selected for a slight increase in adjusted food intake by chance.

The realised heritabilities were calculated for each replicate separately from the regression of response on cumulated selection differential up to generation 11. The response was taken as the deviation of the line-mean from the mean of the Control line in that replicate. The regression coefficients and their standard errors are given in Table 2. The standard errors were calculated assuming the usual regression model - independent errors with equal

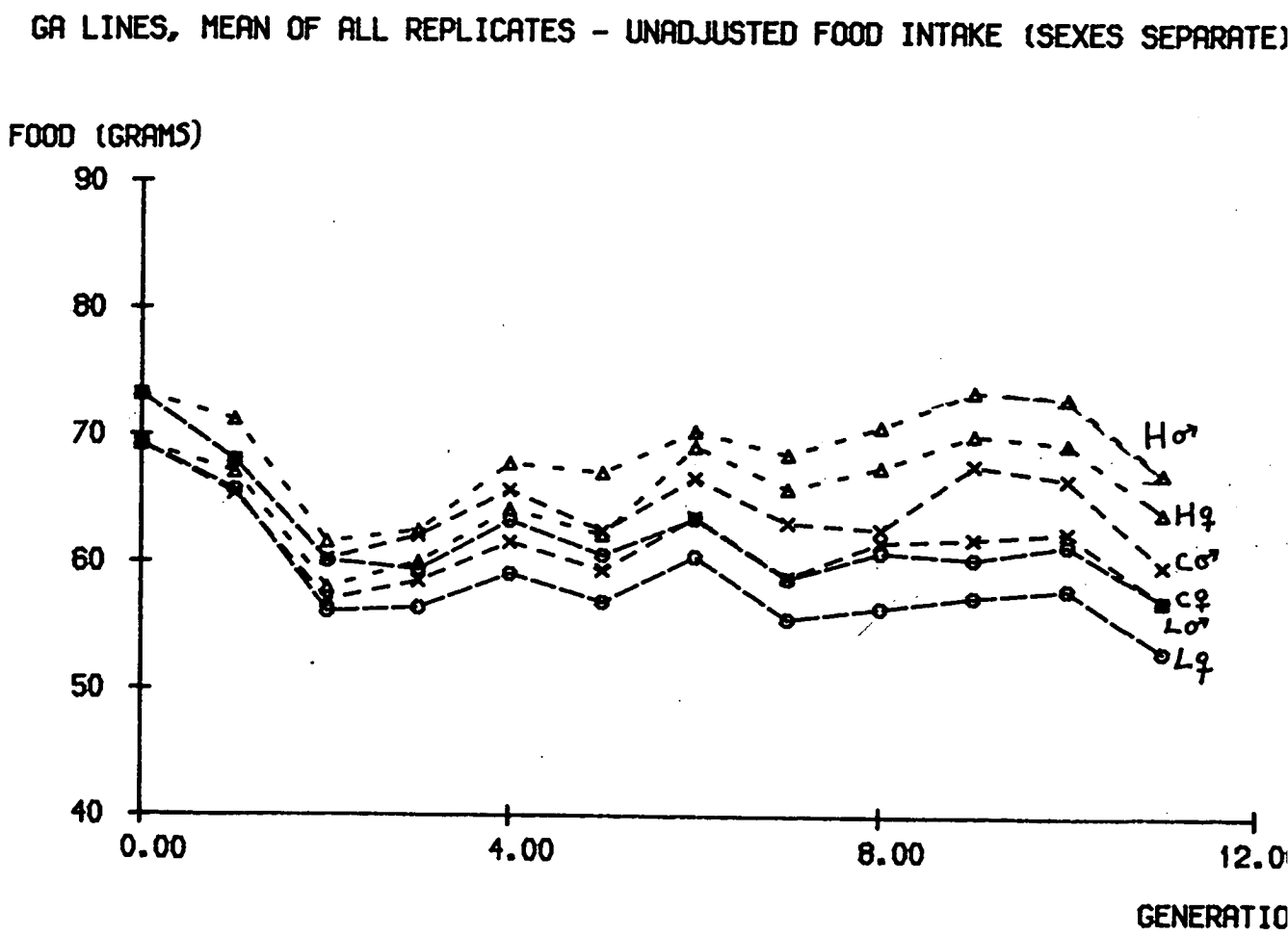

GA LINES, MEAN OF ALL REPLICATES - UNADJUSTED FOOD INTAKE (SEXES SEPARATE)
FOOD (GRAMS)
90
80
70
60
50
40
0.00
4.00
8.00
12.0
GENERATIO
H♂
H♀
C♂
C♀
L♂
L♀

Figure 5

Table 1. Total cumulated selection differentials (g) of GA lines from generations 1-11

Line	Replicate 1	2	3	Mean
High	37.81	35.58	38.41	37.27
Low	-38.28	-37.13	-35.42	-36.94
Control	0.50	2.38	0.25	1.04

Table 2. Realised heritabilities and standard errors in the separate replicates of the GA lines up to generation 11.

Replicate	High	Low	Divergence
1	0.14 ± 0.045	0.25 ± 0.039	0.20 ± 0.025
2	0.08 ± 0.042	0.16 ± 0.038	0.11 ± 0.028
3	0.11 ± 0.071	0.14 ± 0.056	0.13 ± 0.034
Pooled *	0.11 ± 0.045	0.15 ± 0.032	0.14 ± 0.022
Mean **	0.11 ± 0.017	0.18 ± 0.034	0.15 ± 0.027

* Regression of mean of lines on mean selection differential.

** Arithmetic mean of regression coefficients with empirical standard error based on variance of b between replicates.

variances.

Figs. 6a and 6b show the mean responses plotted against the mean cumulated selection differentials, with the calculated regression lines fitted. Although the regression coefficient is an unbiased estimator of the realised heritability, its standard error is not a valid estimate of the standard error of the heritability (Hill,1972). The response used to estimate the heritability includes the cumulated deviation due to random drift, and so the sampling variance of the heritability is larger than that calculated for the regression coefficient. As the selected lines are replicated, the sampling variance of the realised heritability can be estimated empirically from the observed variance of the regression coefficients between the replicates. In Table 2 the 'pooled' estimates are the regression of the mean of lines on the mean selection differential with the standard error of the regression coefficient, the standard errors calculated assuming the usual regression model. The 'mean' estimates are the unweighted means of the separate regression coefficients in each replicate, with the empirical standard error of this mean. These empirical standard errors are unbiased estimators of the standard errors of the realised heritabilities, although they have only two degrees of freedom. Unbiased estimators of the realised heritability and its standard error are the 'pooled' regression coefficient and the empirical standard error of the 'mean' regression cofficient.

Therefore, the realised heritabilities, with their empirical standard errors, are 11 $\pm$ 1.7% and 15 $\pm$ 3.4% for the upward and downward responses respectively, and 14 $\pm$ 2.7 % for the divergence. These are within-family heritabilities, as selection was carried out

GA LINES - MEAN RESPONSE AGAINST MEAN CUMULATED SELECTION DIFFERENTIAL

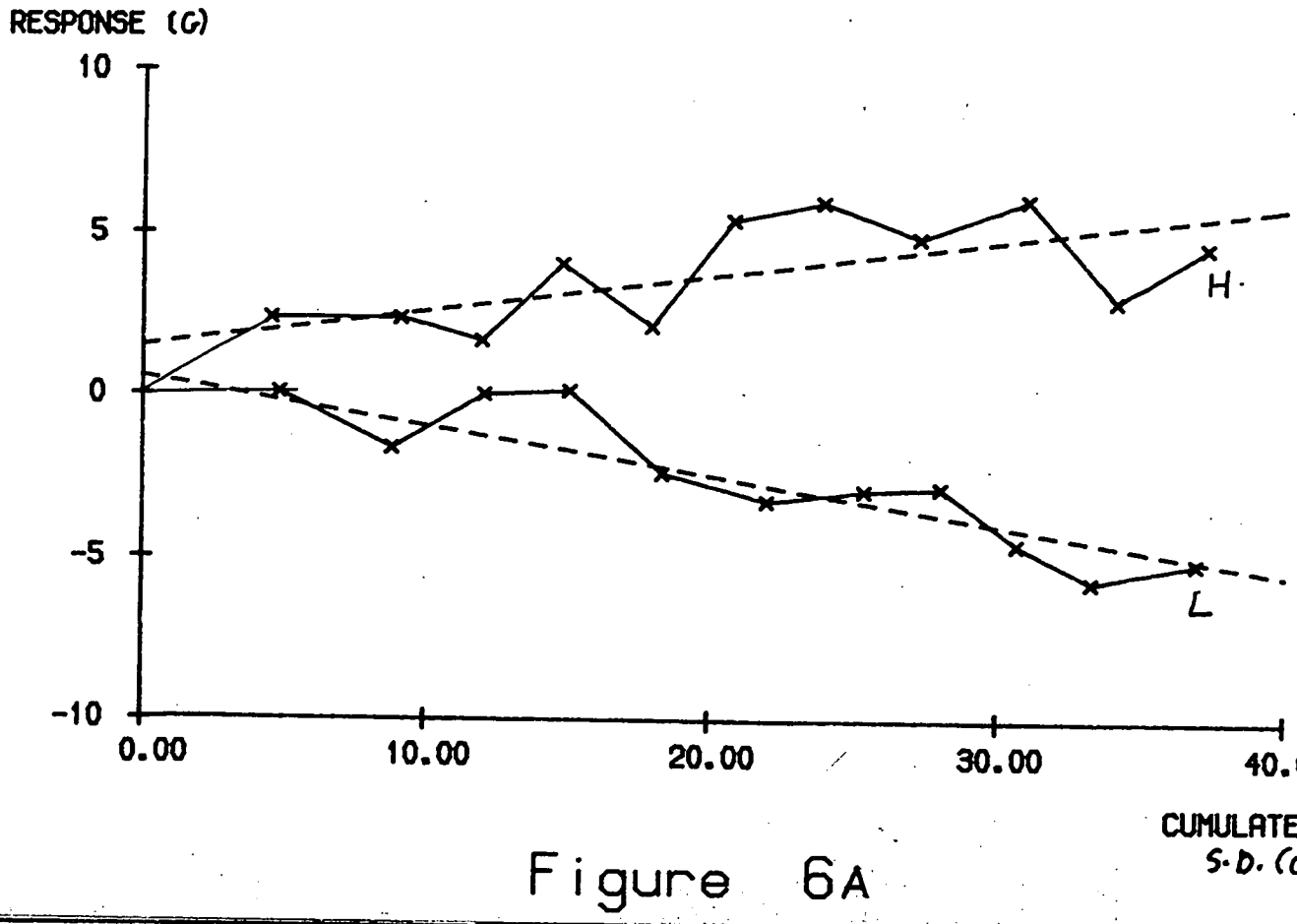
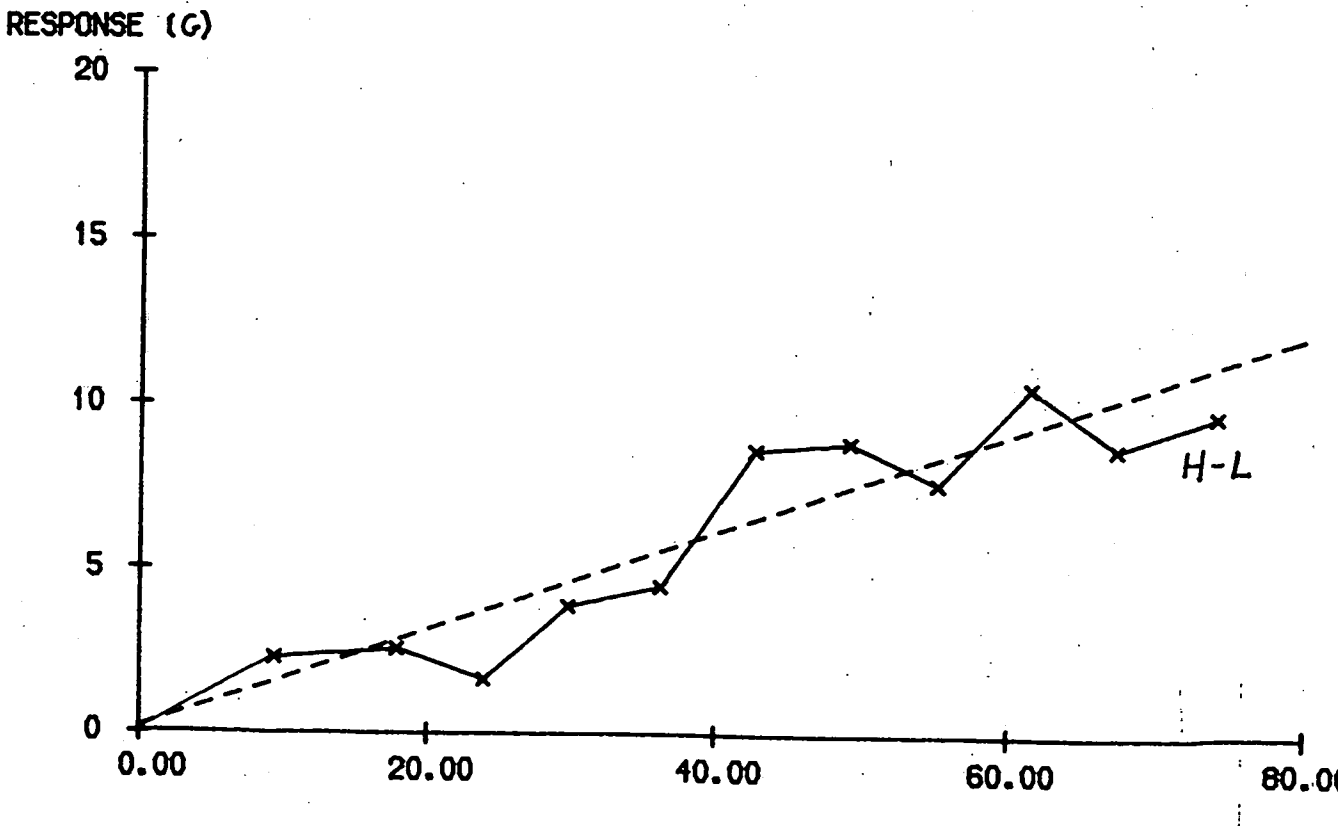


Figure 6A

GA LINES

MEAN DIVERGENCE OF RESPONSE AGAINST MEAN CUMULATED SELECTION DIFFERENTIAL



within litters. There is no significant difference between the heritabilities of upward and downward responses, so there is no evidence of a real asymmetry of response. The apparent asymmetry of response in replicate 2 is probably partly due to the positive selection differential in the Control line.

2. GF Lines - Selection for Gonadal Fat Pad Weight / Body Weight

The results of 11 generations of selection for the ratio of gonadal fat pad weight to body weight in 10 week old males are shown in Figs. 7-10. The High lines were selected for a decrease in this ratio, i.e. an increase in percentage lean, and the Low lines were selected for an increase in this ratio.

Looking first at the mean of all replicates, there appears to be a similar response to selection in the upward and downward direction, the High lines having decreased by 44%, and the Lows having increased by 36% of the Controls by generation 11. The ratio of gonadal fat pad weight to body weight has remained fairly constant in the Controls throughout 11 generations. The divergence between the High and Low lines is large, considering that selection was carried out in only one sex. By generation 9 the Low line mean is more than twice that of the High lines, although the difference has not increased between generations 9 and 11. It is possible that selection limits have been reached, although further generations of selection must be carried out to confirm this.

Looking at the three replicates separately, the High-Low divergence is larger in replicates 1 and 2. Taking the High-Low differences as proportions of the Control line means gives a value of 83.5% for replicate 1, 96.4% for replicate 2 and 61.5% for

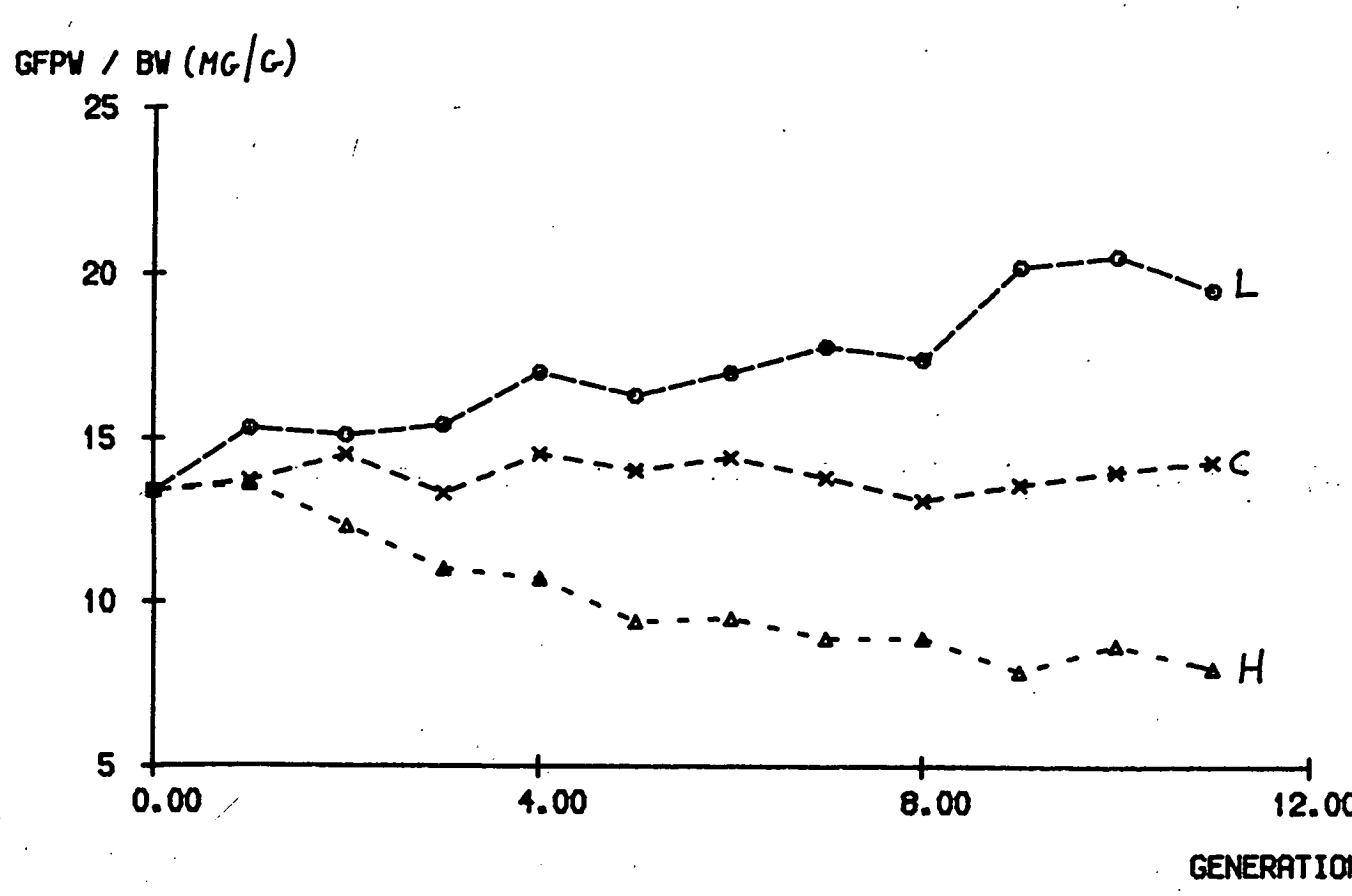


Figure 7

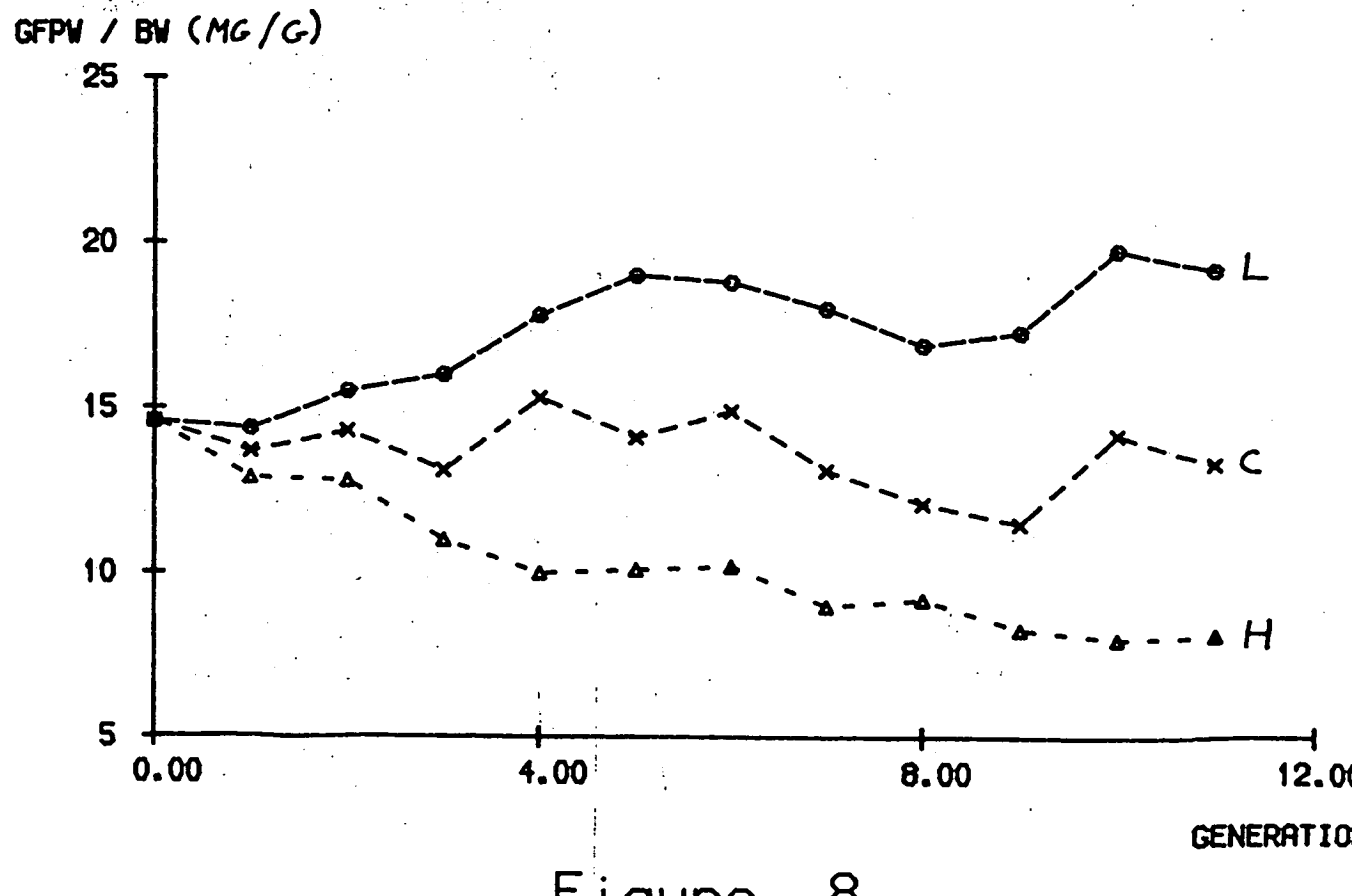


Figure 8

GF LINES, REPLICATE 2 - RATIO OF GONADAL FAT PAD WEIGHT / BODY WEIGHT

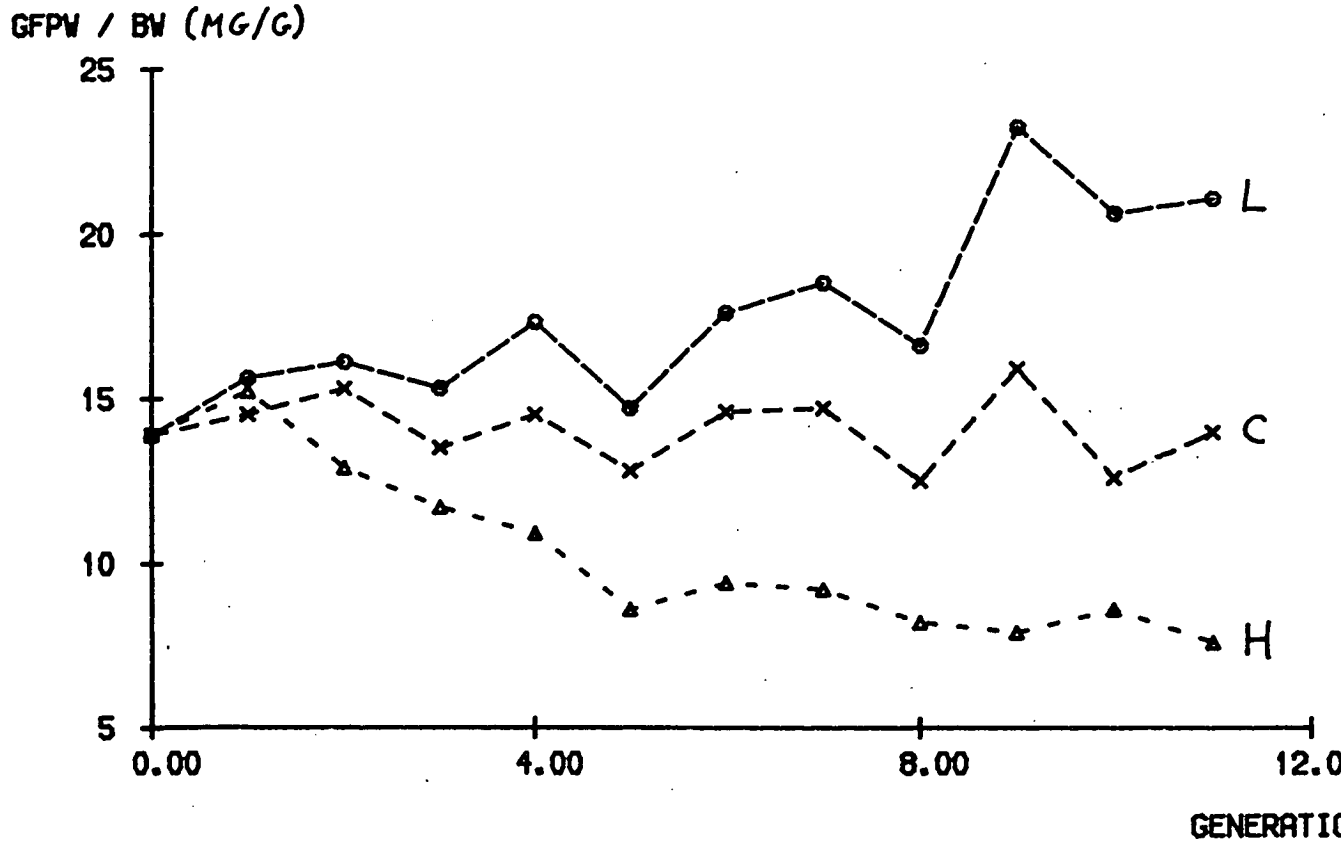


Figure 9

GF LINES, REPLICATE 3 - RATIO OF GONADAL FAT PAD WEIGHT TO BODY WEIGHT

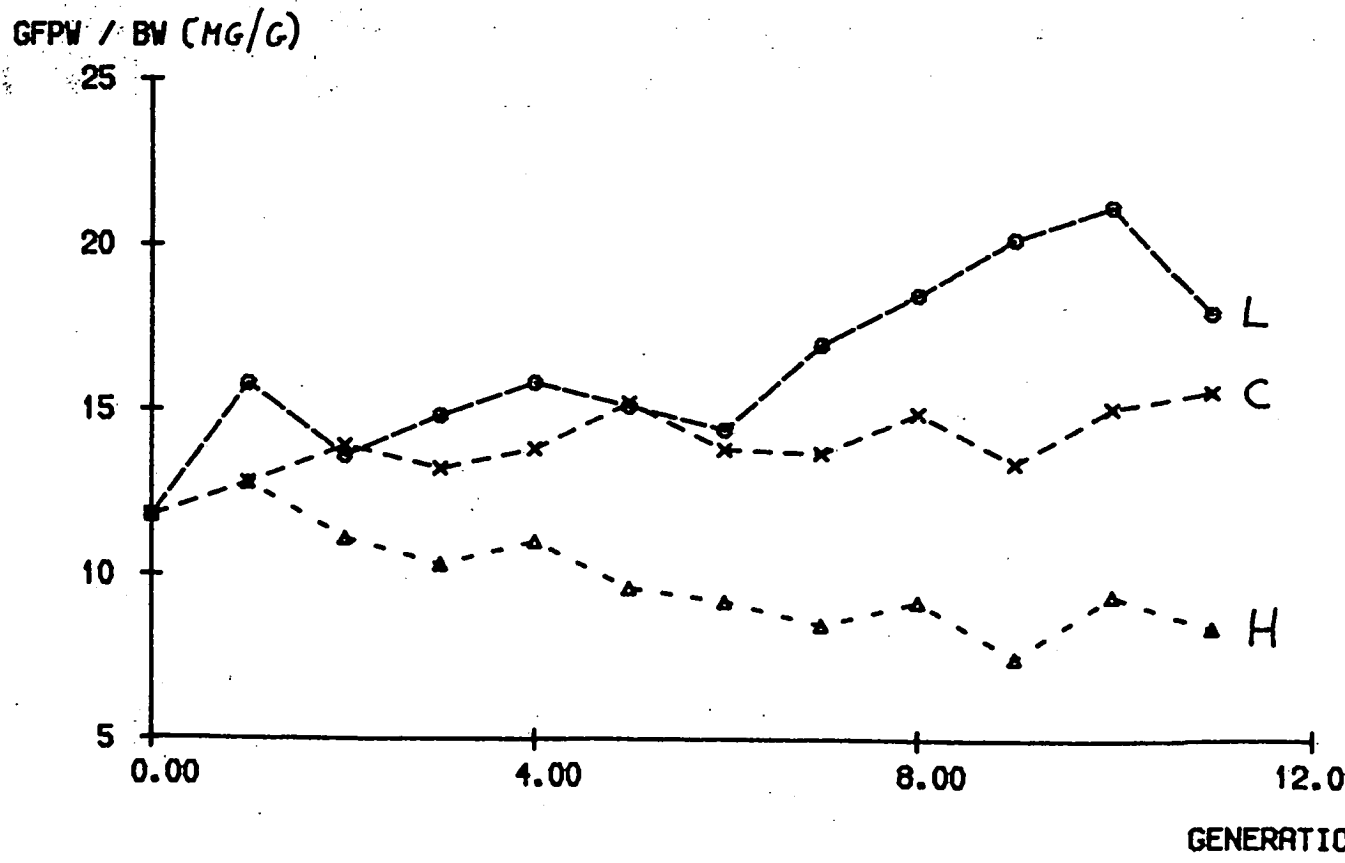


Figure 10

replicate 3. The responses to selection in the upward and downward direction appear symmetrical in all replicates up to generation 10, but become slightly less so in replicates 1 and 3 in generation 11.

Table 3 shows the total cumulated selection differentials in generation 11. The figures have been halved to take account of the fact that selection was in one sex only. It can be seen that the selection differentials were larger in the lines selected for an increase in the ratio of gonadal fat pad weight to body weight because the variance of the selected character has increased in these lines and decreased in the lines selected for a decrease in the ratio. The total cumulated selection differentials are close to zero in the Control lines, except in replicate 3, which was selected for an increase in the character by chance.

The realised heritabilities were calculated as in the GA lines, and they and their standard errors are shown in Table 4.

The mean selection responses plotted against the mean cumulated selection differentials, together with the calculated regression lines are shown in Figs. 11a and b. The realised heritabilities, together with their standard errors, are 55 $\pm$ 9.4% and 37 $\pm$ 6.5% for the downward and upward responses respectively, and 43 $\pm$ 5.9% for the divergence. Although the heritability is larger for the downward response than for the upward response, the difference is not significant. There is therefore no indication of a real asymmetry of response. The apparent asymmetry of response in replicate 3 is probably partly due to the positive selection differential in the Control line.

Table 3. Total cumulated selection differentials (mg/g) in the GF lines from generations 1-11

Line	Replicate 1	2	3	Mean
High	-11.42	-9.90	-10.82	-10.71
Low	16.83	16.93	16.88	16.88
Control	0.17	-0.86	3.06	0.79

Table 4. Realised heritabilities and standard errors in the separate replicates of the GF lines up to generation 11.

Replicate	High	Low	Divergence
1	0.38 ± 0.123	0.34 ± 0.044	0.35 ± 0.055
2	0.68 ± 0.148	0.50 ± 0.068	0.55 ± 0.066
3	0.64 ± 0.086	0.28 ± 0.127	0.41 ± 0.059
Pooled *	0.55 ± 0.071	0.37 ± 0.058	0.43 ± 0.034
Mean**	0.57 ± 0.094	0.37 ± 0.065	0.44 ± 0.059

*Regression of mean of lines on mean selection differential.

**Arithmetic mean of regression coefficients with empirical standard error based on variance of b between replicates.

MEAN RESPONSE AGAINST MEAN CUMULATED SELECTION DIFFERENTIAL

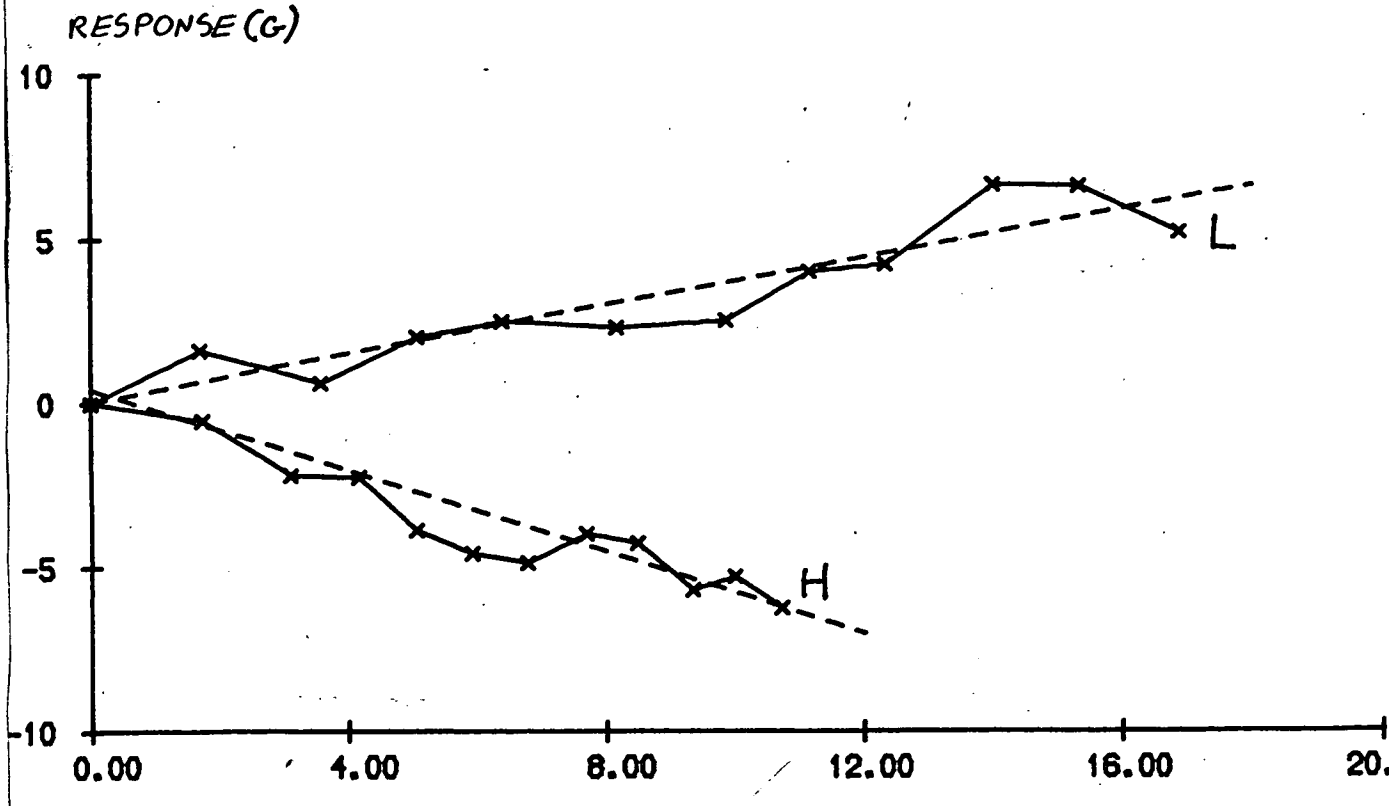


Figure11A

GF LINES- MEAN

DIVERGENCE OF RESPONSE AGAINST MEAN SELECTION DIFFERENTIAL

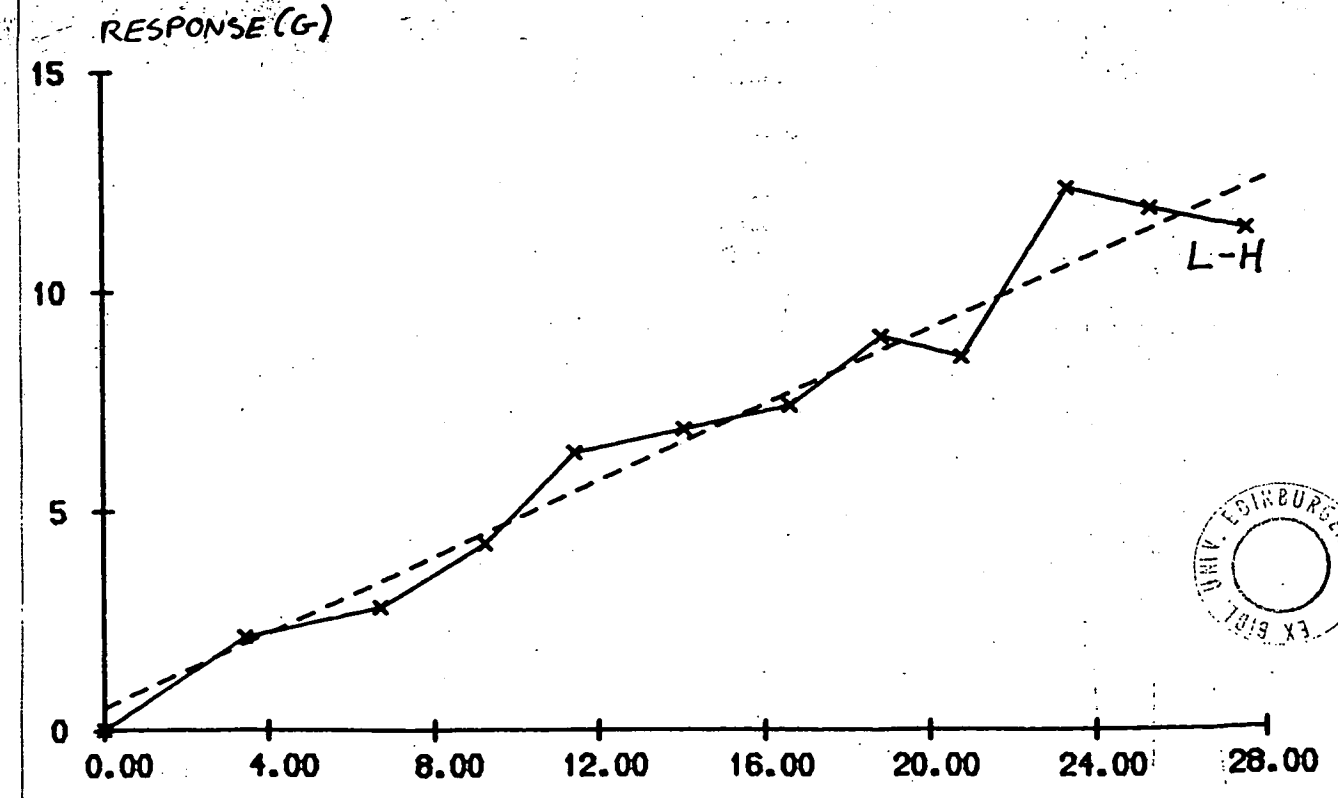


Figure11B

3. GP Lines - Selection for Body Weight - 8 x Gonadal Fat Pad Weight

Figs. 12-15 show the results of eleven generations of selection for the index (body weight - 8 x gonadal fat pad weight) which was constructed to estimate fat-free mass. Selection was carried out on 10 week old males.

Looking at the mean of the three replicates, the Control lines show no change in the selected character throughout the course of 11 generations. There is a marked difference in the response to selection in the upward and downward direction. By generation 11 the High lines have increased to 26.7% and the Low lines have decreased to 13.0% of the Controls. However, this asymmetry is only apparent in generations 10 and 11, and is due almost entirely to the line differences in replicate 1, where the Control line has decreased in the selected character. There is no evidence that selection limits have been reached.

Looking at the three replicates separately, there is little variation in the High-Low differences at generation 11. Taking the High-Low differences as proportions of the Control means gives values of 43.1% for replicate 1, 34.3% for replicate 2 and 41.0% for replicate 3. Only in replicate 1 is there a large difference in the response to selection in the upward and downward direction, because the Control line mean is very little different from that of the Low line.

