THE EFFECT OF CYCLE PERIOD, RATION LEVEL AND REPETITIVE CYCLING ON THE COMPENSATORY GROWTH RESPONSE IN RAINBOW TROUT, *Salmo gairdneri* Richardson

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B.Sc., The University of British Columbia, 1981

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

DEPARTMENT OF ZOOLOGY

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

May 1989

6

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Date April 17, 1989

Abstract

The Effect of Cycle Period, Ration Level and Repetitive Cycling on the Compensatory Growth Response in Rainbow Trout, *Salmo gairdneri* Richardson

Compensatory growth is the phase of rapid growth, greater than normal or control growth, which occurs upon adequate refeeding following a period of undernutrition. The effect of cycle period (length of the starvation and following refeeding periods), ration level and repetitive cycling (repetition of cycle periods) on the compensatory growth response in rainbow trout, *Salmo gairdneri* Richardson were evaluated in two experiments. A cycle period of three weeks produced better results in terms of average percentage changes in weight and length and in specific growth rate than either one or two week cycle periods. There was no significant difference between the cyclically fed fish and a constantly fed control group. Three ration levels were compared using a three week cycle period and the only effect of increased ration was to decrease conversion efficiency. There were no significant differences in the average weight of control and experimental groups after six or twelve weeks of continuous cycling thought the controls had been fed more than twice as much food. Carcass analysis of moisture, fat, protein and ash showed no significant differences between the controls and experimental group after one complete cycle. Possible mechanisms underlying the compensatory growth response are discussed.

Table of Contents

List of Tables

List of Figures

Acknowledgements

I would like to thank my supervisor, Dr. Robert W. Blake and Dr G.E. Scudder and the Department of Zoology of the University of British Columbia for financial support.

Introduction

The purpose of this study is to determine the effect of cycle period, ration level and repetitive cycling on the compensatory growth response in rainbow trout, *Salmo gairdneri* Richardson. Compensatory growth is a phase of rapid growth, greater than normal or control growth rates associated with adequate refeeding of animals following a period of weight loss caused by undernutrition (Dobson and Holmes, 1984). Cycle period is the length of the starvation and following refeeding periods. A three week cycle period would be three weeks of starvation followed by three weeks of feeding. The ration level is the amount of feed fed to the fish per day. This is calculated as a percentage of the total body weight of all fish in an experimental group and is expressed in percent body weight per day. Repetitive cycling means the cycles of starvation and refeeding are repeated, alternating periods of feeding with periods of starvation.

Early References

Compensatory growth has been observed in agricultural animals since the turn of the century. Waters (1908, 1909) showed that undernourished beef steers, if adequately fed, could recover and reach normal mature size and weight. He felt this was an essential trait for any animal subject to periods of undernutrition or starvation. Osbourne and Mendel (1915a,b) found that rats, when given unrestricted food, could recover and reach normal mature size after being held at a constant weight for up to 500 days with restricted diet. Work with dairy heifers (Swett and Eckles, 1918) showed that there was a general tendency for animals to recover from periods of undernutrition but growth could be permanently stunted if the restriction was too severe. This permanent stunting was also found in rats held at constant weight by dietary restriction for 1000 days (McCay *et al*, 1939). Brody (1927) suggested that the increased rate of growth following a period of restriction was proportional to that required to achieve normal adult size. This idea was expressed by Bohman (1955) when he defined compensatory growth as abnormally rapid growth relative to age. This long term compensatory growth has been shown to occur in human children (Sternes and Moore, 1931). Children given a balanced diet after a period of malnutrition showed up to a nine times normal increase in weight and a four times normal increase in height in the first three months. Growth rate can also be affected by other stresses. Crichtion and Aitken (1954) showed that the decline in growth rate which occurs when heifers are mated too early is completely made up during the following lactations if the cattle are adequately fed. Palsson (1955) noted that generally any part, organ or tissue of an animal whose growth has been retarded by nutritional restriction can recover if the restriction has not been too severe. This long term type of compensatory growth response is clearly shown in the negative correlation between winter and summer weight gains of pastured animals. Those animals which lost the most weight over the winter gained the most in the spring and summer when feed became plentiful (Black *et al*, 1940, Pearson-Hughs *et al*, 1955).

In their review of compensatory growth Wilson and Osbourn

(1960) state that compensatory growth, after a period of undernutrition, is a constant feature among higher animals. Their conclusions are summarized below:

i) The growth rate following period of undernutrition is usually enhanced.

ii) Too severe restriction can cause permanent stunting.

iii) Five main factors influence the extent of compensatory growth:a) nature of restricted diet.

b) degree of severity of restriction.

c) length of restriction period.

d) relative rate of maturity of the species.

e) the pattern of refeeding.

iv) Recovery from protein and/or carbohydrate restriction is usually complete.

v) The rate of compensatory growth immediately following refeeding increases with severity of restriction.

vi) The pattern of refeeding may effect the carcass composition.

vii) Recovery may occur either by prolonging the time to reach mature weight or by increasing growth rates during refeeding, especially when refeeding has just begun.

Recent Agricultural Work

There has been a great deal of interest in the compensatory growth response of sheep and cattle. Recent work has focused on the changes in body composition which accompany compensatory growth and attempts to describe some of its underlying mechanisms. Meyer and Clawson's 1964 study looked at undernutrition and refeeding in both rats and sheep. They found that the maintenance ration was about 52% of what was eaten *ad libitum* in both animals. Any less resulted in weight loss, which was similar in proportion to weight gains when fed above this level The alimentary tract decreased in size during starvation, contrary to finding by Wilson and Osbourn (1960). Compensatory growth occurred in both rats and sheep. The total energy content and protein levels of the compensating rats, when given equal feed, were less than that of the controls. There was no significant difference in the total energy content between the refed and control sheep but the protein levels was lower in refed sheep than in the controls. The weight gain of the compensating animals was more fat and less protein than for the animals fed *ad libitum* in both sheep and rats. There was no depression of the metabolic rate during undernutrition or refeeding, nor was there any increase in appetite in either sheep or rats. Increased efficiency of food utilization above maintenance was largely responsible for the compensatory growth in both species.

The study of mature sheep body composition and efficiency during loss and regain of live weight by Keenan *et al* (1969) gave different results. During weight loss the tissue was inefficiently mobilized. A 16% loss of weight resulted in a 30% loss of total body energy. The sheep were maintained at the reduced weight for eight weeks and then fed *ad libitum* for five weeks. Only 75% of the energy deficit was recovered. The regained tissue had a high water and low fat content compared to the continuously grown sheep. This contrasts with the results of Meyers and Clawson (1964) who found that the refed sheep has a greater fat content than their controls.

Walker and Garrett (1970) subjected male rats to prolonged undernutrition and examined the effects of refeeding. The energy intake required for maintenance decreased as the duration of food restriction increased. This reduced maintenance level continued into the feeding period. During both restriction and refeeding there was an increase in the efficiency of utilization of energy. As the refeeding period continued the increased efficiency of utilization of energy declined to the level of the controls.

