EFFECT OF PRE-WEANING NUTRIENT SUPPLY ON POST-WEANING EFFICIENCY

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SUMMARY

A cross-fostering experiment was performed on 400 mice selected for high or low post weaning net feed intake (NFI). Cross fostering was used as a method of altering pre-weaning nutrient supply, which allowed the genotype by environment interaction to be studied. At weaning, mice were placed on a 3 week feed intake test where growth and intake traits were measured. Mice from both selection lines that had restricted pre-weaning nutrient supply had lower weaning weights and intakes but compensated for the lack in nutrient supply with greater rates of post-weaning gain. At the average litter size mice selected for low NFI were generally the same weight, consumed 18% less and were thus more efficient than high NFI mice. The effect of pre-weaning nutrition was greater in high NFI mice than low NFI mice. These results suggest that selection for low NFI could result in animals that are better able to handle fluctuations in nutrient supply.

Keywords: Net feed intake, litter size, mice

INTRODUCTION

Feed is a major cost in all livestock industries with over 50% of feed consumed in a typical beef enterprise being used to maintain the breeding herd (Ferrell and Jenkins 1984). Therefore including feed efficiency as part of a selection criteria would improve the profitability of the production system (Archer *et al.* 1997). Net feed intake (NFI), defined as the variation in intake independent of differences in weight gain, weight maintained and sex, was first proposed by Koch *et al* (1963) as an alternative method for estimating efficiency. More recently, Arthur *et al* (1997) have shown in cattle that there is considerable variation in net feed efficiency and that this variation is moderately heritable indicating improvements could be made by selection.

In Australia, both sheep and cattle are subject to wide seasonal variation in the quality and quantity of food. When food is limited there is often a period of restricted growth, such that when feed becomes readily available, growth is accelerated. This is known as compensatory growth. It is unknown whether a restriction in feed intake will affect animals with high or low NFI, differently. The aim of this study was to test the difference between two lines of mice selected for high or low NFI, in their response to a restriction in pre-weaning nutrient supply.

MATERIALS AND METHODS

The mice used originated from a random mating population (generation 1-4), used previously to estimate phenotypic and genetic parameters for feeding and growth traits (Archer 1996). From generation 5-11 the mice were selected for high or low net feed intake (based on estimated breeding values) to estimate the response to selection for feed efficiency (Hughes *et al.* 1997). The mice used in this experiment were from generation 11.

To limit/enhance pre-weaning nutrient supply, litters within the same selection line were cross fostered to achieve litter size from 3-16 pups. Mice were weaned at 24 days, and weaning weight recorded. Five mice were chosen at random from each litter to be individually housed so that feed intake and body weight measurements could be recorded weekly for 3 weeks. Average daily gain (ADG), daily feed intake (DFI), net feed intake (NFI), and the ratio of feed intake to gain, feed conversion efficiency (FCE) were calculated during the post-weaning test. NFI was calculated as described by Hughes *et al* (1997).

Pre-weaning all mice were housed in the same sort of box. However due to the large number of mice that required individual housing post-weaning 2 box types were used. The boxes varied in size and shape. Mice were fed a standard laboratory feed (New Joint Stock Ration, Milling Industries) *ad libitum*. Following the feed intake test, the body composition (Fat %) of the mice was measured using an EM-SCAN Small Animal Body Composition Analyser.

Both feed intake and body composition traits were analysed using a general linear model. An analysis of variance was used to assess the main effects, covariates and interactions, and interactions or effects that were not significant at the 5% level, were removed from the final model (Table 1).

RESULTS

The results presented in Table 1 show that the type of box the mice were housed in post-weaning affected all of the traits studied. The least squares means indicated that mice housed in the smaller boxes were 4% heavier at weaning, ate 9% more and gained 15% less than mice in larger boxes. Box type accounted for 9% of the variation observed in net feed intake, with animals in the smaller boxes having significantly lower net feed intake than animals in large boxes.

Table 1. Percentage of the variation (type III) accounted for by terms in the statistical model.

	Wean Wt	ADG	FCE	DFI	NFI	Fat %
Sex	3 ***	15 ***	2 **	14 ***	0 ns	3 ***
Box	1 *	2 **	2 **	9 ***	10 ***	1 *
Line	3 ***	2 **	4 ***	5 ***	4 ***	1 *
Litter Size	44 ***	17 ***	5 ***	5 ***	0 ns	6 ***
Litter Size*Line	1 ***	1 *	2 **	0 ns	0 ns	1 ns
Total	6109	11.9	0.765	134	80	842

ns P>0.05; * P<0.05; ** P<0.01; *** P<0.001

As seen in Table 1 litter size had no effect on net feed intake but a large effect on weight, daily gain, feed conversion efficiency, feed intake and body composition. Figures 1 a, b, c, and d show that independent of genotype, mice from larger litters grew faster, consumed less food, were more efficient and had a lower body fat percentage than mice from smaller litters. Litter size explained 44% of the variation observed in weaning weight, with mice from larger litters weighing significantly less than those from small litters.