It was hoped that the selection index used would produce changes in body weight without changes in body composition. To see if body composition had been altered as a result of selection, the mean ratio of gonadal fat pad weight to body weight in these lines was calculated. The means of the three replicates for this character

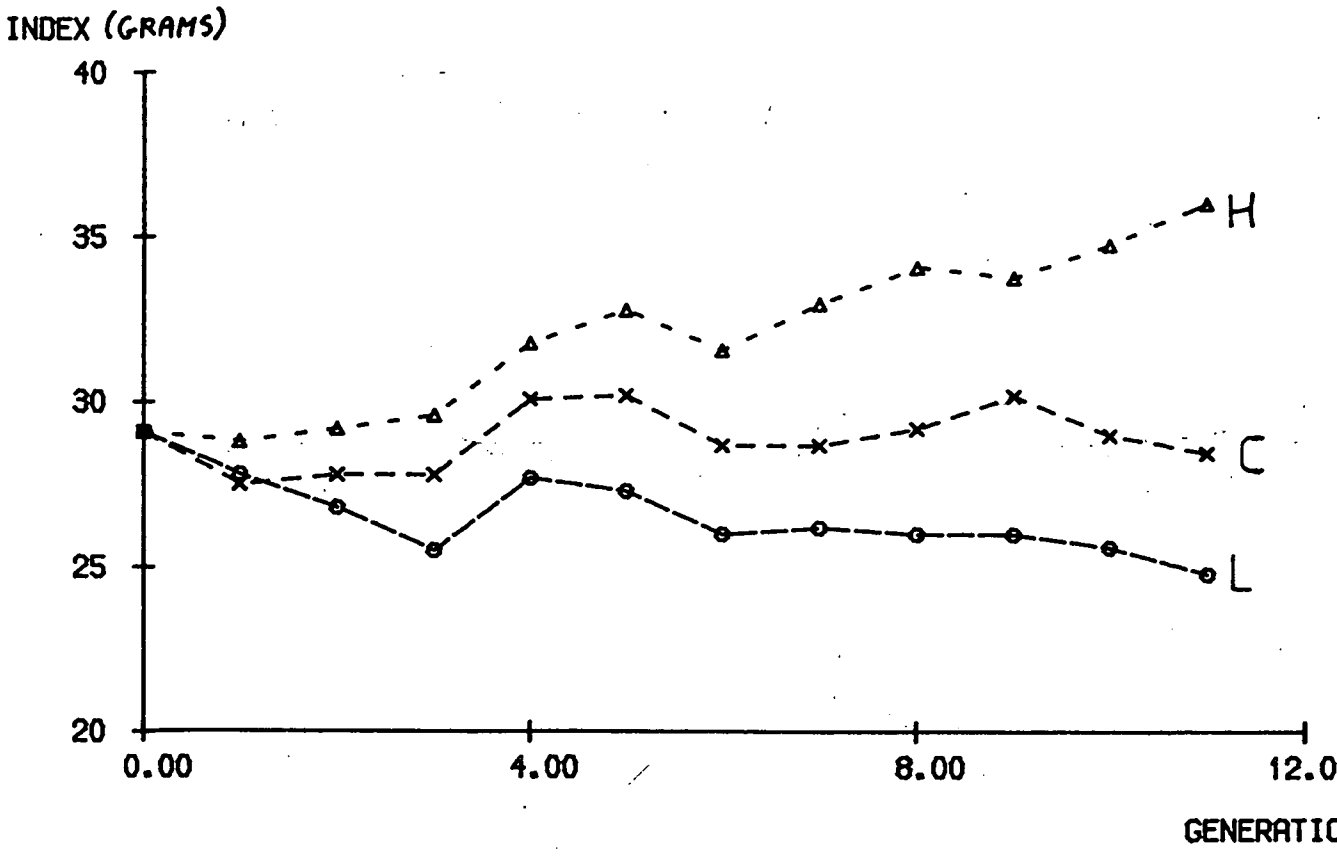
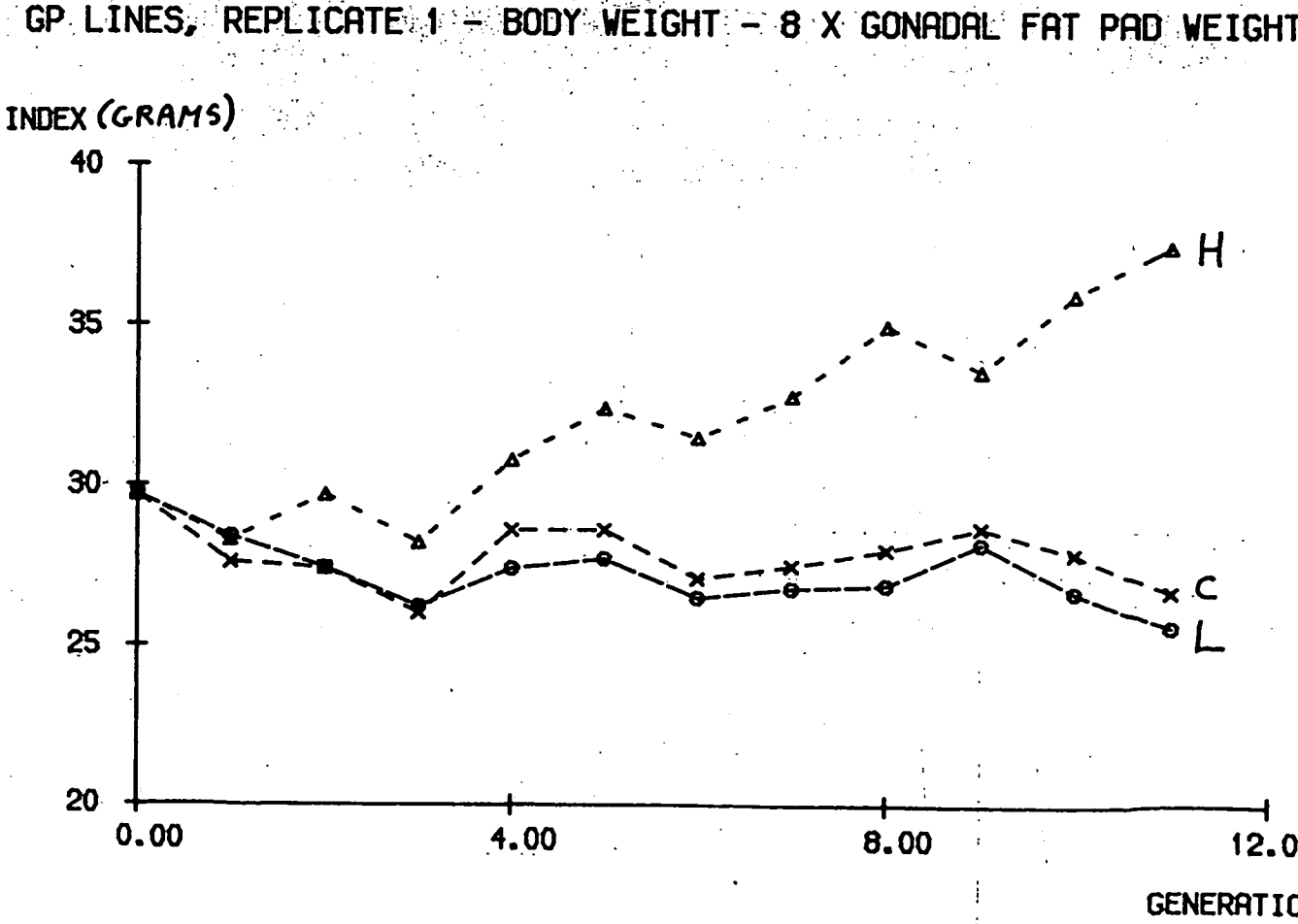

GP LINES, MEAN OF REPS - BODY WEIGHT - 8 X GONADAL FAT PAD WEIGHT
INDEX (GRAMS)
40
35
30
25
20
H
C
L
0.00
4.00
8.00
12.0
GENERATIO

Figure 12


GP LINES, REPLICATE 1 - BODY WEIGHT - 8 X GONADAL FAT PAD WEIGHT
INDEX (GRAMS)
40
35
30
25
20
H
C
L
0.00
4.00
8.00
12.0
GENERATIO

GP LINES, REPLICATE 2 - BODY WEIGHT - 8 X GONADAL FAT PAD WEIGHT

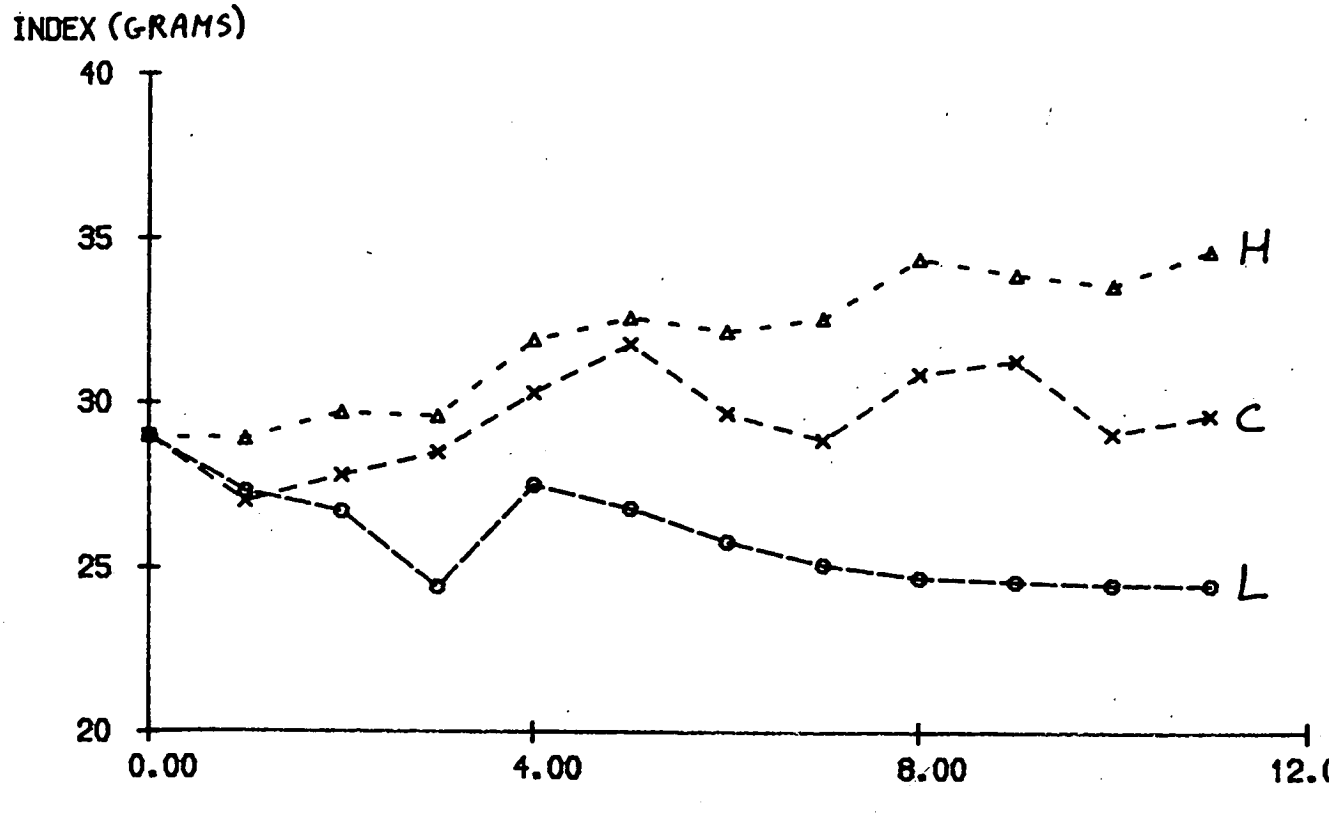


Figure 14

GP LINES, REPLICATE 3 - BODY WEIGHT - 8 X GONADAL FAT PAD WEIGHT

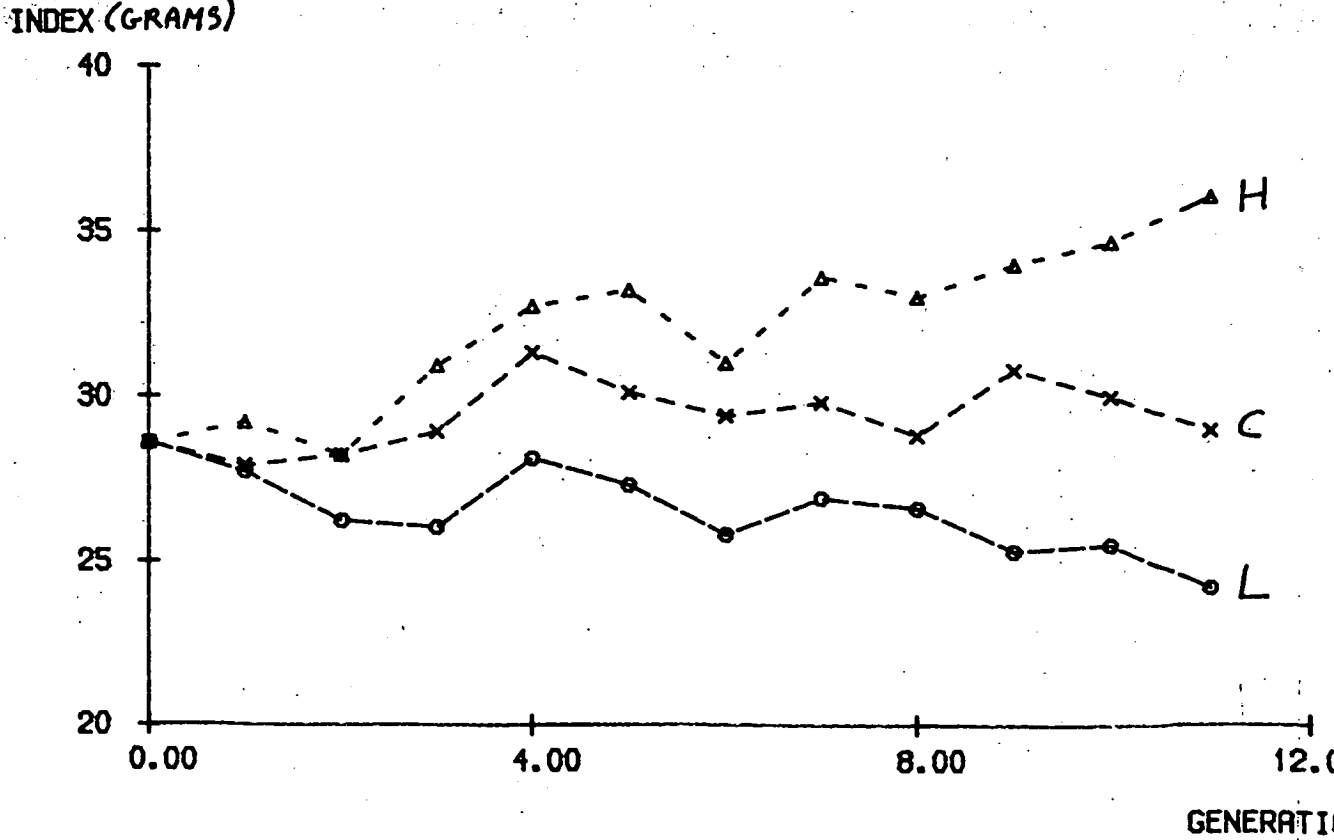


Figure 15

are shown in Fig. 16. It can be seen that the High lines have not increased in fatness as a result of selection. The Low lines seem to have become slightly fatter than the Controls, although the difference in the ratio of gonadal fat pad weight to body weight is only 10.2%, and is only apparent in generations 10 and 11.

The total cumulated selection differentials in each line in generation 11 are given in Table 5. As in the GF lines, the figures have been halved to take account of the fact that selection was carried out in only one sex in this experiment. The selection differentials are larger in the lines selected for an increase in the index, and the total cumulated selection differentials in the Control lines are close to zero.

Realised heritabilities were calculated as in the GA and GF lines, and Table 6 shows the regression coefficients and their standard errors.

Figs. 17 a and b show the mean responses plotted against the mean cumulated selection differential, with the calculated regression lines fitted.

From this analysis the realised heritabilities, with their standard errors, are 56 $\pm$ 10.9% and 46 $\pm$ 15.6% for the upward and downward responses respectively, and 54 $\pm$ 1.2% for the divergence. There is no significant difference between the heritabilities of upward and downward response, so there is no evidence of a real asymmetry of response.

4. Conclusions

Eleven generations of selection for 4 to 6 week food intake, adjusted for 4 week weight, produced a small response in both

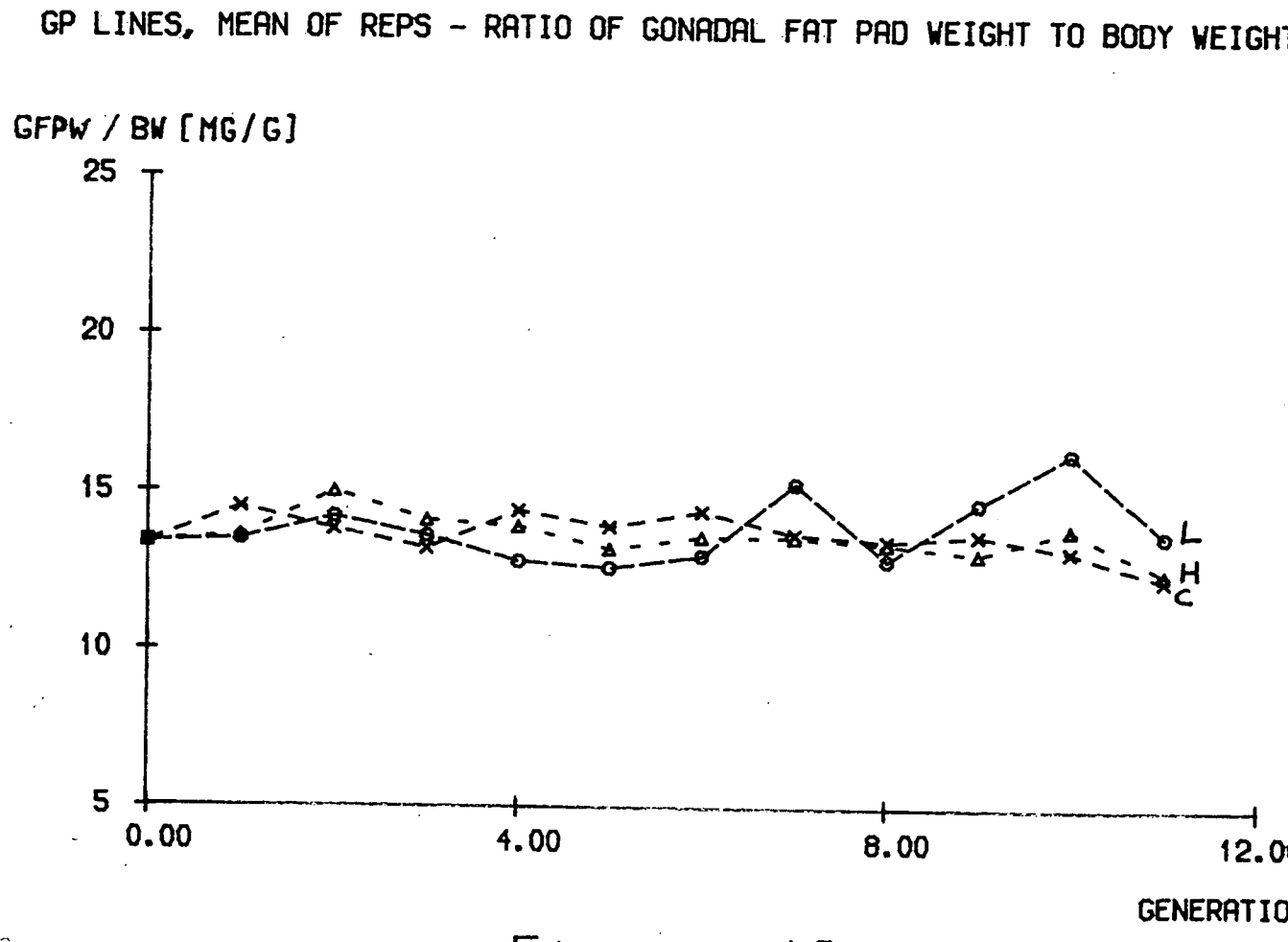

GP LINES, MEAN OF REPS - RATIO OF GONADAL FAT PAD WEIGHT TO BODY WEIGHT
GFPW / BW [MG/G]
25
20
15
10
5
0.00
4.00
8.00
12.0
GENERATIO
L
H
C

Figure 16

Table 5. Total cumulated selection differentials (g) of the GP lines from generations 1-11.

	Replicate			
Line	1	2	3	Mean
High	12.43	10.26	11.29	11.33
Low	-8.71	-8.58	-8.28	-8.52
Control	-0.20	1.11	0.68	0.53

Table 6. Realised heritabilities and standard errors in the separate replicates of the GP lines up to generation 11.

Replicate	High	Low	Divergence
1	0.75 ± 0.091	0.19 ± 0.063	0.52 ± 0.063
2	0.38 ± 0.090	0.73 ± 0.190	0.53 ± 0.049
3	0.50 ± 0.092	0.48 ± 0.133	0.49 ± 0.060
Pooled*	0.56 ± 0.075	0.46 ± 0.086	0.54 ± 0.035
Mean**	0.54 ± 0.109	0.47 ± 0.156	0.51 ± 0.012

*Regression of mean of lines on mean selection differential.

**Arithmetic mean of regression coefficients with empirical standard errors based on variance of b between replicates.

GP LINES, MEAN RESPONSE AGAINST MEAN SELECTION DIFFERENTIAL

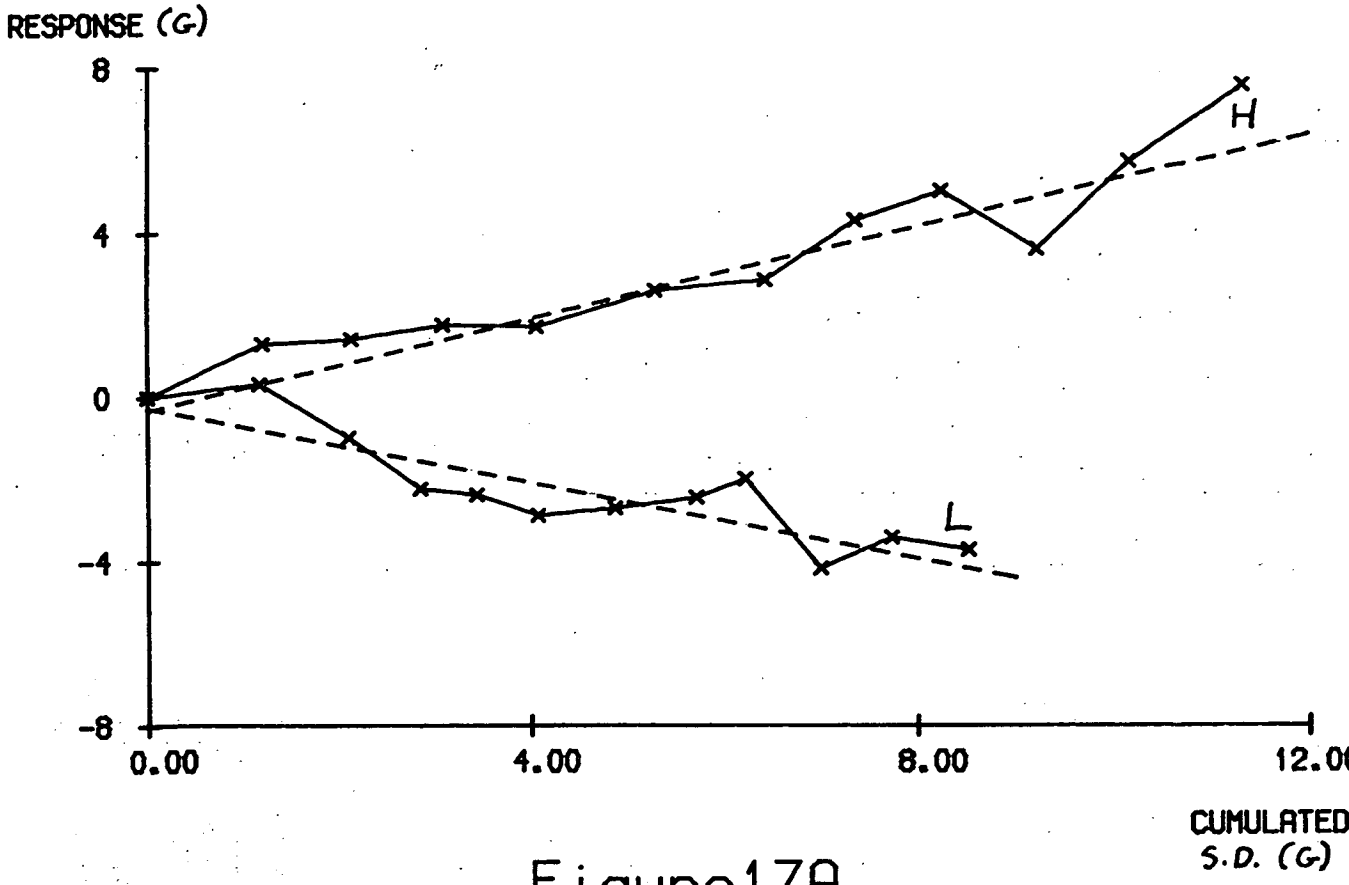


Figure17A

GP LINES

MEAN DIVERGENCE OF RESPONSE AGAINST MEAN CUMULATED SELECTION DIFFERENTIAL

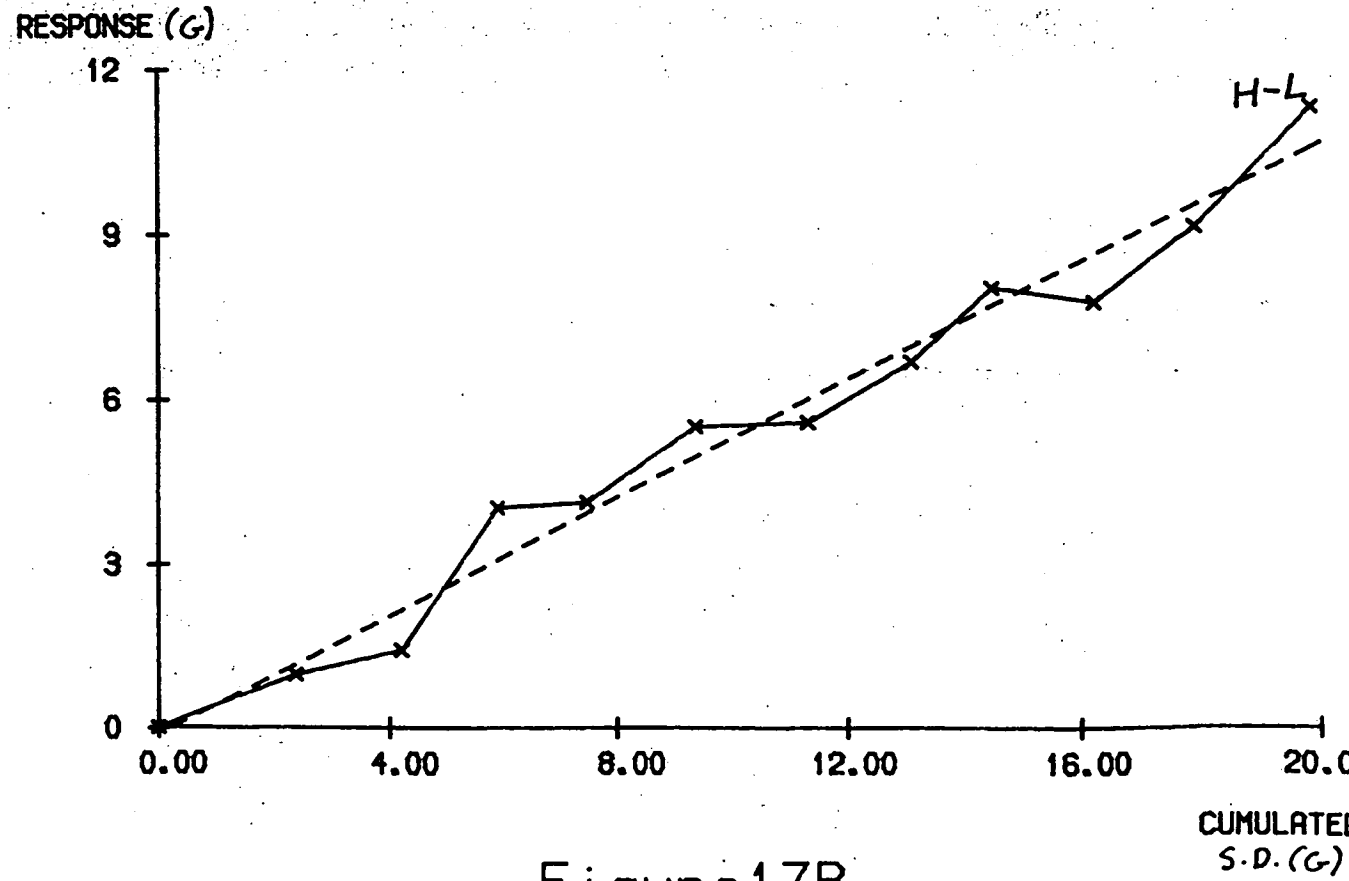


Figure17B

directions. The realised heritability estimate calculated from the High-Low divergence was 14 ± 2.7%. This is lower than the heritability estimate of 20 ± 5.7% obtained for 4 to 11 week food intake by Sutherland et al (1970). A number of reasons may be suggested for this difference. The adjustment for 4 week weight in this experiment might lower the response and the realised heritability, as 4 to 6 week food intake and 4 week weight are highly correlated. The heritability of 4 to 11 week food intake may be higher than that of 4 to 6 week food intake, as the longer period might give a more accurate measurement of food intake. Thirdly, selection in this experiment was carried out within litters, whereas Sutherland et al practised mass selection.

Eleven generations of selection for the ratio of gonadal fat pad weight to body weight produced a large response in both directions, although there is some indication that selection limits have been reached after 9 generations of selection. The realised heritability estimate calculated from the High-Low divergence was 43 ± 5.9%. There therefore seems to be a large amount of genetic variation in this character, although it is psosible that there may be physiological limits to the amount of gonadal fat that a mouse has.

Selection for the index (body weight - 8 x gonadal fat pad weight) for 11 generations produced a large response in both directions. Although there were large differences in the value of the index (and therefore in body weight) between the High and Low selected lines, the differences in fatness (from the ratio of gonadal fat pad weight to body weight) are small. The realised heritability estimate calculated from the High-Low divergence was 54 ± 1.2%. McCarthy and Doolittle (1977) obtained an estimate of 33 ±

2.0% for the (within-litter) heritability of 10 week weight when they selected for 15 generations in both directions. Their estimate for the first 10 generations of selection was slightly higher, about 41%. As body weight and gonadal fat pad weight are almost certainly positively correlated, it would be expected that the index used, which combines the characters in an antagonistic way, would have a lower heritability than 10 week weight alone. The heritability estimate obtained for the index is therefore larger than would have been predicted.

B. Correlated Responses to Selection

1. Changes in Body weight

a. GA Lines

4 and 6 week body weight were measured in the GA lines throughout 11 generations of selection. Figs. 18, 19 and 20 show the mean 4 week weight, 6 week weight and 4 to 6 week gain, respectively. In all cases the mean of the three replicates is shown and results from the sexes are pooled.

The mice were selected for 4 to 6 week food intake, adjusted for 4 week weight by a within-litter (within-sex) regression. It was hoped that no change in 4 week weight would occur in the selected lines. The High-Low difference in 4 week weight at generation 11 is only 0.4g, although both the High and Low selected lines are heavier than the Controls at 4 weeks. The low weight of the Controls is surprising but, up until generation 9, the Control line mean was higher than that of the Low line. Even in generation 11, the

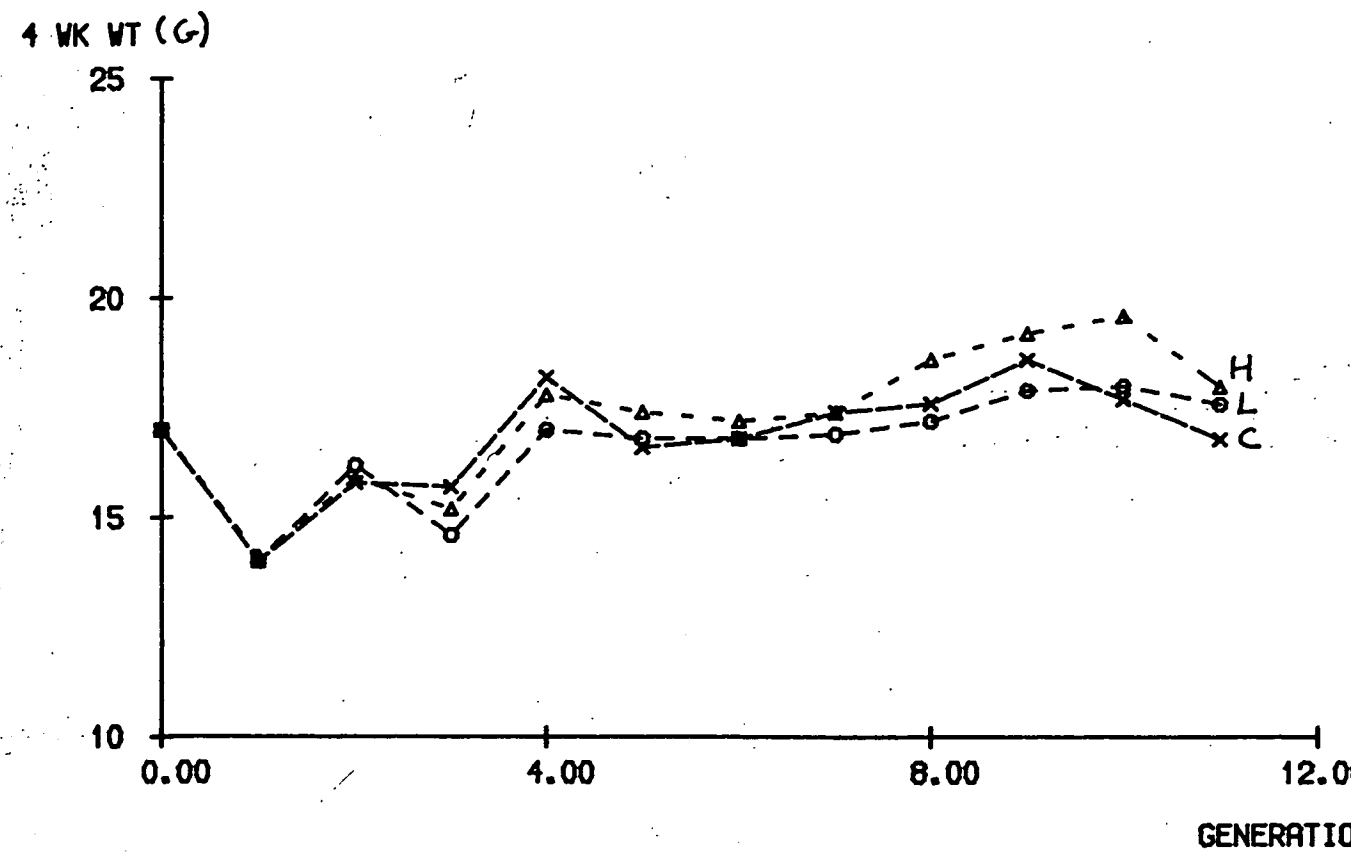


Figure 18

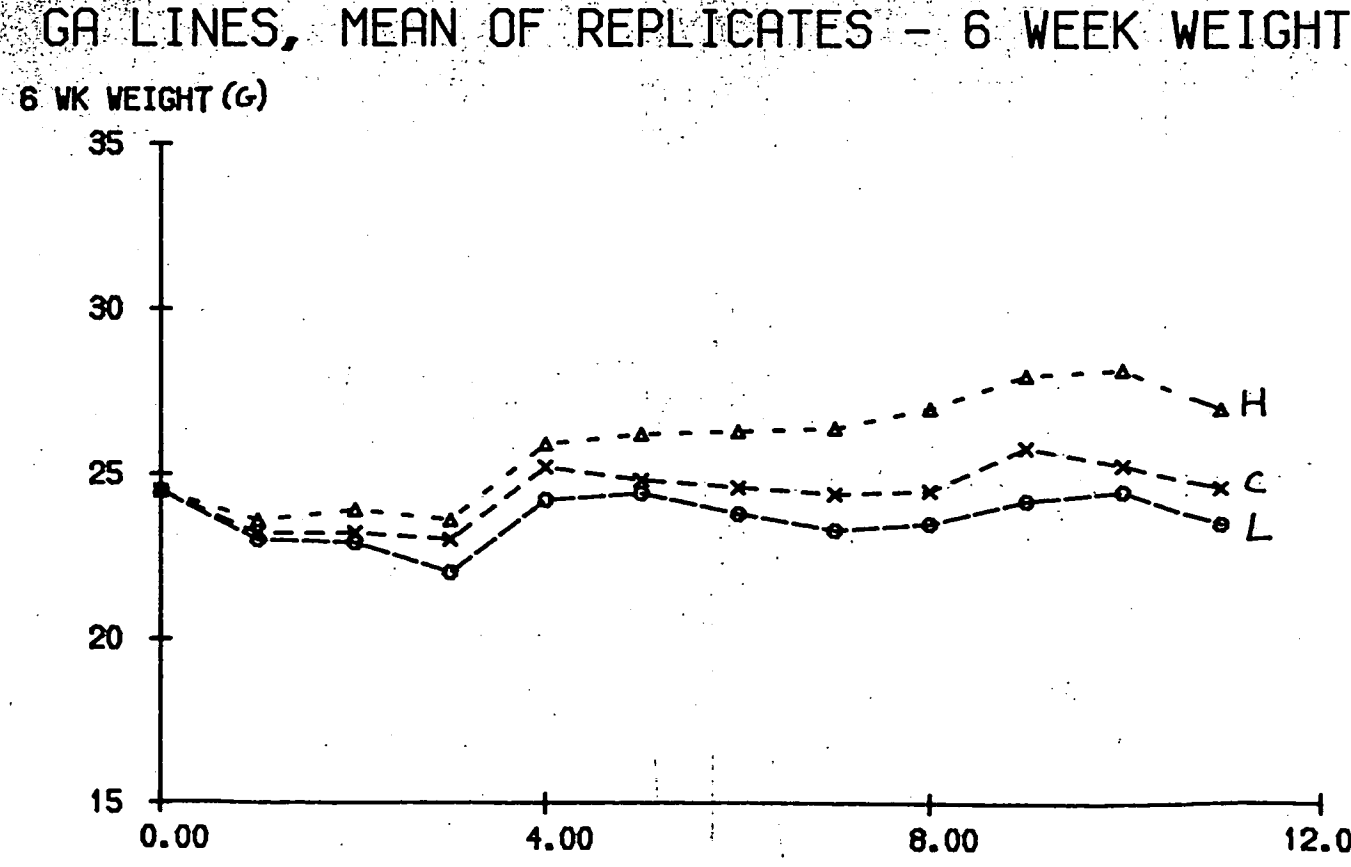


Figure 19

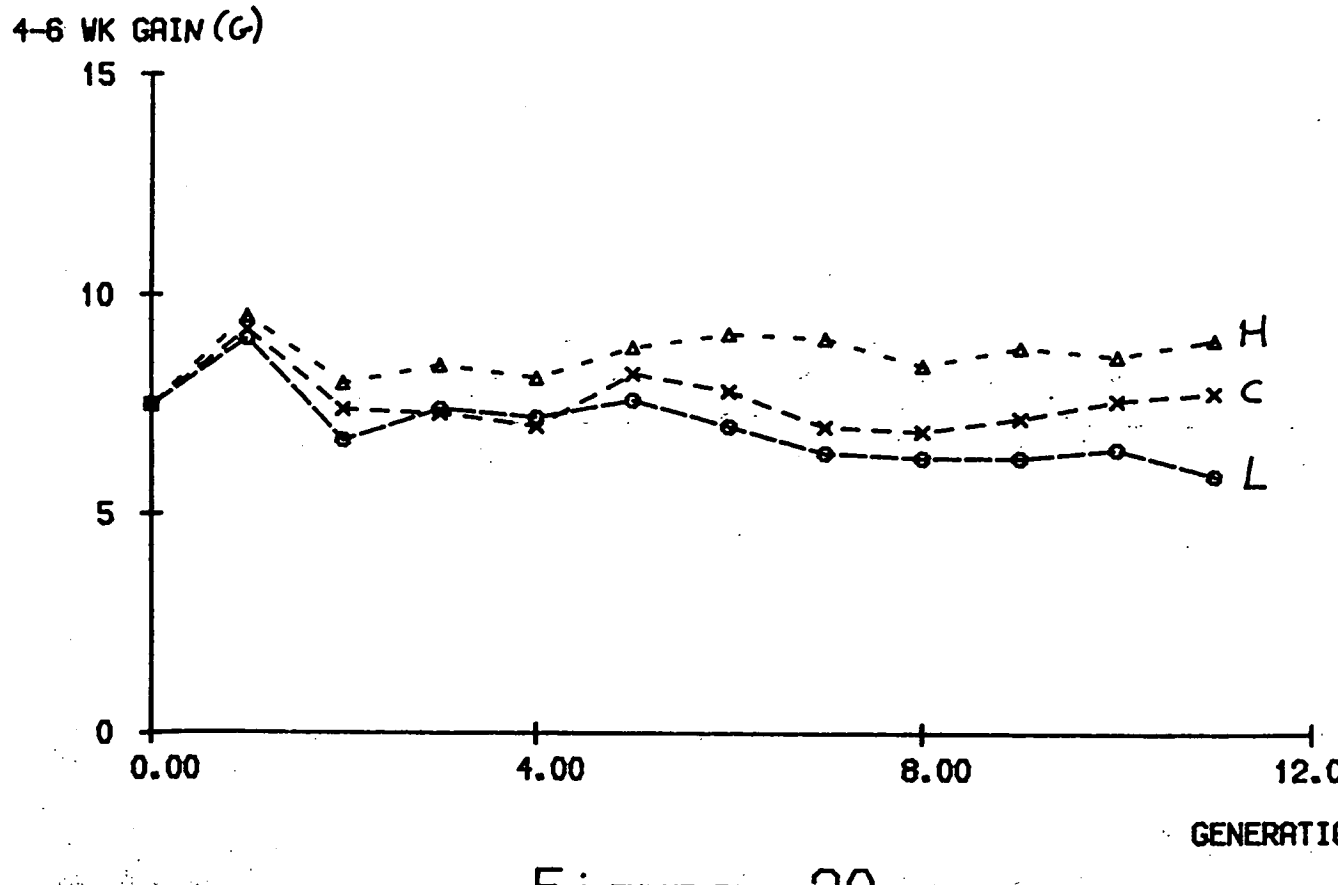


Figure 20

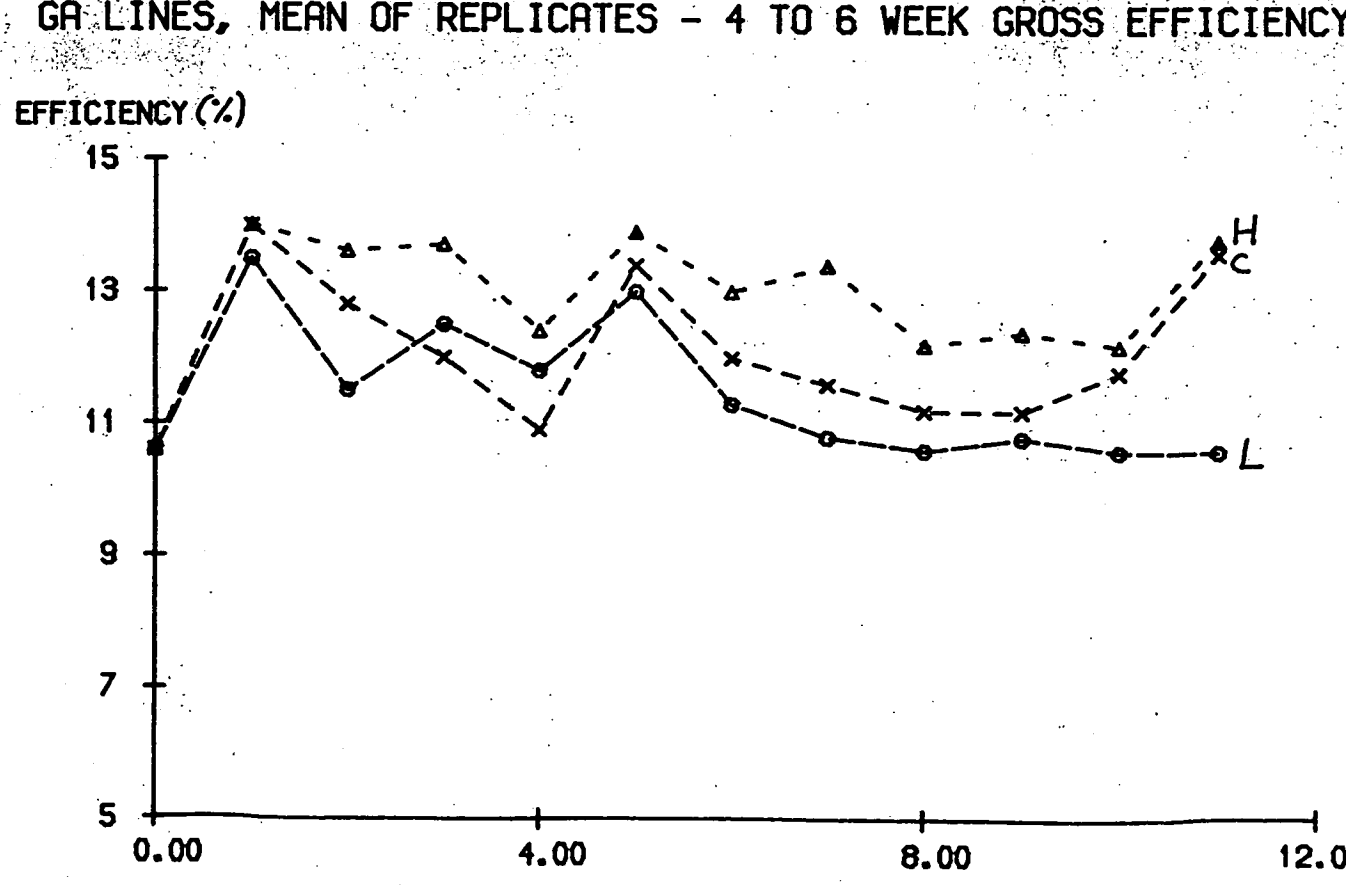


Figure 21

Low-Control difference is only 0.8g, so the difference is not that great. It seems likely that 4 week weight is strongly influenced by maternal effects, so the reduction in the 4 week weight of the Controls may be due to a poor maternal performance in these lines. Maternal performance will be discussed in the next section.

The High lines have increased, and the Low lines have decreased, in 6 week weight with respect to the Controls. The High-Low difference, as a proportion of the Control line mean, is 14.2%. There has been no change in the Control line mean between generations 0 and 11, so there appears to be no effect of inbreeding depression on 6 week weight.

Large differences can be seen between the lines in 4 to 6 week gain. The High-Low difference, as a proportion of the Control line mean is 39.7%. As with 6 week weight, there has been no change in 4 to 6 week gain in the Control lines from generation 0 to 11. As food intake was measured, it was possible to calculate the gross efficiency (weight gain / food intake) from 4 to 6 weeks in these lines. The mean gross efficiencies (replicates and sex combined) are shown in Fig. 21. The High lines have increased with respect to the Controls but, in generation 11, the difference is small. The Low lines have decreased with respect to the Controls. The diet of the mice was changed between generations 1 and 2, so changes in gross efficiency should be looked at from generation 2 to 11. The mean gross efficiency of the Controls did not change much between generations 2 and 10, but increased in generation 11. This may be due to the low 4 week weights of the mice in generation 11 - the mice ate less at an early age than did the heavier mice of previous generations, but gained as much weight from 4 to 6 weeks of age.

b. GF Lines

The 6 week weights of all mice and the 10 week weights of males were measured in the GF lines throughout 11 generations of selection. Figs. 22 and 23 show the mean 6 week weights (sexes pooled) and the mean 10 week weights (males), respectively. In both cases the mean of all replicates is shown.