McMannus *et al* (1972) examined compensatory growth in five to six month old sheep. Uninterrupted growth for 58 days (36.2 % gain) was compared to undernutrition for 27 days (21.7% loss) followed by refeeding for 52 days (62.2% gain). During restriction the sheep used the feed more efficiently that the controls. During refeeding they were less efficient than the controls. The compensating animals drank more water, ingested more food per unit body weight, laid down less fat and more protein and retained more water. There was no significant difference in the THS output from the thyroid between the compensating sheep and the controls. Compensating sheep had significantly lower plasma somatotrophin potency per unit body weight than the underfed sheep and no ACTH activity was detected. With severe undernutrition the anterior pituitary gland decreased in size but not cell number and still elaborated somatotrophin. Decrease in body size with underfeeding resulted in an increase in the ratio of circulating somatotrophin per unit body size. During compensatory growth there was hypertrophy of the anterior pituitary gland and evidence of enhanced synthesizing capacity.

Little and Sandland (1975) studied the distribution of body fat in sheep during continuous growth and after feed restriction and refeeding. Restricted animals had the same proportion of fat per unit wool-free empty body weight as the continuously grown animals. Refeeding sheep accumulated less fat and more protein and water than the continuously grown sheep. There was a relatively greater loss of fat from subcutaneous deposits than from the body. Deposition of fat on the skeleton continued during restriction.

Weaner sheep (Graham and Searle, 1975) had greater voluntary food intake during refeeding. The basal metabolic rate was reduced during weight stasis. The suppressed metabolic rate rose during the first month of recovery but to levels less than that of the controls. In the first week of recovery the net energetic efficiency was higher while the maintenance requirements were lower. The gross efficiency was higher as intake was high relative to maintenance. Nitrogen utilization was found to be more efficient in the first two weeks of compensatory growth.

The body composition of the weaner sheep was then examined (Searle and Graham, 1975). After weight stasis the sheep had less protein, more water and equal fat composition compared to the constantly fed controls. With partial and complete recovery the body composition was the same as the controls.

In immature sheep (Drew and Reid, 1975 a,b,c) underfeeding to and empty body weight (E.B.W.) loss of 25% generally produced changes in body composition similar to reversal of normal growth. The level of body fat however did not decrease during the first half of the restriction period and did not increase for the first two weeks of refeeding. Refed sheep at 45 kg E.B.W. contained more protein and water and less fat than the continuously fed sheep. These effects were greater in the carcass and so the carcasses of the refed sheep were heavier with less fat and more lean than those continuously fed. Sheep fed at 70% *ad libitum* produced carcasses with more protein than those fed *ad libitum* for either continuously fed and refed sheep. The reduction of bone water and accumulation of bone fat during severe underfeeding was rapid. Upon refeeding the bone fat was rapidly mobilized and bone water returned to normal. Initial weight loss was due mostly to loss of water from the bone and fat utilization. In early regrowth there was a stimulation of protein synthesis and a depression of fat synthesis. The ratio of muscle to fat gain in sheep from 30 to 40 kg E.B.W. was 2.23:1 for refed sheep and 1.08:1 for continuously grown sheep. There was a 46% increase in the rate of gain following refeeding with no increase in intake per day compared to continuously grown sheep. Much of this could be due to the rapid accumulation of water (Drew and Reid, 1975c). The total feed cost to reach 45 kg E.B.W. was 27% higher for the refed sheep than those fed *ad libitum* to the same E.B.W.. There was no significant difference between normal growth and refeeding in efficiency of energy retention above maintenance.

Rats showed a significant difference in the compensatory growth response between young and old animals (Miller and Wise, 1976). Young refed animals were 39% more efficient and old animals were 21% more efficient than the controls in food conversion. In gross energetic efficiency the young refed animals were 29% and the old refed animals were 17% more efficient than the continuously fed animals. This was probably due to differences in metabolism between the younger and older animals. The "catch up" growth was associated with an increased food uptake and metabolic adaptations that gave higher efficiencies. Miller and Wise (1976) postulated that the difference between young and old animals was due to either a higher efficiency of synthesis or lower metabolic costs for the younger animals.

Thornton *et al* (1979) was the first work on compensatory growth in sheep to incorporate two periods of weight loss and refeeding on both immature (below 23 kg) and mature (above 43 kg) sheep. Immature sheep were depleted of fat during weight loss. The loss of fat from the meat was associated with both atrophy and hypoplasia of the subcutaneous adipose cells. The meat of mature sheep showed an increase in fat during weight loss but only atrophy with no hypoplasia of the adipose cells. This difference was probably due to the much higher initial fat content of the mature sheep. The greatest loss of fat in both the mature and immature sheep was from the meat but there was a proportionally higher loss from the offal, especially in mature sheep. The amount of protein in the carcass was similar for control, starved or refed sheep of the same body weight. During the first few days of refeeding, the food consumption of the sheep was three to four times as great as during the starvation period. The apparent digestibility coefficient of the food went from 53-68% to 80-90% and the live weight gains were 500 to 600 g per day. The refed sheep showed increased protein, water and fat in their meat. Sheep which were starved and refed, either once or twice, quickly reached the same live weights as the continuously grown animals and were similar in body and meat composition.

The findings regarding compensatory growth in sheep are equivocal for changes in basal metabolic rate, appetite and carcass composition. Thornton *et al* (1979) suggests that although the results cannot be reconciled, they possibly suggest the true variety of results which can result from separate experiments on limited numbers of animals with variable body composition under differing conditions of nutritional restriction and refeeding. The conclusions of many of these studies are that the advantages of the rapid growth following restriction is outweighed by the energy cost of maintenance during restriction (Thornton *et al*, 1979). This may be a problem caused by the experimental design of the studies. All of the previously examined studies used fairly long periods of weight loss and reduced weight stasis in their design. It is during this period that maintenance costs become important. If the period of weight loss and stasis was shortened, the gains made in the compensatory growth phase could outweigh the maintenance costs during the starvation stage. Even a small overall increase greater than constantly fed controls could be of economic importance. The reduced cycle time would allow for a greater number of cycles, the effect being cumulative. The success of this type of feeding would depend on the effect starvation period had on the compensatory growth response. The optimum cycle period for body weight would have to be determined. Some studies showed that body composition can be altered by the pattern of starvation and refeeding to produce increased protein and reduced fat levels in the carcass (Keenan *et al*, 1969, McMannus *et al*, 1972, Drew and Reid, 1975a,b,c, Little and Sandland, 1975). This could be manipulated to produce leaner carcasses in meat producing animals.

Compensatory growth is already an important economic factor of livestock production in Australia's pastoral zones (Thornton *et al*, 1979). Studies such as those by Bennett *et al* (1970) on the effects of grazing cattle and sheep together show that compensatory growth is very important to stock which overwinter on poor pasture. Animals which lost weight heavily in the winter tended to gain weight faster in the spring than those which had lost less weight. Compensatory gains were important for herd management. Supplemental feeding in winter, except for survival, is not only expensive to the farmer but may also deprive him of the benefits of compensatory gains and greater pasture use the following spring.