Significant differences between the lines are also shown in Table 1 for growth, intake and body composition traits. At the average litter size (10 pups) the low feed intake line, were slightly heavier, ate significantly 20 % less, were 51% more efficient and were 8% fatter, than the high feed intake line.

The interaction between litter size and selection line was significant at varying levels for growth traits, (weight and daily gain) feed conversion efficiency (Figures 2a, 2b, and 2d) but not for intake traits (daily or net feed intake, Figure 2c) or body fat percentage. When litter size was small, mice from the low intake line were the same weight but gained more than animals from the high feed intake line. When the litter size was larger mice from the low feed intake line were significantly heavier but gained slower than the high intake line.

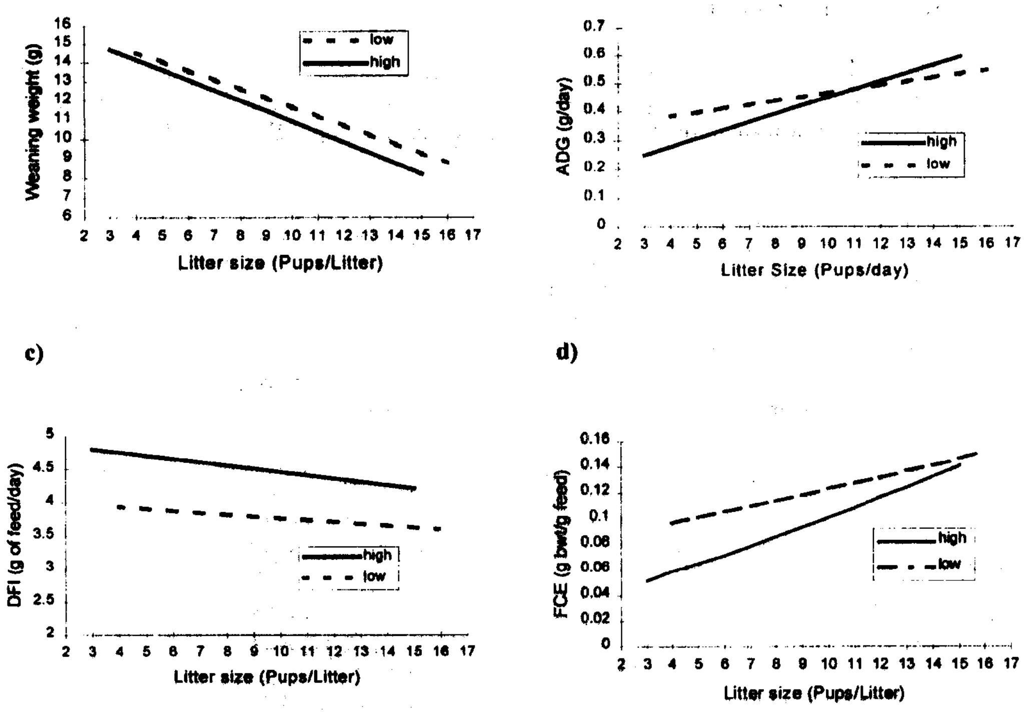

Figure 1.The response by the NFI selection lines in a) weaning weight, b) average daily gain, c) daily feed intake and d) feed conversion efficiency to a change in nutrient supply.

DISCUSSION

A great deal of work has been done, using litter size to restrict pre-weaning nutrition, specifically to study compensatory growth. The unique part of this project is that the interaction between the environment (litter size or pre-weaning nutrient supply) and genotype (selection line) could be examined.

Mice that were tested post-weaning in small boxes had significantly higher weaning weights than animals in larger boxes. The differences observed in weaning weight were purely due to chance, because box type was the same pre-weaning. These mice also ate more but gained less during the post-weaning test, indicating that due to chance mice in smaller boxes could be at a later stage of development than mice in larger boxes.

The differences observed in post-weaning daily gain and body fat between mice from small and large litters were indicative of compensatory growth. The first phase of compensatory growth is associated with high rates of lean deposition which reflects the replenishment of visceral organs and the digestive tract. Animals in this phase are usually leaner than normal growing animals (Wright and Russel 1991). At seven weeks of age mice from large litters were leaner than those from small litters, indicating that compensatory growth was not complete at this stage. Mice from large litters ate significantly less than mice from small litters but when feed intake was adjusted for body weight and weight gain there was no difference between the lines.

After seven generations of selection for low post-weaning net feed intake, there was no change in body weight, an increase in post-weaning efficiency, decreased feed intake, and slightly fatter mice. Limiting pre-weaning nutrient supply did not affect mice with low feed intake as greatly as mice with high feed intake. This is possibly because high intake mice require more food to grow the same rate as low intake mice. If this is generally the case, then when feed is limited (large litter sizes), high intake animals will be most affected. This study has demonstrated that the difference between the efficiency selection lines in their response to a restriction in pre-weaning nutrient supply was a function of growth rather than intake.

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