There is little difference between the High and Low lines in body weight at 6 or 10 weeks of age. Taking the High-Low differences as proportions of the Control line means gives a value of -3.2% for 6 week weight and -4.5% for 10 week weight. Looking at the difference between the Low line and Control line means, it seems that selection for a decrease in percentage lean (i.e. an increase in fatness) has not resulted in an increase, but in a slight decrease in body weight. Selection for an increase in percentage lean (i.e. a decrease in fatness) has resulted in a larger decrease in body weight than that seen in the Low lines.

c. GP Lines

The 6 week weight of all mice and the 10 week weight of males was measured in the GP lines throughout 11 generations of selection. The mean 6 week weights (sexes pooled) and the mean 10 week weights (males) are shown in Figs. 24 and 25. In both cases the mean of the replicates is shown.

In the GP lines 10 week old males were selected on the index (body weight - 8 x gonadal fat pad weight). It would be expected that this index would be highly correlated with 10 week weight, and that large changes in body weight would be seen in these lines. The High-Low differences in both 6 and 10 week weights are very large.

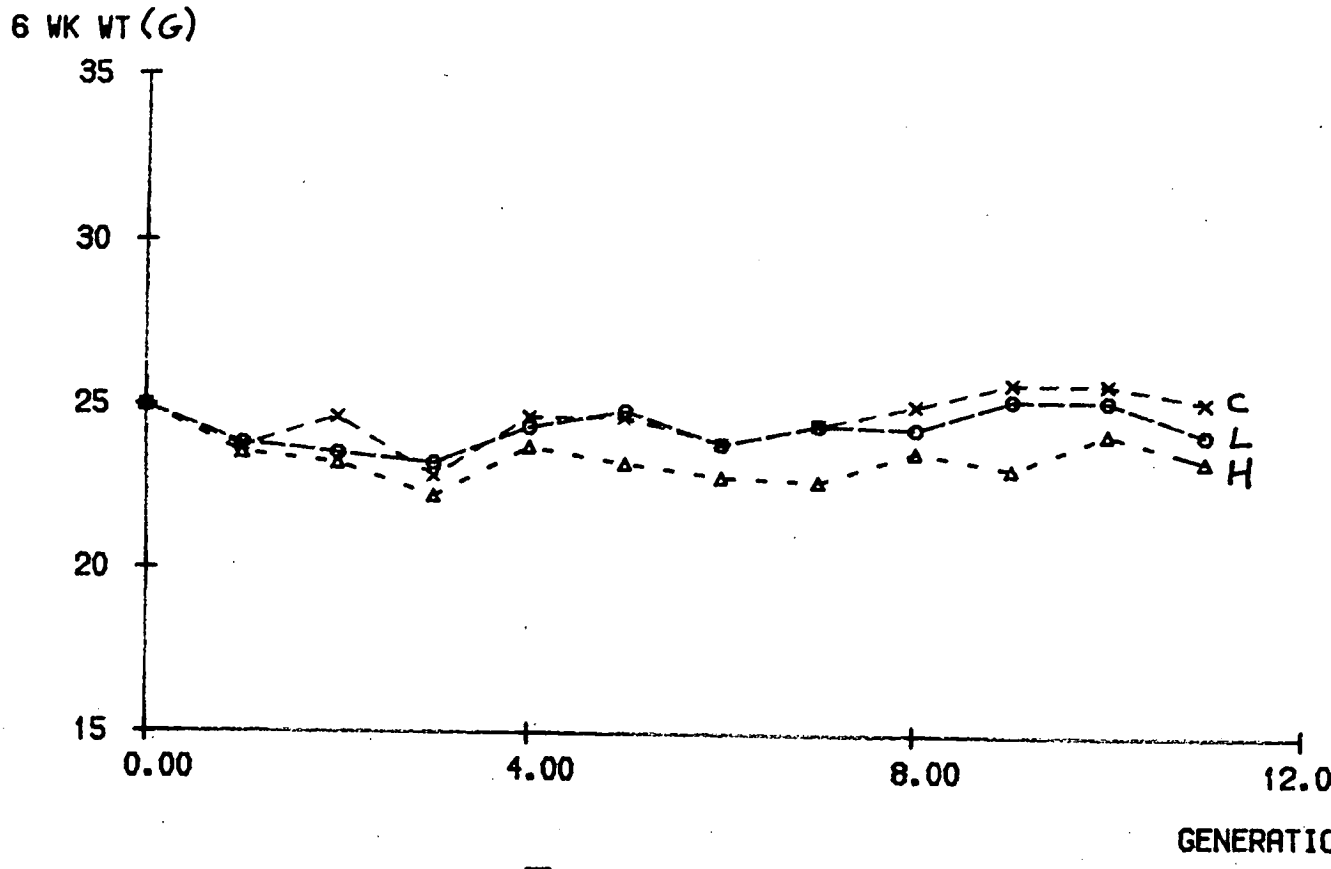


Figure 22

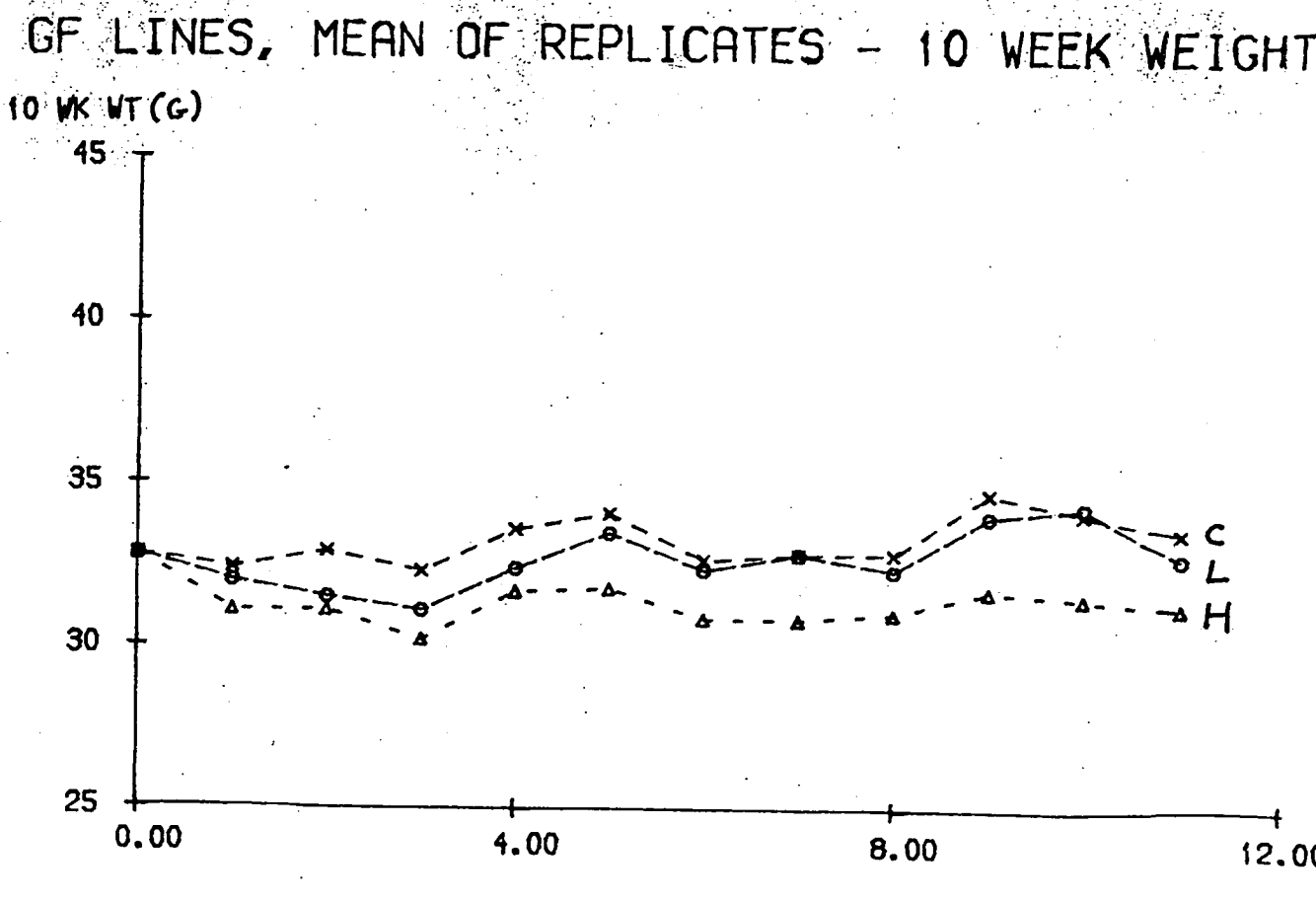


Figure 23

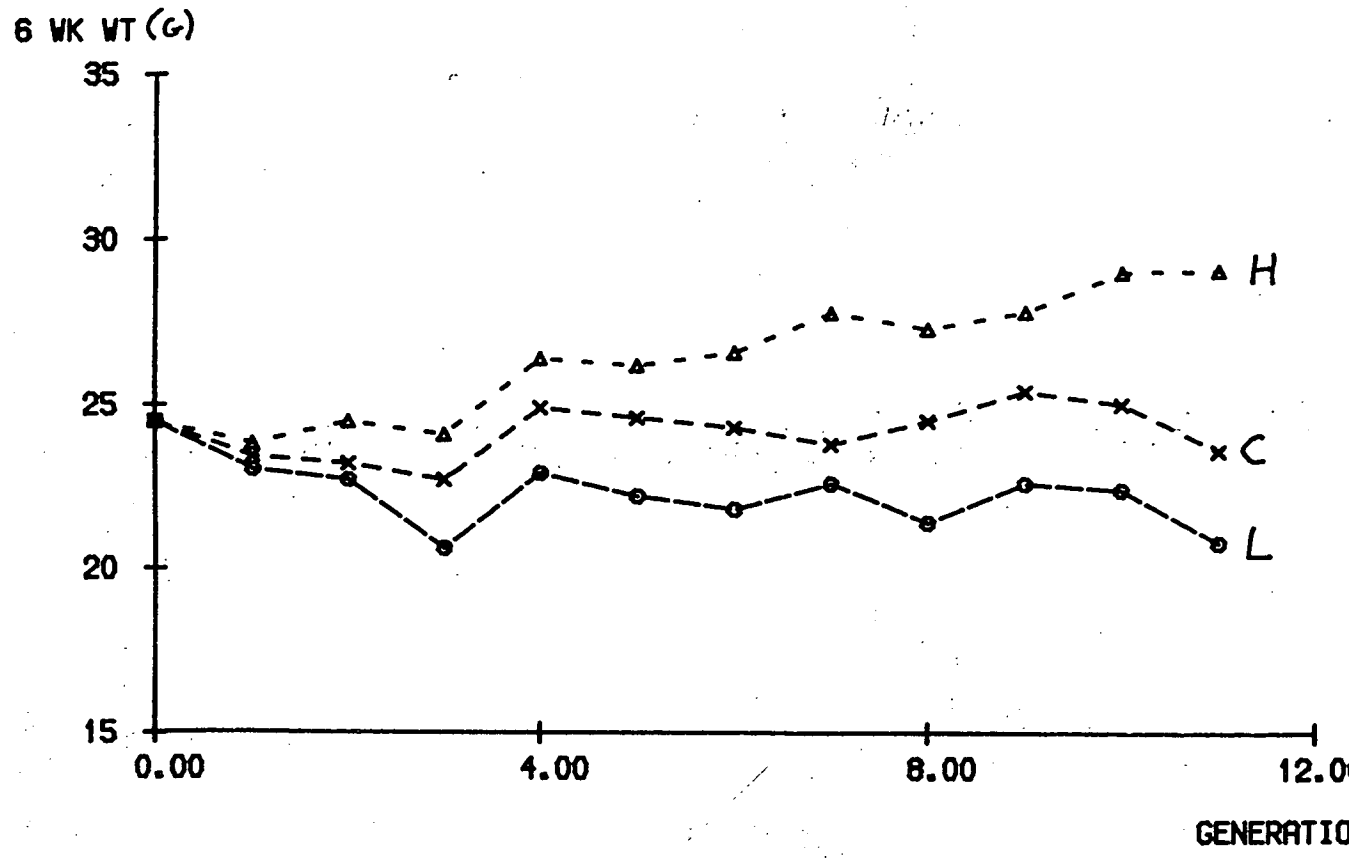


Figure 24

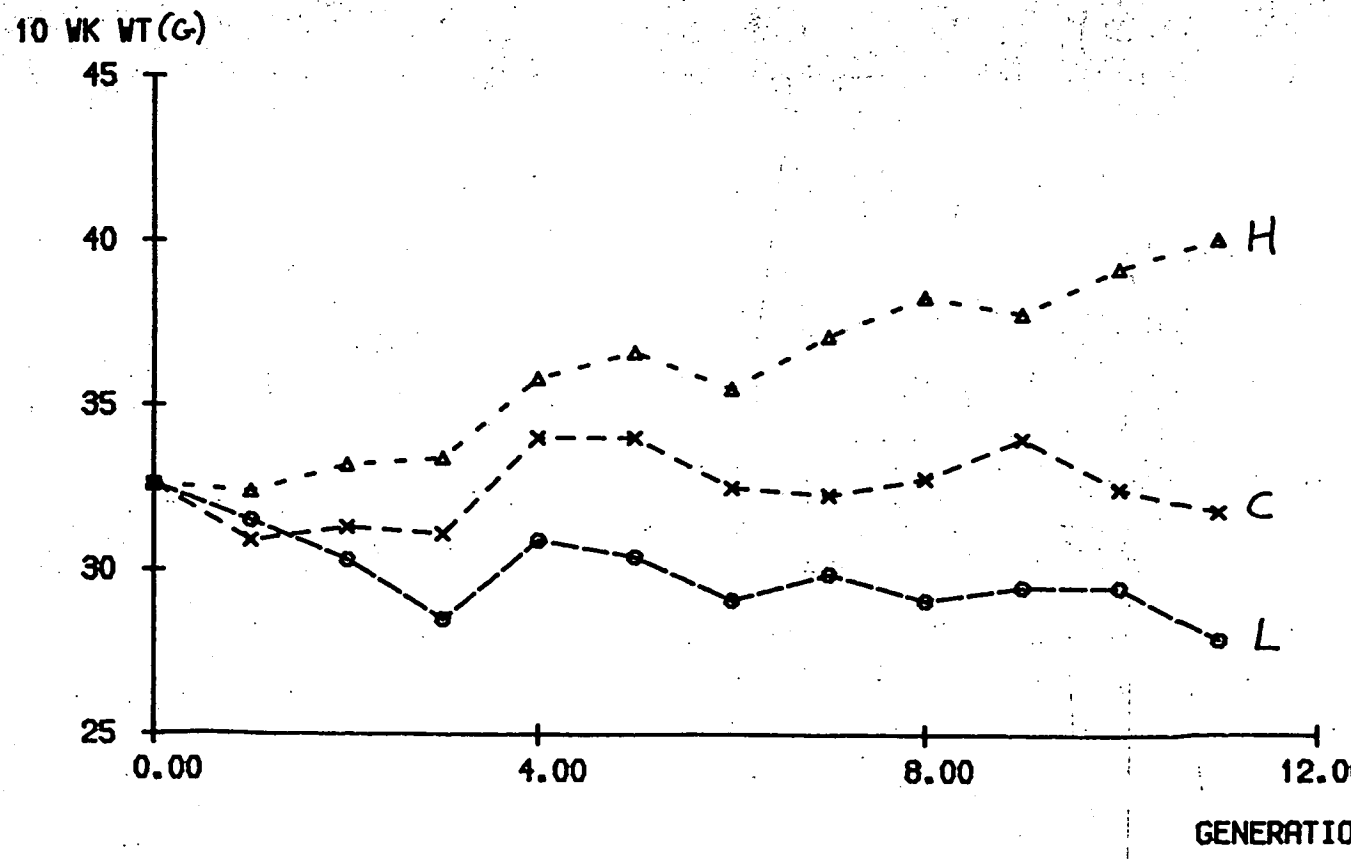


Figure 25

Taking the High-Low differences as proportions of the Control means gives figures of 35.2% and 38.4% for 6 and 10 week weight, respectively. As with the selected character, changes in body weight in the High and Low lines are asymmetrical with respect to the Control lines, the High lines showing larger changes than the Lows.

d. Growth Curves

In generation 9 the body weights of mice from all lines were measured at 4, 6 and 10 weeks of age. About thirty males from each replicate in the High and Low lines, and about fifteen males from each replicate in the Control lines were weighed. Furthermore, eight females from each replicate in all the lines were weighed at 4, 6, 10, 13 and 16 weeks. The mean 4, 6, 10, 13 and 16 week weights of females from each line (replicates pooled) are shown in Fig. 26. Fig. 27 shows the mean 4, 6 and 10 week weights of males from each line (replicates pooled). In both sexes, mice from the GA High and GP High lines are heaviest at all ages. Mice from the GP Low lines are lightest at all ages, except for males at 4 weeks old.

To analyse the changes in body weight in the different lines, body weight at certain ages was calculated as a percentage of that at later ages. This was done for 4 and 6 week weight, 6 and 10 week weight, and 4 and 10 week weight in both sexes, and for 10 and 16 week weight in females. Tables 7, 8 and 9 show the results of these calculations for females, males and the mean of the sexes, respectively.

If the ratio of weight at one age to weight at a later age is small, it means that a proportionately large amount of weight has

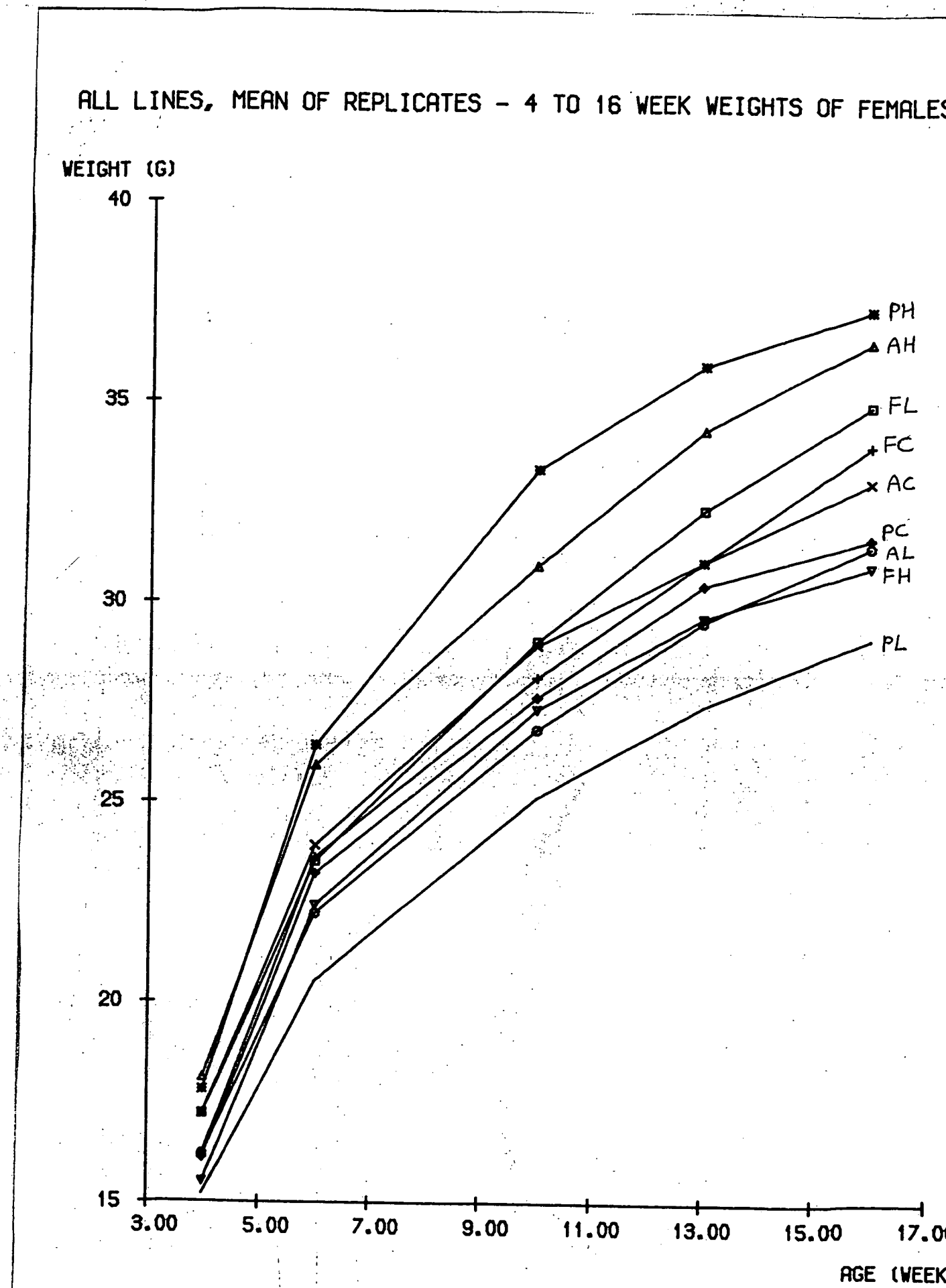

ALL LINES, MEAN OF REPLICATES - 4 TO 16 WEEK WEIGHTS OF FEMALES
WEIGHT (G)
40
35
30
25
20
15
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.0
AGE (WEEK
PH
AH
FL
FC
AC
PC
AL
FH
PL

Figure 26

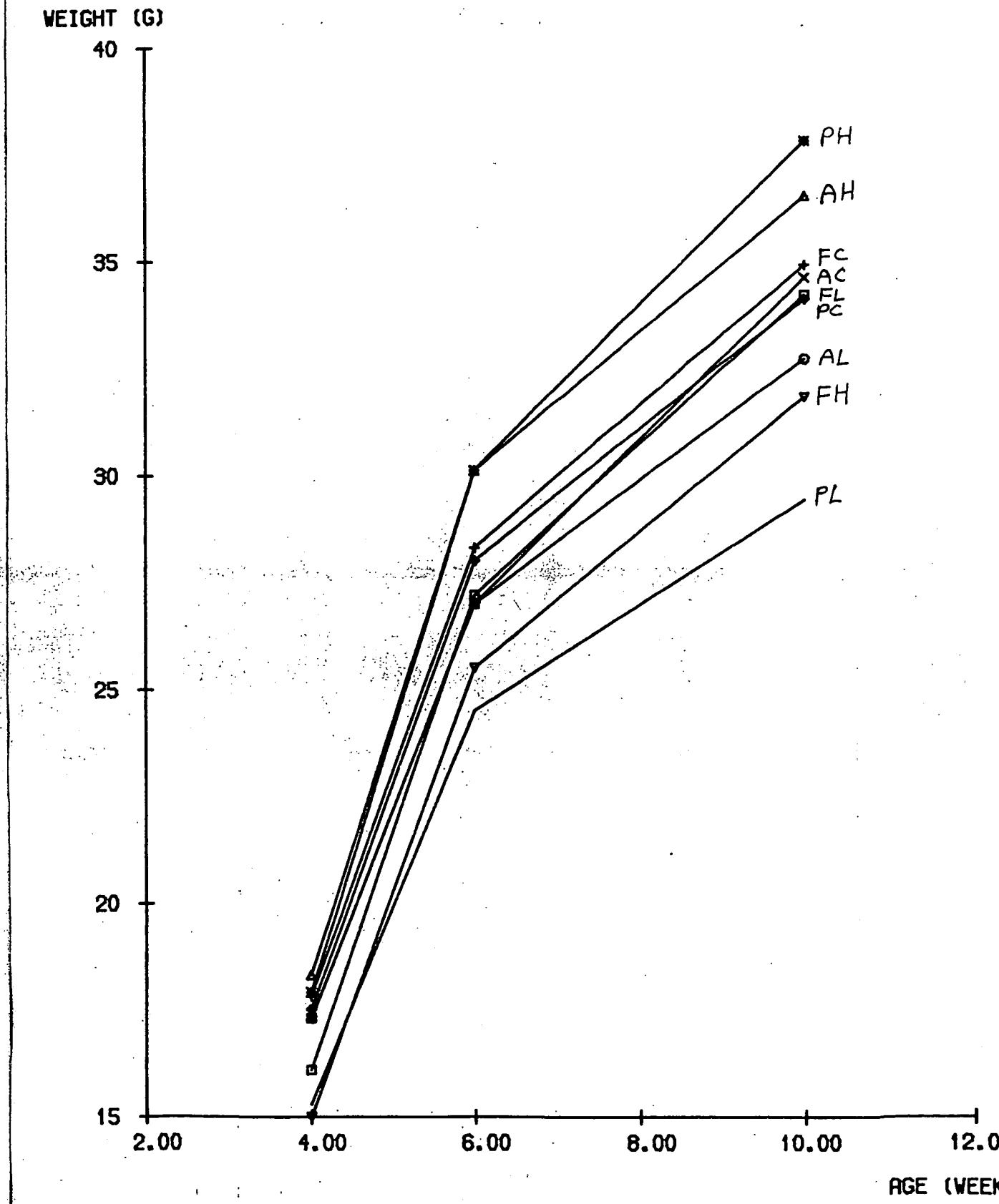

ALL LINES, MEAN OF REPLICATES - 4 TO 10 WEEK WEIGHTS OF MALES
WEIGHT (G)
40
35
30
25
20
15
2.00
4.00
6.00
8.00
10.00
12.0
AGE (WEEK
PH
AH
FC
AC
FL
PC
AL
FH
PL

Figure 27

Table 7. Ratios (x 100) of body weights at different ages in generation 9 - females.

Line	4/6 wk wt (%)	6/10 wk wt (%)	4/10 wk wt (%)	10/16 wk wt (%)
AH	69.1	83.8	58.2	84.7
AC	71.1	82.9	59.2	87.6
AL	72.3	83.3	61.8	85.4
FH	69.3	82.3	57.1	88.3
FC	68.8	84.5	58.2	82.9
FL	73.0	81.1	59.4	83.1
PH	67.1	79.6	53.7	89.3
PC	69.0	84.0	58.3	87.3
PL	73.7	81.8	60.0	86.3
SE*	0.68	0.30	0.65	0.25

*Standard errors calculated from between-replicate (within-line) mean squares (divided by $\sqrt{3}$ to obtain SE for mean of replicates).

Table 8. Ratios (x 100) of body weights at different ages in generation 9 - males

Line	4/6 wk wt (%)	6/10 wk wt (%)	4/10 wk wt (%)
AH	59.4	81.9	48.5
AC	63.4	81.1	51.7
AL	63.5	82.3	52.1
FH	57.7	80.0	47.1
FC	62.0	81.3	50.8
FL	58.7	79.2	47.6
PH	59.5	79.1	47.5
PC	62.6	82.1	51.5
PL	61.4	84.6	52.8
SE*	0.57	0.26	0.55

*Standard errors calculated from between-replicate (within-line) mean squares (divided by $\sqrt{3}$ to obtain SE for mean of replicates).

Table 9. Ratios (x 100) of weights at different ages in generation 9 - sexes pooled

Line	4/6 wk wt (%)	6/10 wk wt (%)	4/10 wk wt (%)
AH	64.2	82.8	53.4
AC	67.2	82.0	55.4
AL	67.9	82.8	57.0
FH	63.5	81.2	52.1
FC	65.4	82.9	54.5
FL	65.8	80.2	53.5
PH	63.3	79.4	50.6
PC	65.8	83.0	54.9
PL	67.6	83.2	56.4
SE*	0.55	0.27	0.54

*Standard errors calculated from between-replicate (within-line) mean squares (divided by $\sqrt{3}$ to obtain SE for mean of replicates).

been gained in this period. Therefore, by comparing the ratios, one can compare growth rate at different ages, and at the same age in different lines. Comparing the sexes, it can be seen that males gain proportionately more weight than females between 4 and 6 weeks, and between 4 and 10 weeks overall, but there is no consistent sex difference between 6 and 10 weeks. The proportionate amount of weight gained declines in both sexes with age, the decline being greater between the two earlier periods. Taking the sexes together and looking at the differences between lines, it seems that mice from the GP High, GF High and GA High lines have the greatest proportionate gain in weight between 4 and 6 weeks, and mice from the GA Low and GP Low lines have the least. The high proportionate weight gain in the GA and GP High line mice is due to the fact that they are the heaviest mice at 6 weeks, whereas the GF High line mice have a very low 4 week weight. From 6 to 10 weeks of age, the GP High and Low line mice have the highest and lowest proportionate weight gains, repectively.

Animals which reach a high proportion of their 10 week weight at 4 weeks of age can be thought of as fast-maturing. Therefore, the mice of the GA High lines have become slower-maturing, and the GA Low line mice have become faster-maturing, than the Controls. The GP Low line mice have become faster-maturing, and the GP High line mice have become slower-maturing, than the Controls. Looking at the GF lines, the High line mice seem to be slower-maturing than the Lows or Controls. This is due to the low 4 week weights of the High line mice.

e. Conclusions.

Selection for 4 to 6 week food intake, adjusted for 4 week weight, has resulted in little change in 4 week weight, but in fairly large differences in 6 week weight, between the High and Low selected lines. The High lines show an increase in 4 to 6 week gain and gross efficiency, and the Low lines show a decrease in these characters, with respect to the Controls. The changes in 6 week weight and 4 to 6 week gain are consistent with the results of previous experiments. When Sutherland (1970) selected mice for increased food intake, the mice showed an increase in weight gain. Sutherland did not, however, observe any change in efficiency in the mice selected for increased food intake. It is likely that if the lines in this experiment had been selected for food intake without adjusting for 4 week weight, the High lines would have increased in 4 week weight, as 4 week weight and 4 to 6 week food intake are highly correlated, as mentioned previously. An increase in 4 week weight would mean that a higher proportion of food intake would be required for maintenance at the beginning of the test period. An increase in food intake for maintenance at the start of test would counteract an increase in weight gain, so gross efficiency might not change. In the selected lines in this experiment 4 week weight was not greatly changed as a result of selection, so expected maintenance requirements at the start of the test were about the same in all lines.

Selection for increased fatness (i.e. a decrease in percentage lean) has resulted in little change in body weights at 6 and 10 weeks of age. Selection for decreased fatness (i.e. an increase in percentage lean) has resulted in a small decrease in body weights at

6 and 10 weeks. If mice are selected for an increase in fatness, there are at least two expectations as to the effect on body weight. We may select mice which eat a large amount of food at an early age, grow fast and then lay down their excess food intake as fat when growth slows down. Alternatively, one might select mice which partition a large proportion of their food intake into stored fat, rather than lean. Such mice will be inefficient, because it is more energetically efficient to lay down lean than fat, and will therefore grow slowly. The small changes in body weight observed in the selected lines do not seem to lend support to either of these simple models, one of which predicts an increase, the other a decrease, in body weight in mice selected for increased fatness. The true picture is undoubtedly much more complicated, with many physiological changes involved in the observed changes in body composition.

Selection for the index (body weight - 8 x gonadal fat pad weight) has resulted in large differences in 6 and 10 week weight between the High and Low selected lines. This is not surprising, as it would be expected that the index would be highly correlated with 10 week weight, and that 6 and 10 week weight are also correlated.

Looking at the growth curves of the lines from 4 to 10 weeks, it seems that the effect of selection in the GA lines has been to change 4 to 6 week growth rate, but not 6 to 10 week growth rate. So the High line mice initially grow faster and the Low line mice slower, than the Controls, but there is no difference in their growth rates after 6 weeks of age. In the GP lines, selection has affected growth rates from 4 to 6 weeks and from 6 to 10 weeks. The High line mice grow faster and the Low line mice grow more slowly

than the Controls in both periods. The differences between the GA and GP lines reflect the age at which selection was carried out - from 4 to 6 weeks in the GA lines and at 10 weeks in the GP lines. The GF lines present a complicated picture. The High line mice grow faster than the Low or Control line mice from 4 to 6 weeks, and the Low line mice grow fastest between 6 and 10 weeks of age. The fast early growth rate of the High line mice reflects the low mean 4 week weight of these mice, which is probably due to poorer maternal performance in these lines.

2. Maternal Performance

a. Litter Size

Figs. 28a, 29 and 30 show the mean litter sizes of the GA, GF and GP lines, respectively. In each case, the mean of the replicates is shown. Litter size in each generation is taken as the mean size of the litters born in that generation, i.e. the mean litter size produced by females from the previous generation. The mean litter sizes of the lines in each of the GA replicates are shown in Figs. 28b-d.

All the lines show a decline in litter size between generations 0 and 4. A decrease in litter size between generations 0 and 1 was expected, as the parents of generation 0 were the products of a three-way cross and had maximum heterosis for litter size. Further breeding led to a reduction in heterosis and therefore in litter size. Further decreases in litter size seem to be a consequence of a decline in the health of the mice. Terramycin was administered to the mothers of generations 4 and 9, and their offspring had, on