The existence of compensatory growth in agricultural animals has been known and noted for a long time. In some areas it is of fundamental economic importance while in others, such as sheep nutrition, the understanding of its mechanisms is incomplete to the extent that it is not presently possible to incorporate it into agricultural practices.

Metabolic Energetics and The Compensatory Growth Response in Fish

In order to examine compensatory growth in fish, we must examine their metabolic energetics. A great deal of work has been done on the nutrition of salmonids. Two excellent reviews on energy partitioning and feeding study techniques are available, Cho *et al* (1982) and Jobling (1983). The utilization of dietary energy is the basis of the study of fish nutrition. The metabolizable energy intake (ME) is equal to the energy retained as new tissue (RE) and the energy dissipated as heat (HE). The gross energy intake (IE) is the product of food consumption and its heat of combustion. The standard value for carbohydrates is 17.2 kJ/g, for protein is 23.4 kJ/g, for fat is 39.2 kJ/g and for ash is 0 kJ/g. The ash content of a feed can thus greatly affect the IE. The digestible energy (DE) is the energy digested and absorbed to be used as fuel. The fecal loss (FE) is the energy value of feed components which are not digested. The feces are made up of both undigested food (FE) and unreabsorbed residues of body origin (FmE). Thus apparent digestible energy = IE - FE while the corrected digestible energy is IE - (FE-FmE). The major loss of ingested gross energy has been found to be fecal energy loss.

Metabolizable energy (ME) is the energy of the absorbed amino acids, fatty acids and sugars to be used less the by-products of the catabolism of the amino acids. The excretion of ammonia in the form of urea is a loss of combustible energy for the fish. The loss of ammonia through the gills (ZE) or kidney (VE) means the digestible energy of the diet is an overestimate of its fuel value to the fish. Thus :

$$ME = IE - (FE + VE + ZE)$$

The loss of combustible energy in the feces depends on the digestibility of the feed components. There appears to be little interaction between the diet components that affect absorption. The loss of energy through the gills and urine depends on the level and digestibility of the protein in the diet. This is influenced by the proportion of other components in the diet, especially the level and type of fat (Cho *et al*, 1982).

The metabolizable energy is the energy available to the fish. The metabolic rate of the fish is the rate at which heat is liberated. Heat is produced by the transformation of food into tissue, tissue turnover and physical activity. The basal metabolic rate is the minimum rate of metabolic activity needed to sustain the structure and function of the fish. Any form of activity increases the metabolic rate. The heat increment of feeding is the increase in metabolic rate caused by ingestion, digestion and utilization of food. This energy is not then available for growth. Growth is only possible if the energy from food (ME) is greater than the total heat loss. The energy required for maintenance is basal metabolism (HeE), thermoregulation in homeotherms (HcE) and involuntary resting activity (HjE). The specific dynamic action (SDA) is the heat produced by the chemical work of the glands. However the SDA is often more broadly defined as the heat or energy required for digestion of food, the heat increment of feeding. The duration of the SDA depends on the quality and quantity of food and on water temperature. The cost of protein deamination for use as an energy source is a major factor contributing to the heat increment of feeding. The heat increment can be 8% to 12% of IE in fish. The heat increment is quite small when compared to the metabolic work however. The physiological basis of SDA is the post-absorptive process related to ingested food, especially protein rich food. It is mainly the metabolic work to form proteins and fats from amino acids and fatty acids, plus the formation of excretory nitrogen products. There is contradictory information regarding the biochemical to the physical/mechanical ratio of heat loss. The variety of results is regarded to be due to the differences in experimental techniques and changes in activity levels (Cho *et al*, 1982). The effect of temperature on the fasting heat production is very marked. An increase in temperature from 3 to 18°C resulted in a doubling of the heat production of Atlantic salmon and rainbow trout (Smith *et al*, 1978a,b). The heat production rates for Atlantic salmon and rainbow trout increased more slowly than for either brook or lake trout as the water temperature increased. Cho and Slinger (1980) measured the heat production of rainbow trout weighing from 47 to 139 g at 7.5, 10, 15 and 20°C. The largest effect occurred between 7.5 and 10°C when heat production doubled. From 10 to 15°C there was a 50% increase in heat production and from 15 to 20°C there was no further increase. These results strongly support the findings of other researchers discussed earlier which suggest that basal metabolic rate and maintenance costs increase with temperature.

Basal metabolism has traditionally been calculated by extrapolation of activity levels back to zero. The basal metabolic rate for rainbow trout was found to be 59 to 63 kJ/kg/day at 15°C for 96 to 145g trout (Cho *et al*, 1975) and 54 to 139 kJ/kg/day for .85 to 57g trout (Smith *et al*, 1978a,b). The following equation relating the body weight to heat production for rainbow trout of 1 to 59g body weight is proposed (Smith *et al*, 1978a,b).

$$\text{Heat Production(kJ/kg/day)} = 204\ W^{0.75} \quad (r=0.92)$$

This relation between heat production and the fractional coefficient of body weight would appear to indicate that surface area rather than body weight may be the important factor in basal metabolism.

Growth and energy retention (RE) is made up of the metabolizable energy not dissipated as heat but retained in the body as new tissue. This retained energy may be stored as fat or protein. As fish increase in maturity a higher proportion of the energy is stored as fat (Cho *et al*, 1982). The relative importance of fat and protein depends on the maturity of the fish, the balance of available amino acids in the dietary protein and the amount by which the dietary energy intake exceeds the energy expended as heat. Proteins of higher biological value promote greater protein deposition (Cho *et al*, 1982). If there is a marginal excess of energy intake a greater proportion of it is retained as protein. As the energy excess increases the total amount of protein deposition increases but the proportion retained as fat increases at a greater rate. Increasing energy levels lead to an overall increase in both total fat and in the fat to protein ration (Cho *et al*, 1982). Temperature has been found to affect energy retention. An increase in temperature from 7.5 to 20^{O}C increased energy retention from 44 to 58% of digestible energy intake (Cho *et al*, 1982). Watanabe *et al* (1979) found that the maximum protein retention and an optimum protein/fat ration was achieved with a diet of 35% protein and 15 to 20% fat.

A number of other factors influence growth and conversion efficiency. The stocking density for a farmed group of fish affect the variability of the growth rate of the fish. Li and Brocksen (1977) found that the metabolic rate of rainbow trout increased with increasing density and attributed this to i) starvation, ii) increased exercise levels and iii) higher levels of excitation. The variance of routine metabolism, growth rate and consumption rate increased with density, due to intraspecific competition. The dominant trout grew faster and more efficiently with a higher lipid content at all densities. At higher densities dominance gave less benefits than at lower ones. Trezeviatowski *et al* (1981) showed that fish production, weight gain per cubic meter of water and the feed conversion rate all increased with stock densities. High stocking levels may produce pollution problems however (Clark *et al,* 1985).

