COMPENSATORY GROWTH IN RATS FEED INTAKE AND GROWTH PATTERNS

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SUMMARY

Studies were conducted to examine the response of rats to different levels of undernutrition followed by realimentation. Rats given a ration sufficient to maintain their body weight at 213 g for 23 days, and then fed *ad libitum* during the realimentation period, consumed 14% more feed, grew 29% faster and were 14% more efficient in converting feed than unrestricted controls of the same weight. When rats were subjected to severe nutritional restrictions resulting in weight losses of 29% and 35% of their initial body weights and then fed *ad libitum*, feed consumption was 35% greater than in unrestricted control and weight gains increased 112% with an increase of 55% in feed conversion efficiency being achieved over unrestricted animals of equivalent body weights. Irrespective of the severity of nutritional restriction, only partial compensatory growth occurred with weight for age of unrestricted controls never being attained by animals on restricted diets.

Keywords: rats, compensatory growth, feed conversion

INTRODUCTION

Compensatory growth refers to the greater than normal growth rates sometimes observed after a period of nutritional restriction. Tanner (1963) used the term "catch up growth" and this phenomenon has been reviewed in a wide range of species by Wilson and Osboum (1960), Allden (1970), Moran and Holmes (1978), O'Donovan (1984), and Ryan (1990). Complete compensation occurs during realimentation where restricted animals exhibit increased growth rates that are sustained for sufficient time to permit the same weight for age as animals not subjected to nutritional insufficiency. While this has been demonstrated on numerous occasions in sheep (Allden 1968; Thornton *et* al. 1979), only Ryan *et al.* (1993) have reported full compensation in cattle. Widdowson and McCance (1960) and Widdowson and Kennedy (1962) showed that pre-weaning undernutrition in rats altered their subsequent development, while Widdowson and McCance (1963) demonstrated undernutrition after weaning made less difference to the ability of rats to recover their weight completely.

The basic mechanisms involved in compensatory growth appear to be an increase in the amount of feed consumed, a reduced maintenance requirement and an alteration in the proportion of fat and protein deposited in the tissues. Factors which may be responsible for the variability in compensatory growth are age at which nutritional restriction is imposed, the severity of restriction and its duration. The objective of this experiment was to determine the relative importance of feed intake and feed conversion efficiency associated with compensatory growth in rats of similar weight, but which had been subjected to varying degrees of feed restriction and then realimented using the same ration that was given to the rats fed *ad libitum.*

MATERIALS AND METHODS

Eighty male rats of the black and white hooded strain were weaned on the same day at a mean age of 21 days and randomly allocated to 4 treatments of 20 animals each. Control animals (treatment, Tr.1) were offered feed *ad Zibitum* during the entire experimental period. Animals in Tr.2 had their feed restricted from day 21 post-weaning to maintain their body weights for 44 days. Animals in Tr.3 were subjected to a more severe feed restriction commencing 35 days after weaning and this was continued until 64 days post-weaning. Animals in Tr.4 were offered less feed than those in Tr.3 from 46 to 64 days post- weaning. Feed offered to the 3 restricted groups was such that body weights of animals were similar at day 64 post-weaning when feed was offered *ad Zibitum.* Periods of feed restriction, realimentation and growth curves are expressed in Figure 1.

The 20 rats in each treatment consisted of 5 replications of 4 animals in each. Rats in each replication were housed separately and maintained at a constant room temperature of 23°C. Body weights were measured on 3 occasions each week and feed intakes were measured on a daily basis.

The diet used was a commercial product* containing 24% crude protein on a dry matter basis. All animals

* "QCMA" Early Piglet Weaner Ration, QCMA Rural, 154 Anzac Avenue, Toowoomba, Qld.

were offered the ration *ad Zibitum* from weaning until the termination of the experiment except for those periods when animals on restricted intakes were offered less.

Data were analysed using general linear model procedure and means separation was done using Tukey's test at $P<0.05$ using SAS (1993).