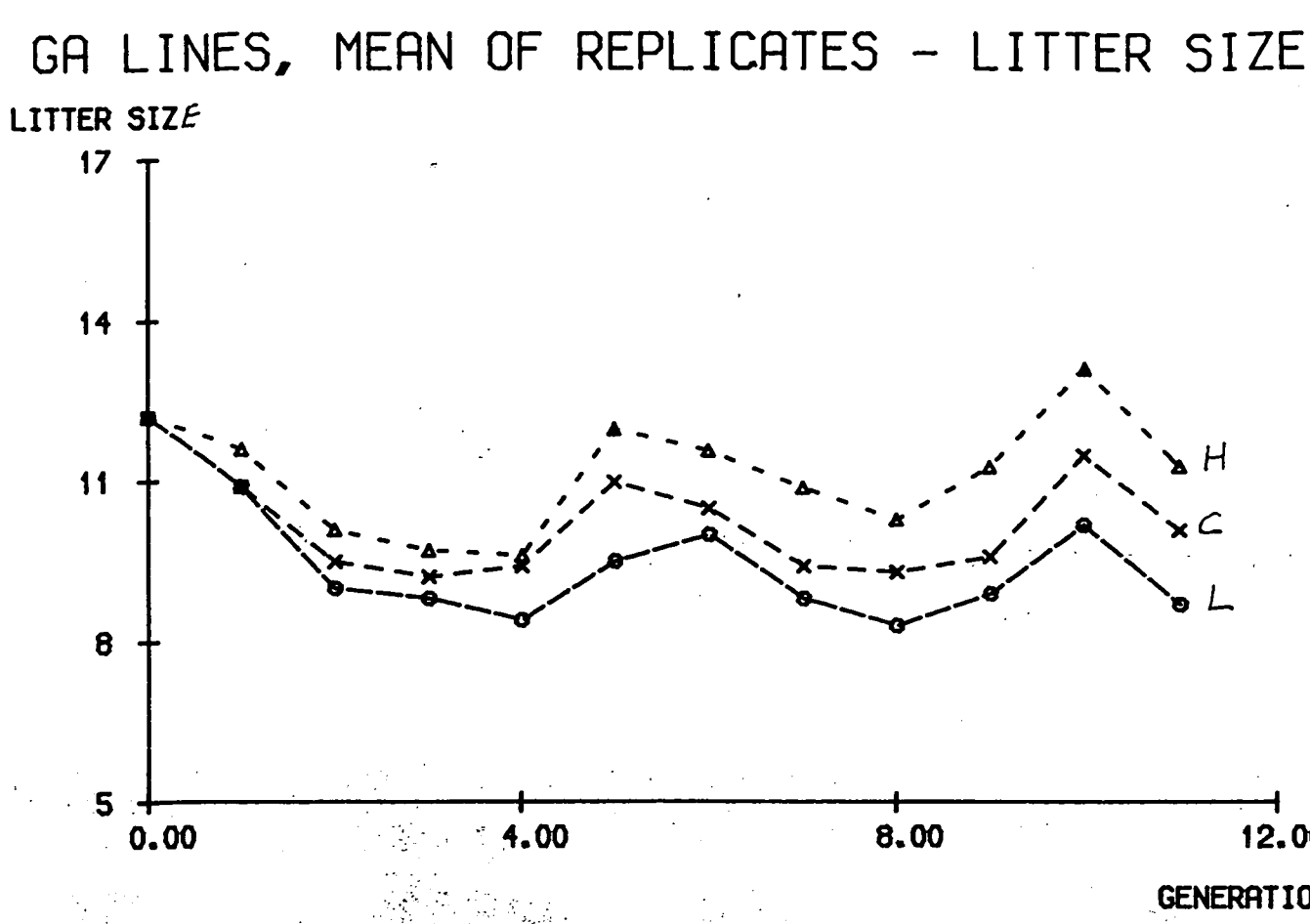


Figure28A

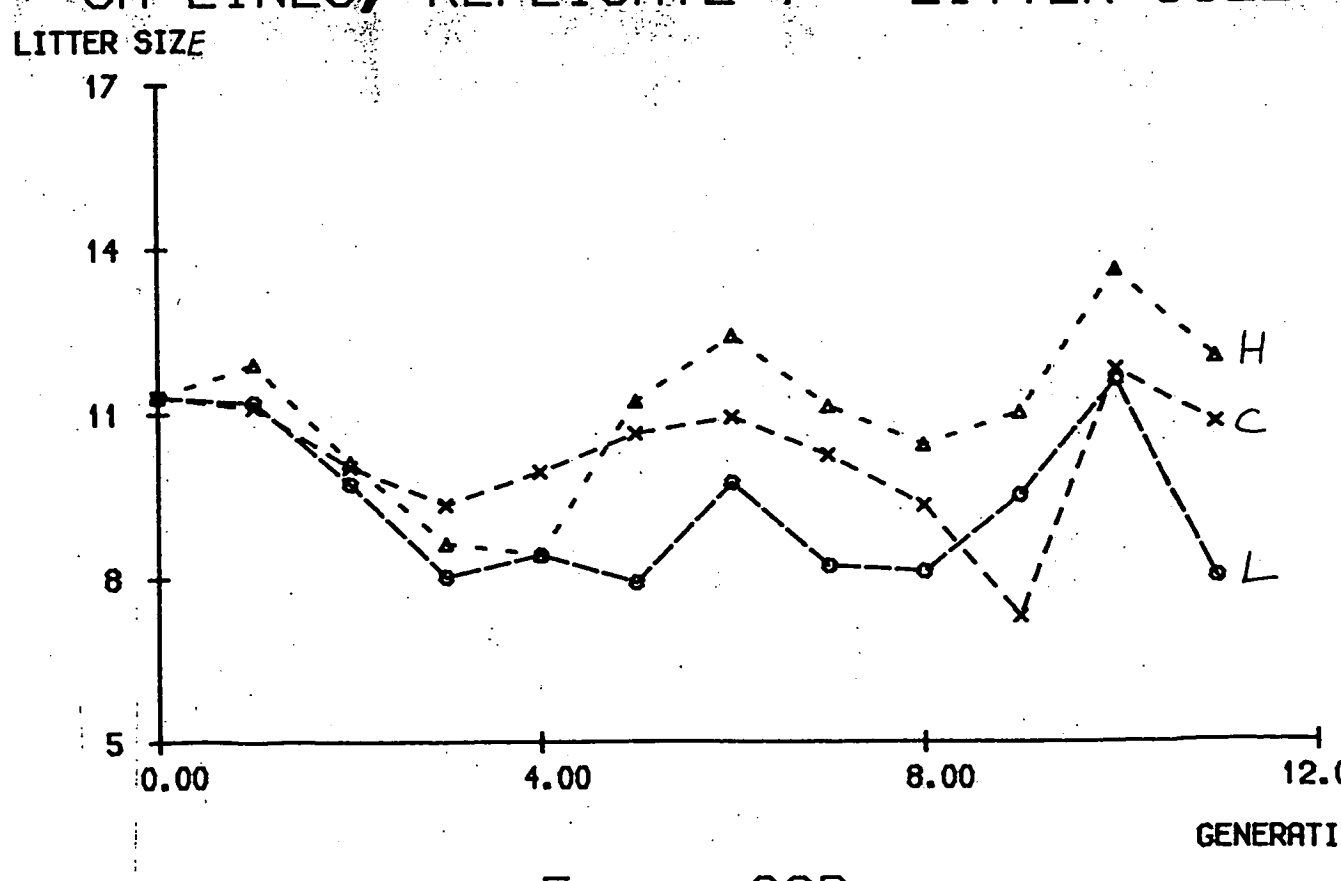


Figure28B

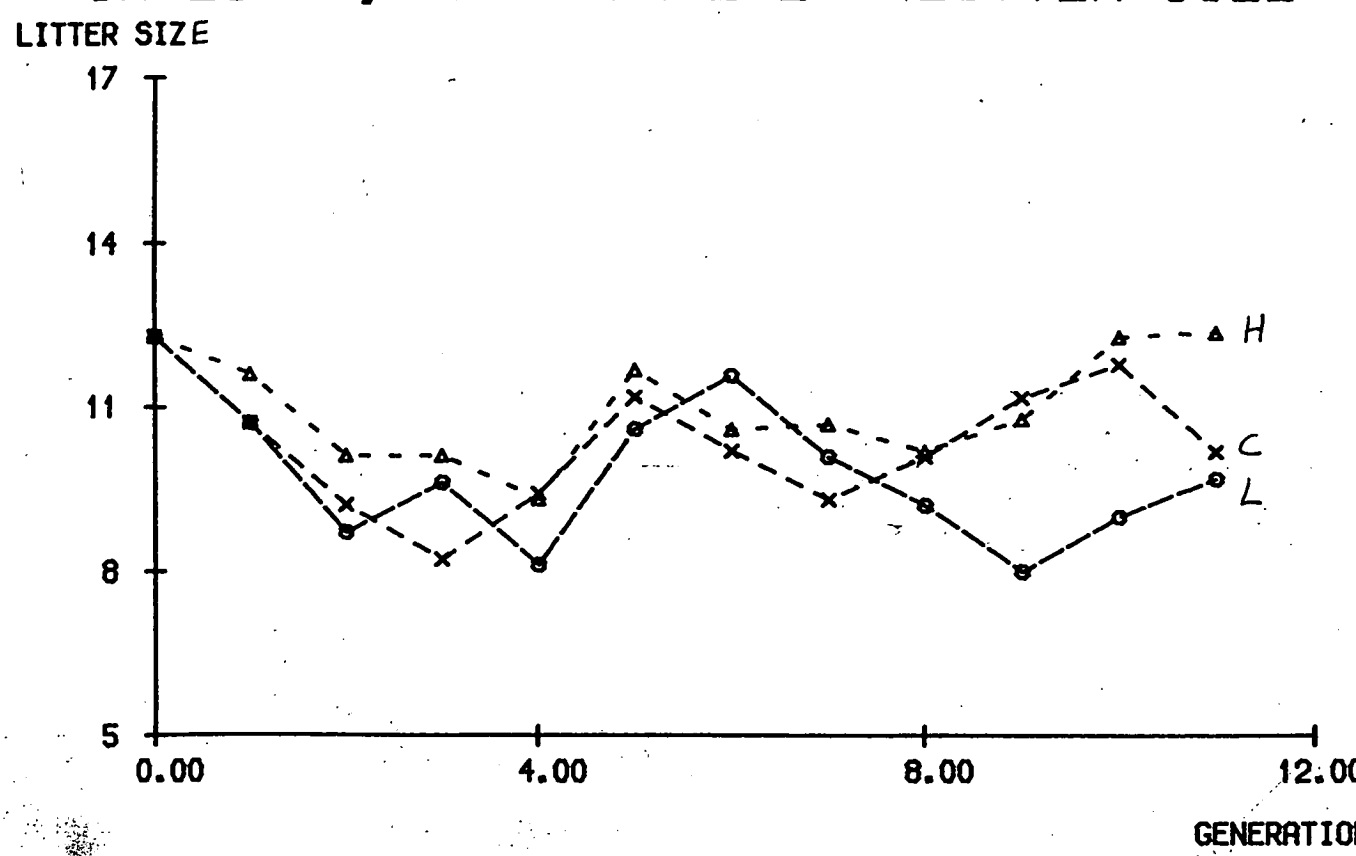


Figure28C

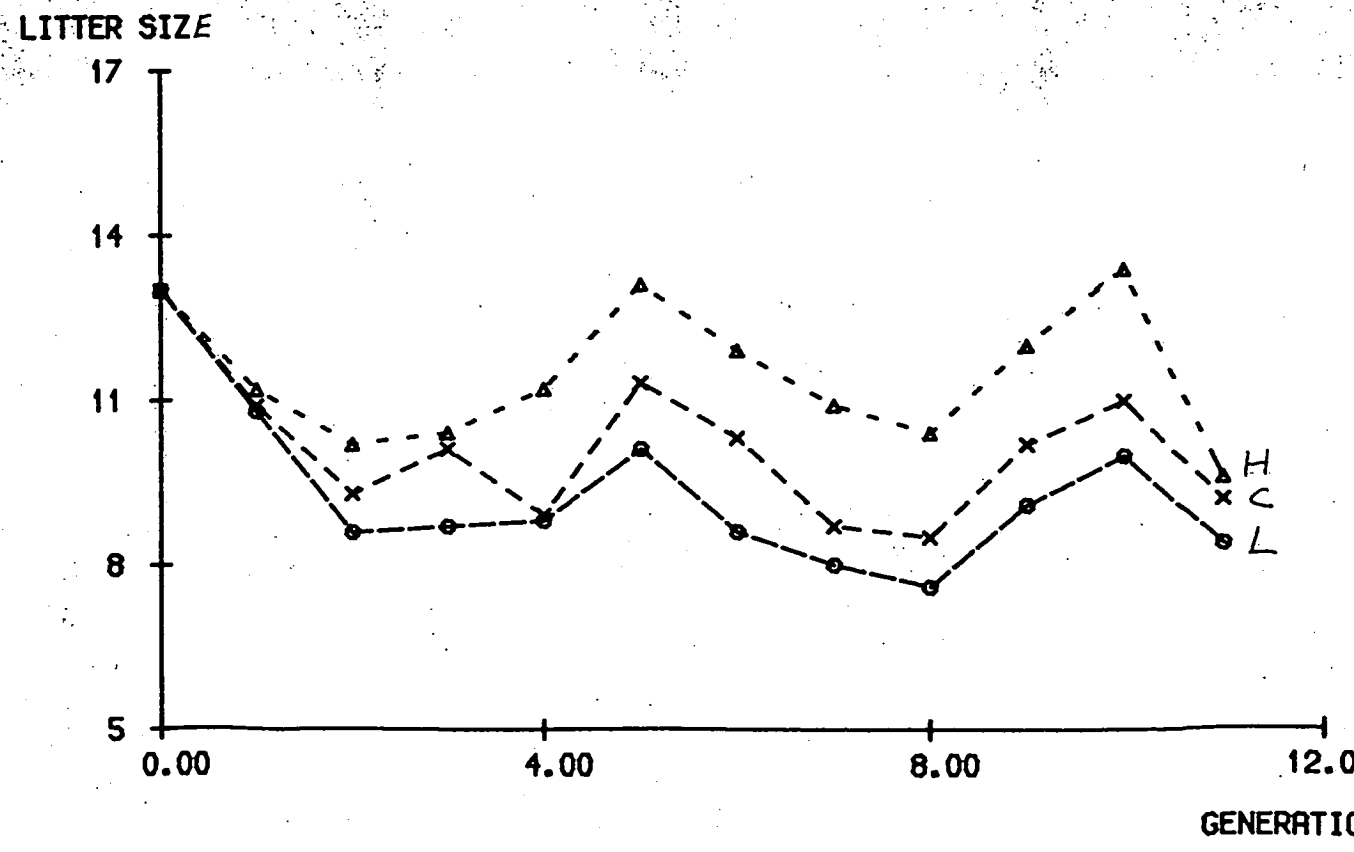


Figure28D

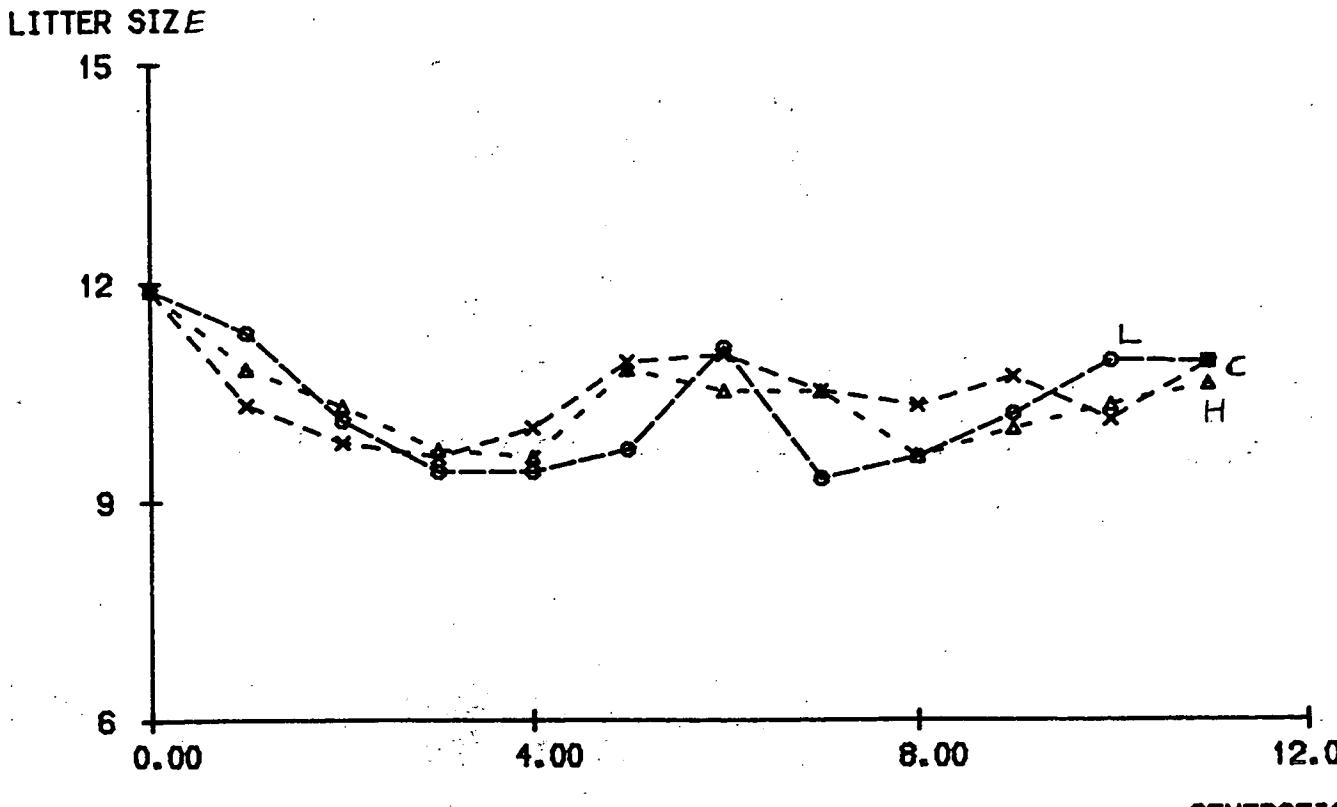


Figure 29

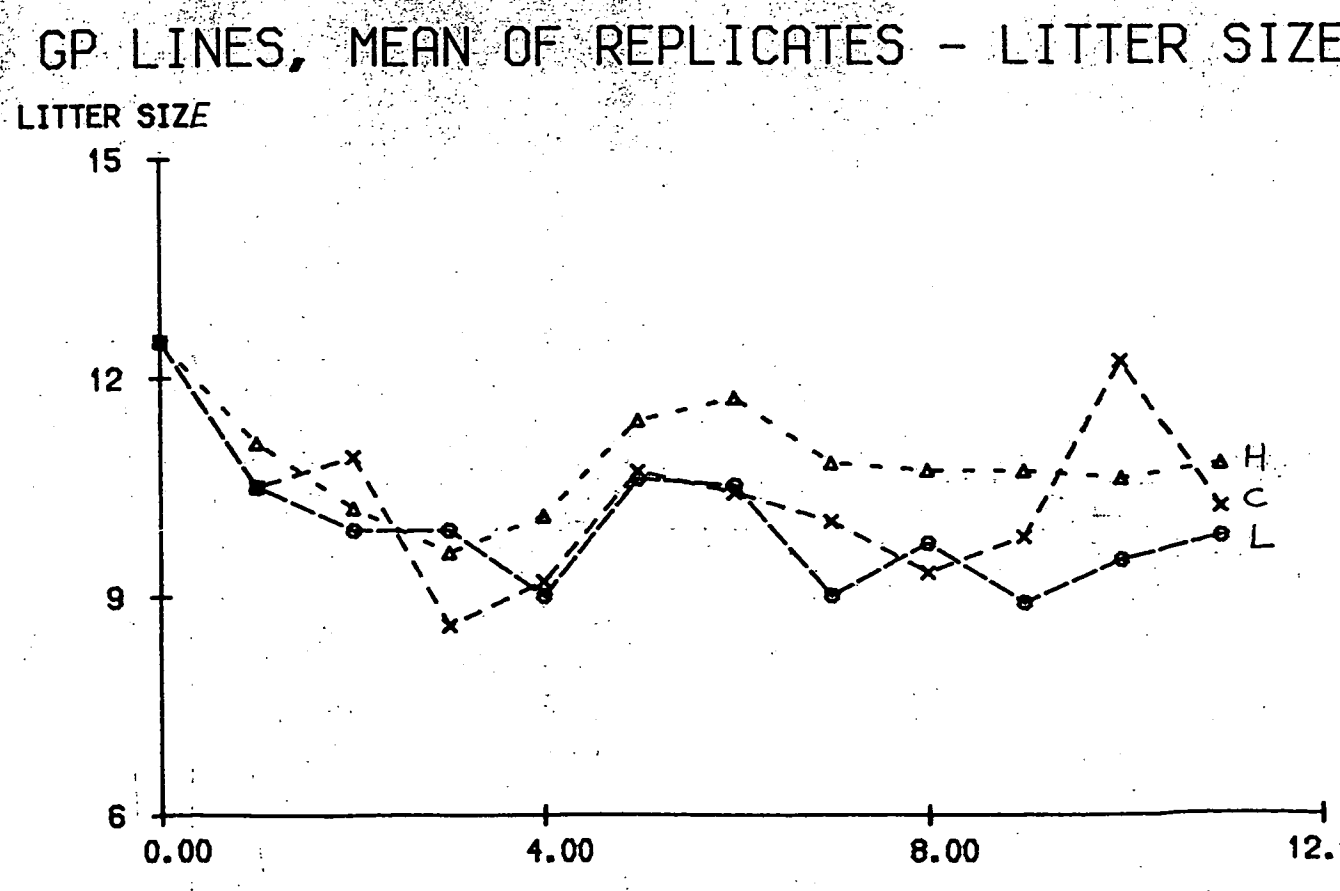


Figure 30

average, larger litters than the previous generations. Inbreeding coefficients at generation 11 ranged from 11.0% to 15.3%, with a mean of 12.7%. Falconer (1970) found a mean reduction of 0.5 pups per litter for each 10% increase in the inbreeding coefficient when selecting for 6 week weight, and Bowman and Falconer (1960) found a mean reduction of 0.58 pups per litter for every 10% increase in the inbreeding coefficient when a strain was rapidly inbred. It might be expected, therefore, that the levels of inbreeding in the lines in this experiment would cause a reduction in litter size of between 0.6 and 0.9 of a pup, but inbreeding alone can not account for the observed reduction in litter size in the lines.

One striking feature of the changes in litter size is the large and constant difference between the GA High, Low and Control lines. In generation 11, the High-Low difference is 2.6, which is 25.7% of the Control line mean. Are differences in the body weights of the mothers responsible for the litter size differences? In generation 10, the High- Low difference in female 6 week weight in the GA lines was 15.0% as a percentage of the Control line mean. However, in the GP lines, the High-Low difference in female 6 week weight was 28.5%, almost twice the difference found in the GA lines. Furthermore, in generation 9, the High-Low differences in female 10 week weight were 14.2% in the GA lines and 29.7% in the GP lines, so there are much larger differences in 10 week weight in the GP lines. But in the GP lines, the High-Low difference in litter size was only 1.0, or 9.8%. So changes in body weight cannot be entirely responsible for the observed changes in litter size in the GA lines. It is possible that the increased food intake of the GA High line mice leads to a higher ovulation rate, and the decreased food intake of the Low line

mice leads to a reduced ovulation rate. Preliminary studies by Mr.F.Brien indicate that differences in ovulation rate are primarily responsible for the observed differences in litter size.

No consistent differences in litter size are apparent between the GF lines.

b. Number Weaned and Weaning Rate

Figs. 31, 32 and 33 show the mean number of mice weaned per litter in the GA, GF and GP lines, respectively. In each case the mean of the replicates is shown. Figs. 34, 35 and 36 show the overall weaning rate in the GA, GF and GP lines, respectively. The weaning rate of each line was calculated as the total number of mice weaned, divided by the total number of mice left with the mothers (after adjusting litter size down to 12 when more than this number were born) in the three replicates.

The line differences in the number of mice weaned tend to parallel those in litter size, although the differences are smaller, because of the adjustment of large litters down to 12 pups. Fewer mice were weaned in each line than are born, partly because of the adjustment, and partly because of pre-weaning deaths.

There are no striking differences between the lines in weaning rate, although there appears to be a higher weaning rate in the GA Low lines than in the GA High lines, suggesting that preweaning mortality is higher in larger litters. In the GP lines, the weaning rate is generally higher in the High lines than in the Lows, suggesting that the larger High line mothers are better able to feed their offspring than are the Low line mothers, although the Control lines have the highest weaning rate of all. There are no consistent

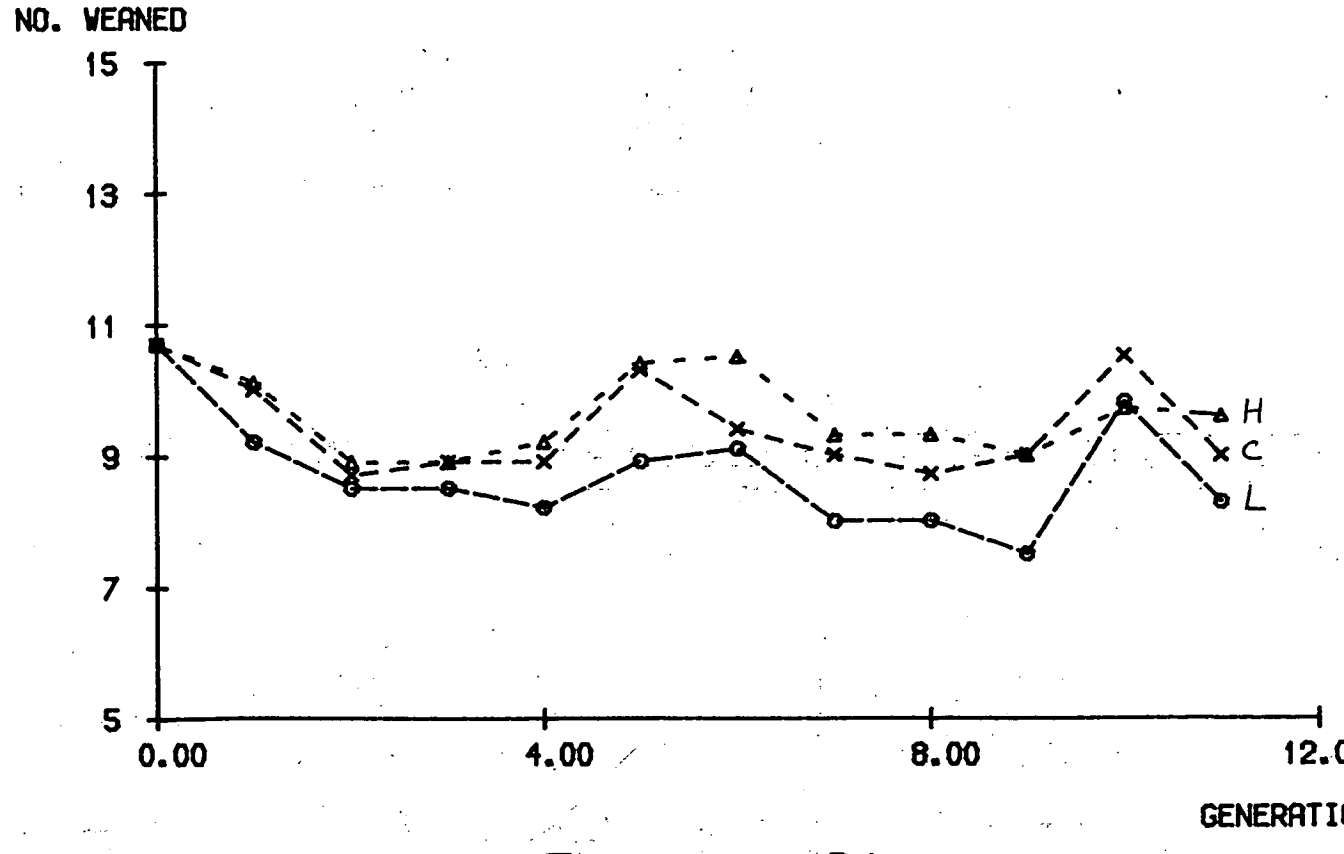


Figure 31

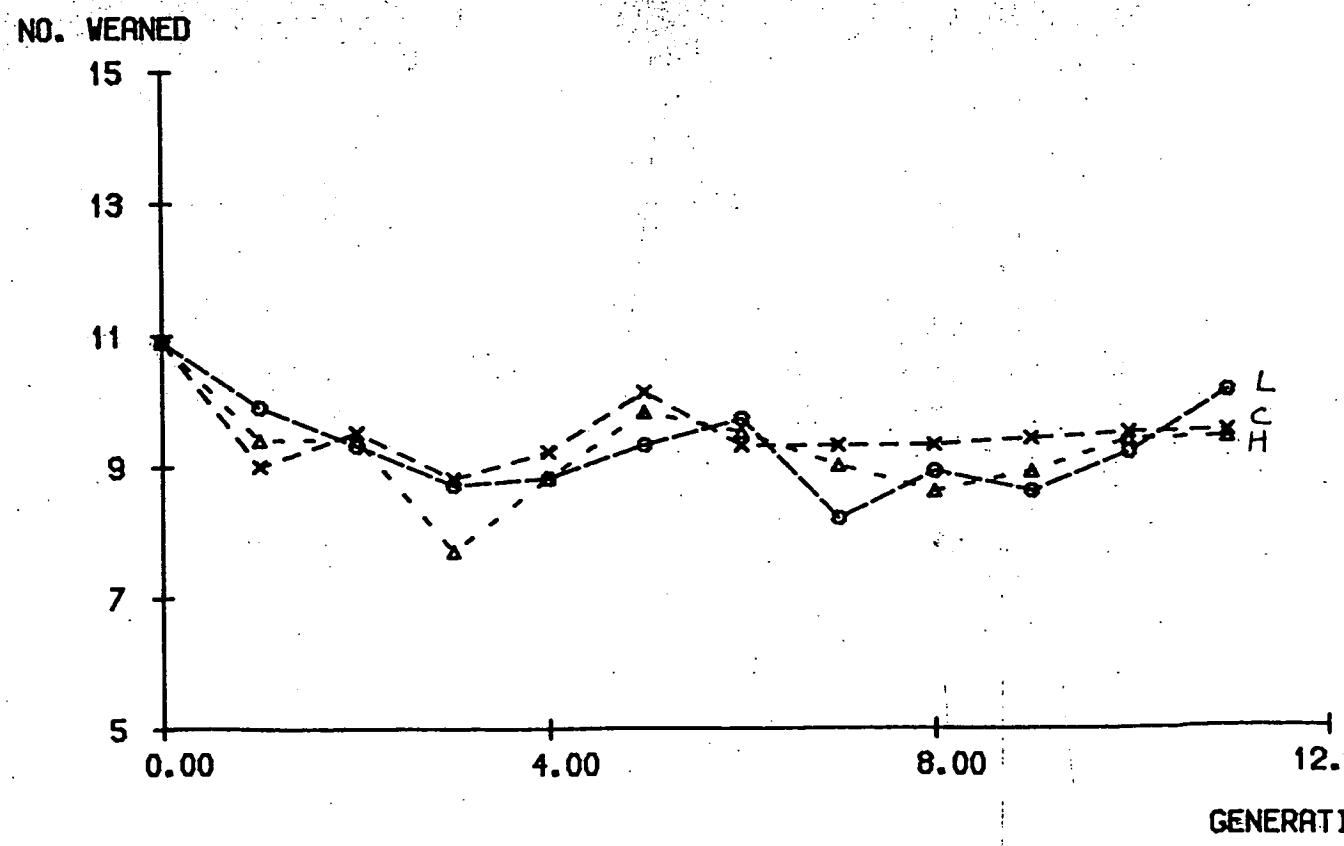


Figure 32

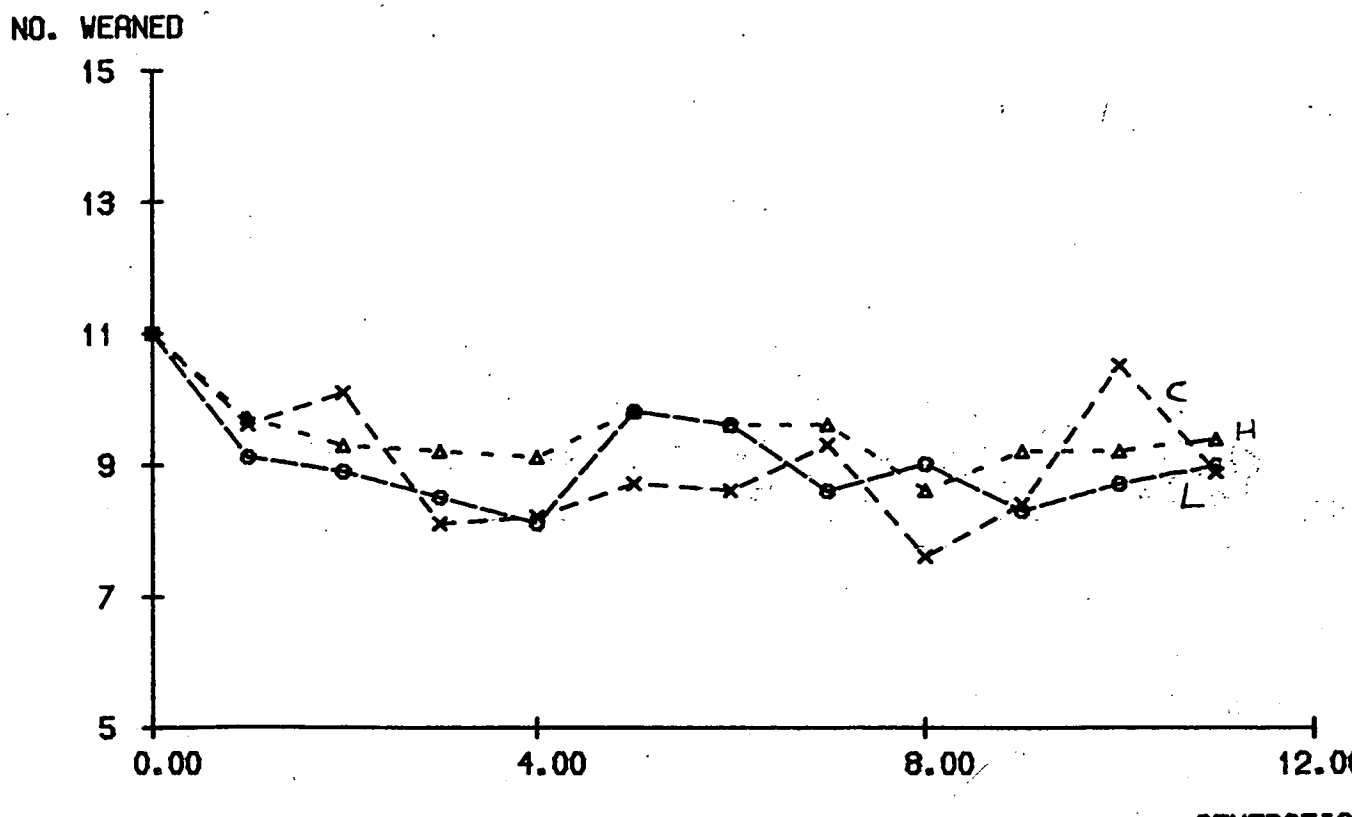


Figure 33

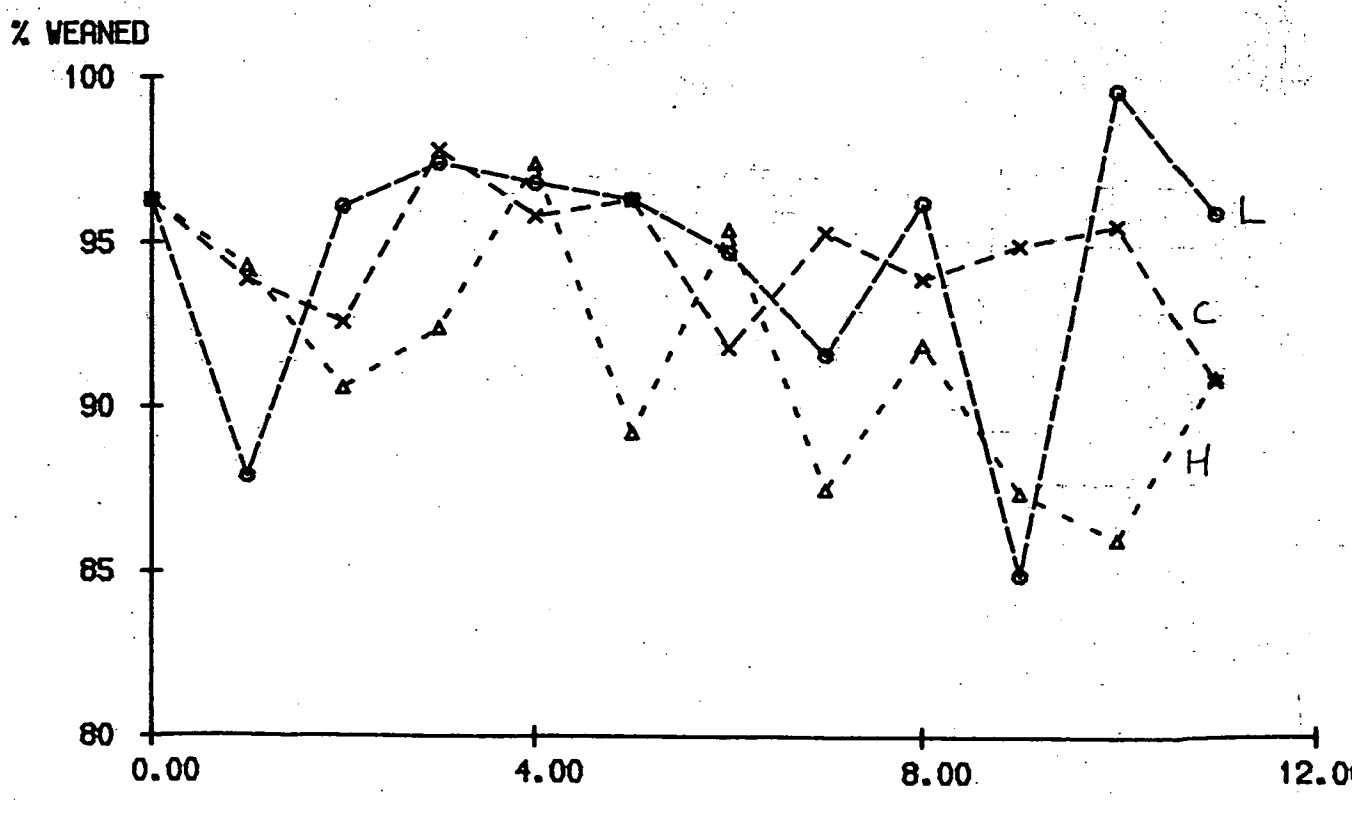


Figure 34

GF LINES, REPLICATES POOLED - WEANING RATE (%)

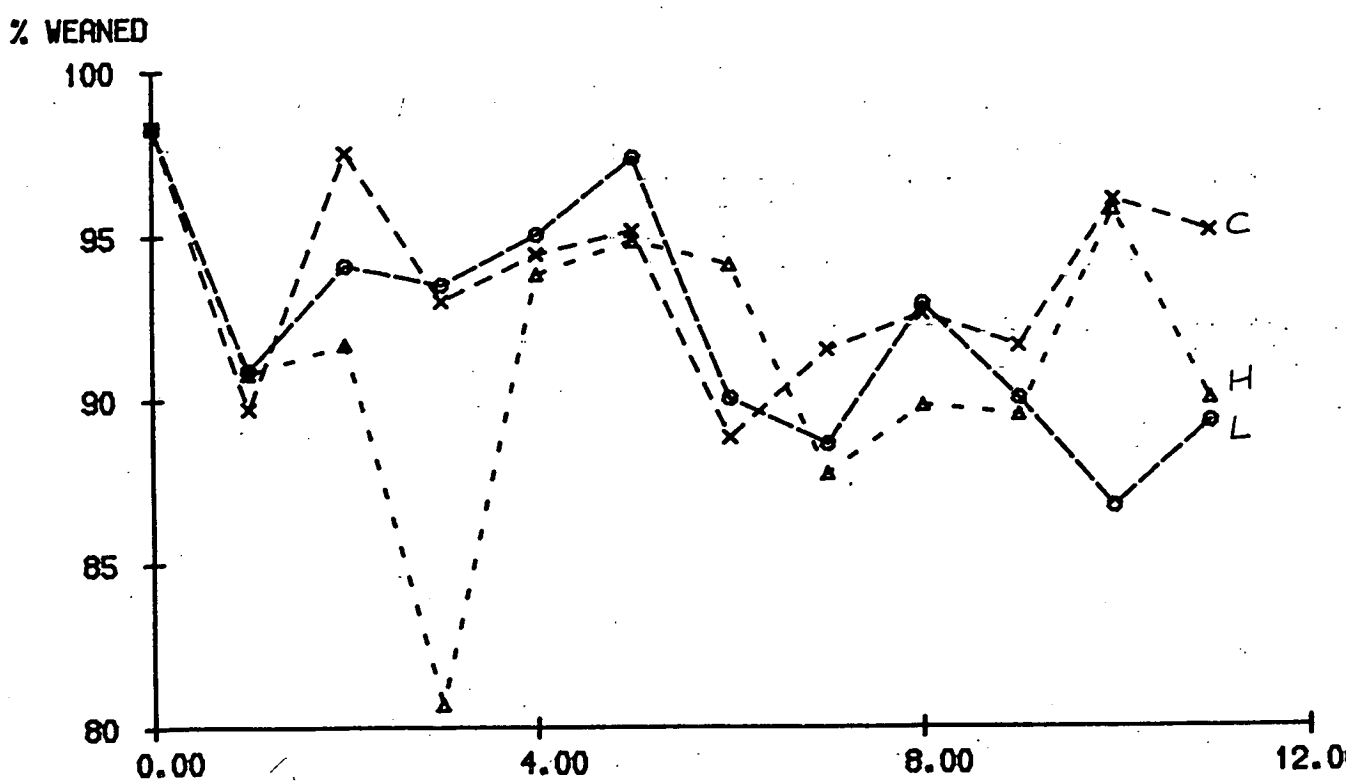


Figure 35

GP LINES, REPLICATES POOLED - WEANING RATE (%)

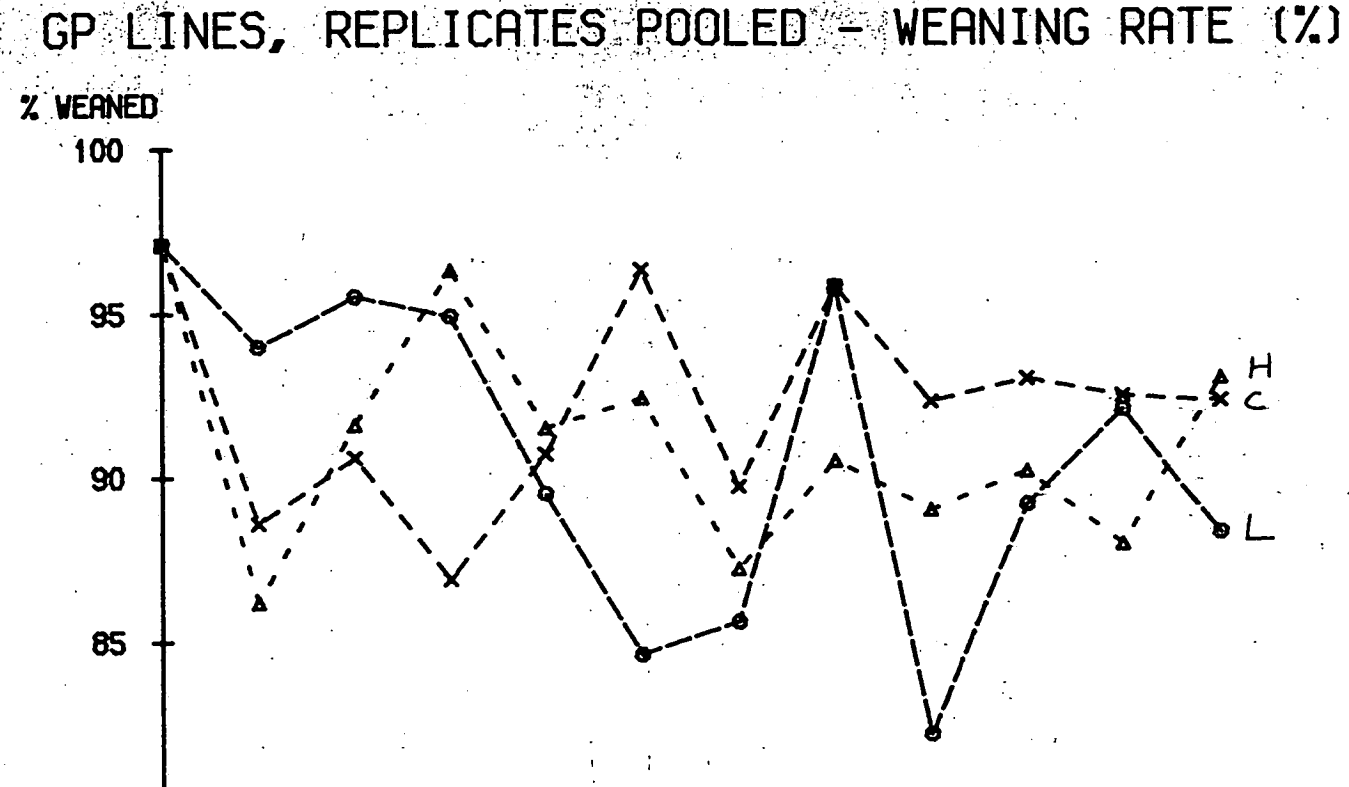


Figure 36

differences in weaning rate between the GF lines.

Infertile matings did not present a major problem in the maintenance of the lines. The percentage of infertile matings in each line from generation 8 to 11 is given in Table 10. There is no indication that any selected line is less fertile than its Controls, so it seems that none of the selection treatments has decreased fertility.

c. Conclusions

Litter size has decreased gradually throughout the course of the experiment, although it was increased in generations 5 and 10 by giving Terramycin to the mothers of generations 4 and 9. Although a reduction in heterosis was probably responsible for the decrease in litter size between generations 0 and 1, further decreases seem to be a result of a general decline in the health of the mice in all lines. At generation 11, coefficients of inbreeding in the lines averaged only 12.7%, so inbreeding depression is unlikely to have been a major factor in reducing litter size.

The large High-Low differences in litter size in the GA lines are surprising, especially as the direct responses to selection were not very large. It is known that differences in body weight can cause differences in ovulation rate and therefore in litter size (Land, 1970), but the GA High-Low differences in female 6 week weight are not that large. The GP lines have much greater High-Low differences in body weight, but fairly small differences in litter size. It is possible that the changes in food intake in the GA lines are responsible for changing ovulation rate in the selected mice, but without detailed hormone assays being carried out, it would be

Table 10. All lines - percentage of infertile matings in generations 8-11

	Selection Treatment		
Line	GA	GF	GP
High	1.7	7.5	3.3
Control	0.8	7.5	5.0
Low	1.7	5.0	6.7

impossible to identify the underlying causes of such changes.

Changes in the number of mice weaned per litter parallel those in litter size, although line differences are smaller. There are no consistent differences between lines in weaning rate.

3. Carcass Composition

In generation 7, two batches of eight 10 week old males from each line underwent a chemical analysis of carcass composition. Tables 11-14 show the mean percentages and weights of each carcass component for the GA, GF and GP lines.

The carcass composition of the GA lines has remained relatively constant, with the exception of percentage fat which is slightly higher in the Low and Control lines than in the High lines. The average weights of fat and protein have increased in the High lines and decreased in the Low lines, as might be expected from the changes in 10 week body weight. Total energy content has decreased in the Low lines and increased in the High lines, with respect to the Controls.

In the GF lines, there are large differences in percentage fat and in total fat between the High and Low lines. Differences in per cent protein are small; the Low lines have decreased, but the High lines show little increase, with respect to the Controls. The seeming lack of difference between the Highs and Controls is mainly because of the apparently high per cent protein in replicate 2 of the Controls. However, the small differences observed in per cent protein represent larger differences in per cent lean tissue, as protein is laid down with 4-5 times its own weight of water. Per

Table 11. GA Lines - carcass composition of 10 week old males from generation 7

Line	%H2O	%Ash	%Fat	%Pro	Body wt(g)	Fat wt (g)	Pro wt (g)	Energy (kcal)
GAH1	66.7	3.26	10.4	19.6	34.8	3.62	6.84	73.0
GAH2	67.4	3.29	9.6	19.7	34.0	3.27	6.68	68.8
GAH3	65.8	3.25	11.6	19.3	33.9	3.94	6.56	74.5
Mean	66.7	3.27	10.5	19.5	34.2	3.61	6.67	72.0
GAC1	66.4	3.48	10.4	19.7	30.0	3.12	5.91	63.0
GAC2	65.2	3.42	11.0	20.3	31.1	3.43	6.32	68.3
GAC3	63.3	3.47	13.4	19.8	32.4	4.35	6.41	77.5
Mean	65.0	3.46	11.7	19.9	31.2	3.63	6.21	69.6
GAL1	66.0	3.47	11.7	18.9	30.2	3.52	5.70	65.6
GAL2	66.6	3.35	11.0	19.0	30.5	3.37	5.80	64.8
GAL3	64.9	3.44	11.7	19.9	29.8	3.50	5.92	66.7
Mean	65.8	3.42	11.5	19.3	30.2	3.46	5.81	65.7

Table 12. GF Lines - carcass composition of 10 week old males from generation 7

Line	%H2O	%Ash	%Fat	%Pro	Body wt (g)	Fat wt (g)	Pro wt(g)	Energy (kcal)
GFH1	66.9	3.63	9.6	19.9	28.2	2.72	5.61	57.5
GFH2	67.5	3.40	9.3	19.8	30.8	2.87	6.08	61.6
GFH3	67.9	3.35	9.4	19.3	27.6	2.61	5.34	55.0
Mean	67.4	3.46	9.5	19.6	28.9	2.73	5.67	58.0
GFC1	65.2	3.56	11.7	19.6	28.4	3.32	5.56	63.0
GFC2	65.0	3.33	11.5	20.2	32.6	3.74	6.56	72.6
GFC3	65.4	3.45	12.0	19.1	30.5	3.65	5.84	67.7
Mean	65.2	3.44	11.7	19.6	30.5	3.57	5.98	67.7
GFL1	63.8	3.23	13.8	19.2	29.0	4.00	5.58	69.5
GFL2	64.3	3.41	13.4	18.9	32.8	4.38	6.20	76.6
GFL3	63.4	3.29	14.0	19.3	29.0	4.07	5.61	70.4
Mean	63.8	3.29	13.7	19.2	30.3	4.15	5.80	72.2

Table 13. GP Lines - carcass composition of 10 week old males from generation 7

Line	%H2O	%Ash	%Fat	%Pro	Body wt (g)	Fat wt (g)	Pro wt (g)	Energy (kcal)
GPH1	65.2	3.50	11.4	19.9	34.6	3.95	6.89	76.5
GPH2	66.0	3.69	11.2	19.1	34.4	3.85	6.56	73.6
GPH3	64.7	3.55	12.2	19.6	35.4	4.32	6.91	80.1
Mean	65.3	3.58	11.6	19.5	34.8	4.04	6.79	76.7
GPC1	65.5	3.51	11.0	20.2	28.2	3.11	5.68	61.6
GPC2	65.6	3.45	11.5	19.5	29.4	3.40	5.73	64.7
GPC3	63.7	3.63	11.9	20.8	30.6	3.65	6.34	70.5
Mean	64.9	3.53	11.5	20.1	29.4	3.39	5.92	65.7
GPL1	63.3	3.74	13.3	19.7	28.9	3.85	5.69	68.7
GPL2	65.5	3.52	12.2	18.7	26.6	3.25	4.98	59.0
GPL3	63.5	3.49	12.9	20.1	29.1	3.77	5.84	68.8
Mean	64.0	3.58	12.8	19.5	28.2	3.62	5.50	65.5

Table 14. Mean of lines - carcass composition of 10 week old males from generation 7

Line	%H2O	%Ash	%Fat	%Pro	Body wt (g)	Fat wt (g)	Pro wt (g)	Energy (kcal)
GAH	66.7	3.27	10.5	19.5	34.2	3.61	6.67	72.0
GAC	65.0	3.46	11.7	19.9	31.2	3.63	6.21	69.6
GAL	65.8	3.42	11.5	19.3	30.2	3.46	5.81	65.7
GFH	66.9	3.46	9.5	19.6	28.9	2.73	5.67	58.0
GFC	65.2	3.44	11.7	19.6	30.5	3.57	5.98	67.7
GFL	63.8	3.29	13.7	19.2	30.3	4.15	5.80	72.2
GPH	65.3	3.58	11.6	19.5	34.8	4.04	6.79	76.7
GPC	64.9	3.53	11.5	20.1	29.4	3.39	5.92	65.7
GPL	64.0	3.58	12.8	19.5	28.2	3.62	5.50	65.5

cent water has changed in the opposite direction to per cent fat. There are no great differences in body weight or protein weight between the lines. The average energy content is higher in the Low lines and lower in the High lines, than in the Controls, because of the changes in per cent fat.

There have been large increases in body weight and protein weight in the GP High lines. The Low lines show a decrease in these characters. The Low lines have a higher percentage of fat than the Controls, but the High lines have not changed in this respect. Total energy content is higher in the High lines and lower in the Low lines than in the Controls, as would be expected from the differences in body weight.

To test whether differences between lines and replicates were significant, an analysis of variance was carried out for each selection treatment group. To provide more degrees of freedom for significance tests, between-line mean squares were tested against pooled between-replicate (within-line) mean squares, and between-replicate (within-line) mean squares were tested against pooled within-replicate mean squares. Table 15 shows the mean squares and which line or replicate differences are significant.

In the GA lines, significant line differences were found in body weight and protein weight. There were no significant differences between replicates for any character.

There were significant line differences in per cent fat, per cent water and fat weight in the GF lines. There were significant differences between replicates in body weight.

In the GP lines, there were significant line differences in body weight and protein weight. There were no significant differences

Table 15. Carcass composition - mean squares and significance of differences between lines

Selection Treatment		%H2O	%Ash	%Fat	%Pro	Body wt	Fat wt	Pro wt
GA	Bet.Lines	4.18	0.066	2.00	0.70	27.3**	0.05	1.17*
	Bet.Reps	2.50	0.005	2.44	0.28	1.19	0.35	0.07
	Error	0.53	0.056	0.60	0.41	2.52	0.15	0.13
GF	Bet.Lines	19.5**	0.057	27.1**	0.46	4.56	3.04**	0.15
	Bet.Reps	0.32	0.030	0.14	0.26	7.84**	0.07	0.35
	Error	0.75	0.022	1.12	0.61	1.79	0.14	0.09
GP	Bet.Lines	2.19	0.007	3.26	0.72	73.2**	0.66	2.57**
	Bet.Reps	2.00	0.027	0.55	0.70	2.35	0.16	0.25
	Error	2.26	0.043	1.44	0.70	1.36	0.15	0.14

* $P<0.05$

** $P<0.01$

otherwise $P>0.05$

Between-lines mean squares tested against pooled between-replicate (within-line) mean squares. Between-replicate (within-line) mean squares tested against pooled within-replicate mean squares.

between replicates for any character.

Conclusions

The GA lines have significant differences in body weight and protein weight. The differences in protein weight reflect the increase in body weight in the High lines and the decrease in the Low lines. The High lines have a lower per cent fat than the Low or Control lines, although this difference is not significant because of the large variation among the replicates of each line. It might have been expected that the High lines would be fatter than the Controls - Sutherland et al (1970) found an increase in per cent fat in mice selected for increased 4 to 11 week food intake. However, in this experiment, the mice were selected for 4 to 6 week food intake, adjusted for 4 week weight, which seems to have a different effect on body composition.

Significant differences in per cent fat and total fat are found between the GF lines. These differences mean that selection for an increased ratio of gonadal fat pad weight to body weight results in changes in the percentage of total fat in the body as well as in the percentage of gonadal fat pad weight. There are no significant differences between the lines in per cent protein, however, which means that selection for increased fatness has not significantly reduced the percentage of protein, and vice versa. There is significant variation between replicates in body weight, probably a result of random genetic drift in the replicates.