The genetic component of growth rate and body composition is difficult to assess as trout are so sensitive to environmental factors which tend to mask genetic effects. Ayles *et al* (1979) suggest that the lipid content of rainbow trout can be significantly different between strains and that breeding programs are viable. They also suggest that any evaluation of a stock's performance must be done under production conditions or the results are confounded by environmental factors. Refstie (1980) found that heritability is higher for length than for weight but genetic variability is much greater for weight than length. The heritability for growth of fingerlings was low, suggesting that individual selection would not be very efficient. They suggest that a combination of family and individual selection would likely give some improvement in growth rate.

Muscle growth plays an important role in compensatory growth. Three different muscle types have been histochemically identified (Gill *et al*, 1982, Hoyle *et al*, 1986): white, red and pink. White muscle constitutes the greater portion of the swimming musculature. It functions anaerobically during contraction and so has reduced myoglobin and mitochondrial content, increased glycolytic enzyme content and is less vascularized (Hoyle *et al*, 1986). Red muscle occurs as a thin superficial layer of triangular cross section below the skin which parallels the lateral line. It is geared for aerobic metabolism with a higher myoglobin and mitochondrial content, more lipid and lipolytic enzymes and is highly vascularized (Hoyle *et al*, 1986). Pink muscle has intermediate properties.

White myotomal muscle forms the bulk of the market portion of the fish. The growth dynamics of muscle fibre was examined by Weatherly *et al* (1979) for yearling rainbow trout. The fish grew faster when fed *ad libitum* at 12^{o}C than at 16^{o}C and that both groups grew faster than those on a restricted ration at 12^{o}C. The growth of the myotomal muscle mass was characterized by an increase in mean muscle fibre diameter, though most of the bulk increase resulted from the increases in fibre number. The ratio of fibre diameter to fish length was lowest for the fastest growing trout, which indicated a greater ability to add new fibres compared to those growing more slowly. The fibre diameter range increased in trout larger than 18 cm but small fibres persisted in diminishing numbers even in the largest fish. In slower growing fish muscle growth was more influenced by mean fibre diameter. In their 1980a work Weatherly *et al* examined the relationship between mosaic muscle fibres and size in rainbow trout form 2.1 to 61.3 cm fork length (FL). In trout < 5 cm all the muscle fibres were < 40 µm in diameter. From 5 to 20 cm the fibres were all in the 0 to 39.9 µm diameter class though the range was extended. The mosaic muscle bulk increased mainly by the recruitment of new small fibres. At > 20 cm the mode of the muscle fibre diameter was in the 40 to 79.9 μm class. Larger fibres appeared,(> 100μm), but the subsequent overall diameter frequency distribution changed very little until 50 cm. The increase in muscle mass was partly due to increases in fibre diameter but was largely the result of the continued recruitment of small fibres. At 55cm the recruitment of new fibres ceased and increases were due to the gains in diameter of the existing fibres. This would seem to place an upper limit on fish size. In fingerling trout (Weatherly 1980b) 2.3 to 5cm no fibres were > 40μm but at > 5cm fibres of > 40μm appeared, ranging up to 100 μm. Trout 5 to 18 cm were dominated by fibres < 40 μm, in the 20 to 39.9 μm class with nothing above 100 μm. This was true for fish with either fast or slow growth rates. There was a marked decrease in the number of fibres in the 0 to 19.9 μm class. Differences in the condition factor, dry weight and, from inference, protein did not significantly affect the fibre diameter frequency. In trout of 18 to 20 cm the fibre diameter mode shifted to the 40 to 59.9 μm class in most growth rate groups and hatchery reared trout. There were a small number of large fibres up to 120 μm and the 0 to 19.9 μm class was further reduced. Above 20 cm the growth by fibre recruitment decreased. Between 20 and 25 cm the increase in cross-sectional area of the muscle was due mainly to gains in fibre diameter. Fish with very rapid growth rates (12^{o}C, *ad libitum*) had smaller fibre diameter to fish length ratios than slower growing fish. This indicated a greater rate of recruitment of new fibres in the faster growing fish and a potential for larger ultimate size. Comparison of the growth dynamics of rainbow trout with bluntnose minnow (*Pimephales notatus* Rafinesque) (Weatherly and Gill, 1984) concluded that the main mechanism of myotomal growth in large fast growing fish was the input of new fibre while for small slow growing fish increase in fibre diameter was of greater relative significance.

During starvation different tissues are utilized sequentially as the energy source (Denton and Yousef, 1976, Elliott, 1975, Smith, 1981, Weatherly and Gill, 1981, Black and Love, 1986) and there are differential rates of mobilization of similar substrates in different organs (Love, 1980).

Red muscle is less affected by starvation than white (Loughna and Goldspink, 1984). The mean fractional rate of synthesis of red muscle is 2.5 times greater than that of white. Prolonged starvation causes a significant decrease in the rate of synthesis in both muscle types (Loughna and Goldspink, 1984). The white muscle tissue responds very quickly during starvation and its mean rate of synthesis is halved during the first week while that of the red muscle remains unchanged. After two weeks the rate of synthesis in the red muscle is also halved (Loughna and Goldspink, 1984). Significant protein utilization does not occur for seven or eight weeks in *Salmo gairdneri* (Denton and Yousef, 1976, Elliott, 1975, Weatherly and Gill, 1981). In prolonged starvation the degradation rate was only slightly above normal (Loughna and Goldspink, 1984). The protein synthesis and degradation rates reach relatively constant values with the degradation rates exceeding the synthesis rates (Loughna and Goldspink, 1984). The reduced synthetic rate is related to both reduced RNA concentration and activity (Loughna and Goldspink, 1984). The energy source during short term starvation in *S. gairdneri* is adipose fat (Weatherly and Gill, 1981) and muscle lipid (Parker and Vanstone, 1966, Smith, 1981) which is proportionally replaced with water (Idler and Bitners, 1959). In *Gadus morhua* liver lipid, liver glycogen and white muscle glycogen are utilized (Black and Love, 1986). Full recovery from short term starvation and very high growth rates are possible (Bilton and Robins, 1973; Smith, 1981; Weatherly and Gill, 1981; Dobson and Holmes, 1984; Kinkschi, 1988).

If the starvation continues there is a point past which full recovery upon refeeding does not occur and the ability to catch up to constantly fed control fish is lost. High mortality begins to occur, especially upon refeeding (Bilton and Robins, 1973; Love, 1970; Love, 1980). The fish may be unable to recover because the ability to utilize feed (Bilton and Robins, 1973) is reduced by gut atrophy (*Salmo gairdneri*: Weatherly and Gill, 1981) and reabsorption of the microvilli, especially in the middle section of the intestine (*Cyprinus carpio*: Love, 1980). Long term starvation results in decreases in the length, weight and diameter of the intestine (Love, 1980). White muscle tissue is then utilized as the energy source (Johnston, 1981, Johnston and Goldspink, 1973, Moon, 1983, Moon and Johnston, 1980). Mammalian studies have produced similar results (Swett and Eckles, 1918, McCay *et al*, 1939; Wilson and Osbourn, 1960; Thornton *et al*, 1979).