RESULTS

The growth patterns are shown in Figure 1. During periods of restricted intakes, animals in Tr.2 were maintained at a relatively constant body weight, while animals in Tr.3 and Tr. 4 were subjected to progressively increasingly levels of undernutrition, with weight losses representing 29% and 35% of pre-treatment body weights respectively. The patterns of growth during realimentation clearly display an initial acceleration in the rate of body weight gain in all restricted treatments but this was not maintained for sufficient time to enable complete compensation, with body weights of all groups running in parallel thereafter.

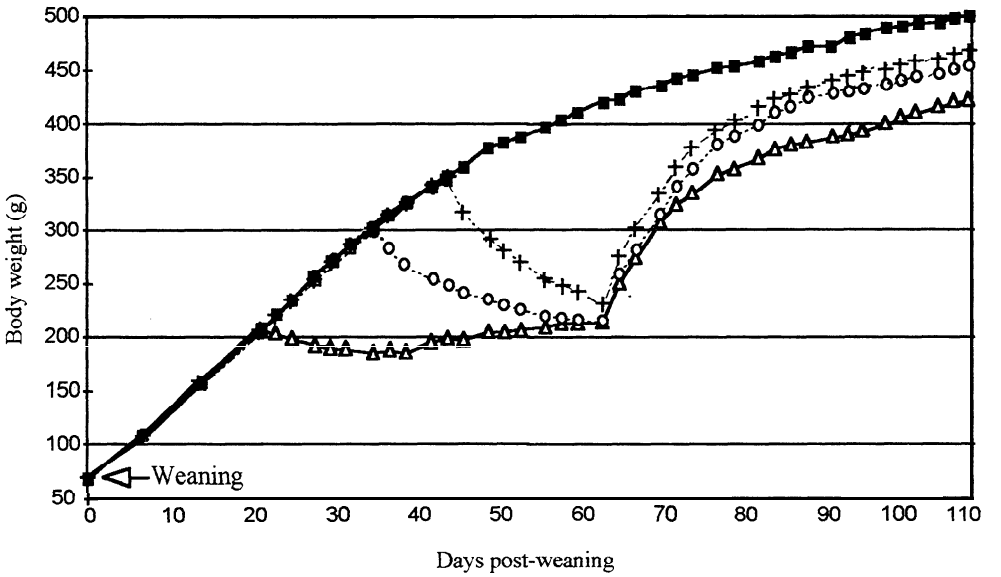

Figure 1. The effect of undernutrition on the growth of rats. ■, *ad libitum* feed after weaning; Δ, maintenance ration from 24 to 64 days post-weaning then *ad libitum* feed; O, moderate weight loss from 35 to 64 days post-weaning then *ad libitum* feed; +, severe weight loss from 46 to 64 days post-weaning then *ad libitum* feed

Table 1. Mean growth rates, dry matter (DM) intakes and feed conversion efficiencies (± sem) of control and restricted rats

Treatment during restriction phase	Initial body weight (g)	Period of determination (days)[A]	Final body weight (g)	Weight gain (g/day)	DM intake (g/kg body weight)	Feed conversion (g DM/g gain)
1. Unrestricted feeding	209.2±4.2	32	388.2±8.5	5.59^{c}±0.15	69.83^{c}±0.25	3.73^{c}±0.06
2. Maintenance	213.4±2.2	23	379.5±9.1	7.22^{b}±0.35	79.68^{b}±0.90	3.27^{b}±0.11
3. Moderate weight loss	213.0±2.2	14	380.1±5.2	11.93^{a}±0.33	95.16^{a}±1.80	2.36^{a}±0.03
4. Severe weight loss	229.3±5.9	14	394.5±7.7	11.80^{a}±0.29	93.41^{a}±2.05	2.47^{a}±0.02

Means in the same column with different superscripts differ significantly ($P < 0.05$).

[A]Note the period of determination is defined as the number of days taken for rats in different treatments to grow from a mean of approximately 216 to 385g body weight.

Growth rates, dry matter intakes and food conversion efficiencies (calculated as g dry matter/g body weight gain) have been compared over a similar weight range and are given in Table 1. Dry matter intake per kg of body weight and feed conversion efficiency during realimentation were influenced by the extent of feed restriction prior to ad *libitum* feeding. Animals experiencing weight loss during feed restriction (Tr. 3 and Tr. 4), consumed greater (P_C 0.05) amounts of feed and converted it more efficiently ($P<$ 0.05) than those maintained at a constant body weight (Tr. 2) or allowed to grow continuously (Tr. 1).