The GP lines show no significant differences in the percentage of any component of the body. Although the Low lines are fatter than either the Highs or Controls, this difference is not significant.

The index used for selection (body weight - 8 x gonadal fat pad weight) was designed to change body weight, while keeping per cent fat constant. This seems to have happened in the High lines, which are much heavier than the Controls, but have the same per cent fat. However, the Low lines have decreased slightly in body weight, but increased in fatness, with respect to the Controls. As expected from the direct responses to selection, there are significant differences between lines in body weight and protein weight.

It must be emphasised that these results come from a small study - only 16 mice per line were examined, in 2 batches, and only males were used. Currently, Dr.M.Nielsen is undertaking a carcass analysis of mice of each sex from each line at 4 and 6 weeks of age. When the results from this analysis are available, a much clearer picture of the changes in body composition in the lines should emerge.

4. Food Intake and Gonadal Fat Pad Weight

a. Food Intake

In generations 8 and 9, mice from all lines had their 4 to 6 week food intake and their 4 and 6 week weights recorded. Tables 16-19 show the means of food intake adjusted for 4 week weight, unadjusted food intake, 4 week weight, 6 week weight and gross efficiency, in the GA, GF and GP lines. In each case the results from both sexes and generations are pooled.

In the GA lines, the High-Low differences, divided by the Control line means, are 15.2% for adjusted food intake, 19.1% for unadjusted food intake, 7.2% for 4 week weight, 13.9% for 6 week weight and

Table 16. GA lines - results of food intake trials in generations 8 & 9

Line	Adj.Food Intake (g)	Food Intake (g)	4 Week Weight (g)	6 Week Weight (g)	Efficiency (%)
H1	66.9	68.9	18.0	27.1	13.3
H2	67.0	71.4	19.2	27.8	12.3
H3	67.4	69.4	19.3	27.7	11.7
Mean	67.1	69.9	18.8	27.5	12.4
C1	60.4	62.4	18.0	24.6	10.5
C2	63.4	64.8	17.7	24.9	11.1
C3	60.2	63.3	18.5	25.9	11.8
Mean	61.3	63.5	18.1	25.1	11.1
L1	57.5	57.1	16.8	23.3	11.2
L2	60.9	59.6	18.2	25.3	11.2
L3	55.1	56.6	17.6	23.4	10.0
Mean	57.8	57.8	17.5	24.0	10.8
SE*	0.47	0.66	0.23	0.30	0.21

*Standard errors calculated from between-replicate (within-line) mean squares.

Table 17. GF lines - results of food intake trials in generations 8 & 9

Line	Adj.Food Intake (g)	Food Intake (g)	4 Week Weight (g)	6 Week Weight (g)	Efficiency (%)
H1	58.0	56.7	16.5	23.1	11.7
H2	60.3	59.8	16.7	24.5	13.0
H3	57.2	56.4	16.7	23.8	12.5
Mean	58.5	57.6	16.6	23.8	12.4
C1	58.3	56.7	15.7	23.4	13.4
C2	60.4	64.3	18.9	25.2	13.2
C3	59.8	57.9	16.0	23.8	13.5
Mean	59.5	59.6	16.9	24.1	13.4
L1	60.6	60.0	16.7	24.8	13.6
L2	59.0	62.6	18.8	27.1	13.5
L3	58.0	55.7	15.8	23.1	13.3
Mean	59.2	59.4	17.1	25.0	13.5
SE*	0.47	0.66	0.23	0.30	0.21

*Standard errors calculated from between-replicate (within-line) mean squares.

Table 18. GP lines - results of food intake trials in generations 8 & 9

Line	Adj.Food Intake (g)	Food Intake (g)	4 Week Weight (g)	6 Week Weight (g)	Efficiency (%)
H1	62.9	66.7	19.4	28.6	14.2
H2	63.4	65.6	18.4	28.2	15.2
H3	62.1	64.0	17.9	28.1	16.3
Mean	62.8	65.4	18.6	28.3	15.2
C1	60.0	58.0	16.1	23.5	12.8
C2	61.7	59.8	16.3	25.7	15.9
C3	58.6	59.8	17.5	25.4	13.2
Mean	60.1	59.2	16.6	24.9	14.0
L1	58.9	57.9	16.4	22.2	10.0
L2	59.1	55.5	15.2	21.9	12.3
L3	56.0	51.6	14.5	21.3	13.3
Mean	58.0	55.0	15.4	21.8	11.9
SE*	0.47	0.66	0.23	0.30	0.21

*Standard errors calculated from between-replicates (within-lines) mean squares.

Table 19. Mean of lines - results of food intake trials in generations 8 & 9

Line	Adj.Food Intake (g)	Food Intake (g)	4 Week Weight (g)	6 Week Weight (g)	Efficiency (%)
GAH	67.1	69.9	18.8	27.5	12.4
GAC	61.3	63.5	18.1	25.1	11.1
GAL	57.8	57.8	17.5	24.0	10.8
GFH	58.5	57.6	16.6	23.8	12.4
GFC	59.5	59.6	16.9	24.1	13.4
GFL	59.2	59.4	17.1	25.0	13.5
GPH	62.8	65.4	18.6	28.3	15.2
GPC	60.1	59.2	16.6	24.9	14.0
GPL	58.0	55.0	15.4	21.8	11.9
SE*	0.27	0.38	0.13	0.17	0.12

*Standard errors calculated from between-replicate (within-line) mean suares (divided by $\sqrt{3}$ to obtain SE for mean of replicates).

14.4% for gross efficiency.

The High-Low differences in the GF lines, divided by the Control line means, are -1.2% for adjusted food intake, -3.0% for adjusted food intake, -5.0% for 4 week weight, -5.0% for 6 week weight and -8.2% for gross efficiency. The Control line mean is higher than that of the High and Low lines for both adjusted and unadjusted food intake.

In the GP lines the High-Low differences, divided by the Control line means, are 8.0% for adjusted food intake, 17.6% for unadjusted food intake, 19.3% for 4 week weight, 26.1% for 6 week weight and 23.6% for gross efficiency.

It seems that selection for 4 to 6 week food intake, adjusted for 4 week weight, has led to changes in unadjusted food intake, 6 week weight and gross efficiency, but little change in 4 week weight. These changes were discussed in an earlier section.

Selection for the ratio of gonadal fat pad weight to body weight has led to little change in food intake, either adjusted or unadjusted for 4 week weight, or in 4 week weight. The lines selected for a high percentage of fat (i.e. a low percentage of lean) show a small increase in 6 week weight, but no change in efficiency. The lines selected for a low percentage fat (i.e. a high percentage of lean) show a small decrease in both 6 week weight and gross efficiency.

Selection for the index (body weight - 8 x gonadal fat pad weight) has led to large changes in unadjusted food intake, 4 week weight, 6 week weight and gross efficiency. There are differences in adjusted food intake between the High and Low lines, but these are much smaller than the differences between the GA High and Low

lines. The High-Low difference in unadjusted food intake in the GA and GP lines is about the same, but in the GP lines, the High-Low differences in 4 week weight are much larger than in the GA lines. The GP lines have greater High-Low differences in 6 week weight and gross efficiency than do the GA lines.

b. Gonadal Fat Pad Weight and Body Weight of 10 Week Old Males

In generations 8 and 9, 10 week old males from all lines had their 10 week body weight and gonadal fat pad weight recorded. This study was designed to provide further information about the fatness of the lines. The means of the ratio of gonadal fat pad weight to body weight, index (body weight - 8 x gonadal fat pad weight) and 10 week weight in the GA, GF and GP lines are given in Tables 20-23. In each case, the results from the two generations are pooled.

The High-Low differences in the GA lines, as proportions of the Control means, are -13.5% for the ratio of gonadal fat pad weight to body weight, 14.6% for the index and 11.9% for 10 week weight.

In the GF lines, the High-Low differences, divided by the Control means, are -76.9% for the ratio of gonadal fat pad weight to body weight, 3.6% for the index and -5.0% for 10 week weight.

The High-Low differences in the GP lines, as proportions of the Control line means, are -3.7% for the ratio of gonadal fat pad weight to body weight, 26.8% for the index and 26.0% for 10 week weight.

Selection for 4 to 6 week food intake, adjusted for 4 week weight, has led to changes in 10 week weight and in the index (body weight - 8 x gonadal fat pad weight). Both the Low and Control lines are fatter than the Highs - the conclusion that was reached

Table 20. GA lines - results from dissections of 10 week old males in generations 8 & 9

Line	GFPW / BW (mg/g)	BW - 8 x GFPW (g)	10 Week Weight (g)
H1	13.3	31.9	35.1
H2	11.7	33.5	37.0
H3	13.7	33.3	37.4
H Mean	12.9	32.9	36.5
C1	13.6	30.8	34.4
C2	14.0	30.7	34.6
C3	18.9	29.0	34.3
C Mean	15.5	30.2	34.4
L1	15.3	27.8	31.8
L2	13.2	29.7	33.2
L3	16.5	27.9	32.2
L Mean	15.0	28.5	32.4
SE*	0.38	0.32	0.34

*Standard errors calculated from between-replicate (within-line) mean squares.

Table 21. GF lines - results of dissection of 10 week old males in generations 8 & 9

Line	GFPW / BW (mg/g)	BW - 8 x GFPW (g)	10 Week Weight (g)
H1	8.7	29.7	32.0
H2	8.1	29.7	31.9
H3	8.4	28.6	30.6
H Mean	8.4	29.3	31.5
C1	11.8	29.0	32.0
C2	14.2	31.8	36.0
C3	14.2	29.7	33.6
C Mean	13.4	30.2	33.9
L1	17.1	28.1	32.6
L2	19.9	29.0	34.6
L3	19.1	27.4	32.5
L Mean	18.7	28.2	33.2
SE*	0.38	0.32	0.34

*Standard errors calculated from between-replicate (within-line) mean squares.

Table 22. GP lines - results of dissection of 10 week old males in generations 8 & 9

Line	GFPW / BW (mg/g)	BW - 8 x GFPW (g)	10 Week Weight (g)
H1	13.7	34.3	38.6
H2	12.8	34.1	38.0
H3	13.3	33.5	37.5
H Mean	13.3	34.0	38.0
C1	16.4	28.3	32.5
C2	11.2	31.1	34.2
C3	13.1	29.9	33.6
C Mean	13.6	29.8	33.4
L1	12.8	27.5	30.7
L2	14.9	24.6	28.0
L3	13.8	25.9	29.1
L Mean	13.8	26.0	29.3
SE*	0.38	0.32	0.34

*Standard errors calculated from between-replicate (within-line) mean squares.

Table 23. Mean of lines - results of dissection of 10 week old males in generations 8 & 9

Line	GFPW / BW (mg/g)	BW - 8 x GFPW (g)	10 Week Weight (g)
GAH	12.9	32.9	36.5
GAC	15.5	30.2	34.4
GAL	15.0	28.5	32.4
GFH	8.4	29.3	31.5
GFC	13.4	30.2	33.9
GFL	18.7	28.2	33.2
GPH	13.3	34.0	38.0
GPC	13.6	29.8	33.4
GPL	13.8	26.0	29.3
SE*	0.22	0.18	0.20

*Standard errors calculated from between-replicate (within-line) mean squares (divided by $\sqrt{3}$ to obtain SE for mean of replicates).

from the results of the chemical carcass analysis of 10 week old males from generation 7.

Selection for the ratio of gonadal fat pad weight to body weight has produced large changes in the selected character, but little change in either 10 week weight or in the value of the index.

Selection for the index (body weight - 8 x gonadal fat pad weight) has produced large changes in the selected character and in 10 week weight , but little change in the ratio of gonadal fat pad weight to body weight. This last result contrasts with the results from the chemical carcass analysis - that the Low line mice were fatter than both the Highs and Controls. In an earlier section, Fig.16 showed the ratio of gonadal fat pad weight to body weight in the GP lines from generations 0 to 11. The results shown on this graph indicate that the Low line mice were markedly fatter than mice from the High and Control lines in generations 7 and 10, but not in other generations.

c. Conclusions

The measurement of 4 to 6 week food intake and of 10 week body weight and gonadal fat pad weight in all lines provides an opportunity to examine the correlated responses of the lines in the characters for which the other lines were selected, and to calculate the genetic correlations between the selected characters.

The GA High line mice increased in 10 week weight and in the index (body weight - 8 x gonadal fat pad weight) as a result of selection for increased 4 to 6 week food intake, adjusted for 4 week weight. They also decreased in fatness, as measured by the ratio of gonadal fat pad weight to body weight. The results of the chemical

carcass analysis also suggested that the High line mice were less fat than the Controls, in contrast to the results of Sutherland et al (1970) who found that mice selected for increased 4 to 11 week food intake were fatter than unselected mice. The Low line mice decreased in 10 week weight and in the index, but showed no change in the ratio of gonadal fat pad weight to body weight, compared with the Controls.

The GF High line mice mice had slightly decreased in adjusted and unadjusted food intake and in efficiency, as a result of selection for a decrease in the ratio of gonadal fat pad weight to body weight. The Low line mice show little change in any of these characters with respect to the Controls.

The GP High lines increased in 4 week weight, unadjusted food intake and efficiency when selected for an increase in the index (body weight - 8 x gonadal fat pad weight). They also increased in food intake, adjusted for 4 week weight, but the increase was small. The Low line mice showed a decrease in these characters. Sutherland et al (1970) found an increase in gross efficiency and in food intake in mice selected for increased 4 to 11 week gain, and others have found similar changes in mice selected for increased weight gain or body weight. Differences between the lines in the ratio of gonadal fat pad weight to body weight were small, which is surprising in view of the fact that significant differences in fatness between the Low and Control lines were found in the chemical carcass analysis. However, the ratio of gonadal fat pad weight to body weight in the GP Low lines was higher in generation 7 than in generation 8 and 9, so this may explain the difference in the results of the two analyses.

It is possible to calculate genetic correlations by using the formula

$$r_A^2 = (CR_{xy} CR_{yx})/(R_x R_y)$$

where r_A^2 is the square of the genetic correlation, CR_{xy} is the correlated response in character X on selection for character Y, CR_{yx} is the correlated response in Y on selection for character X, and R_x and R_y are the direct responses in X and Y, respectively. To calculate the genetic correlations between adjusted food intake and the ratio of gonadal fat pad weight to body weight, and between adjusted food intake and the index (body weight - 8 x gonadal fat pad weight), mean line differences in adjusted food intake in the GP and GF lines, and in gonadal fat pad weight / body weight and the index in the GA lines, in generations 8 and 9, were used. To calculate the genetic correlation between the ratio of gonadal fat pad weight to body weight and the index (body weight - 8 x gonadal fat pad weight), the mean line differences in these characters in the GP and GF lines in generation 11 were used. The line differences in the character for which the lines were selected are direct response and the line differences in the other characters are correlated responses. Table 24 shows the genetic correlations calculated from the High-Control, Low-Control and High-Low differences. If a value is not given, it is because either 1 or 3 of the differences was negative, making it impossible to calculate a value for the genetic correlation.

Table 24. Genetic correlations between selected characters

Characters	H-C	L-C	H-L
GFPW / BW, BW - 8 x GFPW	0.08	0.12	0.12
GFPW / BW, Adj.Food Intake	----	----	----
BW - 8 x GFPW, Adj.Food Intake	0.55	0.52	0.53

No genetic correlation could be calculated between the ratio of gonadal fat pad weight to body weight and adjusted food intake. It seems that although mice selected for decreased fatness eat less than mice selected for increased fatness, mice selected for decreased food intake get fatter than mice selected for increased food intake. The genetic correlation between 4 to 6 week food intake, adjusted for 4 week weight and the ratio of gonadal fat pad weight to body weight at 10 weeks of age is certainly very low. The genetic correlation between the ratio of gonadal fat pad to body weight and the index is small. There is a large genetic correlation between adjusted food intake and and the index (body weight - 8 x gonadal fat pad weight).

ANALYSIS OF FAMILY DATA

A. Methods

Generations 0 to 10 of the Control lines of each selection treatment were used to calculate offspring-parent regressions and intra-class correlations (full-sib) for a number of characters, using a Least-Squares Mixed Model analysis (Harvey, 1976). The F and P lines were pooled, as the same characters had been measured in each. The model used for offspring-parent regressions was

$$Y_{ij} = \mu + RG_i + \beta_1 X_{i1} (+ \beta_2 X_{i2}) + e_{ij}$$

where Y_{ij} is the observation on the jth individual in the ith replicate-generation group, μ is the overall mean, RG_i is the random effect of the ith replicate-generation group, $\beta_1 X_{i1}$ is the effect of regression on a character in the parent, $\beta_2 X_{i2}$ is the effect of regression on the litter size in which the individual was born (after adjustment to between 6 and 12 pups), and e_{ij} is random error.

For a single character, the value of the regression of offspring on one parent estimates one half the heritability of that character. The standard error of the heritability can be estimated by doubling the standard error of the regression coefficient.

For two characters,

$$r_A = \sqrt{(b_{XY} b_{YX})/(b_{XX} b_{YY})}$$

where r_A is the genetic correlation between the two characters, b_{XY} is the regression of character X in the offspring on character Y in the parent, b_{YX} is the regression of character Y in the offspring on character X in the parent, b_{XX} is the regression of character X in

the offspring on character X in the parent, and b is the regression of character Y in the offspring on character Y in the parent. If either b_{xy} or b_{yx} was negative or very small, the formula used was

$$r_A = 1/2(b_{xy} SD_y /SD_x + b_{yx} SD_x /SD_y) / \sqrt{(b_{xx} b_{yy})}$$

where SD_x is the standard deviation of X and SD_y is the standard deviation of Y. Robertson (1960) provides a simple formula that gives an approximate estimate of the standard error of the genetic correlation.

$$SE(r_A) = \sqrt{(1 - r_A^2)^2 (SE(h_x^2) SE(h_y^2))/(2h_x^2 h_y^2)}$$

where r_A is the genetic correlation between X and Y, and h_x^2 and h_y^2 are the heritabilities of X and Y. This formula gives an estimate of the standard error that is very dependent on the value of the genetic correlation - the higher the estimate of the genetic correlation, the lower its standard error will be. However, the estimates calculated using the formula were thought to give a reasonable idea of the range of the standard errors of the genetic correlations that were calculated.

The analysis was done for all possible combinations of sexes in offspring and parent in the A lines (analyses were only done on males in the P and F lines).

The analyses were carried out both with and without adjusting the data for the litter size (adjusted to between 6 and 12 pups) in which the mice were born.

The model used to calculate intra-class correlations was

$$Y_{ijk} = \mu + RG_i + D_{ij} + e_{ijk}$$

where Y_{ijk} is the observation on the kth progeny of the jth litter of the ith replicate-generation group, μ is the overall mean, RG_i is the random effect of the ith replicate-generation class, D_{ij} is the

random effect of the jth dam of the ith replicate generation class, and e_{ijk} is random error.

Intra-class correlations were calculated separately for each sex in the A lines, and with and without correcting for litter size. The correction for litter size was made as follows. A separate analysis was carried out on the data with litter size fitted as a regression (as above). The difference between the error sum of squares when litter size was fitted and the error sum of squares when dams were fitted, divided by the difference between the degrees of freedom, gives the mean square for dams, adjusted for litter size. A similar procedure was used to adjust mean cross products.

Intra-class correlations were calculated from the ratio σ_B^2/σ_P^2, where σ_B^2 is the variance between families and σ_P^2 is the phenotypic variance.

Genetic and phenotypic correlations were calculated from the formulae

$r_A = cov_{BXY} / \sqrt{\sigma_{BX}^2 \sigma_{BY}^2}$, and $r_P = cov_{PXY} / \sqrt{\sigma_{PX}^2 \sigma_{PY}^2}$

where r_A is the genetic correlation between X and Y, cov_{BXY} is the between-family covariance of X and Y, σ_{BX}^2 is the between-family variance of X, σ_{BY}^2 is the between-family variance of Y, r_P is the phenotypic correlation of X and Y, cov_{PXY} is the phenotypic covariance of X and Y, σ_{PX}^2 is the phenotypic variance of X, and σ_{PY}^2 is the phenotypic variance of Y. The standard errors of the genetic correlations were calculated using Robertson's formula above.

B. Results

All analyses were performed with and without adjusting for litter

size, but the adjustment had very little effect on the value of the estimates calculated. Therefore, the estimates of heritability and correlations obtained when the data were adjusted are not given in the text, but in Appendix 3, together with those estimates obtained from the regression of offspring on dam and of son or daughter on sire. The standard errors of the heritability estimates are also given in Appendix 3.

1. GA Lines

The characters examined in the GA lines were 4 to 6 week food intake, adjusted for 4 week weight, unadjusted food intake, 4 week weight, 6 week weight, and 4 to 6 week gain. Table 25 gives the intra-class correlations, means and phenotypic standard deviations of these characters for females and males, respectively. The intra-class correlations over-estimate the heritabilities, as they include a component due to common maternal enviroment.

$t_D = 0.5\ h^2 + 0.25\ V_D / V_P + V_{Ec} / V_P$

where t_D is the intra-class correlation, V_D is the dominance variance, V_P is the phenotypic variance and V_{Ec} is the common enviromental variance.

As the variances of all the characters are higher in males than in females, heritability estimates calculated from the regressions of son on dam and of daughter on sire are biased. Twice the regression of offspring on dam over-estimates the heritability, as it includes maternal effects. The standard errors of the coefficients of regression of son or daughter on sire are biased because there are unequal numbers of offspring from each litter.

To provide unbiased estimates of the heritability of each

Table 25. Intraclass correlations, means and standard deviations of characters measured in GA lines.

	Females			Males		
	t	Mean	SD	t	Mean	SD
Adj.Food Intake (g)	0 38	60.9	6.47	0.47	65.3	7.29
Food Intake (g)	0.46	60.8	6.97	0.52	64.4	7.51
4 Week Weight (g)	0.72	16.1	2.90	0.70	17.3	3.17
6 Week Weight (g)	0.53	22.5	2.49	0.50	26.2	3.21
4-6 Week Gain (g)	0.55	6.41	2.18	0.45	8.84	2.32

Standard errors of intra-class correlations range between 0.026 and 0.046

character, the regression of litter mean on sire was adjusted for the difference in variance between the sexes, using the formula

$b_A = 2\ b\ SD_{PM} / (\ SD_{PM} + SD_{PF})$

where b_A is the adjusted regression of litter mean on sire, SD_{PM} is the phenotypic standard deviation of the character in males and SD_{PF} is the phenotypic standard deviation of the character in females.

The formula assumes equal numbers of males and females in each litter, which was nearly always the case. The heritability is twice the adjusted regression coefficient. Table 26 gives the heritability estimates. Although the realised (within-litter) heritability of adjusted food intake was calculated to be 14 $\pm$ 2.7%, the heritability estimate from the regression of offspring on parent is effectively zero.

Estimates of genetic correlations between the characters were calculated from the regressions of litter mean on sire, and are given in Table 27. If the heritability of a character is negative or close to zero, it is impossible to calculate the genetic correlation between this character and any other. Therefore, no genetic correlations could be calculated between adjusted food intake and any other character.

As the GA High and Low lines had changed markedly in litter size, the coefficients of regression of daughters' litter size on dams' adjusted food intake, unadjusted food intake and litter size, and on sires' adjusted and unadjusted food intake, were calculated. The reciprocal regressions were also computed. The results of these analyses are shown in Tables 28 and 29. Table 30. shows the coefficients of regression of females' litter size on their own adjusted and unadjusted food intake. The regression of females'

Table 26. Heritabilities calculated from 2 x regression of litter mean on sire in GA lines (adjusted for sex-difference in variance).

Character	Heritability
Adj.Food Intake	-0.02 ± 0.078
Food Intake	0.17 ± 0.075
4 Week Weight	0.08 ± 0.088
6 Week Weight	0.26 ± 0.083
4-6 Week Gain	0.16 ± 0.080

Table 27. Genetic correlations calculated from regressions of litter mean on sire in GA lines.

	Food Intake	4 Week Weight	6 Week Weight
4 Week Weight	1.13		
6 Week Weight	0.97	0.78	
4-6 Week Gain	0.51	0.47	0.87

Standard errors of genetic correlations range between 0.015 (s.e. of 0.97) and 0.248 (s.e. of 0.51).

litter size on their own adjusted food intake and that of their dams and their sires is small.

Estimates of genetic and phenotypic correlations were calculated from between and within-family variances and covariances. The estimates of genetic correlation are biased, as the between-family variances and covariances include a component due to common maternal environment. Tables 31 and 32 show the 'genetic' and phenotypic correlations calculated for females and males, respectively. Some of the 'genetic' correlations are surprisingly low - especially those between 4 to 6 week gain and food intake, and between 4 to 6 week gain and 6 week weight. The differences between these estimates of genetic correlation and those obtained from the offspring-parent regressions are probably a consequence of the fact that the former are biased because of maternal effects.

2. GF and GP Lines

As the same characters were measured in the GP and GF lines, their Control lines were put together for analyses of family data from generations 0 to 10. The characters analysed were the ratio of gonadal fat pad weight to body weight, the index (body weight - 8 x gonadal fat pad weight), 10 week weight, 10 week gonadal fat pad weight and 6 week weight.

The intra-class correlations, means and standard deviations of these characters are given in Table 33.

Table 34 shows the heritability estimates, which were calculated from the regression of litter mean on sire, as in the GA lines. As the characters were measured only in males, no adjustment for sex-difference in variance was necessary. The heritability estimate

Table 28. Regression of daughter on dam

	Dam		
Daughter	Food Intake (g)	Adj.Food Intake (g)	Litter Size
Food Intake (g)	0.11 ± 0.052	0.25 ± 0.064	-0.43 ± 0.149
Adj.Food Intake (g)	0.08 ± 0.042	0.18 ± 0.052	0.23 ± 0.120
Litter Size	-0.03 ± 0.020	-0.03 ± 0.025	0.05 ± 0.057

Table 29. Regression of daughter on sire

Daughter	Sire: Food Intake (g)	Sire: Adj.Food Intake (g)
Food Intake (g)	0.14 ± 0.045	0.04 ± 0.058
Adj.Food Intake (g)	0.08 ± 0.036	-0.01 ± 0.046
Litter Size	0.05 ± 0.017	0.05 ± 0.022

Table 30. Regression of daughters' litter size on their own food intake

	Food Intake (g)	Adj.Food Intake (g)
Litter Size	0.11 ± 0.032	0.07 ± 0.036

Table 31. 'Genetic' and phenotypic correlations from between-family analysis in GA lines - females

	Adj.Food Intake	Food Intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Adj.Food Intake		0.50	-0.26	0.21	0.61
Food Intake	0.70		0.71	0.81	-0.10
4 Week Weight	-0.14	0.60		0.73	-0.62
6 Week Weight	0.30	0.72	0.67		0.09
4-6 Week gain	0.53	0.08	-0.48	0.33	

Phenotypic correlations on left of diagonal, 'genetic' correlations on right.

Standard errors of 'genetic' correlations range between 0.017 (s.e. of 0.73) and 0.066 (s.e. of 0.21).

Table 32. 'Genetic' and phenotypic correlations calculated from between-family analysis of GA lines - males

	Adj.Food Intake	Food Intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Adj.Food Intake		0.31	-0.46	0.03	0.78
Food Intake	0.49		0.70	0.87	0.15
4 Week Weight	-0.38	0.63		0.79	-0.44
6 Week Weight	0.23	0.82	0.72		0.21
4-6 Week Gain	0.53	0.32	-0.31	0.44	

Phenotypic correlations on left of diagonal, 'genetic' correlations on right.

Standard errors of 'genetic' correlations range between 0.015 (s.e. of 0.79) and 0.059 (s.e. of 0.21).

Table 33. Intra-class correlations, means and standard deviations of characters measured in GF and GP lines

	t	Mean	SD
GFPW/BW (mg/g)	0.43	13.9	4.17
BW - 8 x GFPW (g)	0.48	29.1	3.19
Gonadal Fat Pad Weight (mg)	0.46	0.462	0.166
10 Week Weight (g)	0.51	32.8	3.78
6 Week Weight (g)	0.41	26.4	3.53

Standard errors of intra-class correlations range between 0.027 and 0.030

Table 34. Heritabilities calculated from 2 x regression of litter mean on sire in GF and GP lines

Character	Heritability
Ratio of GFPW/BW	0.45 ± 0.066
BW - 8 x GFPW	0.29 ± 0.070
Gonadal Fat Pad Weight	0.46 ± 0.067
10 Week Weight	0.35 ± 0.071
6 Week Weight	0.20 ± 0.073

for the index is considerably lower than the realised (within-litter) heritability estimate calculated in the GP lines (54 ± 1.2%), but the heritability estimate for the ratio of gonadal fat pad weight to body weight is very similar to the realised (within-litter) heritability estimate calculated in the GF lines (43 ± 5.9%).

Estimates of genetic correlations, calculated from the regressions of litter-mean on sire, are given in Table 35.

The coefficients of regression of daughters' litter mean on sires' 10 week weight, index (body weight - 8 x gonadal fat pad weight) and ratio of gonadal fat pad weight to body weight, were calculated and are shown in Table 36. The coefficient of regression of litter size on the ratio of gonadal fat pad weight to body weight is close to zero, but the coefficient of regression of litter size on the index (body weight - 8 x gonadal fat pad weight) is larger.

Estimates of genetic and phenotypic correlations were calculated from the within and between-family variances and covariances, and are given in Table 37.

3. Conclusions

Heritabilities

In all the selection experiments selection was carried out within litters, so the realised heritabilities calculated are within-family heritabilities. The heritability estimates obtained from the offspring-parent regressions predict the realised heritabilities that would be obtained if mass selection was practised. To convert these heritabilities to within-family heritabilities, the following

Table 35. Genetic correlations calculated from regressions of litter mean on sire in GF and GP lines

	GFPW/BW	BW - 8 x GFPW	Gonadal Fat Pad Weight	10 Week Weight
BW - 8 x GFPW	0.13			
Gonadal Fat Pad Weight	0.97	0.31		
10 Week Weight	0.48	0.91	0.68	
6 Week Weight	0.42	0.94	0.62	0.99

Standard errors of genetic correlations range between 0.002 (s.e of 0.99) and 0.136 (s.e. of 0.42).

Table 36. Regression of daughter on sire.

	Sire		
Daughter	10 Week Weight (g)	BW - 8 x GFPW (g)	GFPW/BW (mg/g)
Litter Size	0.11 $\pm$ 0.032	0.14 $\pm$ 0.037	-0.00 $\pm$ 0.026

Table 37. 'Genetic' and phenotypic correlations calculated from between-family analysis in GP and GF lines

	GFPW/BW	BW - 8 x GFPW	GFPW	10 Week Weight	6 Week Weight
GFPW/BW		0.09	0.95	0.40	0.62
BW - 8 x GFPW	-0.03		0.37	0.95	1.17
Gonadal Fat Pad Weight	0.95	0.25		0.65	0.92
10 Week Weight	0.33	0.94	0.58		1.27
6 Week Weight	0.36	0.89	0.59	0.97	

Standard errors of 'genetic' correlations range between 0.004 (s.e. of 0.95) and 0.045 (s.e. of 0.09).

formula can be used.

$h^2_w = h^2 (1-r)/(1-t)$

where h^2_w is the within-family heritability, r is the coefficient of relationship (0.5 for full sibs) and t is the intra-class correlation.

The heritability estimate for 4 to 6 week food intake, adjusted for 4 week weight, from the offspring-parent regression analysis was effectively zero. The realised within-family heritability was 0.14 $\pm$ 0.027. The adjustment of food intake for 4 week weight was based on an index calculated from the within-litter regression of food intake on 4 week weight. It is possible that if the same index had been used for mass selection, no response in the selected character would have been seen. However, if mass selection had been practised, a different index would have been used.

The heritability estimate for unadjusted 4 to 6 week food intake was 0.17 $\pm$ 0.075, which is fairly close to the realised heritability estimate of 0.20 $\pm$ 0.057 obtained for 4 to 11 week food intake by Sutherland *et al* (1970).

A very low estimate of 0.08 $\pm$ 0.088 was obtained for the heritability of 4 week weight (0.06 if converted to within-family heritability). These values are lower than realised heritability estimates previously obtained for early weights. Frahm and Brown (1975) found a realised within-family heritability of 0.17 for 3 week weight, and McCarthy and Doolittle (1977) obtained a realised within-family heritabilty of 0.39 for 5 week weight.

Heritability estimates for 6 week weight ranged from 0.20 $\pm$ 0.073 (GF and GP lines) to 0.26 $\pm$ 0.083 (GA lines). If converted to within-family heritabilities, using the intra-class correlations

calculated in the different lines, these become 0.25 and 0.24, respectively. Previous estimates of the realised heritability of 6 week weight range from 0.13 (mass selection, Cheung and Parker, 1974) to 0.55 (mass selection, Eisen, 1978).

For 4 to 6 week gain, the heritability estimate was 0.16 ± 0.080 (0.16 as a within-family heritability). Previous estimates of the realised heritability of 3 to 6 week gain range from 0.18 (mass selection, Rahnefeld et al, 1963) to 0.35 (within-litter selection, Hanrahan et al, 1973).

The heritability estimate calculated for the ratio of gonadal fat pad weight to body weight was 0.45 ± 0.066 (0.52 if converted to a within-litter heritability). The realised heritability estimate obtained for this character was 0.43 ± 0.059, which is slightly lower than that predicted from the offspring-parent regression.

For the index (body weight - 8 x gonadal fat pad weight) the heritability estimate was 0.29 ± 0.070 (0.30 as a within-family heritability). This is lower than the realised heritability of 0.54 ± 0.012 calculated from the response to selection.

The heritability of 10 week weight was estimated to be 0.35 ± 0.071 (0.34 as a within-family heritability). The within-family estimate is in good agreement with the realised heritability estimate of 0.33 obtained by McCarthy and Doolittle (1977) when they selected within litters for increased and decreased 10 week weight.

Genetic Correlations

As the heritability of 4 to 6 week food intake, adjusted for 4 week weight, was estimated to be zero from the offspring-parent regression analysis, no genetic correlations between this character

and any other could be estimated from the offspring-parent regressions. Genetic correlations were calculated from the between-family variances and covariances, but they include maternal effects and are therefore biased.

Unadjusted food intake has a high positive genetic correlation with both 4 week weight and 6 week weight and a lower genetic correlation with 4 to 6 week gain. It seems likely that the index used in the selection of the GA lines, which was designed to increase food intake without increasing 4 week weight, had positive genetic correlations with 6 week weight and 4 to 6 week gain.

Four week weight was highly genetically correlated with 6 week weight, but not significantly correlated with 4 to 6 week gain.

There was a high genetic correlation between 6 week weight and 4 to 6 week gain.

The genetic correlation between the ratio of gonadal fat pad weight to body weight and gonadal fat pad weight was high. The genetic correlations between the ratio and 6 and 10 week weight were lower, and the genetic correlation between the ratio and the index (gonadal fat pad weight - 8 x gonadal fat pad weight) was close to zero. These genetic correlations predict that when selecting for the ratio of gonadal fat pad weight to body weight, we would expect to see large changes in gonadal fat pad weight, smaller changes in body weight and no change in the index (body weight - 8 x gonadal fat pad weight). This is what has happened as a result of selection in the GF lines.

The index (body weight - 8 x gonadal fat pad weight) is highly positively genetically correlated with both 6 and 10 week weight. It has a lower positive genetic correlation with gonadal fat pad

weight, and a genetic correlation of effectively zero with the ratio of gonadal fat pad weight to body weight. These genetic correlations predict that when selecting for the index (body weight - 8 x gonadal fat pad weight), large changes would be occur in body weight and 6 and 10 weeks, small changes in the amount of gonadal fat pad weight and no change in the ratio of gonadal fat pad weight to body weight. This is what has happened as a result of selection in the GP lines.

Phenotypic correlations

The phenotypic correlations calculated in the GA lines are generally similar in sign and relative magnitude to the genetic correlations calculated from the offspring-parent regressions.

Food intake, adjusted for 4 week weight, is negatively correlated with 4 week weight and positively correlated with unadjusted food intake, 6 week weight and 4 to 6 week gain. Four week weight and 4 to 6 week gain are negatively correlated.

The phenotypic correlations calculated in the GF and GP lines are similar in sign and relative magnitude to the genetic correlations calculated from the offspring-parent regressions, although the phenotypic correlations are generally smaller.

Litter Size

The mean difference in litter size between the GA High and Low lines in generation 11 (generation 10 females) was 2.6 pups. The regression of daughters' litter size on sires' adjusted food intake was 0.05, and the High-Low difference in sires' adjusted food intake in generation 9 was 16.4g. From these figures, the High-Low

difference in the litter size of generation 10 females would be predicted to be 0.8 pups. The regression of daughters' litter size on their own food intake was 0.07, and the High-Low difference in the adjusted food intake of selected females in generation 10 was 15.2g. Using these figures, a High-Low difference in litter size of 1.1 pups would be predicted. Therefore, neither the regression of daughters' litter size on their sires' adjusted food intake nor on their own adjusted food intake is sufficiently large to account for the observed differences in litter size in the GA lines.

In generation 11, the mean difference in litter size btween the GF High and Low lines was only 0.3 pups. The regression of daughters' litter size on sires' ratio of gonadal fat pad weight to body weight was 0.00, so no differences in litter size would be expected.

In the GP lines, the mean High-Low difference in litter size was 1.0 pups in generation 11 (generation 10 females). The regression of daughters' litter size on sires' index (body weight - 8 x gonadal fat pad weight) was 0.14, and the High-Low difference in the index of sires in generation 9 was 11.3g. These figures would predict that there would be a High-Low difference in litter size of 1.58 pups from generation 10 females. Therefore, the difference in litter size between the GP High and Low lines seems to be a consequence of the selection in these lines.

DISCUSSION

GA Lines

The GA lines were selected for 4 to 6 week food intake, adjusted for 4 week weight. The realised (within-litter) heritability of this character, from the High-Low divergence, was 0.14 ± 0.027. This is not greatly different from the figure of 0.20 ± 0.057 obtained for the realised heritability of 4 to 11 week food intake by Sutherland *et al* (1970).

The High lines increased in 6 week weight, gross efficiency and litter size, compared with the Controls, although the increase in gross efficiency was small. The High lines were less fat than the Controls. The Low lines had a decrease in 6 week weight, litter size and gross efficiency, and no change in percentage fat. Changes in 4 week weight were small in the High and Low lines.

The large High-Low differences in litter size were very surprising. The High-Low differences in body weight of females at 6 and 10 weeks of age were much smaller than the High-Low weight differences in the GP lines, although the High-Low difference in litter size was much smaller in the GP lines. It seems, therefore that differences in body weight cannot account for all of the difference in litter size between the GA High and Low lines. From the offspring-parent regression analysis, there is no evidence that there is a genetic relationship between litter size and the selected character, adjusted food intake. The results of an analysis by Mr.F.Brien of the ovulation rate of mice from all lines, suggest that differences in ovulation rate are primarily responsible for the observed differences in litter size. Although the coefficient of

regression of females' food intake on their own adjusted food intake is small, it is possible that the food intake per unit body weight of a mouse influences her ovulation rate, and that the High line females shed more eggs because of their greater food consumption. Further studies must be carried out to see whether this is the case, and to investigate the underlying physiology. One proposed experiment is the restriction of the food intake of High line females to see the effect on ovulation rate and litter size. Hormone assays of mice from the different lines which have been fed ad libitum and restricted diets, might also be undertaken.

Increased food intake has previously been selected for in mice (Sutherland et al, 1970) and chickens (Pym and Solvyns, 1979), and in both experiments the selected animals were fatter than unselected Controls. A decrease in gross efficiency was observed in the selected chickens, and no change in gross efficiency was seen in the selected mice. However, in this experiment the mice selected for increased food intake, adjusted for initial weight, decreased in percentage fat and increased slightly in gross efficiency. The mice selected for a decrease in adjusted food intake showed a decrease in gross efficiency and no change in fatness.

It is probable that there are many genes controlling food intake, which differ in their effects on body composition and gross efficiency. It may be that the restriction on change in 4 week weight in the selected lines in this experiment meant that the genes selected in the High lines were those that increased appetite without leading to an increase in fatness. Another explanation for the difference in body composition of the GA lines is the size of the litter in which they were raised. Although all litters were

standardised to between 6 and 12 pups, the average size of litter raised was 1.7 pups higher in the High lines than the Low lines in generations 8 and 9. Eisen and Roberts (1981) found that the size of litter in which a mouse was raised had a large effect on its fatness (measured by gonadal fat pad weight and per cent) at 6 weeks of age. Mice raised in litters of 4 had, on average, 104 mg and 0.26 % more gonadal fat than mice raised in litters of 8.

The results of a small investigation by S.Copeland of mice from all lines suggested that there were large differences in fatness between the GA High and Low line mice at 4 weeks of age. The differences were larger than those found at 10 weeks, although the Low line mice were fatter than the High line mice at both ages. Although the results from this investigation are not conclusive because of the small number of mice examined, they suggest that the line differences in body composition are greatest at an early age, and may therefore be at least partly due to maternal effects. It is also possible that the difference in fatness between the High and Low lines is a direct effect of selection for adjusted food intake. If mice are fatter at 4 weeks, they may eat less food because of their greater energy reserves.

At this time, Dr.M.Nielsen is carrying out an experiment that will yield information about the body composition at 4 and 6 weeks of age, the maintenance requirement and the energetic efficiency of mice from all the lines. These results should lead to a better understanding of the changes in gross efficiency, food intake and body composition that have occurred in the GA lines.

GF Lines

Selection for the ratio of gonadal fat pad weight to body weight was carried out in the GF lines. The realised (within-litter) heritability of this character, from the High-Low divergence, was 0.44 ± 0.059. This agrees fairly closely with the heritability estimate from the offspring-parent regression analysis. Although there were large differences in the ratio of gonadal fat pad weight to body weight between the lines at generation 11, it seems that selection limits may have been reached. There may be physiological limits to the proportion of gonadal fat in a mouse. There is no indication that natural selection is opposing the effects of the artificial selection - from generation 8 to 11, the percentage of infertile matings in the High and Low lines was no greater than that in the Controls. There were no differences in litter size between the lines.

The High line mice, selected for a decrease in the ratio of gonadal fat pad weight to body weight (i.e. an increase in percentage lean), have decreased slightly in body weight at 6 and 10 weeks. The Low line mice, selected in the opposite direction, have not changed in 6 or 10 week body weight, compared with the Controls. Gross efficiency and 4 to 6 week food intake have decreased slightly in the High lines, and have not changed in the Low lines, compared with the Controls. There were large differences in percentage carcass fat between the lines, although no significant differences in percentage protein. It seems therefore, that selection for a change in percentage fat may not result in a change in percentage lean. The use of the ratio of gonadal fat pad weight to body weight as an estimator of total percentage fat has limitations. In

generation 7, the High-Low difference in per cent total fat, as a proportion of the Control mean, was 35.9%, compared with a difference in the ratio of gonadal fat pad weight to body weight of 64.5%. If two or more fat depots had been dissected out and weighed, and the information combined in an index, larger changes in total percentage fat might have been obtained. Larger changes in percentage total fat may have been accompanied by corresponding changes in per cent lean.

GP Lines

The GP lines were selected for the index (10 week body weight - 8 x gonadal fat pad weight). The realised (within-litter) heritability of this index, from the High-Low divergence, was 0.54 $\pm$ 0.012. This is higher than the estimate of heritbility from the offspring-parent regression analysis, and higher than the estimate of 0.33 $\pm$ 0.020 obtained for the realised heritability of 10 week weight by McCarthy and Doolittle (1977).

There were large changes in the selected lines in 4, 6 and 10 week weight; the High line mice being heavier and the Low line mice lighter than the Controls.

There was an average difference of 1.0 pups per litter between the High and Low lines in generation 11. This difference is not surprising in view of the large differences in body weight between the High and Low line mice. There was no great difference between the lines in the percentage of fertile matings from generation 8 to 11, so it seems that there is no adverse effect of selection in either direction on fertility.

The index (body weight - 8 x gonadal fat pad weight) was designed

to maximise change in body weight without a change in carcass composition. The High, Low and Control lines were not significantly different in fatness. Although the Lows were fatter at generation 7, this was not the case in later generations.

When the index (body weight - 8 x gonadal fat pad weight) was constructed, no information was available about the genetic and phenotypic variances and covariances of 10 week weight, gonadal fat pad weight and the ratio of gonadal fat pad weight to body weight. Using the values obtained from the analysis of family data, an index of body weight and gonadal fat pad weight was constructed that would maximise change in body weight, while holding the ratio of gonadal fat pad weight to body weight (i.e. percentage fat) constant. The index obtained was (body weight - 9.5 x gonadal fat pad weight), which is very similar to the index that was used.