The presence of compensatory growth in fish is far less well documented than for mammals. Bilton and Robbins (1973) examined the effects of starving and feeding on the survival and growth of sockeye salmon fry. The fry were capable of withstanding three to four weeks of starvation with less than a 10% mortality but many were incapable of recovery. Beyond four weeks of starvation mortality increased sharply to 90% at seven weeks. The pattern of mortality was similar in all experimental groups with a sharp increase after 30 days. The mortality continued when the fish were offered food. The length and weight of the fry starved up to seven weeks decreased significantly. The decrease in length may have been due to reabsorption of cartilaginous material from the skeletal system. There was an accelerated growth rate among some groups of fish which survived to the end of the eight week feeding period following starvation. Those fish which were starved from one to three weeks caught up in length and weight to the control group when fed. It appeared that these fry utilized feed more efficiently. Survivors of four weeks starvation and eight weeks feeding did not catch up to the controls in either length or weight. Starvation of up to three weeks did not prevent the sockeye fry from reaching the size of others in the population which had not been starved. Prolonged starvation, longer than three weeks, inhibited the fry's ability to utilize the feed when offered and resulted in permanent stunting or death.

Weatherly and Gill (1981) compared the starvation response and subsequent recovery of fingerling rainbow trout (*Salmo gairdneri* Richardson) on restricted rations for 16 weeks, starved for 3 weeks (14.5% weight loss) and starved for 16 weeks (32.5% weight loss). The visceral fat was completely utilized in both the long and short term starvation groups. The gut was significantly reduced in the long term group. Subsequent recovery at full rations produced growth rates that were approximately equal to those of the controls with respect to wet body weight and condition factor. The recovery fish surpassed the controls in percent dry weight, heart, liver, gonad and gut and visceral fat weight. This indicated an overcompensative response. The gut, skin and dry carcass weight were less in the controls and in the three week starved group than in the reduced ration and severely starved group. This indicated that the slow growth from limited rations resembled severe starvation rather than short term starvation.

Dobson and Holmes (1984) examined the effects of starvation and feeding in farmed rainbow trout (*Salmo gairdneri* Richardson). Fish were divided into three groups: group A was fed for three weeks then starved for three weeks; group B was starved for three weeks then fed for three weeks; and group C, the control, was fed constantly for the six week period. The fish were all fed Omega pelleted trout food at the manufacturer's recommended level of 5% of body weight per day. The experiment was repeated five times. The fish gained weight when fed and lost weight when starved. Comparisons of subgroups with controls showed that in four of the five periods the total percentage weight gain of subgroup B (starved then fed) was equal or greater than the control, group C. Thus fish starved then fed for three weeks gained as much weight as fish fed throughout the six weeks of the experiment, though fed half as much feed. Comparison of weight gain prior to starvation with weight gain after starvation showed a significant increase in weight gain if feeding is preceded by a period of starvation. Comparison of overall weight gain for starvation and refeeding with the weight gain for the first three weeks of group A (feeding only) shows the mean weight gain for starvation and feeding is greater than that of feeding only for three weeks. Length changes were measured and showed that starving and refeeding produced greater overall length increases than feeding and starving. This indicated that the weight gains made after the starvation period were associated with increases in length and could be considered as growth and not just gut fat deposits or water uptake. Unfortunately no data was presented comparing the length increases of the starved then fed group (B) with the controls (C). Figures for weight loss during starvation showed a reduction in the rate of weight loss over the three week period.

The experiments performed here were designed to determine the effect of different short starvation and refeeding periods, feeding levels and repetitive cycles on the compensatory growth response and the carcass composition. The first experiment compares the average percentage increases in weight and length, the conversion efficiency and specific growth rate of a constantly fed control group with experimental groups. These experimental groups were starved then fed for one, two or three week cycles or were starved then fed for three weeks cycles at ration levels higher or lower than the control.

The second experiment compares the average percentage increases in weight and length, conversion efficiency and specific growth rate of the constantly fed control group with the experimental group which was starved then fed for alternate three week periods. The ration level was the same for both groups. Samples from both the control and experimental groups were analyzed for moisture, fat, protein, and ash composition at the start, at three weeks and at six weeks in order to determine if the compensatory growth response altered carcass composition.

Materials and Methods

Rainbow trout, *Salmo gairdneri* Richardson were purchased from the Sun Valley Trout Farm of Mission, British Columbia and delivered to the Animal Care Centre of the University of British Columbia. The layout of the experimental facilities is shown in Fig. 1. The experiments were performed in circular fibreglass tanks eight feet in diameter and four feet in depth with a central standpipe to control water level and a standpipe sleeve to improve water circulation and flushing. Water was supplied from the general service of the University, mixed with hot water to maintain a constant temperature of 12 to 14^{o}C and run through two large activated charcoal filters (Triton model TR-140, capacity 140 gallons per minute) to remove particulate matter and chlorine. A thiosulfate injection system was used (Mec-o-matic Powermatic II continuous injection pump) to further reduce chlorine levels. The water was supplied to the tanks through aerator bars mounted on the sides of the tanks to insure normal dissolved oxygen levels.

For the first experiment the fish (length: mean: 13.27 cm, range: 9.5 to 19.1 cm, weight: mean: 36.24 g, range:10 to 110 g) were acclimated for a two week period and then divided into experimental groups as follows. Fish were netted from the holding tank and placed in a temperature controlled anesthetic tank containing 2-phenoxy-ethanol (0.4 ml per litre, Syndel Laboratories, Vancouver, B.C.). Once anesthetized, the fish were removed from the anesthetic, weighed (Mettler balance, P1200 ±

Figure 1: Legend

A: Hot Water

B: Cold Water

C: Air Compressor

D: Carbon Filter

E: Thiosulphate Injection System

F: Air Line

G: Water Line

H: Experimental Tanks

I: Water Supply Valves

J: Air Supply Valves

K: Tank Drains

L: Gutter

Scale: 1/4" = 1.0'