Daily dry matter intakes of control rats fluctuated over the experimental period with consumption increasing only slightly as body weights increased (Figure 2). Daily dry matter intake per animal was much greater (P_C 0.05) in the realimentation phase in animals subjected to feed restriction, with the response being greatest in those treatments in which weight loss had occurred and intermediate in the treatment in which body weight was maintained prior to realimentation. The increased daily dry matter intake of restricted rats was maintained for about 14 days in animals held at constant body weight and was extended to 21 days where weight loss occurred prior to ad *libitum* feeding.

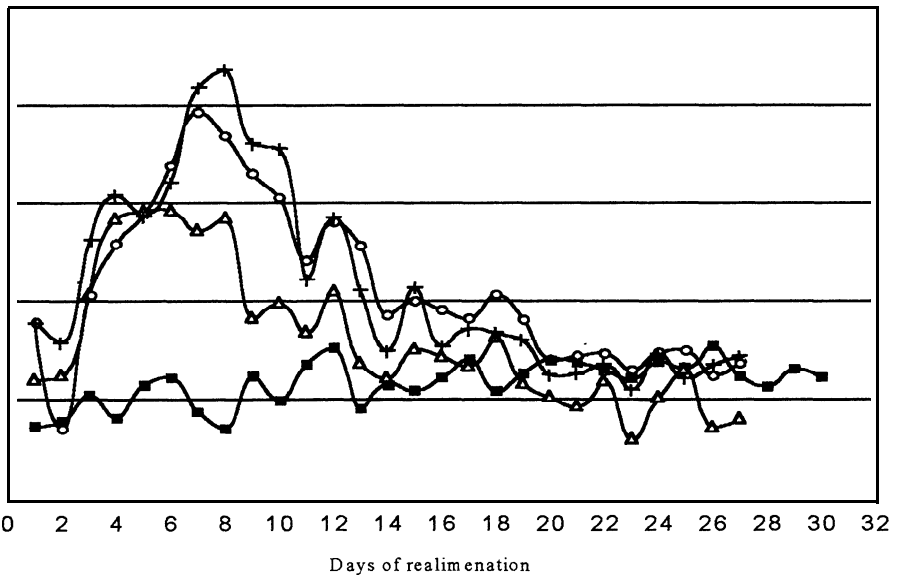

Figure 2. Dry matter (DM) intakes during realimentation. ■, *ad libitum* feed after weaning; Δ, maintenance ration from 24 to 64 days post weaning then *ad libitum* feed; O, moderate weight loss from 35 to 64 days post weaning then *ad libitum* feed; +, severe weight loss from 46 to 64 days post weaning then *ad libitum* feed

DISCUSSION

The degree of partial compensatory growth in rats was influenced by the magnitude of body weight loss imposed during the period of feed restriction. The degree of the partial compensatory growth was due to both increased dry matter intake and efficiency of feed conversion. The magnitude of these 2 functions was influenced by the severity of feed restriction with both feed intake and feed conversion efficiency being significantly greater in those rats where appreciable weight loss was imposed. In addition, the age at which weight loss was imposed may also have had an effect on compensatory growth during the realimentation period.

The partial compensation seen in rats in this study is in agreement with responses in cattle (Graham and Searle 1975) whereas sheep were able to compensate completely (Allden 1968; Thornton 1979). All the experiments involved in compensatory growth studies attributed feed intake as being the major determinant that controls the degree of compensation during the realimentation period. It has been shown that feed intakes in rats is controlled by central mechanisms in the brain (McShane *et al.* 1992) associated with neuropeptide y. The secretion of this neuropeptide y was influenced by the body condition of rats (Schwartz *et al.* 1991). This may explain the variability in compensatory growth responses seen in cattle and sheep. The interaction of age, severity and duration of feed restriction and the effect of this interaction on the central control mechanism needs further investigation in domestic animals.

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