There were large differences in 4 to 6 week food intake between the High and Low lines in generation 8 and 9; the High-Low differences were nearly as large as those in the GA lines, although much lower if adjusted for 4 week weight. Despite the fact that the High-Low differences in food intake were similar in the GA and GP lines, the GP lines had a much larger High-Low difference in 4 to 6 week weight gain. Therefore the High-Low differences in gross efficiency were much larger in the GP lines. The GA High line mice may have a higher maintenance requirement per unit body weight, or be less energetically efficient, than the GP High line mice. The results of the study by Dr.Nielsen should resolve which, if either, is the case.

There were two reasons for carrying out the selection experiment.

The first was to discover how much certain characters could be changed by selection. The second, and most important, was to establish lines of mice that had large differences in food intake, body composition and lean growth rate, and to examine the differences between these lines in other characters. Some of the correlated responses to selection have already been examined, and have been discussed in this and preceding chapters. Some of the studies of the mouse lines that have been, or that will be, carried out by other people have been referred to previously. There are many other experiments that have yet to be done.

Body weights from birth to 16 weeks of age of mice from each line will be measured to provide more information about the growth curves of mice from the different lines. Some of these mice will have their food intake recorded to provide information about the relationship between growth and food intake of mice at different ages in each line. Previous measurements of body weights from 4 to 10 weeks of age showed that the GP High line mice grew faster than the Lows from 4 to 6 weeks and from 6 to 10 weeks. The Highs ate more than the Lows from 4 to 6 weeks, but were more efficient. It would be expected that the Highs would eat more than the Lows from 6 to 10 weeks, because of their greater 6 week weight and 6 to 10 week gain, and the Highs would probably still be more efficient than the Lows during this period. Only a few females from each line were weighed after 10 weeks, but the results suggested that the growth rate of the GP Highs and Lows was similar between 10 and 16 weeks. If this is true, it would be expected that the Highs would still eat more during this period, because of their greater weight, but they would be less efficient.

The GA High line mice grew faster than the Lows between 4 and 6 weeks, but not between 6 and 10 weeks, or between 10 and 16 weeks. The High line mice were more efficient than the Lows from 4 to 6 weeks, although their food intake was higher. It would be expected that the Highs would continue to eat more at later ages because of their higher body weight, but they would be less efficient.

Differences in 4 to 6 week food intake, growth rate and gross efficiency between the GF High and Low lines were small. There was no difference in the growth rate of the Highs and Lows between 6 and 16 weeks, and it is unlikely that there would be large differnces in food intake and gross efficiency during this period.

Mice from at least some of the lines will be put on a 'cafeteria' diet (a diet consisting of rich and varied foodstuffs) to encourage them to eat excessively. Observations will be made on the amount of extra weight gained by these mice relative to their excess energy intake. It might be particularly interesting to compare the GA High and Low lines with the GP High and Low lines, as the High-Low difference in food intake is the same in the two groups, although there is a much larger High-Low difference in 4 to 6 week weight gain in the GP lines. It has been suggested by Trayhurn et al (1982) that regulatory dietary-induced thermogenesis, mediated by brown adipose tissue, plays an important role in energy balance. It would be interesting, therefore, to examine the amount and/or the activity of brown adipose tissue of mice from different lines, after both normal feeding and 'cafeteria' feeding, to see whether differences in the capacity for dietary-induced thermogenesis are responsible for the observed differences in gross efficiency among the lines.

Another study that might yield some interesting results is the measurement of the rates of protein synthesis and degredation in mice from the different lines, to see what differences have occurred as a result of the selection treatments used.

What are the implications for large animal breeding of the results of this experiment? The ideal meat animal would grow quickly, have a low percentage of fat in its carcass, and have a high fertility. Expenditure on food is a major part of the costs of rearing meat animals. If an animal breeder can produce animals that gain the same amount of weight on less food, or more weight on the same amount of food, this will increase the amount of profit that can be made.

If we look at the results of the food intake trials on all the lines of mice, and compare the High and Low line mice with the mean of all the Controls, we can get some idea of the effects of the different selection treatments on weight gain relative to food intake.

In the GP High lines, selection for increased (body weight - 8 x gonadal fat pad weight) has increased 4 to 6 week food intake by 3.3%, and 4 to 6 week gain by 29.3%, compared with the Controls. If we assume that growth rate and food intake are constant over this period (food intake almost certainly increases), the Highs gain as much weight in 10.8 days as the Controls do in 14 days, and eat 20.1% less food to gain this weight. The GP Lows would take 16.4 days, and would eat 11.8% more food than the Controls to gain the same amount of weight.

Similar calculations were performed for the lines that were selected for 4 to 6 week food intake, adjusted for 4 week weight,

and for the ratio of fat pad weight to body weight. The GA Highs gain as much weight in 12.1 days as the Controls do in 14 days, and eat 4.8% less food to do so. The GA lows would take 16.2 days to gain this amount of weight and would eat 9.7% more food than the Controls.

The GF Low lines (selected for an increase in fatness) take 13.3 days to gain as much weight as the Controls do in 14 days, and eat 7.5% less food to do so. The GF Highs (selected for a decrease in fatness) would take 14.6 days to gain the same amount of weight as the Controls do in 14 days, but eat the same amount of food to do so.

Therefore, on the assumptions that food intake and weight gain are constant from 4 to 6 weeks, selection has decreased the amount of food eaten to gain a fixed amount of weight in the GP High lines and, to a lesser extent, in the GA High and GF Low lines.

The GP High lines were selected for an increase in the index (body weight - 8 x gonadal fat pad weight). This index is similar to indices used in pig breeding, which combine weight gain and live backfat depth. The difference is that the index used in the mouse selection experiment was designed to keep fat percentage constant, whereas the indices used in pig breeding are designed to reduce percentage fat. As the GP High lines show a large reduction in the amount of food eaten to gain a fixed amount of weight, it seems likely that similar selection procedures in pigs would have the same effect. It was found in this experiment that direct selection for a reduction in percentage fat in mice led to a slight decrease in growth rate, but there was a corresponding decrease in food intake. Does this mean that the selection indices used in pig breeding,

which reduce percentage fat, will produce a smaller response in growth rate than if growth alone was selected for? The results from studies on pigs indicate that growth rate and percentage fat are negatively correlated in pigs, although they seem to be positively correlated in mice. This being so, selection for an increased growth rate and decreased percentage fat is unlikely to be less effective in increasing growth rate than selection for growth rate alone.

The GA High lines were selected for an increase in 4 to 6 week food intake, adjusted for 4 week weight. The reduction in the amount of food eaten to gain a fixed amount of weight was only 4.8%, but a large increase in litter size and a decrease in percentage fat was seen in these lines. Increased fertility would be advantageous in some animal species, but the relationship between litter size and food intake may not be the same in all species. Furthermore, measuring food intake is time-consuming and expensive, so this type of selection is unlikely to be practical for large animals.

The GF Low lines were selected for an increase in the ratio of gonadal fat pad weight to body weight at 10 weeks. These lines showed a reduction of 7.5% in the amount of food eaten to gain a fixed amount of weight. However, because of the negative genetic correlation between growth rate and percentage fat in pigs, fatter pigs would probably eat more food to gain a fixed amount of weight, and an increase in fatness is undesirable in any meat animal.

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APPENDIX 1.

Beta Diets
for laboratory animals

	Rat & Mouse No. 1 Expanded Maintenance 801 160W		Rat & Mouse No. 3 Expanded Breeder 801 180W		Rat & Mouse No. 6 Expanded Breeder 18 801 190W	
Crude Oil %	3·0		4·9		4·0	
Crude Protein %	14·8		21·0		18·5	
Crude Fibre %	4·0		3·7		3·8	
Ash %	4·8		7·3		7·0	
Crude Carbohydrate %	63·6		50·3		56·7	
Dig. Crude Oil %	2·1		3·8		3·4	
„ „ Protein %	12·0		20·0		15·4	
„ „ Fibre %	0·8		0·7		0·7	
„ „ Carbohydrate %	56·5		45·3		49·5	
T.D.N.	74		74		73	
Gross Energy Cal/kg	3390		3430		3380	
Met. „ Cal/kg	3120		3150		3050	
Dig. „ Cal/kg	2810		2890		2810	
Myristoleic Acid %	0·02		0·02		0·02	
Palmitoleic Acid %	0·13		0·26		0·22	
Oleic Acid %	0·92		1·14		1·05	
Linoleic Acid %	0·92		1·70		1·39	
Linolenic Acid %	0·10		0·19		0·16	
Arachidonic Acid %	0·19		0·40		0·36	
Clupanodonic Acid %	—		0·04		0·04	
Lauric Acid %	0·02		0·06		0·05	
Myristic Acid %	0·16		0·19		0·18	
Palmitic Acid %	0·47		0·56		0·50	
Stearic Acid %	0·10		0·17		0·14	
Arginine %	0·74		1·39		1·07	
Lysine %	0·75	0·10	1·58	0·10	1·07	0·10
Methionine %	0·28	0·05	0·55	0·10	0·42	0·10
Cystine %	0·25		0·33		0·30	
Tryptophan %	0·19		0·32		0·26	
Histidine %	0·33		0·55		0·44	
Threonine %	0·54		0·88		0·70	
Isoleucine %	0·61		1·10		0·90	
Leucine %	1·10		1·65		1·40	
Phenylalanine %	0·70		1·02		0·84	
Valine %	0·75		1·18		0·98	
Tyrosine %	0·50		0·74		0·53	
Glycine %	0·92		1·78		1·25	
Aspartic Acid %	0·81		1·62		1·15	
Glutamic Acid %	3·00		3·94		3·33	
Proline %	1·15		1·35		1·24	
Serine %	0·57		0·99		0·76	
Hydroxyproline %	—		0·07		0·04	
Hydroxylysine %	—		—		—	
Alanine %	0·13		0·11		0·11	
Calcium %	0·90	0·77	1·31	0·57	1·05	0·54
Phosphorus %	0·50		0·80	0·10	0·75	0·10
Sodium %	0·25	0·20	0·32	0·20	0·34	0·20
Chlorine %	0·38	0·30	0·49	0·30	0·41	0·30
Magnesium %	0·14		0·21	0·04	0·23	0·04
Potassium %	0·72		0·89		0·97	
Sulphur %	0·19		0·28		0·24	
Iron mg/kg	70		116	25	110	25
Copper mg/kg	9	2	19	10	20	10
Manganese mg/kg	74	20	91	80	95	60
Zinc mg/kg	76		35	10	37	10
Cobalt mcg/kg	57		575	500	570	500
Iodine mcg/kg	811	750	830	750	1115	750
Selenium mcg/kg	117		444		243	
Fluorine mg/kg	2		12	10	12	10
Vitamin A iu/kg	6610	6000	20523	20000	20580	20000
„ D iu/kg	603	600	4503	3000	3760	3000
„ B_1 mg/kg	7·2	2·0	26·3	20·0	27·8	20·0
„ B_2 mg/kg	11·3	1·0	13·2	8·0	11·7	8·0
„ B_6 mg/kg	5·5	0·6	20·0	15·1	19·1	15·1
„ B_{12} mcg/kg	7·7	6·0	29·2	18·0	24·5	18·0
„ C mg/kg	—		—		—	
„ E mg/kg	66·2	45·0	115·3	100·0	118·6	100·0
„ K mg/kg	10·5	1·0	4·3	4·0	4·5	4·0
Folic Acid mg/kg	0·8		2·4	0·5	2·1	0·5
Nicotinic Acid mg/kg	57·0	2·5	75·6	20·0	81·3	20·0
Pantothenic Acid mg/kg	23·8	5·6	36·6	23·2	38·5	25·2
Choline g/kg	1·60	0·04	1·75	0·04	1·65	0·04
Inositol g/kg	2·55		1·82		1·94	
Biotin mcg/kg	265·0		248·0		310·6	
Carotene mg/kg	0·36		0·31		0·34	
Xanthophyll mg/kg	1·20		1·20		1·20	

Note 1: All calculated to nominal 10% moisture content.

Note 2: Values on left all Total Calculated Values.

Note 3: Values on right all amounts added via supplementation.

RD nutrition

APPENDIX 2

TABLE A1. GAH LINES - MEAN ADJUSTED FOOD INTAKE (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	74.0 ± 0.60	66.6 ± 0.70	73.0 ± 0.49	71.2 ± 0.35
1	85.0 ± 0.71	77.3 ± 0.78	65.5 ± 0.61	75.9 ± 0.41
2	63.3 ± 0.64	63.6 ± 0.57	60.0 ± 0.50	62.3 ± 0.33
3	64.2 ± 0.72	64.5 ± 0.60	64.6 ± 0.47	64.4 ± 0.35
4	65.4 ± 0.52	65.2 ± 0.49	62.6 ± 0.52	64.4 ± 0.29
5	64.2 ± 0.54	62.2 ± 0.51	65.2 ± 0.40	63.9 ± 0.28
6	71.4 ± 0.47	68.9 ± 0.49	69.1 ± 0.44	69.8 ± 0.27
7	66.4 ± 0.58	67.5 ± 0.50	65.1 ± 0.49	66.3 ± 0.30
8	65.0 ± 0.75	66.1 ± 0.77	67.8 ± 0.84	66.3 ± 0.45
9	68.6 ± 0.73	67.9 ± 0.66	66.9 ± 0.54	67.8 ± 0.37
10	67.4 ± 0.66	66.1 ± 0.68	65.4 ± 0.71	66.3 ± 0.39
11	68.6 ± 0.62	61.6 ± 0.67	60.8 ± 0.96	63.7 ± 0.44

TABLE A2. GAL LINES - MEAN ADJUSTED FOOD INTAKE (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	74.0 ± 0.60	66.6 ± 0.70	73.0 ± 0.49	71.2 ± 0.35
1	83.0 ± 0.76	74.7 ± 0.76	63.3 ± 0.50	73.6 ± 0.40
2	61.0 ± 0.62	62.4 ± 0.60	55.7 ± 0.58	59.7 ± 0.35
3	63.0 ± 0.53	64.2 ± 0.63	61.2 ± 0.63	62.8 ± 0.35
4	62.0 ± 0.58	63.7 ± 0.58	57.9 ± 0.50	61.2 ± 0.32
5	57.7 ± 0.72	58.6 ± 0.49	61.6 ± 0.51	59.2 ± 0.34
6	64.2 ± 0.56	63.0 ± 0.51	59.9 ± 0.49	62.3 ± 0.30
7	55.4 ± 0.49	60.4 ± 0.38	56.2 ± 0.54	57.3 ± 0.27
8	55.7 ± 0.66	62.7 ± 0.75	56.6 ± 0.69	58.4 ± 0.40
9	59.5 ± 0.60	58.9 ± 0.71	53.3 ± 0.66	57.2 ± 0.38
10	56.3 ± 0.61	59.0 ± 0.81	57.3 ± 0.54	57.5 ± 0.38
11	53.6 ± 0.65	55.3 ± 0.83	52.8 ± 0.57	53.9 ± 0.40

TABLE A3. GAC LINES - MEAN ADJUSTED FOOD INTAKE (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	74.0 ± 0.60	66.6 ± 0.70	73.0 ± 0.49	71.2 ± 0.35
1	80.3 ± 1.09	75.2 ± 0.93	65.2 ± 0.65	73.6 ± 0.52
2	61.7 ± 0.85	64.1 ± 0.72	58.3 ± 0.78	61.4 ± 0.45
3	61.9 ± 0.65	64.0 ± 0.61	62.4 ± 0.82	62.8 ± 0.40
4	63.5 ± 0.81	62.6 ± 0.73	57.1 ± 0.68	62.0 ± 0.43
5	60.3 ± 0.77	60.9 ± 0.80	64.0 ± 0.58	61.8 ± 0.42
6	68.7 ± 0.68	65.1 ± 0.73	63.0 ± 0.63	65.6 ± 0.39
7	59.9 ± 0.75	63.7 ± 0.69	57.1 ± 0.60	60.2 ± 0.39
8	59.0 ± 0.84	63.6 ± 0.78	60.8 ± 0.88	61.1 ± 0.48
9	62.4 ± 1.29	63.1 ± 0.62	59.6 ± 0.74	61.7 ± 0.54
10	62.3 ± 1.04	63.7 ± 1.15	64.0 ± 1.05	63.3 ± 0.62
11	60.7 ± 0.84	59.6 ± 0.90	56.6 ± 1.05	59.0 ± 0.54

TABLE A4. GAH LINES - MEAN FOOD INTAKE OF MALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	76.4 ± 1.15	70.8 ± 0.96	72.3 ± 0.91	73.2 ± 0.58
1	80.3 ± 1.11	70.9 ± 1.49	62.3 ± 1.06	71.2 ± 0.71
2	61.9 ± 1.20	61.0 ± 1.18	62.0 ± 1.04	61.6 ± 0.66
3	61.8 ± 1.28	61.3 ± 1.20	64.4 ± 1.00	62.5 ± 0.67
4	67.0 ± 0.89	68.9 ± 0.86	67.6 ± 0.90	67.8 ± 0.51
5	67.8 ± 0.89	61.8 ± 1.25	71.6 ± 0.78	67.1 ± 0.57
6	73.4 ± 1.04	66.9 ± 0.91	70.8 ± 0.88	70.4 ± 0.55
7	68.2 ± 1.18	68.0 ± 1.20	69.6 ± 0.76	68.6 ± 0.62
8	69.7 ± 1.62	70.3 ± 2.17	72.5 ± 1.06	70.8 ± 0.97
9	72.3 ± 1.17	74.7 ± 1.58	73.9 ± 1.14	73.6 ± 0.76
10	72.2 ± 1.06	74.4 ± 1.14	72.7 ± 1.24	73.1 ± 0.66
11	73.3 ± 1.23	63.4 ± 1.59	64.8 ± 1.68	67.2 ± 0.87

TABLE A5. GAL LINES - MEAN FOOD INTAKE OF MALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	76.4 ± 1.15	70.8 ± 0.96	72.3 ± 0.91	73.2 ± 0.58
1	72.6 ± 1.85	69.8 ± 1.13	61.6 ± 0.79	68.0 ± 0.77
2	59.6 ± 1.06	60.6 ± 0.90	60.2 ± 0.73	60.1 ± 0.52
3	57.0 ± 1.02	60.8 ± 0.94	60.5 ± 0.62	59.4 ± 0.51
4	59.9 ± 0.98	68.1 ± 0.90	62.0 ± 0.80	63.3 ± 0.52
5	58.6 ± 1.01	60.2 ± 0.86	63.0 ± 1.01	60.6 ± 0.56
6	66.2 ± 0.81	64.6 ± 0.82	59.8 ± 0.98	63.5 ± 0.50
7	57.3 ± 1.02	60.1 ± 0.93	59.1 ± 0.90	58.8 ± 0.55
8	60.3 ± 1.30	63.4 ± 0.82	59.0 ± 1.02	60.9 ± 0.61
9	57.2 ± 1.27	66.5 ± 1.56	57.5 ± 1.36	60.4 ± 0.81
10	62.0 ± 0.91	63.0 ± 0.89	59.4 ± 0.88	61.5 ± 0.52
11	57.2 ± 1.15	57.9 ± 1.39	56.1 ± 1.07	57.1 ± 0.70

TABLE A6. GAC LINES - MEAN FOOD INTAKE OF MALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	76.4 ± 1.15	70.8 ± 0.96	72.3 ± 0.91	73.2 ± 0.58
1	75.7 ± 1.81	68.2 ± 2.26	60.1 ± 1.11	68.0 ± 1.03
2	59.7 ± 1.76	61.3 ± 1.17	59.5 ± 1.07	60.2 ± 0.79
3	62.2 ± 1.28	61.3 ± 1.23	62.8 ± 1.24	62.1 ± 0.72
4	65.6 ± 1.44	66.8 ± 1.19	64.8 ± 1.05	65.7 ± 0.71
5	60.3 ± 1.10	60.2 ± 1.01	67.1 ± 0.93	62.5 ± 0.59
6	68.1 ± 1.15	68.2 ± 1.00	63.9 ± 0.92	66.7 ± 0.59
7	62.6 ± 1.32	64.8 ± 0.78	62.1 ± 1.02	63.2 ± 0.61
8	59.8 ± 1.17	63.8 ± 1.70	64.4 ± 1.33	62.7 ± 0.82
9	69.4 ± 1.47	67.1 ± 1.25	67.0 ± 1.66	67.8 ± 0.85
10	63.5 ± 1.55	66.1 ± 1.25	70.4 ± 1.20	66.7 ± 0.77
11	59.0 ± 1.90	57.5 ± 1.45	63.2 ± 1.66	59.9 ± 0.97

TABLE A7. GAH LINES - MEAN FOOD INTAKE OF FEMALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	72.2 ± 1.04	65.4 ± 0.94	70.3 ± 0.78	69.3 ± 0.53
1	77.1 ± 1.18	65.7 ± 1.35	58.5 ± 0.70	67.1 ± 0.64
2	58.2 ± 0.86	57.8 ± 0.75	58.0 ± 0.76	58.0 ± 0.46
3	58.0 ± 0.89	58.7 ± 1.06	62.6 ± 0.74	60.0 ± 0.52
4	64.3 ± 0.66	66.0 ± 0.81	62.2 ± 0.76	64.2 ± 0.43
5	61.6 ± 0.77	57.9 ± 0.75	67.2 ± 0.66	62.2 ± 0.42
6	71.6 ± 0.64	66.9 ± 0.91	69.0 ± 0.80	69.2 ± 0.46
7	66.1 ± 0.96	64.3 ± 0.85	67.3 ± 0.80	65.9 ± 0.50
8	66.2 ± 1.27	68.5 ± 1.05	68.2 ± 1.15	67.6 ± 0.67
9	67.0 ± 1.03	72.3 ± 1.12	71.4 ± 1.43	70.2 ± 0.70
10	68.4 ± 1.03	69.7 ± 1.30	70.5 ± 1.04	69.5 ± 0.65
11	68.0 ± 0.90	60.2 ± 0.97	64.0 ± 0.88	64.1 ± 0.53

TABLE A8. GAL LINES - MEAN FOOD INTAKE OF FEMALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	72.2 ± 1.04	65.4 ± 0.94	70.3 ± 0.78	69.3 ± 0.53
1	71.5 ± 1.62	68.1 ± 1.01	57.4 ± 0.66	65.7 ± 0.67
2	55.0 ± 1.17	57.7 ± 0.78	55.5 ± 0.81	56.1 ± 0.54
3	55.2 ± 0.86	58.3 ± 0.75	55.6 ± 1.06	56.4 ± 0.52
4	56.6 ± 0.92	64.5 ± 0.78	56.2 ± 0.73	59.1 ± 0.47
5	55.2 ± 0.88	57.1 ± 0.71	58.5 ± 0.68	56.9 ± 0.44
6	63.3 ± 0.70	62.0 ± 0.59	56.2 ± 0.73	60.5 ± 0.39
7	54.2 ± 0.87	57.3 ± 0.71	55.4 ± 0.82	55.6 ± 0.46
8	53.0 ± 1.23	60.6 ± 0.92	55.8 ± 0.66	56.5 ± 0.56
9	56.2 ± 0.92	62.6 ± 1.42	53.5 ± 1.14	57.4 ± 0.68
10	54.9 ± 0.55	61.7 ± 0.83	57.5 ± 0.75	58.0 ± 0.42
11	53.8 ± 0.80	54.1 ± 1.09	51.5 ± 0.99	53.1 ± 0.56

TABLE A9. GAC LINES - MEAN FOOD INTAKE OF FEMALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	72.2 ± 1.04	65.4 ± 0.94	70.3 ± 0.78	69.3 ± 0.53
1	73.3 ± 1.41	66.8 ± 1.54	56.0 ± 0.80	65.4 ± 0.75
2	56.9 ± 1.06	57.3 ± 1.15	56.9 ± 0.95	57.0 ± 0.61
3	58.0 ± 1.20	58.6 ± 1.00	59.0 ± 1.16	58.5 ± 0.65
4	59.8 ± 1.43	64.8 ± 1.43	60.3 ± 0.91	61.6 ± 0.74
5	57.6 ± 1.11	57.2 ± 0.66	63.5 ± 0.82	59.4 ± 0.51
6	66.4 ± 1.01	63.1 ± 1.10	61.3 ± 0.84	63.6 ± 0.57
7	57.1 ± 1.08	60.8 ± 1.07	58.7 ± 1.02	58.9 ± 0.61
8	61.4 ± 1.40	63.8 ± 1.00	60.0 ± 1.87	61.7 ± 0.85
9	60.3 ± 1.36	64.5 ± 1.31	61.3 ± 1.54	62.0 ± 0.81
10	61.7 ± 1.04	60.8 ± 1.63	65.1 ± 1.22	62.5 ± 0.76
11	55.5 ± 1.24	57.2 ± 1.14	58.6 ± 1.17	57.1 ± 0.68

TABLE A10. GA LINES - SELECTION DIFFERENTIALS (GRAMS)

GEN.	GAH1	GAH2	GAH3	GAL1	GAL2	GAL3	GAC1	GAC2	GAC3
1	4.51	4.22	4.90	-5.19	-4.94	-4.38	0.10	0.32	-0.30
2	5.66	4.26	3.71	-4.39	-4.15	-2.81	1.71	0.12	0.37
3	2.70	2.25	3.58	-3.91	-2.90	-2.91	-0.23	0.55	-0.56
4	2.10	2.85	3.54	-2.27	-3.31	-3.43	-0.47	-0.46	0.12
5	2.81	3.72	2.93	-3.31	-3.18	-3.35	-0.52	0.63	-0.08
6	2.50	3.06	2.98	-3.60	-3.75	-3.69	0.08	0.11	-0.11
7	3.35	2.70	3.27	-4.01	-3.14	-2.93	0.17	-0.30	-0.43
8	2.78	3.22	3.99	-2.61	-2.46	-2.84	-0.09	0.65	0.44
9	3.67	3.36	4.25	-2.73	-2.79	-2.50	-0.91	-0.46	0.12
10	4.23	2.49	2.73	-2.13	-2.82	-2.96	-0.25	0.19	0.33
11	3.49	3.45	2.53	-3.59	-3.69	-3.62	0.91	1.03	0.34

TABLE A11. GFH LINES - MEAN GONADAL FAT PAD WT / BODY WT (MG/G)

GENERATION	GFH1	GFH2	GFH3	GFH mean
0	14.6 ± 0.48	13.9 ± 0.54	11.8 ± 0.42	13.4 ± 0.28
1	12.9 ± 0.57	15.2 ± 0.64	12.8 ± 0.50	13.6 ± 0.33
2	12.8 ± 0.45	12.9 ± 0.49	11.1 ± 0.42	12.3 ± 0.26
3	11.0 ± 0.56	11.7 ± 0.54	10.3 ± 0.39	11.0 ± 0.29
4	10.0 ± 0.31	10.9 ± 0.37	11.0 ± 0.31	10.7 ± 0.19
5	10.1 ± 0.32	8.6 ± 0.32	9.6 ± 0.40	9.4 ± 0.20
6	10.2 ± 0.35	9.4 ± 0.27	9.2 ± 0.42	9.5 ± 0.20
7	9.0 ± 0.34	9.2 ± 0.25	8.5 ± 0.32	8.9 ± 0.18
8	9.2 ± 0.44	8.2 ± 0.28	9.2 ± 0.34	8.9 ± 0.21
9	8.3 ± 0.56	7.9 ± 0.29	7.5 ± 0.33	7.9 ± 0.24
10	8.0 ± 0.49	8.6 ± 0.26	9.4 ± 0.51	8.7 ± 0.25
11	8.1 ± 0.28	7.6 ± 0.56	8.4 ± 0.53	8.0 ± 0.27

TABLE A12. GFL LINES - MEAN GONADAL FAT PAD WT / BODY WT (MG/G)

GENERATION	GFL1	GFL2	GFL3	GFL mean
0	14.6 ± 0.48	13.9 ± 0.54	11.8 ± 0.42	13.4 ± 0.28
1	14.4 ± 0.44	15.6 ± 0.64	15.8 ± 0.61	15.3 ± 0.33
2	15.5 ± 0.58	16.1 ± 0.68	13.6 ± 0.54	15.1 ± 0.35
3	16.0 ± 0.72	15.3 ± 0.48	14.8 ± 0.65	15.4 ± 0.36
4	17.8 ± 0.66	17.3 ± 0.63	15.8 ± 0.69	17.0 ± 0.38
5	19.0 ± 0.68	14.7 ± 0.50	15.1 ± 0.62	16.3 ± 0.35
6	18.8 ± 0.73	17.6 ± 0.59	14.4 ± 0.43	17.0 ± 0.34
7	18.0 ± 0.73	18.5 ± 0.48	17.0 ± 0.63	17.8 ± 0.36
8	16.9 ± 0.80	16.6 ± 0.82	18.5 ± 1.26	17.4 ± 0.57
9	17.3 ± 0.78	23.2 ± 1.35	20.2 ± 2.00	20.2 ± 0.85
10	19.8 ± 1.32	20.6 ± 0.76	21.2 ± 0.73	20.5 ± 0.56
11	19.2 ± 0.88	21.1 ± 0.94	18.0 ± 0.84	19.5 ± 0.51

TABLE A13. GFC LINES - MEAN GONADAL FAT PAD WT / BODY WT (MG/G)

GENERATION	GFC1	GFC2	GFC3	GFC mean
0	14.6 ± 0.48	13.9 ± 0.42	11.8 ± 0.42	13.4 ± 0.25
1	13.7 ± 0.72	14.5 ± 0.75	12.8 ± 0.77	13.7 ± 0.43
2	14.3 ± 0.79	15.3 ± 0.74	13.9 ± 0.83	14.5 ± 0.45
3	13.1 ± 0.54	13.5 ± 0.47	13.2 ± 0.46	13.3 ± 0.28
4	15.3 ± 0.79	14.5 ± 0.68	13.8 ± 0.79	14.5 ± 0.44
5	14.1 ± 1.02	12.8 ± 0.70	15.2 ± 0.85	14.0 ± 0.50
6	14.9 ± 0.88	14.6 ± 0.59	13.8 ± 0.79	14.4 ± 0.44
7	13.1 ± 0.55	14.7 ± 0.84	13.7 ± 0.86	13.8 ± 0.44
8	12.1 ± 0.60	12.5 ± 0.87	14.9 ± 1.14	13.1 ± 0.52
9	11.5 ± 0.92	15.9 ± 1.15	13.4 ± 0.74	13.6 ± 0.55
10	14.2 ± 1.46	12.6 ± 0.73	15.1 ± 1.55	14.0 ± 0.75
11	13.3 ± 0.99	14.0 ± 0.49	15.6 ± 1.23	14.3 ± 0.55

TABLE A14. GF LINES - SELECTION DIFFERENTIALS (MG/G)

GEN.	GFH1	GFH2	GFH3	GFL1	GFL2	GFL3	GFC1	GFC2	GFC3
1	-1.71	-1.95	-1.55	1.94	2.12	1.99	-0.04	0.02	-0.01
2	-1.17	-1.46	-1.48	1.35	1.40	1.93	-0.51	0.21	0.38
3	-1.29	-0.91	-0.98	1.67	1.62	1.18	0.38	0.12	0.52
4	-1.06	-0.97	-0.64	1.52	1.13	1.28	0.47	-0.50	0.77
5	-1.01	-0.76	-0.81	1.50	1.73	2.12	0.37	-0.27	0.24
6	-0.84	-0.80	-0.96	1.93	1.42	1.76	0.06	-0.44	0.52
7	-0.92	-0.71	-1.10	1.33	1.26	1.28	0.29	0.02	0.61
8	-0.97	-0.63	-0.75	1.66	1.24	0.62	-0.38	-0.23	0.40
9	-0.94	-0.72	-0.94	1.55	1.36	2.09	-0.30	0.71	-0.39
10	-0.84	-0.52	-0.58	1.16	1.85	1.01	-0.01	-0.27	0.02
11	-0.67	-0.47	-1.03	1.22	1.80	1.62	-0.16	-0.44	0.00

TABLE A15. GPH LINES - MEAN (BODY WT - 8 X GONADAL FAT PAD WT)(G)

GENERATION	GPH1	GPH2	GPH3	GPH mean
0	29.7 $\pm$ 0.35	29.0 $\pm$ 0.33	28.6 $\pm$ 0.31	29.1 $\pm$ 0.19
1	28.3 $\pm$ 0.30	28.9 $\pm$ 0.43	29.2 $\pm$ 0.37	28.8 $\pm$ 0.21
2	29.7 $\pm$ 0.40	29.7 $\pm$ 0.40	28.2 $\pm$ 0.35	29.2 $\pm$ 0.22
3	28.2 $\pm$ 0.38	29.6 $\pm$ 0.50	30.9 $\pm$ 0.42	29.6 $\pm$ 0.25
4	30.8 $\pm$ 0.39	31.9 $\pm$ 0.49	32.7 $\pm$ 0.51	31.8 $\pm$ 0.27
5	32.4 $\pm$ 0.39	32.6 $\pm$ 0.43	33.2 $\pm$ 0.38	32.8 $\pm$ 0.23
6	31.5 $\pm$ 0.34	32.2 $\pm$ 0.40	31.0 $\pm$ 0.50	31.6 $\pm$ 0.24
7	32.8 $\pm$ 0.44	32.6 $\pm$ 0.50	33.6 $\pm$ 0.42	33.0 $\pm$ 0.26
8	35.0 $\pm$ 0.71	34.4 $\pm$ 0.72	33.0 $\pm$ 0.68	34.1 $\pm$ 0.41
9	33.6 $\pm$ 0.54	33.9 $\pm$ 0.69	34.0 $\pm$ 0.59	33.8 $\pm$ 0.35
10	36.0 $\pm$ 0.74	33.6 $\pm$ 1.06	34.7 $\pm$ 0.51	34.8 $\pm$ 0.46
11	37.5 $\pm$ 0.62	34.7 $\pm$ 0.57	36.1 $\pm$ 0.77	36.1 $\pm$ 0.38

TABLE A16. GPL LINES - MEAN (BODY WT - 8 X GONADAL FAT PAD WT)(G)

GENERATION	GPL1	GPL2	GPL3	GPL mean
0	29.7 ± 0.35	29.0 ± 0.33	28.6 ± 0.31	29.1 ± 0.19
1	28.4 ± 0.37	27.3 ± 0.36	27.7 ± 0.47	27.8 ± 0.23
2	27.4 ± 0.28	26.7 ± 0.38	26.2 ± 0.34	26.8 ± 0.19
3	26.2 ± 0.38	24.4 ± 0.21	26.0 ± 0.28	25.5 ± 0.17
4	27.4 ± 0.43	27.5 ± 0.35	28.1 ± 0.33	27.7 ± 0.22
5	27.7 ± 0.32	26.8 ± 0.26	27.3 ± 0.33	27.3 ± 0.17
6	26.5 ± 0.27	25.8 ± 0.26	25.8 ± 0.26	26.0 ± 0.15
7	26.8 ± 0.34	25.1 ± 0.29	26.9 ± 0.30	26.2 ± 0.18
8	26.9 ± 0.56	24.7 ± 0.32	26.6 ± 0.32	26.0 ± 0.24
9	28.2 ± 0.58	24.6 ± 0.45	25.3 ± 0.37	26.0 ± 0.24
10	26.7 ± 0.48	24.5 ± 0.40	25.5 ± 0.37	25.6 ± 0.24
11	25.6 ± 0.37	24.5 ± 0.29	24.2 ± 0.40	24.8 ± 0.21

TABLE A17. GPC LINES - MEAN (BODY WT - 8 X GONADAL FAT PAD WT)(G)

GENERATION	GPC1	GPC2	GPC3	GPC mean
0	29.7 ± 0.35	29.0 ± 0.33	28.6 ± 0.31	29.1 ± 0.19
1	27.6 ± 0.52	27.0 ± 0.45	27.9 ± 0.55	27.5 ± 0.29
2	27.4 ± 0.46	27.8 ± 0.50	28.2 ± 0.60	27.8 ± 0.30
3	26.0 ± 0.42	28.5 ± 0.44	28.9 ± 0.54	27.8 ± 0.27
4	28.6 ± 0.44	30.3 ± 0.56	31.3 ± 0.62	30.1 ± 0.31
5	28.6 ± 0.37	31.8 ± 0.56	30.1 ± 0.49	30.2 ± 0.28
6	27.1 ± 0.56	29.7 ± 0.51	29.4 ± 0.43	28.7 ± 0.29
7	27.5 ± 0.46	28.9 ± 0.59	29.8 ± 0.78	28.7 ± 0.36
8	28.0 ± 0.85	30.9 ± 0.65	28.8 ± 0.54	29.2 ± 0.40
9	28.7 ± 1.28	31.3 ± 0.82	30.8 ± 0.65	30.2 ± 0.55
10	27.9 ± 0.76	29.1 ± 0.82	30.0 ± 0.50	29.0 ± 0.41
11	26.7 ± 0.48	29.7 ± 0.74	29.0 ± 0.73	28.5 ± 0.38

TABLE A18. GP LINES - MEAN GONADAL FAT PAD WT / BODY WT (MG/G)

GENERATION	GPH mean	GPC mean	GPL mean
0	13.4 ± 0.25	13.4 ± 0.25	13.4 ± 0.25
1	13.6 ± 0.32	14.5 ± 0.48	13.5 ± 0.30
2	15.0 ± 0.32	13.8 ± 0.37	14.2 ± 0.34
3	14.1 ± 0.36	13.2 ± 0.38	12.6 ± 0.32
4	13.9 ± 0.34	14.4 ± 0.47	12.8 ± 0.40
5	13.2 ± 0.30	13.9 ± 0.38	12.6 ± 0.28
6	13.6 ± 0.28	14.4 ± 0.45	13.0 ± 0.26
7	13.6 ± 0.30	13.7 ± 0.49	15.2 ± 0.33
8	13.4 ± 0.47	13.5 ± 0.73	12.9 ± 0.45
9	13.1 ± 0.41	13.7 ± 0.58	14.7 ± 0.53
10	13.9 ± 0.45	13.2 ± 0.32	16.3 ± 0.50
11	12.5 ± 0.34	12.3 ± 0.59	13.7 ± 0.46

TABLE A19. GP LINES - SELECTION DIFFERENTIALS (GRAMS)

GEN.	GPH1	GPH2	GPH3	GPL1	GPL2	GPL3	GPC1	GPC2	GPC3
1	1.19	1.26	1.16	-1.31	-1.30	-0.91	-0.08	0.06	0.04
2	0.88	0.93	0.95	-0.63	-0.96	-1.15	0.38	0.05	0.13
3	1.01	1.07	0.77	-0.61	-0.82	-0.80	-0.07	0.15	0.08
4	0.97	0.90	1.10	-0.55	-0.53	-0.69	0.21	0.31	-0.04
5	1.38	0.86	1.07	-0.85	-0.39	-0.72	0.25	0.34	-0.14
6	1.30	1.49	1.06	-0.80	-0.66	-0.98	-0.13	-0.01	0.13
7	1.03	0.71	1.00	-0.82	-0.82	-0.90	0.28	0.21	-0.13
8	1.10	0.21	1.34	-0.72	-0.54	-0.23	-0.76	0.32	0.09
9	1.07	0.73	1.14	-0.95	-0.71	-0.63	-0.10	-0.97	-0.28
10	1.11	1.11	1.61	-0.67	-0.66	-0.81	-0.10	0.09	0.67
11	1.40	0.98	1.10	-0.81	-1.18	-0.45	-0.08	0.56	0.12

TABLE A20. GAH LINES - MEAN 4 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	18.0 ± 0.33	18.5 ± 0.29	16.8 ± 0.37	17.8 ± 0.19
1	15.0 ± 0.42	13.7 ± 0.44	15.0 ± 0.41	14.6 ± 0.24
2	15.6 ± 0.62	15.3 ± 0.65	17.6 ± 0.41	16.2 ± 0.33
3	14.5 ± 0.55	15.0 ± 0.38	16.6 ± 0.40	15.4 ± 0.26
4	17.8 ± 0.40	18.6 ± 0.37	18.6 ± 0.49	18.3 ± 0.24
5	18.2 ± 0.48	16.1 ± 0.62	20.0 ± 0.33	18.1 ± 0.28
6	17.7 ± 0.44	16.9 ± 0.47	17.5 ± 0.37	17.4 ± 0.25
7	17.3 ± 0.60	16.8 ± 0.58	19.1 ± 0.39	17.7 ± 0.31
8	19.2 ± 0.95	19.6 ± 1.08	19.7 ± 0.47	19.5 ± 0.50
9	18.0 ± 0.73	20.6 ± 0.74	20.5 ± 0.55	19.7 ± 0.39
10	18.8 ± 0.49	21.2 ± 0.54	20.2 ± 0.61	20.1 ± 0.32
11	18.7 ± 0.70	17.6 ± 0.70	19.6 ± 1.01	18.6 ± 0.47

TABLE A21. GAL LINES - MEAN 4 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	18.0 ± 0.33	18.5 ± 0.29	16.8 ± 0.37	17.8 ± 0.19
1	12.4 ± 0.50	14.6 ± 0.45	15.9 ± 0.36	14.3 ± 0.25
2	15.8 ± 0.49	16.0 ± 0.41	18.3 ± 0.36	16.7 ± 0.24
3	13.8 ± 0.42	14.8 ± 0.40	15.9 ± 0.25	14.8 ± 0.21
4	15.5 ± 0.36	18.7 ± 0.46	18.8 ± 0.37	17.7 ± 0.23
5	17.1 ± 0.30	17.6 ± 0.33	17.1 ± 0.48	17.3 ± 0.22
6	18.0 ± 0.43	17.0 ± 0.31	16.6 ± 0.40	17.2 ± 0.22
7	17.9 ± 0.37	16.7 ± 0.44	18.0 ± 0.54	17.5 ± 0.26
8	19.2 ± 0.58	16.8 ± 0.54	18.0 ± 0.54	18.0 ± 0.32
9	15.7 ± 0.50	20.8 ± 0.61	19.0 ± 0.54	18.5 ± 0.32
10	19.1 ± 0.35	18.8 ± 0.70	18.3 ± 0.42	18.7 ± 0.30
11	18.7 ± 0.61	17.7 ± 0.53	18.8 ± 0.54	18.4 ± 0.32

TABLE A22. GAC LINES - MEAN 4 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	18.0 ± 0.33	18.5 ± 0.29	16.8 ± 0.37	17.8 ± 0.19
1	14.8 ± 0.50	14.4 ± 0.70	14.5 ± 0.54	14.6 ± 0.34
2	16.0 ± 0.72	15.4 ± 0.58	17.4 ± 0.48	16.3 ± 0.35
3	16.6 ± 0.48	15.1 ± 0.46	16.9 ± 0.48	16.2 ± 0.27
4	17.3 ± 0.53	19.3 ± 0.40	20.8 ± 0.52	19.1 ± 0.28
5	16.8 ± 0.56	16.3 ± 0.53	18.3 ± 0.52	17.1 ± 0.31
6	16.8 ± 0.66	18.4 ± 0.49	17.6 ± 0.60	17.6 ± 0.34
7	17.5 ± 0.66	16.9 ± 0.31	19.7 ± 0.43	18.0 ± 0.28
8	17.4 ± 0.66	17.4 ± 0.71	18.6 ± 0.75	17.8 ± 0.41
9	19.1 ± 0.32	18.9 ± 0.68	20.4 ± 0.66	19.5 ± 0.33
10	17.5 ± 0.60	17.4 ± 0.47	19.3 ± 0.48	18.1 ± 0.30
11	16.0 ± 0.91	16.1 ± 0.50	19.8 ± 0.93	17.3 ± 0.46

TABLE A23. GAH LINES - MEAN 4 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	16.1 ± 0.24	16.6 ± 0.22	15.7 ± 0.30	16.1 ± 0.15
1	13.5 ± 0.32	12.6 ± 0.46	14.6 ± 0.31	13.6 ± 0.21
2	15.4 ± 0.54	15.0 ± 0.46	16.4 ± 0.38	15.6 ± 0.27
3	14.6 ± 0.49	14.3 ± 0.28	16.4 ± 0.31	15.1 ± 0.21
4	16.3 ± 0.37	17.7 ± 0.37	17.7 ± 0.40	17.2 ± 0.22
5	16.4 ± 0.31	15.4 ± 0.38	18.2 ± 0.27	16.7 ± 0.16
6	17.4 ± 0.28	16.4 ± 0.40	17.5 ± 0.33	17.1 ± 0.20
7	17.5 ± 0.56	15.8 ± 0.38	18.4 ± 0.40	17.2 ± 0.26
8	17.8 ± 0.60	17.7 ± 0.55	17.6 ± 0.45	17.7 ± 0.31
9	17.1 ± 0.51	19.1 ± 0.64	19.5 ± 0.64	18.6 ± 0.35
10	18.3 ± 0.40	18.8 ± 0.59	20.0 ± 0.58	19.0 ± 0.31
11	17.3 ± 0.45	16.6 ± 0.55	18.0 ± 0.77	17.3 ± 0.35