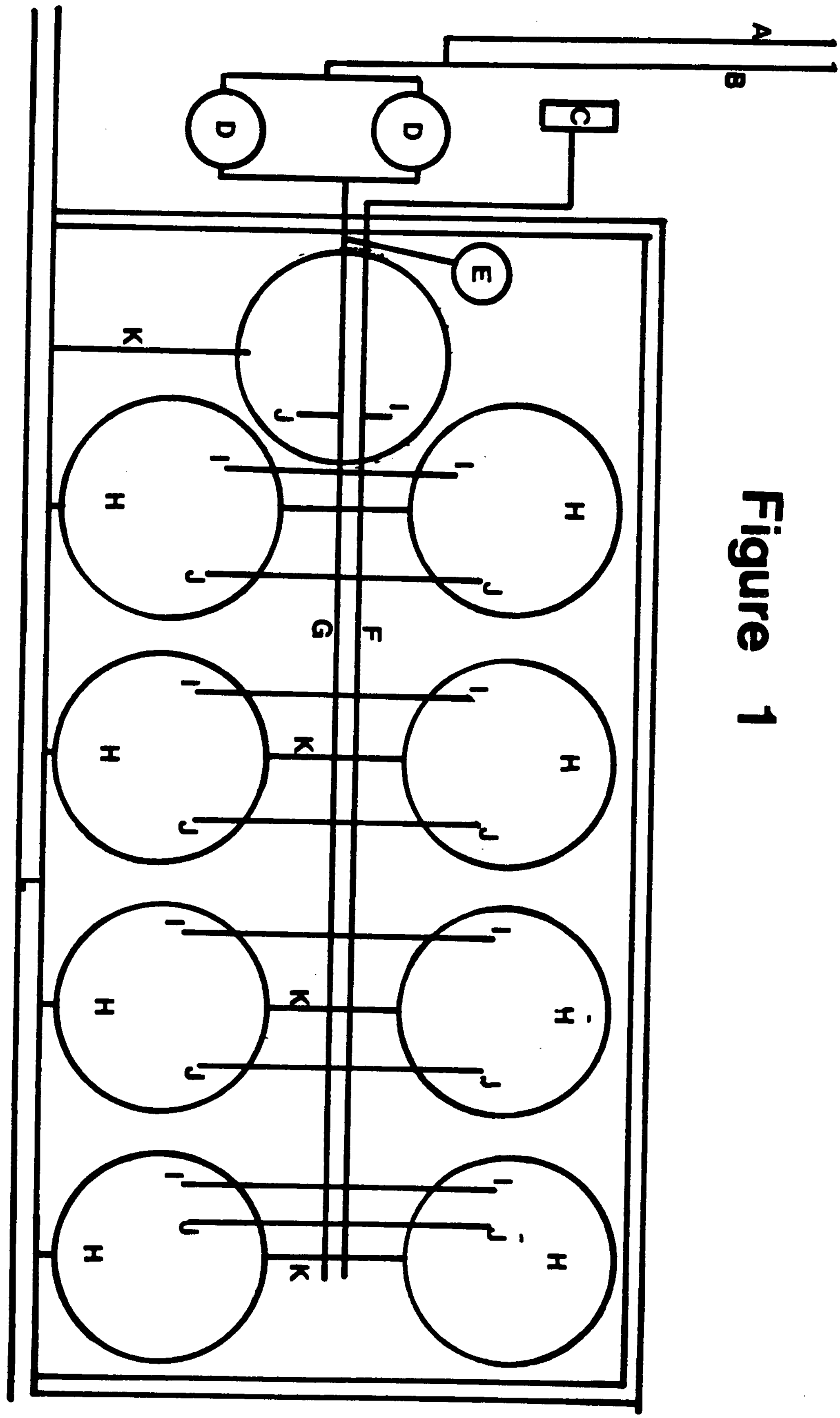


Figure 1

0.01 gm.), measured for standard length using calipers which were then compared to a steel rule (± 0.5 cm), and tagged with individually numbered fingerling tags (Floy Tag Co., Seattle, Washington, U.S.A.) sutured through the dorsal musculature just posterior to the dorsal fin.

Following measurement and recovery from the anesthetic the fish were placed in one of six experimental tanks. There were a total of 40 fish in each experimental group. The group treatments are summarized in Table I. Groups were sampled by netting 10 fish out of each tank, anesthetizing and measuring them and then returning them to their experimental groups. All groups were sampled once per week for the six week duration of the experiment (Appendix).

Experiment 2 fish (length: mean: 18.98cm, range:13.3 to 22.5 cm, weight: mean: 120.22 g, range:42 to 189 g) were treated as per those in experiment 1. Shortly after arrival the fish were taken out of the holding tank, anesthetized, measured for standard length and weight and tagged with the individually numbered fingerling tags. They were then divided into two groups of 50 fish each. The treatments of the two groups are summarized in Table I.

The length and weight of five fish from the holding tank were recorded, then these fish were killed and immediately frozen and stored in the freezer (Bel-Par Industries, -20^{O} C). Both groups were sampled at three week intervals, tag number, weight and length were recorded for each fish in the sample. After three weeks 15 fish were sampled from each tank , five of which were

Table I: Group Treatments for Experiments 1 and 2

Group	Cycle Period	Ration Level
1A	Constant	5%
1B	1 Week	5%
1C	2 Weeks	5%
1D	3 Weeks	3%
1E	3 Weeks	5%
1F	3 Weeks	7%
2A	Constant	5%
2B	3 Weeks	5%

killed, frozen and stored. After six weeks 30 fish from each tank were sampled, five of which were killed, frozen and stored. The percentage of moisture, fat, protein, and ash were assessed for the 25 frozen samples (General Testing Laboratories, Vancouver, B.C.; Official Methods of Analysis of the Association of Official Analytical Chemists, Tests # 24.003 (moisture), 24.005 (fat), 24.009 (ash) and 24.027 (protein as nitrogen)). The groups were sampled again after 9, 12, 15 and 18 weeks (Appendix).

All groups of fish were fed once per day when fed. Moore Clarke Extruded New Age Salmon Feed of appropriate size was the feed used.

The tag number, weight and length of each fish sampled in both experiments were recorded and the average percentage changes in weight, length and condition factor were calculated as :

$$\text{Average \% Weight Change} = \left(\Sigma \frac{W_s - W_i}{W_i} \times 100\right) \div n$$

$$\text{Average \% Length Change} = \Sigma \left(\frac{L_s - L_i}{L_i} \times 100\right) \div n$$

$$\text{Average \% Condition Factor} = \left(\Sigma \frac{(W_s/L_s^3) - (W_i/L_i^3)}{(W_i/L_i^3)} \times 100\right) \div n$$

(Black and Love, 1986)

Where W_s is sample weight, W_i is initial weight, L_s is sample length, L_i is initial length and n is number of individual samples. Conversion efficiency (C.E.), specific growth rate (S.G.R.) and percentage average change in body composition were also calculated.

$$\text{Conversion Efficiency} = \frac{W_f - W_i}{\Sigma F}$$

$$\text{Specific Growth Rate (\% / day)} = \frac{W_f - W_i}{(W_f + W_i)/2} \times \frac{100}{T}$$

$$\text{\% Average Change in Body Composition} = \frac{\Sigma C_f/n - \Sigma C_i/n}{\Sigma C_i/n} \times 100$$

where F is food fed per day, W_f is the final weight, W_i is the initial weight, T is the time in days, C_f is the final composition and C_i is the initial composition.

Non parametric statistical analysis is used to examine the average percentage change data (Kruskal-Wallis single factor analysis of variance by ranks, Zar, 1984).