TABLE A24. GAL LINES - MEAN 4 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	16.1 ± 0.24	16.6 ± 0.22	15.7 ± 0.30	16.1 ± 0.15
1	12.2 ± 0.46	14.4 ± 0.46	14.8 ± 0.31	13.8 ± 0.24
2	15.0 ± 0.42	15.0 ± 0.42	17.5 ± 0.37	15.8 ± 0.23
3	13.6 ± 0.39	14.5 ± 0.32	15.5 ± 0.27	14.5 ± 0.19
4	14.8 ± 0.30	17.8 ± 0.33	16.3 ± 0.30	16.3 ± 0.18
5	16.3 ± 0.32	16.5 ± 0.31	15.9 ± 0.33	16.2 ± 0.18
6	16.4 ± 0.25	17.5 ± 0.29	15.4 ± 0.34	16.4 ± 0.17
7	16.7 ± 0.36	15.3 ± 0.41	17.0 ± 0.35	16.3 ± 0.22
8	15.9 ± 0.59	16.8 ± 0.68	16.6 ± 0.35	16.4 ± 0.32
9	15.6 ± 0.45	18.9 ± 0.42	17.5 ± 0.39	17.3 ± 0.24
10	16.8 ± 0.33	18.8 ± 0.38	16.7 ± 0.25	17.4 ± 0.19
11	17.2 ± 0.44	17.2 ± 0.39	16.2 ± 0.32	16.9 ± 0.22

TABLE A25. GAC LINES - MEAN 4 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	16.1 ± 0.24	16.6 ± 0.22	15.7 ± 0.30	16.1 ± 0.15
1	14.1 ± 0.44	12.9 ± 0.52	13.3 ± 0.46	13.4 ± 0.27
2	15.0 ± 0.63	14.4 ± 0.51	16.4 ± 0.40	15.3 ± 0.30
3	15.5 ± 0.50	14.7 ± 0.38	15.4 ± 0.41	15.2 ± 0.25
4	15.7 ± 0.66	17.9 ± 0.49	18.7 ± 0.37	17.4 ± 0.30
5	16.0 ± 0.48	15.5 ± 0.35	17.0 ± 0.24	16.2 ± 0.21
6	15.8 ± 0.44	16.0 ± 0.60	15.9 ± 0.57	15.9 ± 0.31
7	16.2 ± 0.46	16.3 ± 0.48	17.6 ± 0.41	16.7 ± 0.26
8	18.4 ± 0.44	16.8 ± 0.61	16.8 ± 1.06	17.3 ± 0.43
9	17.2 ± 0.55	17.8 ± 0.67	18.1 ± 0.58	17.7 ± 0.35
10	16.9 ± 0.62	16.2 ± 0.45	18.6 ± 0.64	17.3 ± 0.33
11	14.3 ± 0.76	15.7 ± 0.52	18.6 ± 0.79	16.2 ± 0.40

TABLE A26. GAH LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	26.6 ± 0.44	27.0 ± 0.40	25.7 ± 0.36	26.4 ± 0.23
1	26.3 ± 0.47	23.9 ± 0.50	25.8 ± 0.52	25.3 ± 0.29
2	25.3 ± 0.60	25.5 ± 0.61	26.1 ± 0.49	25.6 ± 0.33
3	24.6 ± 0.51	23.9 ± 0.42	26.1 ± 0.53	24.9 ± 0.28
4	26.7 ± 0.36	27.6 ± 0.38	28.6 ± 0.46	27.6 ± 0.23
5	29.3 ± 0.45	26.7 ± 0.60	29.3 ± 0.35	28.4 ± 0.28
6	27.8 ± 0.42	27.5 ± 0.45	28.1 ± 0.41	27.8 ± 0.25
7	28.0 ± 0.44	27.8 ± 0.56	28.4 ± 0.39	28.1 ± 0.27
8	29.0 ± 0.73	29.3 ± 0.80	29.5 ± 0.39	29.3 ± 0.38
9	28.9 ± 1.13	31.0 ± 0.75	30.1 ± 0.60	30.0 ± 0.49
10	29.9 ± 0.48	31.0 ± 0.53	30.5 ± 0.69	30.5 ± 0.33
11	30.4 ± 0.59	27.7 ± 0.66	28.3 ± 1.00	28.8 ± 0.45

TABLE A27. GAL LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	26.6 ± 0.44	27.0 ± 0.40	25.7 ± 0.36	26.4 ± 0.23
1	22.8 ± 0.63	25.3 ± 0.37	25.8 ± 0.43	24.6 ± 0.28
2	23.8 ± 0.50	24.8 ± 0.49	24.7 ± 0.33	24.4 ± 0.26
3	22.6 ± 0.47	23.5 ± 0.35	24.2 ± 0.30	23.4 ± 0.22
4	23.8 ± 0.47	27.6 ± 0.42	26.9 ± 0.42	26.1 ± 0.25
5	25.8 ± 0.42	26.8 ± 0.40	26.0 ± 0.50	26.2 ± 0.26
6	26.1 ± 0.38	26.0 ± 0.31	24.7 ± 0.43	25.6 ± 0.22
7	24.4 ± 0.47	25.7 ± 0.45	24.6 ± 0.51	24.9 ± 0.28
8	25.5 ± 0.69	25.9 ± 0.44	24.7 ± 0.59	25.4 ± 0.34
9	24.5 ± 0.66	28.9 ± 0.72	25.4 ± 0.70	26.3 ± 0.40
10	26.4 ± 0.30	27.5 ± 0.48	25.5 ± 0.46	26.5 ± 0.24
11	25.2 ± 0.48	26.6 ± 0.72	25.0 ± 0.63	25.6 ± 0.36

TABLE A28. GAC LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	26.6 ± 0.44	27.0 ± 0.40	25.7 ± 0.36	26.4 ± 0.23
1	25.9 ± 0.61	23.9 ± 0.75	24.6 ± 0.61	24.8 ± 0.38
2	24.5 ± 0.72	25.2 ± 0.55	25.0 ± 0.53	24.9 ± 0.35
3	24.4 ± 0.51	23.8 ± 0.58	25.4 ± 0.66	24.5 ± 0.34
4	26.5 ± 0.54	26.7 ± 0.61	28.7 ± 0.52	27.3 ± 0.32
5	26.1 ± 0.51	25.9 ± 0.51	27.4 ± 0.38	26.5 ± 0.27
6	26.3 ± 0.54	27.6 ± 0.48	26.0 ± 0.55	26.6 ± 0.30
7	26.1 ± 0.60	26.2 ± 0.40	26.7 ± 0.49	26.3 ± 0.29
8	24.6 ± 0.74	26.1 ± 0.89	27.6 ± 0.75	26.1 ± 0.46
9	28.4 ± 0.43	27.7 ± 0.66	29.1 ± 0.86	28.4 ± 0.39
10	26.4 ± 0.44	25.9 ± 0.55	29.3 ± 0.64	27.2 ± 0.32
11	25.5 ± 0.88	25.2 ± 0.77	28.7 ± 0.81	26.5 ± 0.47

TABLE A29. GAH LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	22.7 ± 0.27	23.0 ± 0.32	22.1 ± 0.26	22.6 ± 0.16
1	23.0 ± 0.34	20.3 ± 0.41	22.8 ± 0.33	22.0 ± 0.21
2	22.3 ± 0.39	22.0 ± 0.38	22.4 ± 0.35	22.2 ± 0.22
3	21.9 ± 0.38	21.1 ± 0.30	23.5 ± 0.33	22.2 ± 0.20
4	23.7 ± 0.27	24.1 ± 0.39	24.7 ± 0.31	24.2 ± 0.19
5	24.7 ± 0.36	23.0 ± 0.32	24.7 ± 0.26	24.1 ± 0.18
6	24.7 ± 0.32	24.3 ± 0.33	25.4 ± 0.34	24.8 ± 0.19
7	24.8 ± 0.41	24.3 ± 0.33	24.8 ± 0.36	24.6 ± 0.21
8	24.5 ± 0.47	24.8 ± 0.48	24.6 ± 0.52	24.6 ± 0.28
9	25.4 ± 0.35	26.5 ± 0.43	26.4 ± 0.62	26.1 ± 0.28
10	25.7 ± 0.50	25.7 ± 0.48	26.7 ± 0.56	26.0 ± 0.30
11	26.0 ± 0.40	24.5 ± 0.41	25.1 ± 0.48	25.2 ± 0.25

TABLE A30. GAL LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	22.7 ± 0.27	23.0 ± 0.32	22.1 ± 0.26	22.6 ± 0.16
1	20.7 ± 0.49	22.0 ± 0.28	21.4 ± 0.27	21.4 ± 0.21
2	20.6 ± 0.45	21.8 ± o.32	21.9 ± 0.36	21.4 ± 0.20
3	20.2 ± 0.35	21.0 ± 0.21	20.8 ± 0.54	20.7 ± 0.23
4	20.8 ± 0.33	23.6 ± 0.29	22.9 ± 0.32	22.4 ± 0.18
5	22.7 ± 0.35	23.0 ± 0.31	22.2 ± 0.28	22.6 ± 0.18
6	22.0 ± 0.25	22.8 ± 0.24	21.2 ± 0.36	22.0 ± 0.17
7	21.4 ± 0.33	22.5 ± 0.28	21.1 ± 0.37	21.7 ± 0.19
8	20.3 ± 0.64	22.8 ± 0.49	21.6 ± 0.27	21.6 ± 0.28
9	21.4 ± 0.35	23.3 ± 0.34	21.9 ± 0.42	22.2 ± 0.21
10	21.5 ± 0.33	24.8 ± 0.36	21.3 ± 0.38	22.5 ± 0.21
11	21.5 ± 0.42	22.4 ± 0.39	20.6 ± 0.45	21.5 ± 0.24

TABLE A31. GAC LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	22.7 ± 0.27	23.0 ± 0.32	22.1 ± 0.26	22.6 ± 0.15
1	22.7 ± 0.46	21.0 ± 0.45	21.5 ± 0.45	21.7 ± 0.26
2	21.6 ± 0.44	21.5 ± 0.38	21.8 ± 0.42	21.6 ± 0.24
3	21.4 ± 0.46	21.0 ± 0.40	22.1 ± 0.60	21.5 ± 0.29
4	21.5 ± 0.54	23.4 ± 0.55	24.2 ± 0.40	23.0 ± 0.29
5	22.7 ± 0.33	22.9 ± 0.25	23.4 ± 0.32	23.0 ± 0.17
6	22.7 ± 0.49	22.7 ± 0.51	22.2 ± 0.39	22.5 ± 0.27
7	22.1 ± 0.37	22.9 ± 0.46	22.8 ± 0.46	22.6 ± 0.25
8	22.9 ± 0.50	22.7 ± 0.57	23.0 ± 0.82	22.9 ± 0.37
9	23.2 ± 0.49	23.1 ± 0.60	23.6 ± 0.61	23.3 ± 0.33
10	23.3 ± 0.46	22.2 ± 0.53	24.6 ± 0.45	23.4 ± 0.28
11	21.4 ± 0.42	22.5 ± 0.49	24.6 ± 0.55	22.8 ± 0.28

TABLE A32. GA LINES - 4 TO 6 WEEK GAIN OF FEMALES (GRAMS)

GENERATION	GAH mean	GAC mean	GAL mean
0	6.5 ± 0.22	6.5 ± 0.22	6.5 ± 0.22
1	8.4 ± 0.30	8.4 ± 0.37	7.6 ± 0.32
2	6.6 ± 0.35	6.3 ± 0.38	5.6 ± 0.30
3	7.1 ± 0.29	6.3 ± 0.38	6.2 ± 0.30
4	7.0 ± 0.29	5.4 ± 0.42	6.1 ± 0.25
5	7.4 ± 0.24	6.8 ± 0.27	6.4 ± 0.25
6	7.7 ± 0.28	6.6 ± 0.41	5.6 ± 0.24
7	7.4 ± 0.43	5.9 ± 0.36	5.4 ± 0.29
8	6.9 ± 0.42	5.6 ± 0.57	5.2 ± 0.43
9	7.5 ± 0.44	5.6 ± 0.48	4.9 ± 0.32
10	7.0 ± 0.43	6.1 ± 0.43	5.1 ± 0.28
11	7.9 ± 0.43	6.6 ± 0.49	4.6 ± 0.32

TABLE A33. GA LINES - 4 TO 6 WEEK GAIN OF MALES (GRAMS)

GENERATION	GAH mean	GAC mean	GAL mean
0	8.6 ± 0.30	8.6 ± 0.30	8.6 ± 0.30
1	10.7 ± 0.38	10.2 ± 0.51	10.3 ± 0.38
2	9.4 ± 0.47	8.6 ± 0.49	7.7 ± 0.35
3	9.5 ± 0.38	8.3 ± 0.43	8.6 ± 0.30
4	9.3 ± 0.33	8.2 ± 0.43	8.4 ± 0.34
5	10.3 ± 0.40	9.4 ± 0.41	8.9 ± 0.34
6	10.4 ± 0.35	9.0 ± 0.45	8.4 ± 0.31
7	10.4 ± 0.41	8.3 ± 0.40	7.4 ± 0.38
8	9.8 ± 0.63	8.3 ± 0.62	7.4 ± 0.47
9	10.3 ± 0.63	8.9 ± 0.51	7.8 ± 0.51
10	10.4 ± 0.46	9.1 ± 0.44	7.8 ± 0.38
11	10.2 ± 0.65	9.2 ± 0.66	7.2 ± 0.48

TABLE A34. GAH LINES - MEAN EFFICIENCY OF MALES (%)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	11.3 ± 0.35	11.9 ± 0.38	12.5 ± 0.41	11.9 ± 0.22
1	14.0 ± 0.41	14.4 ± 0.55	17.4 ± 0.49	15.3 ± 0.28
2	15.9 ± 0.77	17.1 ± 0.66	13.8 ± 0.42	15.6 ± 0.37
3	16.5 ± 0.64	14.8 ± 0.46	14.9 ± 0.50	15.4 ± 0.31
4	13.3 ± 0.40	13.2 ± 0.43	14.9 ± 0.51	13.8 ± 0.26
5	16.5 ± 0.44	17.5 ± 0.69	13.2 ± 0.45	15.7 ± 0.31
6	13.8 ± 0.50	15.5 ± 0.45	15.1 ± 0.37	14.8 ± 0.26
7	15.9 ± 0.48	16.4 ± 0.53	13.5 ± 0.43	15.3 ± 0.28
8	14.5 ± 0.73	14.5 ± 1.27	13.6 ± 0.50	14.2 ± 0.52
9	15.4 ± 0.42	14.1 ± 0.69	13.0 ± 0.62	14.2 ± 0.34
10	15.4 ± 0.52	13.2 ± 0.53	14.0 ± 0.59	14.2 ± 0.32
11	16.1 ± 0.67	16.1 ± 0.67	13.4 ± 0.79	15.2 ± 0.41

TABLE A35. GAL LINES - MEAN EFFICIENCY OF MALES (%)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	11.3 ± 0.35	11.9 ± 0.38	12.5 ± 0.41	11.9 ± 0.22
1	14.6 ± 0.47	15.5 ± 0.60	16.1 ± 0.39	15.4 ± 0.29
2	13.5 ± 0.51	14.6 ± 0.49	10.6 ± 0.38	12.9 ± 0.27
3	15.4 ± 0.46	14.4 ± 0.45	13.7 ± 0.31	14.5 ± 0.24
4	13.8 ± 0.48	13.0 ± 0.47	13.2 ± 0.38	13.3 ± 0.26
5	14.5 ± 0.72	15.3 ± 0.38	14.4 ± 0.45	14.7 ± 0.31
6	12.2 ± 0.50	13.5 ± 0.52	13.8 ± 0.45	13.3 ± 0.28
7	11.3 ± 0.38	15.2 ± 0.49	11.2 ± 0.49	12.6 ± 0.26
8	10.5 ± 0.55	14.5 ± 0.53	11.2 ± 0.63	12.1 ± 0.33
9	15.3 ± 0.60	12.1 ± 0.48	11.2 ± 0.52	12.9 ± 0.31
10	11.7 ± 0.46	13.9 ± 0.79	12.1 ± 0.52	12.6 ± 0.35
11	11.5 ± 0.72	15.3 ± 0.65	11.1 ± 0.57	12.6 ± 0.38

TABLE A36. GAC LINES - MEAN EFFICIENCY OF MALES (%)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	11.3 ± 0.35	11.9 ± 0.38	12.5 ± 0.41	11.9 ± 0.22
1	14.5 ± 0.54	13.9 ± 0.95	17.0 ± 0.80	15.1 ± 0.45
2	14.4 ± 0.82	16.1 ± 0.74	12.7 ± 0.69	14.4 ± 0.43
3	12.5 ± 0.60	14.1 ± 0.46	13.5 ± 0.67	13.4 ± 0.34
4	14.3 ± 0.54	11.1 ± 0.53	12.3 ± 0.53	12.6 ± 0.31
5	15.5 ± 0.65	16.0 ± 0.81	13.6 ± 0.47	15.0 ± 0.33
6	14.0 ± 0.72	13.5 ± 0.52	13.4 ± 0.56	13.6 ± 0.35
7	14.0 ± 0.88	14.3 ± 0.45	11.3 ± 0.53	13.2 ± 0.37
8	12.0 ± 0.69	13.6 ± 0.52	14.0 ± 0.81	13.2 ± 0.39
9	13.4 ± 0.47	13.1 ± 0.70	13.1 ± 0.58	13.2 ± 0.34
10	14.0 ± 0.70	12.8 ± 0.76	14.2 ± 0.62	13.7 ± 0.40
11	16.4 ± 1.04	15.8 ± 0.78	14.3 ± 0.81	15.5 ± 0.51

TABLE A37. GAH LINES - MEAN EFFICIENCY OF FEMALES (%)

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	9.1 ± 0.27	9.7 ± 0.34	9.3 ± 0.35	9.4 ± 0.19
1	12.3 ± 0.40	12.1 ± 0.64	14.0 ± 0.49	12.8 ± 0.30
2	12.2 ± 0.77	12.2 ± 0.60	10.4 ± 0.53	11.6 ± 0.37
3	12.7 ± 0.55	11.8 ± 0.43	11.5 ± 0.36	12.0 ± 0.26
4	11.5 ± 0.54	9.8 ± 0.51	11.5 ± 0.60	10.9 ± 0.32
5	13.5 ± 0.58	13.1 ± 0.52	9.7 ± 0.38	12.1 ± 0.29
6	10.3 ± 0.43	12.0 ± 0.52	11.4 ± 0.32	11.2 ± 0.25
7	11.2 ± 0.56	13.5 ± 0.49	9.6 ± 0.45	11.4 ± 0.29
8	10.4 ± 0.81	10.4 ± 0.76	10.0 ± 0.71	10.3 ± 0.44
9	12.5 ± 0.66	10.4 ± 0.87	9.8 ± 0.52	10.7 ± 0.40
10	10.9 ± 0.56	9.9 ± 0.59	9.5 ± 0.54	10.1 ± 0.33
11	12.9 ± 0.69	13.2 ± 0.92	11.2 ± 0.82	12.4 ± 0.47

TABLE A38. GAL LINES - MEAN EFFICIENCY OF FEMALES (%)

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	9.1 ± 0.27	9.7 ± 0.34	9.3 ± 0.35	9.4 ± 0.19
1	12.1 ± 0.40	11.4 ± 0.62	11.4 ± 0.42	11.6 ± 0.28
2	10.1 ± 0.46	11.8 ± 0.57	8.0 ± 0.36	10.0 ± 0.27
3	12.0 ± 0.58	11.2 ± 0.52	8.3 ± 1.95	10.5 ± 0.70
4	10.6 ± 0.39	9.0 ± 0.37	11.7 ± 0.48	10.4 ± 0.24
5	11.6 ± 0.56	11.3 ± 0.46	10.9 ± 0.48	11.3 ± 0.29
6	8.8 ± 0.33	10.7 ± 0.77	10.4 ± 0.55	9.3 ± 0.33
7	8.6 ± 0.41	12.8 ± 0.61	7.4 ± 0.39	9.6 ± 0.28
8	8.2 ± 0.52	10.0 ± 1.05	9.0 ± 0.61	9.1 ± 0.44
9	10.6 ± 0.58	7.2 ± 0.56	8.3 ± 0.51	8.7 ± 0.32
10	8.6 ± 0.34	9.6 ± 0.60	7.9 ± 0.42	8.7 ± 0.27
11	8.5 ± 0.61	9.8 ± 0.44	7.9 ± 0.61	8.7 ± 0.32

TABLE A39. GAC LINES - MEAN EFFICIENCY OF FEMALES (%)

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	9.1 ± 0.27	9.7 ± 0.34	9.3 ± 0.35	9.4 ± 0.19
1	11.8 ± 0.43	12.5 ± 0.85	14.8 ± 1.13	13.0 ± 0.49
2	11.8 ± 0.98	12.7 ± 0.71	9.4 ± 0.54	11.3 ± 0.44
3	10.4 ± 0.59	10.7 ± 0.61	11.1 ± 0.61	10.7 ± 0.35
4	10.0 ± 0.89	8.4 ± 0.38	9.1 ± 0.43	9.2 ± 0.35
5	11.8 ± 0.91	13.0 ± 0.61	10.2 ± 0.41	11.7 ± 0.39
6	10.5 ± 0.55	10.7 ± 0.77	10.3 ± 0.69	10.5 ± 0.39
7	10.4 ± 0.86	10.9 ± 0.49	8.9 ± 0.63	10.1 ± 0.39
8	7.4 ± 0.37	9.2 ± 0.74	10.7 ± 1.03	9.1 ± 0.44
9	10.0 ± 0.99	8.3 ± 0.57	9.1 ± 0.47	9.1 ± 0.41
10	10.4 ± 0.88	9.8 ± 0.65	7.9 ± 0.42	9.8 ± 0.39
11	13.0 ± 1.15	12.0 ± 1.02	10.2 ± 0.84	11.7 ± 0.58

TABLE A40. GFH LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GFH1	GFH2	GFH3	GFH mean
0	27.0 ± 0.27	27.6 ± 0.31		27.3 ± 0.21
1	25.1 ± 0.32	25.9 ± 0.39	23.7 ± 0.44	24.9 ± 0.22
2	25.5 ± 0.35	25.4 ± 0.42	24.7 ± 0.37	25.2 ± 0.22
3	23.8 ± 0.53	24.1 ± 0.50	23.4 ± 0.38	23.8 ± 0.27
4	25.5 ± 0.36	26.0 ± 0.50	25.2 ± 0.33	25.6 ± 0.23
5	25.8 ± 0.45	24.7 ± 0.64	24.0 ± 0.37	24.8 ± 0.29
6	26.5 ± 0.26	23.0 ± 0.38	23.6 ± 0.44	24.4 ± 0.21
7	24.5 ± 0.34	25.2 ± 0.37	23.1 ± 0.54	24.3 ± 0.26
8	25.9 ± 0.32	26.8 ± 0.38	24.5 ± 0.32	25.7 ± 0.20
9	27.1 ± 0.58	25.0 ± 0.54	23.6 ± 0.76	25.2 ± 0.37
10	25.8 ± 0.27	26.6 ± 0.39	26.2 ± 0.57	26.2 ± 0.25
11	26.0 ± 0.46	25.2 ± 0.55	25.5 ± 0.64	25.6 ± 0.32

TABLE A41. GFL LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GFL1	GFL2	GFL3	GFL mean
0	27.0 ± 0.27	27.6 ± 0.31		27.3 ± 0.21
1	25.6 ± 0.32	25.4 ± 0.39	25.8 ± 0.32	25.6 ± 0.20
2	25.2 ± 0.49	25.8 ± 0.44	24.8 ± 0.49	25.3 ± 0.27
3	24.7 ± 0.48	25.2 ± 0.55	24.6 ± 0.36	24.8 ± 0.27
4	25.6 ± 0.47	26.9 ± 0.40	25.9 ± 0.36	26.1 ± 0.24
5	26.4 ± 0.36	27.8 ± 0.40	26.7 ± 0.37	27.0 ± 0.20
6	25.8 ± 0.36	26.1 ± 0.32	24.1 ± 0.37	25.3 ± 0.20
7	25.8 ± 0.46	28.3 ± 0.42	25.4 ± 0.37	26.5 ± 0.24
8	25.9 ± 0.43	27.9 ± 0.35	24.4 ± 0.56	26.1 ± 0.26
9	26.2 ± 0.31	28.6 ± 0.49	26.0 ± 0.71	26.9 ± 0.31
10	27.8 ± 0.49	29.6 ± 0.36	26.3 ± 0.40	26.9 ± 0.24
11	27.0 ± 0.43	27.5 ± 0.46	24.2 ± 0.53	26.2 ± 0.27

TABLE A42. GFC LINES - MEAN 6 WEEK WEIGHT OF MALES

GENERATION	GFC1	GFC2	GFC3	GFC mean
0	27.0 ± 0.27	27.6 ± 0.31		27.3 ± 0.21
1	25.7 ± 0.42	24.9 ± 0.36	25.5 ± 0.46	25.4 ± 0.24
2	27.5 ± 0.33	26.7 ± 0.30	26.5 ± 0.41	26.9 ± 0.20
3	25.6 ± 0.48	23.4 ± 0.38	25.2 ± 0.34	24.7 ± 0.23
4	26.3 ± 0.40	25.6 ± 0.45	27.3 ± 0.45	26.4 ± 0.25
5	26.1 ± 0.35	26.6 ± 0.46	27.8 ± 0.41	26.8 ± 0.24
6	27.6 ± 0.39	26.2 ± 0.40	23.4 ± 0.43	25.7 ± 0.23
7	24.7 ± 0.36	27.7 ± 0.36	25.8 ± 0.48	26.1 ± 0.23
8	25.9 ± 0.44	28.7 ± 0.41	26.3 ± 0.54	27.0 ± 0.27
9	25.7 ± 0.38	29.9 ± 0.50	28.2 ± 0.55	27.9 ± 0.28
10	27.6 ± 0.53	27.6 ± 0.55	27.9 ± 0.36	27.7 ± 0.28
11	27.4 ± 0.40	26.7 ± 0.59	27.6 ± 0.32	27.2 ± 0.26

TABLE A43. GFH LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GFH1	GFH2	GFH3	GFH mean
0	22.2 ± 0.18	22.9 ± 0.23		22.6 ± 0.15
1	22.2 ± 0.27	23.0 ± 0.32	21.2 ± 0.30	22.1 ± 0.17
2	21.0 ± 0.31	21.9 ± 0.36	20.4 ± 0.30	21.1 ± 0.19
3	19.9 ± 0.34	21.8 ± 0.40	19.9 ± 0.34	20.5 ± 0.21
4	21.6 ± 0.26	22.1 ± 0.26	21.7 ± 0.24	21.8 ± 0.15
5	22.5 ± 0.41	21.8 ± 0.33	20.6 ± 0.29	21.6 ± 0.20
6	22.4 ± 0.21	20.6 ± 0.28	20.7 ± 0.28	21.2 ± 0.15
7	21.0 ± 0.28	21.9 ± 0.28	20.5 ± 0.33	21.1 ± 0.17
8	21.2 ± 0.30	22.6 ± 0.26	20.8 ± 0.26	21.5 ± 0.16
9	21.7 ± 0.34	22.6 ± 0.26	18.7 ± 0.64	21.0 ± 0.26
10	23.3 ± 0.30	21.7 ± 0.33	21.6 ± 0.41	22.2 ± 0.20
11	21.5 ± 0.33	21.0 ± 0.43	21.4 ± 0.38	21.3 ± 0.22

TABLE A44. GFL LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GFL1	GFL2	GFL3	GFL mean
0	22.2 ± 0.18	22.9 ± 0.23		22.6 ± 0.15
1	22.3 ± 0.27	22.1 ± 0.23	21.2 ± 0.30	21.9 ± 0.15
2	21.9 ± 0.34	22.0 ± 0.29	21.2 ± 0.29	21.7 ± 0.18
3	21.9 ± 0.27	22.6 ± 0.37	20.6 ± 0.30	21.7 ± 0.18
4	21.8 ± 0.35	23.0 ± 0.32	22.8 ± 0.22	22.5 ± 0.17
5	22.0 ± 0.26	23.6 ± 0.20	22.1 ± 0.31	22.6 ± 0.15
6	21.9 ± 0.22	23.5 ± 0.28	21.2 ± 0.27	22.2 ± 0.15
7	22.2 ± 0.32	23.6 ± 0.27	21.2 ± 0.37	22.3 ± 0.19
8	23.0 ± 0.31	23.9 ± 0.27	20.6 ± 0.39	22.5 ± 0.19
9	22.8 ± 0.33	24.0 ± 0.28	23.8 ± 0.56	23.5 ± 0.24
10	24.3 ± 0.43	24.5 ± 0.19	22.1 ± 0.30	23.6 ± 0.19
11	23.1 ± 0.26	22.8 ± 0.39	21.0 ± 0.33	22.3 ± 0.19

TABLE A45. GFC LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GFC1	GFC2	GFC3	GFC mean
0	22.2 ± 0.18	22.9 ± 0.23		22.6 ± 0.15
1	22.2 ± 0.35	22.3 ± 0.27	21.5 ± 0.28	22.0 ± 0.17
2	23.1 ± 0.31	22.5 ± 0.36	21.7 ± 0.31	22.4 ± 0.19
3	20.9 ± 0.40	19.9 ± 0.34	21.7 ± 0.32	20.8 ± 0.20
4	22.6 ± 0.29	22.5 ± 0.36	23.4 ± 0.32	22.8 ± 0.19
5	22.2 ± 0.26	22.4 ± 0.25	22.3 ± 0.33	22.3 ± 0.16
6	22.7 ± 0.20	22.5 ± 0.26	20.6 ± 0.39	21.9 ± 0.17
7	22.0 ± 0.26	23.2 ± 0.25	22.9 ± 0.41	22.7 ± 0.18
8	21.5 ± 0.30	24.7 ± 0.28	22.8 ± 0.32	23.0 ± 0.17
9	21.8 ± 0.35	25.4 ± 0.36	23.3 ± 0.60	23.5 ± 0.26
10	24.4 ± 0.32	23.9 ± 0.34	22.7 ± 0.27	23.7 ± 0.18
11	23.2 ± 0.35	23.3 ± 0.43	23.5 ± 0.39	23.3 ± 0.23

TABLE A46. GFH LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GFH1	GFH2	GFH3	GFH mean
0	32.9 ± 0.37	33.5 ± 0.52	32.1 ± 0.35	32.8 ± 0.24
1	31.5 ± 0.37	31.7 ± 0.59	30.2 ± 0.39	31.1 ± 0.27
2	30.9 ± 0.42	31.9 ± 0.42	30.4 ± 0.39	31.1 ± 0.24
3	29.7 ± 0.46	31.6 ± 0.45	29.4 ± 0.44	30.2 ± 0.26
4	30.6 ± 0.40	32.8 ± 0.46	31.8 ± 0.37	31.7 ± 0.24
5	33.1 ± 0.54	32.1 ± 0.48	30.3 ± 0.47	31.8 ± 0.29
6	31.7 ± 0.33	30.6 ± 0.34	30.3 ± 0.40	30.9 ± 0.21
7	31.1 ± 0.40	32.2 ± 0.37	29.3 ± 0.41	30.9 ± 0.23
8	30.8 ± 0.59	32.6 ± 0.48	30.0 ± 0.66	31.1 ± 0.34
9	33.1 ± 0.64	31.0 ± 0.58	31.2 ± 0.56	31.8 ± 0.34
10	31.1 ± 0.54	31.8 ± 0.54	31.9 ± 0.58	31.6 ± 0.32
11	31.9 ± 0.65	30.7 ± 0.60	31.2 ± 0.79	31.3 ± 0.40

TABLE A47. GFL LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GFL1	GFL2	GFL3	GFL mean
0	32.9 ± 0.37	33.5 ± 0.52	32.1 ± 0.35	32.8 ± 0.24
1	32.4 ± 0.38	31.3 ± 0.64	32.3 ± 0.39	32.0 ± 0.28
2	32.2 ± 0.58	32.0 ± 0.45	30.3 ± 0.50	31.5 ± 0.30
3	30.7 ± 0.54	32.1 ± 0.60	30.5 ± 0.38	31.1 ± 0.30
4	31.6 ± 0.55	33.6 ± 0.49	32.0 ± 0.38	32.4 ± 0.28
5	33.2 ± 0.44	34.7 ± 0.41	32.6 ± 0.46	33.5 ± 0.25
6	32.8 ± 0.39	33.7 ± 0.36	30.7 ± 0.27	32.4 ± 0.20
7	32.4 ± 0.41	35.1 ± 0.49	31.2 ± 0.38	32.9 ± 0.25
8	32.4 ± 0.50	32.8 ± 0.45	32.0 ± 0.69	32.4 ± 0.32
9	32.7 ± 0.40	36.3 ± 0.76	33.4 ± 1.26	34.1 ± 0.51
10	34.5 ± 0.59	36.8 ± 0.52	31.8 ± 0.50	34.4 ± 0.31
11	33.6 ± 0.54	34.8 ± 0.58	30.1 ± 0.50	32.8 ± 0.31

TABLE A48. GFC LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GFC1	GFC2	GFC3	GFC mean
0	32.9 ± 0.37	33.5 ± 0.52	32.1 ± 0.35	32.8 ± 0.24
1	33.3 ± 0.70	31.9 ± 0.46	31.9 ± 0.65	32.4 ± 0.35
2	33.0 ± 0.71	33.4 ± 0.57	32.4 ± 0.70	32.9 ± 0.38
3	31.9 ± 0.90	33.7 ± 0.53	31.2 ± 0.50	32.3 ± 0.39
4	32.8 ± 0.71	33.6 ± 0.56	34.4 ± 0.75	33.6 ± 0.39
5	33.0 ± 0.55	34.6 ± 0.91	34.6 ± 0.82	34.1 ± 0.45
6	33.1 ± 0.54	33.1 ± 0.51	31.8 ± 0.66	32.7 ± 0.34
7	31.2 ± 0.44	34.5 ± 0.51	33.1 ± 0.83	32.9 ± 0.36
8	31.7 ± 0.77	33.9 ± 0.79	33.0 ± 1.00	32.9 ± 0.50
9	32.4 ± 0.50	38.0 ± 1.20	34.1 ± 0.78	34.8 ± 0.51
10	33.6 ± 0.71	34.7 ± 0.67	34.2 ± 0.76	34.2 ± 0.41
11	33.2 ± 0.80	34.6 ± 1.09	33.1 ± 0.50	33.6 ± 0.48

TABLE A49. GPH LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPH1	GPH2	GPH3	GPH mean
0	27.3 ± 0.26	27.0 ± 0.25	25.4 ± 0.20	26.6 ± 0.14
1	25.3 ± 0.31	25.9 ± 0.50	25.1 ± 0.43	25.4 ± 0.24
2	26.9 ± 0.36	26.7 ± 0.43	25.3 ± 0.51	26.3 ± 0.25
3	24.8 ± 0.35	25.1 ± 0.48	27.1 ± 0.46	25.7 ± 0.25
4	28.7 ± 0.36	27.9 ± 0.56	28.3 ± 0.50	28.3 ± 0.28
5	28.4 ± 0.43	27.8 ± 0.49	28.7 ± 0.49	28.3 ± 0.27
6	28.3 ± 0.35	28.8 ± 0.45	27.1 ± 0.64	28.1 ± 0.29
7	29.4 ± 0.44	28.6 ± 0.47	30.7 ± 0.39	29.6 ± 0.25
8	30.4 ± 0.66	29.3 ± 0.59	28.4 ± 0.52	29.4 ± 0.34
9	28.4 ± 0.43	30.6 ± 0.65	29.9 ± 0.47	29.6 ± 0.30
10	31.2 ± 0.66	30.7 ± 1.49	31.6 ± 0.61	31.2 ± 0.58
11	31.4 ± 0.47	30.4 ± 0.45	31.4 ± 0.82	31.1 ± 0.35

TABLE A50. GPL LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPL1	GPL2	GPL3	GPL mean
0	27.3 ± 0.26	27.0 ± 0.25	25.4 ± 0.20	26.6 ± 0.14
1	25.2 ± 0.36	24.8 ± 0.30	24.1 ± 0.45	24.7 ± 0.22
2	25.7 ± 0.26	24.4 ± 0.35	23.7 ± 0.52	24.6 ± 0.23
3	22.7 ± 0.39	21.3 ± 0.38	22.4 ± 0.28	22.1 ± 0.20
4	24.9 ± 0.44	25.4 ± 0.49	23.8 ± 0.67	24.7 ± 0.31
5	24.4 ± 0.46	23.5 ± 0.27	24.8 ± 0.40	24.2 ± 0.22
6	24.3 ± 0.31	23.4 ± 0.28	22.8 ± 0.35	23.5 ± 0.18
7	24.8 ± 0.32	23.5 ± 0.44	25.2 ± 0.39	24.5 ± 0.22
8	24.2 ± 0.45	21.2 ± 0.31	22.9 ± 0.36	22.8 ± 0.22
9	26.8 ± 0.51	24.0 ± 0.37	23.4 ± 0.53	24.7 ± 0.27
10	25.2 ± 0.40	24.5 ± 0.33	24.2 ± 0.42	24.6 ± 0.22
11	24.0 ± 0.37	23.3 ± 0.36	20.4 ± 0.57	22.6 ± 0.26

TABLE A51. GPC LINES - MEAN 6 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPC1	GPC2	GPC3	GPC mean
0	27.3 ± 0.26	27.0 ± 0.25	25.4 ± 0.20	26.6 ± 0.14
1	25.3 ± 0.32	24.5 ± 0.29	24.9 ± 0.40	24.9 ± 0.20
2	24.0 ± 0.35	25.1 ± 0.34	25.8 ± 0.50	25.0 ± 0.23
3	23.6 ± 0.30	24.1 ± 0.40	25.2 ± 0.44	24.3 ± 0.22
4	26.5 ± 0.37	26.2 ± 0.47	28.4 ± 0.40	27.0 ± 0.24
5	25.0 ± 0.36	25.9 ± 0.36	29.3 ± 0.37	26.7 ± 0.21
6	26.4 ± 0.47	25.1 ± 0.43	26.9 ± 0.34	26.1 ± 0.24
7	25.2 ± 0.37	25.4 ± 0.42	27.0 ± 0.69	25.9 ± 0.30
8	26.0 ± 0.40	25.5 ± 0.42	27.5 ± 0.56	26.3 ± 0.27
9	25.4 ± 0.91	27.6 ± 0.75	28.0 ± 0.58	27.0 ± 0.44
10	25.5 ± 0.47	27.7 ± 0.63	28.6 ± 0.38	27.3 ± 0.29
11	24.4 ± 0.26	27.3 ± 0.43	24.9 ± 0.89	25.5 ± 0.34

TABLE A52. GPH LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GPH1	GPH2	GPH3	GPH mean
0	22.4 ± 0.18	22.8 ± 0.17	21.9 ± 0.18	22.4 ± 0.10
1	22.7 ± 0.26	22.6 ± 0.26	21.0 ± 0.29	22.1 ± 0.16
2	22.9 ± 0.24	22.6 ± 0.34	22.6 ± 0.24	22.7 ± 0.16
3	21.9 ± 0.22	22.8 ± 0.32	22.7 ± 0.36	22.5 ± 0.16
4	24.2 ± 0.28	25.1 ± 0.42	24.0 ± 0.39	24.4 ± 0.19
5	24.0 ± 0.35	24.3 ± 0.34	24.1 ± 0.35	24.1 ± 0.20
6	24.3 ± 0.25	25.6 ± 0.29	25.3 ± 0.37	25.1 ± 0.18
7	25.6 ± 0.29	25.3 ± 0.38	25.5 ± 0.33	25.5 ± 0.19
8	25.3 ± 0.39	24.8 ± 0.37	25.6 ± 0.36	25.2 ± 0.18
9	25.1 ± 0.43	26.6 ± 0.62	26.4 ± 0.56	26.0 ± 0.31
10	26.2 ± 0.55	26.7 ± 0.56	27.1 ± 0.48	26.7 ± 0.31
11	28.7 ± 0.50	26.1 ± 0.34	26.8 ± 0.38	27.2 ± 0.24

TABLE A53. GPL LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GPL1	GPL2	GPL3	GPL mean
0	22.4 ± 0.18	22.8 ± 0.17	21.9 ± 0.18	22.4 ± 0.10
1	22.0 ± 0.33	20.9 ± 0.33	20.7 ± 0.32	21.2 ± 0.19
2	21.7 ± 0.21	21.1 ± 0.22	19.5 ± 0.26	20.8 ± 0.13
3	19.1 ± 0.29	18.6 ± 0.30	19.9 ± 0.26	19.2 ± 0.16
4	21.4 ± 0.19	21.2 ± 0.32	20.6 ± 0.32	21.1 ± 0.16
5	21.1 ± 0.27	19.4 ± 0.23	20.5 ± 0.26	20.3 ± 0.15
6	20.4 ± 0.23	19.9 ± 0.19	20.1 ± 0.32	20.1 ± 0.15
7	21.1 ± 0.26	20.4 ± 0.23	20.7 ± 0.37	20.7 ± 0.17
8	20.2 ± 0.46	19.5 ± 0.24	20.6 ± 0.72	20.1 ± 0.30
9	21.2 ± 0.37	20.6 ± 0.29	19.8 ± 0.31	20.5 ± 0.19
10	20.7 ± 0.44	20.8 ± 0.36	19.2 ± 0.37	20.2 ± 0.23
11	20.3 ± 0.36	19.3 ± 0.28	17.6 ± 0.37	19.1 ± 0.20

TABLE A54. GPC LINES - MEAN 6 WEEK WEIGHT OF FEMALES (GRAMS)

GENERATION	GPC1	GPC2	GPC3	GPC mean
0	22.4 ± 0.18	22.8 ± 0.17	21.9 ± 0.18	22.4 ± 0.10
1	22.6 ± 0.25	21.5 ± 0.26	21.6 ± 0.32	21.9 ± 0.16
2	20.8 ± 0.29	21.8 ± 0.26	21.2 ± 0.33	21.3 ± 0.17
3	19.7 ± 0.37	20.9 ± 0.41	22.7 ± 0.40	21.1 ± 0.16
4	22.3 ± 0.27	22.4 ± 0.30	23.8 ± 0.25	22.8 ± 0.16
5	21.5 ± 0.28	22.3 ± 0.30	24.0 ± 0.35	22.6 ± 0.18
6	22.2 ± 0.31	22.2 ± 0.26	23.2 ± 0.30	22.5 ± 0.17
7	21.5 ± 0.23	21.8 ± 0.36	21.9 ± 0.34	21.7 ± 0.18
8	22.3 ± 0.26	22.6 ± 0.29	23.1 ± 0.39	22.7 ± 0.18
9	22.8 ± 0.43	24.0 ± 0.64	24.2 ± 0.37	23.7 ± 0.29
10	22.6 ± 0.25	22.2 ± 0.41	23.5 ± 0.40	22.8 ± 0.21
11	20.4 ± 0.24	22.3 ± 0.30	22.6 ± 0.44	21.8 ± 0.19

TABLE A55. GPH LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPH1	GPH2	GPH3	GPH mean
0	33.2 ± 0.36	32.4 ± 0.36	32.2 ± 0.36	32.6 ± 0.21
1	31.6 ± 0.39	32.4 ± 0.49	33.1 ± 0.45	32.4 ± 0.26
2	34.1 ± 0.50	33.7 ± 0.44	31.9 ± 0.42	33.2 ± 0.26
3	31.9 ± 0.44	33.2 ± 0.58	35.0 ± 0.48	33.4 ± 0.29
4	35.1 ± 0.52	35.6 ± 0.56	36.8 ± 0.60	35.8 ± 0.32
5	36.5 ± 0.49	36.1 ± 0.46	37.3 ± 0.49	36.6 ± 0.28
6	35.4 ± 0.35	35.9 ± 0.41	35.2 ± 0.66	35.5 ± 0.28
7	36.8 ± 0.55	36.3 ± 0.60	38.2 ± 0.49	37.1 ± 0.32
8	39.6 ± 0.71	38.1 ± 0.84	37.2 ± 0.87	38.3 ± 0.47
9	37.6 ± 0.60	37.9 ± 0.75	37.8 ± 0.60	37.8 ± 0.38
10	40.5 ± 0.89	37.8 ± 1.11	39.3 ± 0.71	39.2 ± 0.53
11	42.3 ± 0.78	38.3 ± 0.61	39.9 ± 0.82	40.1 ± 0.43