Results

The results for experiment 1 are summarized in Table II. The individual measurements of all the samples are found in appendix 1 as are the calculations for percentage change in weight and length. The changes in average percentage weight and length for groups 1A through 1F are shown in Figs. 2 through 7. The results for group E, those starved for three weeks then fed for three weeks were anomolous (Fig.6) due to a mechanical breakdown which resulted in an interruption in the water supply to the tank. The treatment of group 2B for the first six weeks of the second experiment was identical to that for group 1E and are substituted into the results for experiment 1. The average percentage change in weight for each of the groups is shown in Fig. 8 A Kruskal-Wallis analysis of variance showed no significant differences in the average percentage change in weight (q=11.0346, α(75 d.f.) > 0.05) (Fig. 8), length (q = 10.0122, α(75 d.f.) > 0.074) (Fig. 9) and specific growth rate (q = 8.78718, α(75 d.f.) > 0.11)(Fig. 10) though the average values for 1D, 1E and 1F are greater than that of the controls while those of 1B and 1C are less (Table II). The greatest differences between the groups are seen in the conversion efficiency (Table 2, Fig. 11). All cyclicly fed group values except 1B were higher than that of the controls. The trend in groups 1D, 1E and 1F was that increased ration level did not increase percentage change in weight (Fig. 8) or length (Fig. 9) but decreased conversion efficiency (Fig. 11). The pattern of weight loss and gain during starvation and refeeding is shown for group 1D in Fig. 5. There is a significant difference in

Table II: Summary of Results of Experiment 1

Group	% change weight	% change length	% change cond. fact.	conver. effic.	spec. gr rate
1A	18.68	3.69	2.92	0.074	0.407
1B	7.99	3.50	-4.26	0.069	0.183
1C	7.61	3.65	-3.66	0.108	0.175
1D	27.24	7.36	2.46	0.527	0.571
1E	27.91	6.59	4.58	0.299	0.583
1F	24.91	6.04	8.42	0.188	0.527

Figure 2

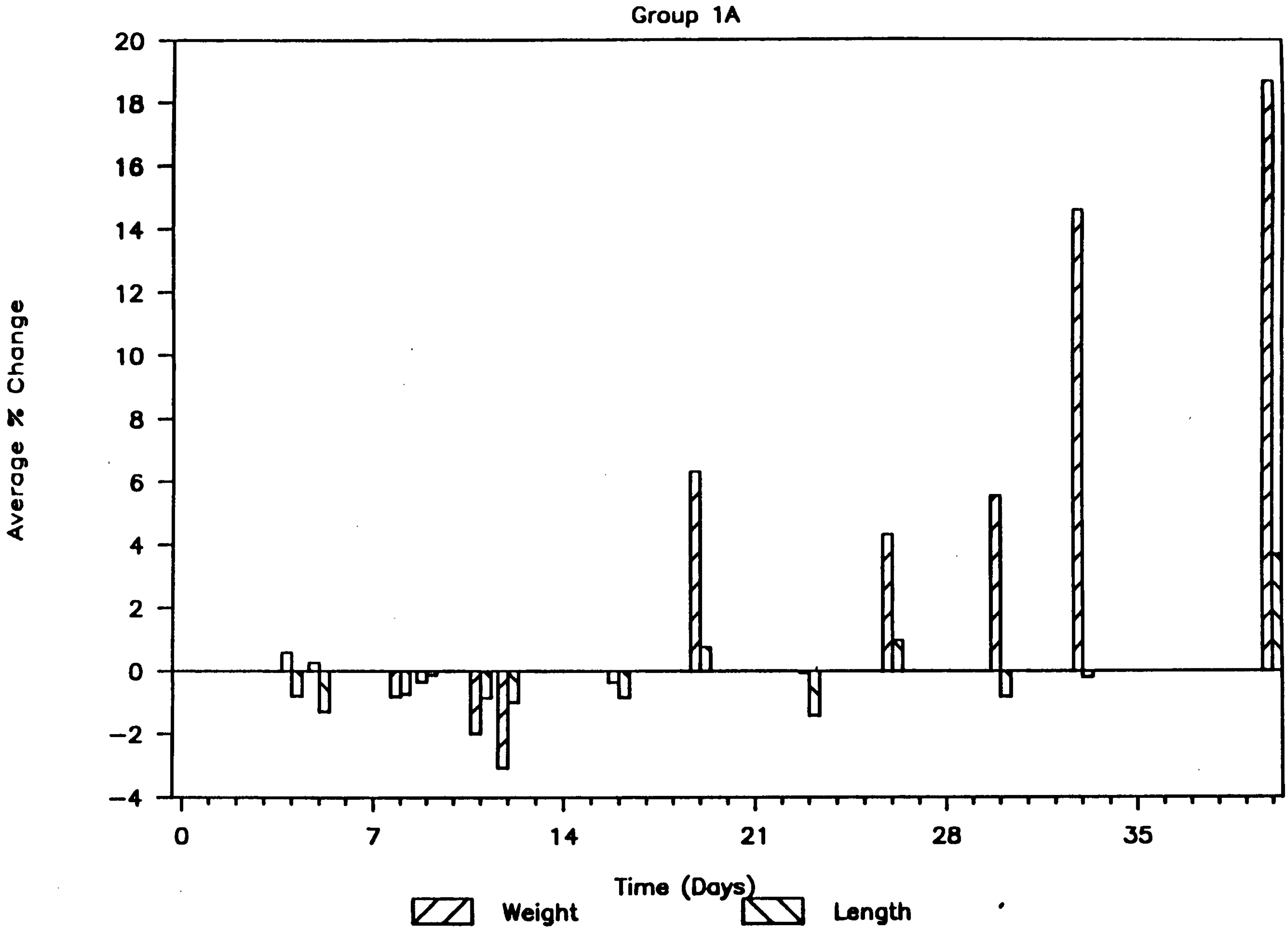

Group 1A
Average % Change
20
18
16
14
12
10
8
6
4
2
0
-2
-4
0
7
14
21
28
35
Time (Days)
Weight
Length