TABLE A56. GPL LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPL1	GPL2	GPL3	GPL mean
0	33.2 ± 0.36	32.4 ± 0.36	32.2 ± 0.36	32.6 ± 0.21
1	32.0 ± 0.44	30.8 ± 0.40	31.7 ± 0.71	31.5 ± 0.27
2	31.6 ± 0.33	30.0 ± 0.45	29.2 ± 0.41	30.3 ± 0.23
3	29.3 ± 0.44	27.2 ± 0.27	29.0 ± 0.38	28.5 ± 0.21
4	30.2 ± 0.51	30.8 ± 0.43	31.6 ± 0.44	30.9 ± 0.27
5	30.7 ± 0.38	29.5 ± 0.32	30.9 ± 0.41	30.4 ± 0.21
6	29.6 ± 0.32	28.8 ± 0.29	28.9 ± 0.34	29.1 ± 0.18
7	30.3 ± 0.38	28.7 ± 0.36	30.8 ± 0.45	29.9 ± 0.23
8	29.8 ± 0.68	27.6 ± 0.39	29.9 ± 0.41	29.1 ± 0.29
9	31.7 ± 0.69	28.5 ± 0.52	28.5 ± 0.60	29.5 ± 0.35
10	30.3 ± 0.63	28.9 ± 0.53	29.3 ± 0.58	29.5 ± 0.34
11	28.9 ± 0.50	28.3 ± 0.33	26.4 ± 0.48	27.9 ± 0.26

TABLE A57. GPC LINES - MEAN 10 WEEK WEIGHT OF MALES (GRAMS)

GENERATION	GPC1	GPC2	GPC3	GPC mean
0	33.2 ± 0.36	32.4 ± 0.36	32.2 ± 0.36	32.6 ± 0.21
1	31.4 ± 0.61	30.4 ± 0.46	30.8 ± 0.52	30.9 ± 0.31
2	30.9 ± 0.55	31.1 ± 0.59	31.8 ± 0.73	31.3 ± 0.36
3	29.0 ± 0.46	31.3 ± 0.49	33.0 ± 0.73	31.1 ± 0.33
4	32.1 ± 0.56	34.0 ± 0.62	36.0 ± 0.71	34.0 ± 0.37
5	32.0 ± 0.48	35.0 ± 0.60	34.9 ± 0.62	34.0 ± 0.33
6	30.9 ± 0.63	33.4 ± 0.60	33.3 ± 0.59	32.5 ± 0.35
7	31.4 ± 0.54	31.9 ± 0.63	33.6 ± 1.02	32.3 ± 0.44
8	32.5 ± 0.76	33.8 ± 0.66	32.0 ± 0.71	32.8 ± 0.41
9	32.6 ± 1.49	34.6 ± 1.07	34.8 ± 0.79	34.0 ± 0.67
10	30.8 ± 0.82	32.2 ± 0.89	34.4 ± 0.89	32.5 ± 0.46
11	30.2 ± 0.62	32.8 ± 0.78	32.4 ± 0.86	31.8 ± 0.44

TABLE A58. GAH LINES - MEAN LITTER SIZE

GENERATION	GAH1	GAH2	GAH3	GAH mean
0	11.3 ± 0.52	12.3 ± 0.40	13.0 ± 0.42	12.2 ± 0.26
1	11.9 ± 0.60	11.6 ± 0.50	11.2 ± 0.54	11.6 ± 0.32
2	10.1 ± 0.79	10.1 ± 0.56	10.2 ± 0.38	10.1 ± 0.35
3	8.6 ± 0.66	10.1 ± 0.66	10.4 ± 0.55	9.7 ± 0.36
4	8.4 ± 0.68	9.3 ± 0.62	11.2 ± 0.64	9.6 ± 0.37
5	11.2 ± 0.36	11.7 ± 0.51	13.1 ± 0.50	12.0 ± 0.27
6	12.4 ± 0.46	10.6 ± 0.63	11.9 ± 0.48	11.6 ± 0.31
7	11.1 ± 0.62	10.7 ± 0.55	10.9 ± 0.42	10.9 ± 0.31
8	10.4 ± 0.69	10.2 ± 0.40	10.4 ± 0.75	10.3 ± 0.37
9	11.0 ± 1.02	10.8 ± 1.52	12.0 ± 1.07	11.3 ± 0.71
10	13.6 ± 0.84	12.3 ± 1.23	13.4 ± 1.36	13.1 ± 0.67
11	12.0 ± 0.66	12.4 ± 0.86	9.6 ± 1.89	11.3 ± 0.73

TABLE A59. GAL LINES - MEAN LITTER SIZE

GENERATION	GAL1	GAL2	GAL3	GAL mean
0	11.3 ± 0.52	12.3 ± 0.40	13.0 ± 0.42	12.2 ± 0.26
1	11.2 ± 0.71	10.7 ± 0.44	10.8 ± 0.41	10.9 ± 0.31
2	9.7 ± 0.81	8.7 ± 0.62	8.6 ± 0.29	9.0 ± 0.35
3	8.0 ± 0.60	9.6 ± 0.61	8.7 ± 0.49	8.8 ± 0.33
4	8.4 ± 0.42	8.1 ± 0.79	8.8 ± 0.33	8.4 ± 0.32
5	7.9 ± 0.54	10.6 ± 0.88	10.1 ± 0.59	9.5 ± 0.40
6	9.7 ± 0.49	11.6 ± 0.63	8.6 ± 0.58	10.0 ± 0.33
7	8.2 ± 0.59	10.1 ± 0.48	8.0 ± 0.39	8.8 ± 0.28
8	8.1 ± 0.83	9.2 ± 0.61	7.6 ± 0.41	8.3 ± 0.37
9	9.5 ± 0.19	8.0 ± 0.82	9.1 ± 0.58	8.9 ± 0.34
10	11.6 ± 0.60	9.0 ± 0.73	10.0 ± 0.50	10.2 ± 0.36
11	8.0 ± 0.46	9.7 ± 0.36	8.4 ± 0.92	8.7 ± 0.36

TABLE A60. GAC LINES - MEAN LITTER SIZE

GENERATION	GAC1	GAC2	GAC3	GAC mean
0	11.3 ± 0.52	12.3 ± 0.40	13.0 ± 0.42	12.2 ± 0.26
1	11.1 ± 0.46	10.7 ± 0.75	10.9 ± 0.48	10.9 ± 0.33
2	10.0 ± 0.89	9.2 ± 0.69	9.3 ± 0.36	9.5 ± 0.39
3	9.3 ± 0.30	8.2 ± 0.52	10.1 ± 0.67	9.2 ± 0.30
4	9.9 ± 0.50	9.4 ± 0.45	8.9 ± 0.56	9.4 ± 0.29
5	10.6 ± 0.46	11.2 ± 0.48	11.3 ± 0.55	11.0 ± 0.29
6	10.9 ± 0.60	10.2 ± 0.48	10.3 ± 0.66	10.5 ± 0.34
7	10.2 ± 0.68	9.3 ± 0.43	8.7 ± 0.48	9.4 ± 0.31
8	9.3 ± 0.69	10.1 ± 0.48	8.5 ± 0.64	9.3 ± 0.35
9	7.3 ± 1.32	11.2 ± 0.56	10.2 ± 0.56	9.6 ± 0.51
10	11.8 ± 0.62	11.8 ± 0.90	11.0 ± 0.50	11.5 ± 0.40
11	10.8 ± 0.70	10.2 ± 0.75	9.2 ± 0.70	10.1 ± 0.41

TABLE A61. GFH LINES - MEAN LITTER SIZE

GENERATION	GFH1	GFH2	GFH3	GFH mean
0	11.4 ± 0.44	12.0 ± 0.32	12.3 ± 0.49	11.9 ± 0.24
1	10.7 ± 0.64	10.8 ± 0.49	11.0 ± 0.65	10.8 ± 0.35
2	10.2 ± 0.49	10.4 ± 0.42	10.2 ± 0.68	10.3 ± 0.31
3	9.1 ± 0.67	9.8 ± 0.60	10.2 ± 0.39	9.7 ± 0.33
4	9.1 ± 0.51	10.2 ± 0.55	9.5 ± 0.46	9.6 ± 0.29
5	10.0 ± 0.68	12.0 ± 0.58	10.5 ± 0.72	10.8 ± 0.38
6	9.9 ± 0.76	10.8 ± 0.86	10.8 ± 0.51	10.5 ± 0.42
7	10.5 ± 0.75	11.2 ± 0.31	9.7 ± 0.44	10.5 ± 0.31
8	9.1 ± 0.46	10.7 ± 0.42	9.0 ± 0.69	9.6 ± 0.31
9	9.2 ± 0.92	10.8 ± 0.49	9.9 ± 0.81	10.0 ± 0.44
10	9.6 ± 1.14	12.2 ± 0.75	9.0 ± 0.63	10.3 ± 0.50
11	11.2 ± 0.45	11.1 ± 0.67	9.5 ± 0.60	10.6 ± 0.34

TABLE A62. GFL LINES - MEAN LITTER SIZE

GENERATION	GFL1	GFL2	GFL3	GFL mean
0	11.4 ± 0.44	12.0 ± 0.32	12.3 ± 0.49	11.9 ± 0.24
1	11.0 ± 0.38	11.9 ± 0.61	11.1 ± 0.42	11.3 ± 0.27
2	10.6 ± 0.76	10.3 ± 0.62	9.5 ± 0.64	10.1 ± 0.39
3	9.3 ± 0.35	9.0 ± 0.74	9.9 ± 0.50	9.4 ± 0.32
4	7.8 ± 0.55	10.6 ± 0.55	9.7 ± 0.61	9.4 ± 0.33
5	9.4 ± 0.47	10.2 ± 0.69	9.6 ± 0.70	9.7 ± 0.36
6	10.9 ± 0.50	11.1 ± 0.52	11.4 ± 0.44	11.1 ± 0.28
7	8.9 ± 0.57	10.5 ± 0.68	8.6 ± 0.26	9.3 ± 0.31
8	9.4 ± 0.45	10.6 ± 0.47	8.9 ± 0.53	9.6 ± 0.28
9	10.4 ± 0.89	11.0 ± 0.76	9.3 ± 0.78	10.2 ± 0.41
10	10.8 ± 0.56	11.4 ± 0.71	10.6 ± 0.46	10.9 ± 0.34
11	10.5 ± 0.80	11.6 ± 0.53	10.5 ± 0.50	10.9 ± 0.36

TABLE A63. GFC LINES - MEAN LITTER SIZE

GENERATION	GFC1	GFC3	GFC3	GFC mean
0	11.4 ± 0.44	12.0 ± 0.32	12.3 ± 0.49	11.9 ± 0.24
1	10.3 ± 0.47	10.9 ± 0.86	9.6 ± 0.87	10.3 ± 0.44
2	10.2 ± 0.40	9.4 ± 0.74	9.7 ± 0.50	9.8 ± 0.33
3	9.3 ± 0.80	9.6 ± 0.82	10.0 ± 0.38	9.6 ± 0.40
4	8.7 ± 0.77	11.2 ± 0.60	10.0 ± 0.51	10.0 ± 0.37
5	10.5 ± 0.57	10.8 ± 0.57	11.4 ± 0.67	10.9 ± 0.35
6	11.1 ± 0.53	11.6 ± 0.65	10.3 ± 0.58	11.0 ± 0.34
7	11.9 ± 0.56	10.3 ± 0.49	9.3 ± 0.44	10.5 ± 0.29
8	10.2 ± 0.37	11.9 ± 0.49	8.9 ± 0.53	10.3 ± 0.27
9	11.4 ± 0.46	11.5 ± 1.00	9.3 ± 0.78	10.7 ± 0.45
10	7.9 ± 1.20	11.9 ± 0.70	10.6 ± 0.46	10.1 ± 0.49
11	12.0 ± 0.50	11.7 ± 0.47	8.9 ± 0.70	10.9 ± 0.33

TABLE A64. GPH LINES - MEAN LITTER SIZE

GENERATION	GPH1	GPH2	GPH3	GPH mean
0	12.1 ± 0.33	12.2 ± 0.50	13.1 ± 0.42	12.5 ± 0.24
1	11.3 ± 0.49	10.8 ± 0.56	11.1 ± 0.43	11.1 ± 0.29
2	10.6 ± 0.34	10.1 ± 0.66	10.0 ± 0.41	10.2 ± 0.28
3	9.6 ± 0.56	9.6 ± 0.58	9.7 ± 0.44	9.6 ± 0.31
4	10.4 ± 0.35	9.8 ± 0.57	10.1 ± 0.46	10.1 ± 0.27
5	11.6 ± 0.68	11.9 ± 0.73	10.6 ± 0.84	11.4 ± 0.43
6	13.1 ± 0.49	10.9 ± 0.88	11.2 ± 0.60	11.7 ± 0.39
7	11.1 ± 0.45	10.7 ± 0.57	10.6 ± 0.35	10.8 ± 0.27
8	10.8 ± 0.83	9.3 ± 0.85	9.8 ± 0.26	10.7 ± 0.41
9	12.2 ± 0.94	9.4 ± 1.18	10.5 ± 1.09	10.7 ± 0.62
10	12.0 ± 0.42	9.8 ± 1.29	10.0 ± 0.78	10.6 ± 0.52
11	11.0 ± 1.75	9.9 ± 1.53	11.5 ± 0.38	10.8 ± 0.79

TABLE A65. GPL LINES - MEAN LITTER SIZE

GENERATION	GPL1	GPL2	GPL3	GPL mean
0	12.1 ± 0.33	12.2 ± 0.50	13.1 ± 0.42	12.5 ± 0.24
1	10.6 ± 0.75	10.0 ± 0.50	10.9 ± 0.53	10.5 ± 0.35
2	10.1 ± 0.60	10.1 ± 0.71	9.6 ± 0.32	9.9 ± 0.33
3	9.0 ± 0.69	10.5 ± 0.46	10.2 ± 0.42	9.9 ± 0.31
4	9.4 ± 0.44	8.5 ± 0.60	9.0 ± 0.44	9.0 ± 0.29
5	10.5 ± 0.57	11.2 ± 0.54	9.7 ± 0.72	10.6 ± 0.36
6	11.1 ± 0.38	10.5 ± 0.61	10.0 ± 0.56	10.5 ± 0.30
7	9.2 ± 0.52	9.6 ± 0.30	8.2 ± 0.62	9.0 ± 0.27
8	9.8 ± 0.52	10.2 ± 0.36	9.1 ± 0.52	9.7 ± 0.27
9	7.8 ± 0.92	9.9 ± 0.48	9.1 ± 0.69	8.9 ± 0.42
10	9.0 ± 0.80	9.4 ± 0.60	10.1 ± 0.77	9.5 ± 0.42
11	9.6 ± 0.86	9.6 ± 0.80	10.2 ± 0.75	9.8 ± 0.46

TABLE A66. GPC LINES - MEAN LITTER SIZE

GENERATION	GPC1	GPC2	GPC3	GPC mean
0	12.1 ± 0.33	12.2 ± 0.50	13.1 ± 0.42	12.5 ± 0.24
1	10.1 ± 0.63	10.9 ± 0.45	10.4 ± 0.65	10.5 ± 0.34
2	11.5 ± 0.44	10.5 ± 0.29	10.6 ± 0.73	10.9 ± 0.30
3	9.3 ± 0.65	8.4 ± 0.81	8.1 ± 0.84	8.6 ± 0.44
4	8.7 ± 0.54	9.6 ± 0.56	9.3 ± 0.66	9.2 ± 0.34
5	11.1 ± 0.50	10.9 ± 0.68	10.0 ± 0.57	10.7 ± 0.34
6	10.0 ± 0.79	11.1 ± 0.74	10.1 ± 0.95	10.4 ± 0.48
7	10.9 ± 0.64	9.5 ± 0.84	9.5 ± 0.55	10.0 ± 0.40
8	9.1 ± 0.52	9.6 ± 0.62	9.2 ± 0.46	9.3 ± 0.31
9	9.6 ± 1.64	10.1 ± 1.03	9.8 ± 1.52	9.8 ± 0.82
10	11.9 ± 0.71	12.1 ± 0.64	12.7 ± 0.92	12.2 ± 0.44
11	11.0 ± 0.50	9.4 ± 0.50	10.1 ± 0.61	10.2 ± 0.31

TABLE A67. GA LINES - MEAN NUMBER WEANED

GENERATION	GAH mean	GAC mean	GAL mean
0	10.7 ± 0.16	10.7 ± 0.16	10.7 ± 0.16
1	10.1 ± 0.40	10.0 ± 0.16	9.2 ± 0.40
2	8.9 ± 0.33	8.7 ± 0.44	8.5 ± 0.29
3	8.9 ± 0.38	8.9 ± 0.27	8.5 ± 0.31
4	9.2 ± 0.29	8.9 ± 0.29	8.2 ± 0.33
5	10.4 ± 0.38	10.3 ± 0.22	8.9 ± 0.37
6	10.5 ± 0.24	9.4 ± 0.46	9.1 ± 0.34
7	9.3 ± 0.40	9.0 ± 0.30	8.0 ± 0.38
8	9.3 ± 0.39	8.7 ± 0.37	8.0 ± 0.37
9	9.0 ± 0.72	9.0 ± 0.67	7.5 ± 0.60
10	9.7 ± 0.48	10.5 ± 0.35	9.8 ± 0.38
11	9.6 ± 0.68	9.0 ± 0.52	8.3 ± 0.38

TABLE A68. GA LINES - MEAN WEANING RATE (%)

GENERATION	GAH mean	GAC mean	GAL mean
0	96.3	96.3	96.3
1	94.3	93.9	87.9
2	90.6	92.6	96.1
3	92.4	97.8	97.4
4	97.4	95.8	96.8
5	89.2	96.3	96.3
6	95.4	91.8	94.7
7	87.5	95.3	91.6
8	91.9	93.9	96.2
9	87.4	94.9	84.9
10	86.0	95.5	99.6
11	90.9	90.8	95.9

TABLE A69. GF LINES - MEAN NUMBER WEANED

GENERATION	GFH mean	GFC mean	GFL mean
0	10.9 $\pm$ 0.16	10.9 $\pm$ 0.16	10.9 $\pm$ 0.16
1	9.4 $\pm$ 0.40	9.0 $\pm$ 0.39	9.9 $\pm$ 0.26
2	9.4 $\pm$ 0.38	9.5 $\pm$ 0.30	9.3 $\pm$ 0.36
3	7.7 $\pm$ 0.47	8.8 $\pm$ 0.46	8.7 $\pm$ 0.34
4	8.8 $\pm$ 0.37	9.2 $\pm$ 0.39	8.8 $\pm$ 0.36
5	9.8 $\pm$ 0.39	10.1 $\pm$ 0.32	9.3 $\pm$ 0.30
6	9.5 $\pm$ 0.37	9.3 $\pm$ 0.45	9.7 $\pm$ 0.37
7	9.0 $\pm$ 0.42	9.3 $\pm$ 0.39	8.2 $\pm$ 0.36
8	8.6 $\pm$ 0.42	9.3 $\pm$ 0.37	8.9 $\pm$ 0.30
9	8.9 $\pm$ 0.72	9.4 $\pm$ 0.40	8.6 $\pm$ 0.67
10	9.4 $\pm$ 0.58	9.5 $\pm$ 0.51	9.2 $\pm$ 0.64
11	9.4 $\pm$ 0.34	9.5 $\pm$ 0.43	10.1 $\pm$ 0.31

TABLE A70. GF LINES - MEAN WEANING RATE (%)

GENERATION	GFH mean	GFC mean	GFL mean
0	98.3	98.3	98.3
1	90.8	89.7	90.9
2	91.7	97.5	94.1
3	80.7	93.0	93.5
4	93.8	94.4	95.0
5	94.8	95.1	97.3
6	94.1	88.8	90.0
7	87.7	91.5	88.6
8	89.8	92.6	92.9
9	89.5	91.6	90.0
10	95.7	96.0	86.7
11	90.0	95.1	89.3

TABLE A71. GP LINES - MEAN NUMBER WEANED

GENERATION	GPH mean	GPC mean	GPL mean
0	11.0 $\pm$ 0.15	11.0 $\pm$ 0.15	11.0 $\pm$ 0.15
1	9.7 $\pm$ 0.43	9.6 $\pm$ 0.34	9.1 $\pm$ 0.44
2	9.3 $\pm$ 0.37	10.1 $\pm$ 0.27	8.9 $\pm$ 0.41
3	9.2 $\pm$ 0.26	8.1 $\pm$ 0.41	8.5 $\pm$ 0.43
4	9.1 $\pm$ 0.38	8.2 $\pm$ 0.42	8.1 $\pm$ 0.35
5	9.8 $\pm$ 0.41	8.7 $\pm$ 0.44	9.8 $\pm$ 0.27
6	9.6 $\pm$ 0.41	8.6 $\pm$ 0.55	9.6 $\pm$ 0.38
7	9.6 $\pm$ 0.40	9.3 $\pm$ 0.36	8.6 $\pm$ 0.29
8	8.6 $\pm$ 0.42	7.6 $\pm$ 0.52	9.0 $\pm$ 0.36
9	9.2 $\pm$ 0.69	8.4 $\pm$ 0.76	8.3 $\pm$ 0.39
10	9.2 $\pm$ 0.56	10.5 $\pm$ 0.29	8.7 $\pm$ 0.43
11	9.4 $\pm$ 0.63	8.9 $\pm$ 0.55	9.0 $\pm$ 0.44

TABLE A72. GP LINES - MEAN WEANING RATE (%)

GENERATION	GPH mean	GPC mean	GPL mean
0	97.1	97.1	97.1
1	86.2	88.6	94.0
2	91.6	90.6	95.5
3	96.3	86.9	94.9
4	91.5	90.7	89.5
5	92.4	96.3	84.6
6	87.2	89.7	85.6
7	90.5	95.8	95.8
8	89.0	92.3	82.2
9	90.2	93.0	89.2
10	88.0	92.5	92.1
11	93.0	92.3	88.3

TABLE A73. GF LINES - RESULTS FROM 4 TO 6 WEEK FOOD INTAKE TRIALS

LINE	ADJ. FOOD	FOOD F	FOOD M	4 WK WT F	4 WK WT M
GFH1 g8	58.4 ± 0.83	53.8 ± 0.65	58.2 ± 1.15	15.8 ± 0.42	16.6 ± 0.67
GFH1 g9	57.5 ± 0.71	55.6 ± 0.75	59.7 ± 1.22	16.0 ± 0.43	17.8 ± 0.47
GFH2 g8	58.8 ± 0.77	59.0 ± 1.08	57.6 ± 1.63	16.4 ± 0.43	17.0 ± 0.44
GFH2 g9	61.4 ± 0.67	60.3 ± 0.96	61.3 ± 1.26	16.8 ± 0.41	16.7 ± 0.49
GFH3 g8	59.9 ± 0.80	54.3 ± 1.24	55.0 ± 1.13	14.7 ± 0.56	14.4 ± 0.60
GFH3 g9	54.7 ± 0.90	56.8 ± 1.02	59.0 ± 0.99	17.4 ± 0.43	19.7 ± 0.66
GFC1 g8	58.6 ± 1.55	50.9 ± 1.71	59.4 ± 1.71	14.8 ± 0.58	16.1 ± 0.94
GFC1 g9	57.9 ± 0.93	53.9 ± 1.08	58.5 ± 1.45	15.2 ± 0.45	16.8 ± 0.47
GFC2 g8	61.6 ± 1.06	59.1 ± 1.09	67.3 ± 2.04	16.9 ± 0.48	18.8 ± 0.86
GFC2 g9	59.3 ± 0.84	61.6 ± 1.34	68.4 ± 1.64	18.7 ± 0.47	21.0 ± 0.43
GFC3 g8	62.1 ± 1.00	60.6 ± 1.28	59.8 ± 1.33	17.1 ± 0.68	15.4 ± 0.79
GFC3 g9	58.0 ± 0.88	53.6 ± 1.22	58.3 ± 0.95	14.9 ± 0.44	16.7 ± 0.46
GFL1 g8	61.1 ± 0.76	58.2 ± 1.35	59.5 ± 1.32	14.9 ± 0.56	16.7 ± 0.74
GFL1 g9	60.2 ± 0.88	57.3 ± 1.04	64.2 ± 1.35	17.0 ± 0.58	18.0 ± 0.73
GFL2 g8	60.4 ± 0.51	59.3 ± 1.05	64.6 ± 0.90	15.6 ± 0.60	19.6 ± 0.53
GFL2 g9	57.8 ± 0.59	61.4 ± 0.80	65.2 ± 1.08	19.1 ± 0.39	20.5 ± 0.43
GFL3 g8	61.0 ± 0.95	54.0 ± 1.86	54.7 ± 1.85	13.7 ± 0.81	13.6 ± 0.79
GFL3 g9	54.8 ± 0.89	54.3 ± 1.08	59.6 ± 0.66	17.1 ± 0.45	19.1 ± 0.59

ADJ. FOOD = 4 to 6 week food intake, adjusted for 4 week weight (grams)

FOOD F = 4 to 6 week food intake of females (grams)

FOOD M = 4 to 6 week food intake of males (grams)

4 WK WT F = 4 week weight of females (grams)

4 WK WT M = 4 week weight of males (grams)

g8 = generation 8, g9 = generation 9

TABLE A74. GF LINES - RESULTS FROM 4 TO 6 WEEK FOOD INTAKE TRIALS

LINE	6 WK WT F	6 WK WT M	EFF F	EFF M
GFH1 g8	20.6 ± 0.32	25.0 ± 0.47	8.8 ± 0.50	14.8 ± 1.00
GFH1 g9	21.7 ± 0.30	25.5 ± 0.36	10.3 ± 0.74	13.1 ± 0.74
GFH2 g8	22.9 ± 0.40	24.7 ± 0.72	10.9 ± 0.52	13.1 ± 0.52
GFH2 g9	23.9 ± 0.36	26.5 ± 0.59	11.7 ± 0.72	16.1 ± 0.59
GFH3 g8	20.6 ± 0.40	23.6 ± 0.46	10.8 ± 1.05	17.0 ± 0.93
GFH3 g9	22.4 ± 0.45	27.4 ± 0.83	8.9 ± 0.63	12.2 ± 0.93
GFC1 g8	19.8 ± 0.66	25.8 ± 0.94	9.9 ± 0.88	16.2 ± 1.12
GFC1 g9	20.9 ± 0.49	26.3 ± 0.62	10.5 ± 0.63	16.1 ± 0.83
GFC2 g8	24.0 ± 0.43	29.3 ± 0.94	12.1 ± 0.72	15.6 ± 0.79
GFC2 g9	24.6 ± 0.72	31.6 ± 0.76	9.5 ± 0.62	15.5 ± 0.52
GFC3 g8	24.0 ± 0.65	25.1 ± 0.66	11.5 ± 0.70	16.2 ± 0.88
GFC3 g9	21.6 ± 0.49	24.9 ± 0.59	12.4 ± 0.63	14.0 ± 0.57
GFL1 g8	21.8 ± 0.51	26.2 ± 0.64	12.0 ± 0.86	16.2 ± 0.95
GFL1 g9	23.0 ± 0.45	27.3 ± 0.63	10.5 ± 0.68	14.8 ± 0.97
GFL2 g8	23.9 ± 0.51	28.6 ± 0.48	14.3 ± 0.78	14.1 ± 0.43
GFL2 g9	25.7 ± 0.32	30.2 ± 0.52	10.7 ± 0.45	15.0 ± 0.52
GFL3 g8	21.1 ± 0.62	22.6 ± 0.77	14.4 ± 1.14	16.7 ± 0.93
GFL3 g9	21.8 ± 0.39	26.7 ± 0.42	8.7 ± 0.63	12.7 ± 0.69

6 WK WT F = 6 week weight of females (grams)

6 WK WT M = 6 week weight of males (grams)

EFF F = gross efficiency of females (%)

EFF M = gross efficiency of males (%)

g8 = generation 8

g9= generation 9

TABLE A75. GP LINES - RESULTS FROM 4 TO 6 WEEK FOOD INTAKE TRIALS

LINE	ADJ. FOOD	FOOD F	FOOD M	4 WK WT F	4 WK WT M
GPH1 g8	62.1 ± 0.98	63.1 ± 1.33	62.0 ± 1.70	18.3 ± 0.90	16.4 ± 0.98
GPH1 g9	61.4 ± 0.89	64.4 ± 1.44	71.3 ± 1.88	20.2 ± 0.66	20.6 ± 0.73
GPH2 g8	62.6 ± 0.91	61.4 ± 2.24	64.6 ± 1.38	17.8 ± 1.25	17.2 ± 0.67
GPH2 g9	62.9 ± 0.80	63.8 ± 0.94	69.5 ± 1.22	18.0 ± 0.49	19.7 ± 0.62
GPH3 g8	64.1 ± 0.83	58.3 ± 1.14	64.8 ± 1.36	15.0 ± 0.62	16.3 ± 0.82
GPH3 g9	59.8 ± 0.73	63.4 ± 1.20	70.1 ± 1.82	19.6 ± 0.87	21.5 ± 1.05
GPC1 g8	59.7 ± 1.03	57.8 ± 1.28	56.8 ± 1.68	16.4 ± 0.50	15.4 ± 0.95
GPC1 g9	60.3 ± 1.10	58.8 ± 1.93	58.9 ± 1.61	16.7 ± 0.41	16.0 ± 0.52
GPC2 g8	62.4 ± 1.62	57.4 ± 2.65	56.9 ± 2.53	16.4 ± 0.99	14.0 ± 0.99
GPC2 g9	61.2 ± 0.93	60.6 ± 1.45	62.6 ± 1.75	17.3 ± 0.88	17.1 ± 0.75
GPC3 g8	60.1 ± 1.31	52.8 ± 2.27	68.0 ± 2.14	14.4 ± 0.80	19.6 ± 1.26
GPC3 g9	57.3 ± 0.99	56.9 ± 0.90	60.6 ± 1.17	16.6 ± 0.70	18.7 ± 0.79
GPL1 g8	59.1 ± 0.77	54.9 ± 0.92	56.5 ± 1.80	15.4 ± 0.48	14.7 ± 0.87
GPL1 g9	58.6 ± 0.66	57.8 ± 0.79	62.9 ± 0.94	17.0 ± 0.28	18.7 ± 0.43
GPL2 g8	60.1 ± 0.67	53.5 ± 0.82	51.2 ± 1.38	13.4 ± 0.32	12.9 ± 0.68
GPL2 g9	58.0 ± 0.92	55.6 ± 0.96	62.9 ± 0.81	16.5 ± 0.49	18.5 ± 0.61
GPL3 g8	57.4 ± 0.78	50.4 ± 1.72	51.4 ± 1.54	12.2 ± 0.50	14.7 ± 0.61
GPL3 g9	55.0 ± 0.77	51.1 ± 1.00	53.5 ± 1.32	15.2 ± 0.40	16.3 ± 0.45

ADJ. FOOD = 4 to 6 week food intake, adjusted for 4 week weight (grams)

POOD F = 4 to 6 week food intake of females (grams)

FOOD M = 4 to 6 week food intake of males (grams)

4 WK WT F = 4 week weight of females (grams)

4 WK WT M = 4 week weight of males (grams)

g8 = generation 8, g9 = generation 9

TABLE A76. GP LINES - RESULTS FROM 4 TO 6 WEEK FOOD INTAKE TRIALS

LINE	6 WK WT F	6 WK WT M	EFF F	EFF M
GPH1 g8	25.2 ± 0.56	27.3 ± 0.81	11.2 ± 1.01	18.0 ± 1.03
GPH1 g9	27.1 ± 0.51	32.2 ± 0.84	11.0 ± 0.75	16.5 ± 0.64
GPH2 g8	25.8 ± 0.78	27.9 ± 0.62	13.9 ± 1.76	16.6 ± 0.80
GPH2 g9	26.3 ± 0.42	31.2 ± 0.58	13.1 ± 0.67	16.7 ± 0.61
GPH3 g8	25.2 ± 0.46	28.6 ± 0.74	17.6 ± 0.94	19.2 ± 0.76
GPH2 g9	27.2 ± 0.74	31.8 ± 0.92	12.2 ± 0.76	15.2 ± 0.91
GPC1 g8	21.9 ± 0.47	25.2 ± 0.96	9.6 ± 0.78	17.4 ± 0.95
GPC1 g9	22.0 ± 0.69	24.8 ± 0.52	9.0 ± 0.79	15.1 ± 0.62
GPC2 g8	23.9 ± 0.72	24.8 ± 1.18	12.9 ± 1.47	19.2 ± 1.41
GPC2 g9	24.9 ± 0.77	28.0 ± 0.90	12.8 ± 1.22	17.4 ± 0.51
GPC3 g8	21.0 ± 0.66	30.1 ± 1.21	12.7 ± 1.11	15.6 ± 0.86
GPC3 g9	22.6 ± 0.36	27.2 ± 0.62	10.6 ± 0.74	14.0 ± 1.03
GPL1 g8	19.5 ± 0.43	22.7 ± 0.71	7.4 ± 0.51	14.5 ± 0.97
GPL1 g9	21.4 ± 0.40	26.1 ± 0.46	7.6 ± 0.37	11.8 ± 0.57
GPL2 g8	19.7 ± 0.28	20.8 ± 0.59	12.0 ± 0.74	15.7 ± 0.96
GPL2 g9	21.4 ± 0.35	26.3 ± 0.58	8.7 ± 0.67	12.3 ± 0.61
GPL3 g8	19.5 ± 0.48	22.1 ± 0.62	14.8 ± 0.92	14.6 ± 1.01
GPL3 g9	19.8 ± 0.52	23.5 ± 0.47	9.0 ± 0.61	13.5 ± 0.75

6 WK WT F = 6 week weight of females (grams)

6 WK WT M = 6 week weight of males (grams)

EFF F = gross efficiency of females (%)

EFF M = gross efficiency of males (%)

g8 = generation 8

g9 = generation 9

TABLE A77. GA LINES - RESULTS FROM DISSECTION OF 10 WEEK OLD MALES

LINE	RATIO	INDEX	10 WK WT
GAH1 g8	12.4 ± 0.57	31.7 ± 0.71	35.1 ± 0.75
GAH1 g9	10.5 ± 0.52	32.2 ± 0.64	35.2 ± 0.75
GAH2 g8	12.2 ± 0.42	32.6 ± 0.87	36.1 ± 0.93
GAH2 g9	11.3 ± 0.59	34.2 ± 0.66	37.6 ± 0.73
GAH3 g8	13.8 ± 0.89	34.0 ± 0.65	38.2 ± 0.65
GAH3 g9	13.5 ± 0.95	32.5 ± 0.74	36.5 ± 0.91
GAC1 g8	15.6 ± 1.68	29.1 ± 0.74	33.4 ± 1.13
GAC1 g9	11.8 ± 1.05	32.2 ± 0.64	35.2 ± 0.75
GAC2 g8	13.8 ± 0.78	30.7 ± 0.79	34.5 ± 0.86
GAC2 g9	14.2 ± 0.75	30.7 ± 0.90	34.7 ± 0.97
GAC3 g8	19.8 ± 1.30	29.0 ± 0.73	34.5 ± 1.00
GAC3 g9	17.8 ± 1.33	29.1 ± 0.88	34.0 ± 0.88
GAL1 g8	13.9 ± 1.18	26.5 ± 0.61	29.9 ± 0.74
GAL1 g9	16.8 ± 1.16	29.2 ± 0.78	33.7 ± 0.72
GAL2 g8	12.0 ± 0.78	29.9 ± 0.56	33.0 ± 0.62
GAL2 g9	14.2 ± 0.80	29.6 ± 0.48	33.4 ± 0.63
GAL3 g8	17.6 ± 0.86	28.5 ± 0.49	33.2 ± 0.58
GAL3 g9	15.3 ± 0.80	27.2 ± 0.59	31.1 ± 0.76

RATIO = ratio of gonadal fat pad weight to body weight (mg/g)

INDEX = body weight - 8 x (gonadal fat pad weight) (grams)

10 WK WT = 10 week weight (grams)

g8 = generation 8, g9 = generation 9

TABLE A78.

GA LINES - INTRA-CLASS CORRELATIONS CALCULATED WHEN DATA WERE ADJUSTED FOR LITTER SIZE

Character	Females	Males
Adj.Food Intake	0.36 ± 0.046	0.42 ± 0.044
Food Intake	0.45 ± 0.042	0.52 ± 0.039
4 Week Weight	0.68 ± 0.028	0.62 ± 0.032
6 Week Weight	0.52 ± 0.039	0.50 ± 0.040
4-6 Week	0.52 ± 0.039	0.40 ± 0.045

TABLE A79.

GA LINES - HERITABILITY ESTIMATES FROM TWICE REGRESSION OF OFFSPRING ON DAM

	Daughter	Son	Litter Mean
Adj.Food Intake	0.35 ± 0.076 0.30 ± 0.076	0.35 ± 0.085 0.25 ± 0.083	0.34 ± 0.081 0.28 ± 0.080
Food Intake	0.19 ± 0.075 0.29 ± 0.078	0.42 ± 0.080 0.52 ± 0.084	0.28 ± 0.082 0.38 ± 0.084
4 Week Weight	-0.03 ± 0.077 0.15 ± 0.074	0.17 ± 0.084 0.37 ± 0.080	0.06 ± 0.090 0.24 ± 0.090
6 Week Weight	0.37 ± 0.072 0.53 ± 0.074	0.60 ± 0.088 0.77 ± 0.091	0.48 ± 0.086 0.63 ± 0.088
4-6 Week Gain	0.37 ± 0.074 0.28 ± 0.073	0.37 ± 0.076 0.31 ± 0.073	0.36 ± 0.079 0.30 ± 0.074

Second figures are those obtained when data were adjusted for litter size.

All figures unadjusted for sex-difference in variance.

TABLE A80.

GA LINES - HERITABILITY ESTIMATES FROM TWICE REGRESSION OF OFFSPRING ON SIRE

	Daughter	Son	Litter Mean
Adj.Food	0.00 ± 0.066	-0.06 ± 0.077	-0.02 ± 0.072
Intake	0.01 ± 0.065	-0.05 ± 0.074	-0.02 ± 0.069
Food	0.25 ± 0.065	0.08 ± 0.072	0.16 ± 0.072
Intake	0.25 ± 0.064	0.08 ± 0.072	0.16 ± 0.072
4 Week	0.08 ± 0.068	0.07 ± 0.076	0.08 ± 0.084
Weight	0.09 ± 0.064	0.08 ± 0.071	0.09 ± 0.076
6 Week	0.37 ± 0.059	0.11 ± 0.075	0.23 ± 0.074
Weight	0.36 ± 0.058	0.11 ± 0.075	0.23 ± 0.073
4-6 Week	0.24 ± 0.069	0.07 ± 0.074	0.16 ± 0.078
Gain	0.25 ± 0.066	0.08 ± 0.072	0.17 ± 0.072

Second figures are those obtained when the data were adjusted for litter size.

All figures unadjusted for sex-difference in variance.

TABLE A81.

GA LINES - GENETIC CORRELATIONS CALCULATED FROM REGRESSIONS OF DAUGHTER AND SON ON DAM

	Adj.Food Intake	Food intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Adj.Food		0.87	0.28	0.59	0.66
Intake		0.65	0.16	0.24	0.56
Food intake	1.01		0.72	0.83	0.65
Intake	0.76		0.78	0.85	0.43
4 Week				0.78	0.35
Weight	0.02	0.45		0.81	0.15
6 Week	0.44	0.64			0.86
Weight	0.22	0.72	0.65		0.67
4-6 Week	0.61	0.93		1.07	
Gain	0.48	0.63	0.38	0.74	

Daughter on dam on left of diagonal, son on dam on right.

Second figures are those obtained when data were adjusted for litter size.

Standard errors range from 0.003 (s.e. of 1.01) to 0.252 (s.e. of 0.02).

TABLE A82.

GA LINES - GENETIC CORRELATIONS CALCULATED FROM REGRESSIONS OF DAUGHTER AND SON ON SIRE

	Food Intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Food		1.08	0.88	-0.06
Intake		1.06	0.86	-0.02
4 Week	1.28		0.61	0.11
Weight	1.21		0.59	-0.02
6 Week	0.97	0.93		0.67
Weight	0.97	0.88		0.62
4-6 Week	0.64	0.89	1.00	
Gain	0.59	0.68	0.95	

Daughter on sire on right of diagonal, son on sire on left.

Second figures are those obtained when data were adjusted for litter size.

Standard errors range from 0.001 (s.e of 1.00) to 0.737 (s.e. of 0.11).

TABLE A83.

GA LINES - GENETIC CORRELATIONS CALCULATED FROM REGRESSIONS OF LITTER MEAN ON SIRE AND DAM.

	Adj.Food Intake	Food Intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Food	0.92		1.13	0.97	0.51
Intake	0.68		1.11	0.97	0.45
4 Week		0.49		0.78	0.47
Weight	0.06	0.62		0.79	0.35
6 Week	0.52	0.77	0.85		0.87
Weight	0.20	0.81	0.76		0.79
4-6 Week	0.66	0.81	0.68	0.97	
Gain	0.56	0.48	0.28	0.73	

Litter mean on dam on left of diagonal, litter mean on sire on right.

Second figures are those obtained when data were adjusted for litter size.

Standard errors range from 0.015 (s.e. of 0.97) to 0.379 (s.e. of 0.47).

TABLE A84.

GA LINES - PHENOTYPIC CORRELATIONS CALCULATED WHEN DATA WERE ADJUSTED FOR LITTER SIZE

	Adj.Food Intake	Ffod Intake	4 Week Weight	6 Week Weight	4-6 Week Gain
Adj.Food Intake		0.53	-0.31	0.30	0.48
Food Intake	0.74		0.64	0.82	0.36
4 Week Weight	-0.09	0.60		0.73	-0.23
6 Week Weight	0.33	0.72	0.66		0.50
4-6 Week	0.52	0.12	-0.44	0.38	

Females on left of diagonal, males on right.

TABLE A85.

GF & GP LINES - INTRA-CLASS CORRELATIONS CALCULATED WHEN DATA ADJUSTED FOR LITTER SIZE

Character	t
Ratio of GFPW/BW	0.41 ± 0.030
BW - 8 x GFPW	0.48 ± 0.028
GFPW	0.44 ± 0.030
10 Week Weight	0.50 ± 0.028
6 Week Weight	0.35 ± 0.032

TABLE A86.

GF & GP LINES - HERITABILITY ESTIMATES FROM TWICE REGRESSION OF SON AND LITTER MEAN ON SIRE

	Son	Litter Mean
Ratio of	0.44 ± 0.053	0.45 ± 0.066
GFPW/BW	0.48 ± 0.052	0.48 ± 0.064
BW - 8 x	0.28 ± 0.056	0.29 ± 0.070
GFPW	0.26 ± 0.056	0.27 ± 0.070
Gonadal Fat	0.47 ± 0.054	0.46 ± 0.067
Pad Weight	0.49 ± 0.052	0.48 ± 0.064
10 Week	0.35 ± 0.056	0.35 ± 0.071
Weight	0.34 ± 0.055	0.33 ± 0.070
6 Week	0.17 ± 0.056	0.20 ± 0.073
Weight	0.16 ± 0.053	0.20 ± 0.069

Second figures are those obtained when data were adjusted for litter size.

TABLE A87.

GF & GP LINES - GENETIC CORRELATIONS CALCULATED FROM REGRESSIONS OF SON AND LITTER MEAN ON SIRE

	Ratio of GFPW/BW	BW - 8 x GFPW	Gonadal Fat Pad Weight	10 Week Weight	6 Week Weight
Ratio of		0.13	0.97	0.48	0.42
GFPW/BW		0.06	0.97	0.50	0.47
BW - 8 x	0.08		0.31	0.91	0.94
GFPW	0.12		0.29	0.90	0.88
Gonadal Fat	0.97	0.36		0.68	0.62
Pad Weight	0.97	0.35		0.68	0.65
10 Week	0.52	0.92	0.71		0.99
Weight	0.54	0.90	0.72		0.97
6 Week	0.43	0.91	0.63	0.96	
Weight	0.50	0.86	0.67	0.94	

Son on sire on left of diagonal, litter mean on sire on right.
Second figures are those obtained when the data were adjusted for litter size.
Standard errors range from 0.002 (s.e. of 0.99) to 0.136 (s.e. of 0.42).

TABLE A88.

GF & GP LINES - PHENOTYPIC CORRELATIONS CALCULATED WHEN DATA WERE ADJUSTED FOR LITTER SIZE

	Ratio of GFPW/BW	BW - 8 x GFPW	Gonadal Fat Pad Weight	10 Week Weight
BW - 8 x GFPW	-0.05			
Gonadal Fat Pad Weight	0.95	0.24		
10 Week Weight	0.30	0.94	0.56	
6 Week	0.36	0.89	0.54	0.95