Figure 3

Group 1B

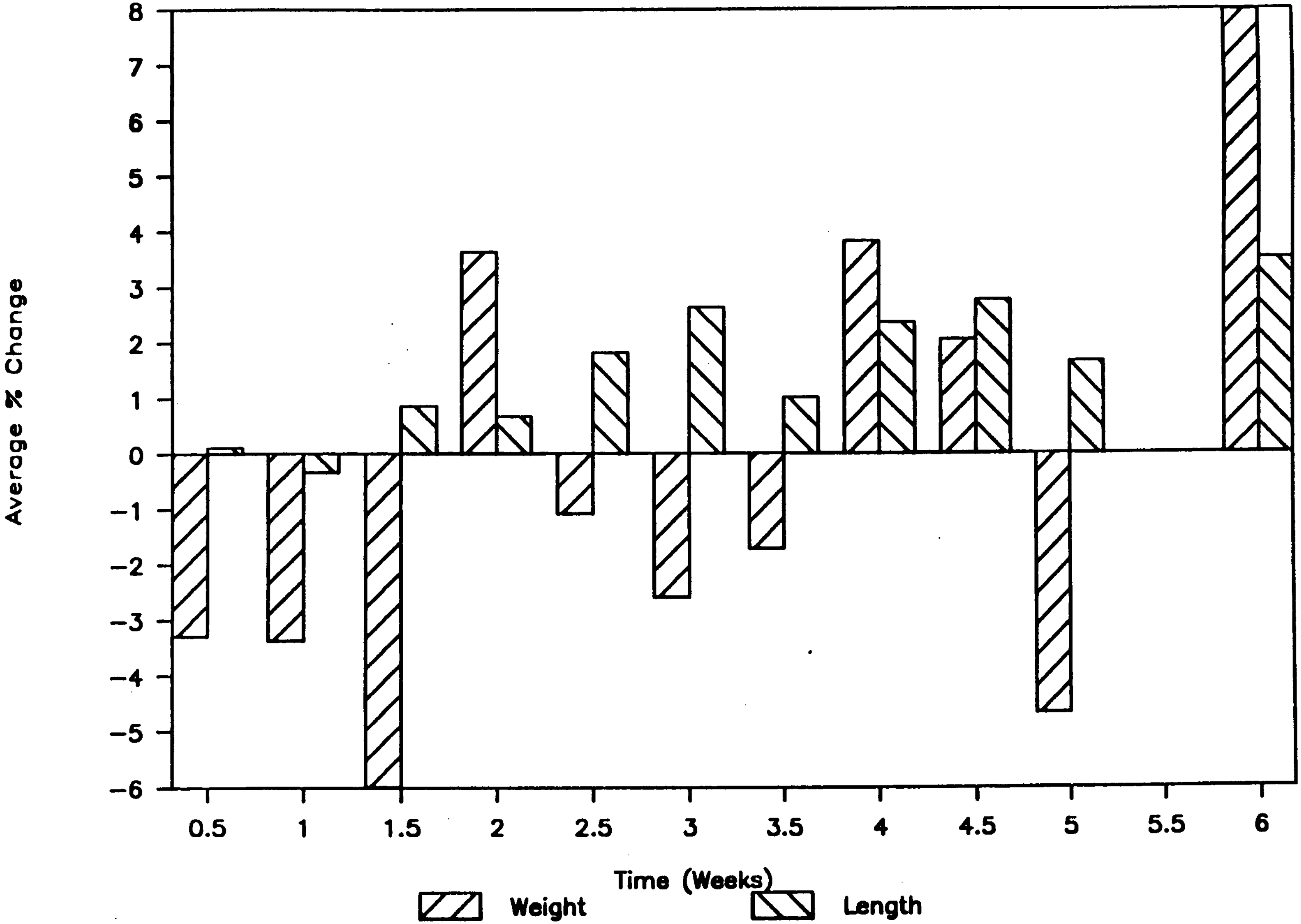


Figure 4

Group 1C

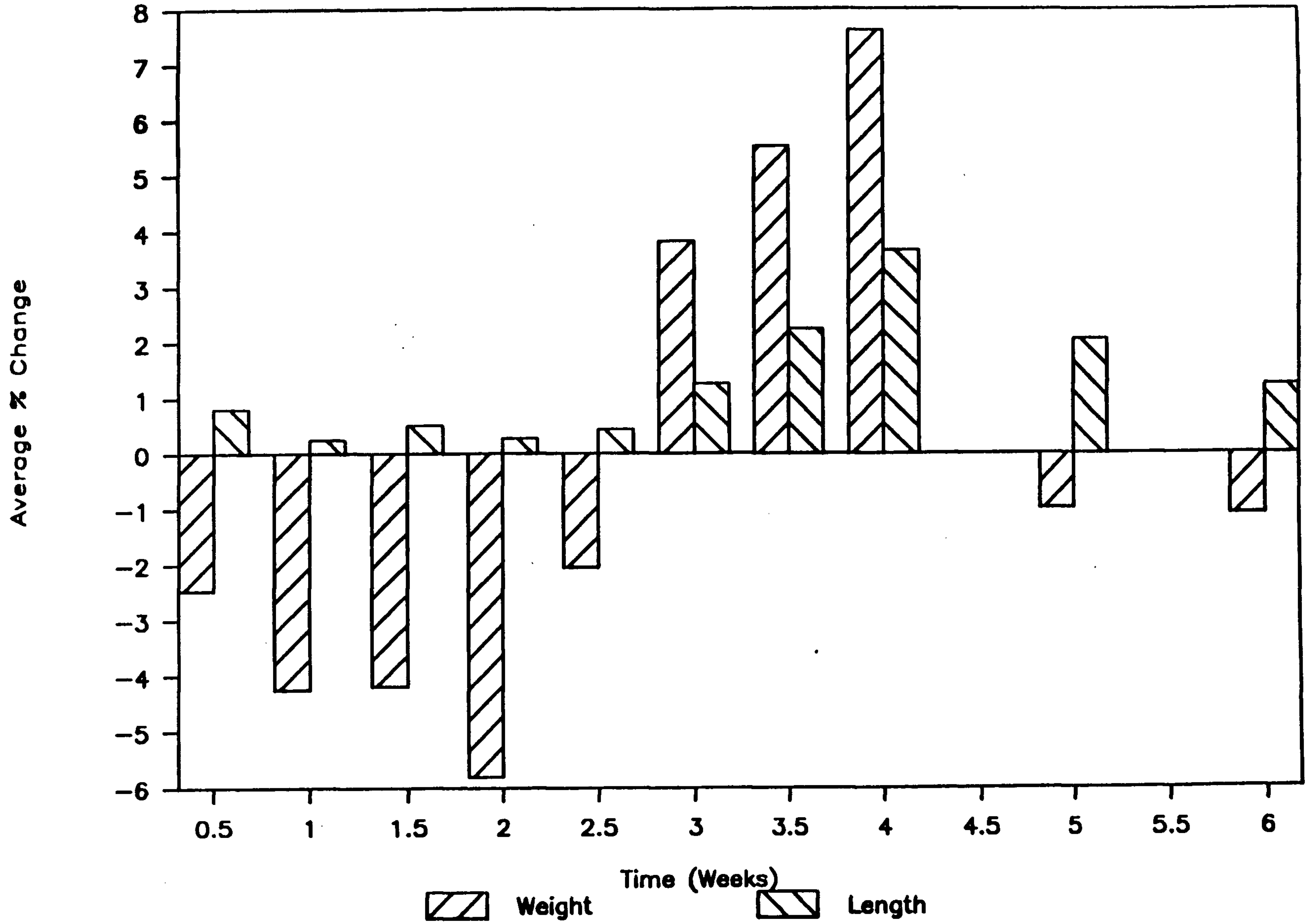


Figure 5

Group D

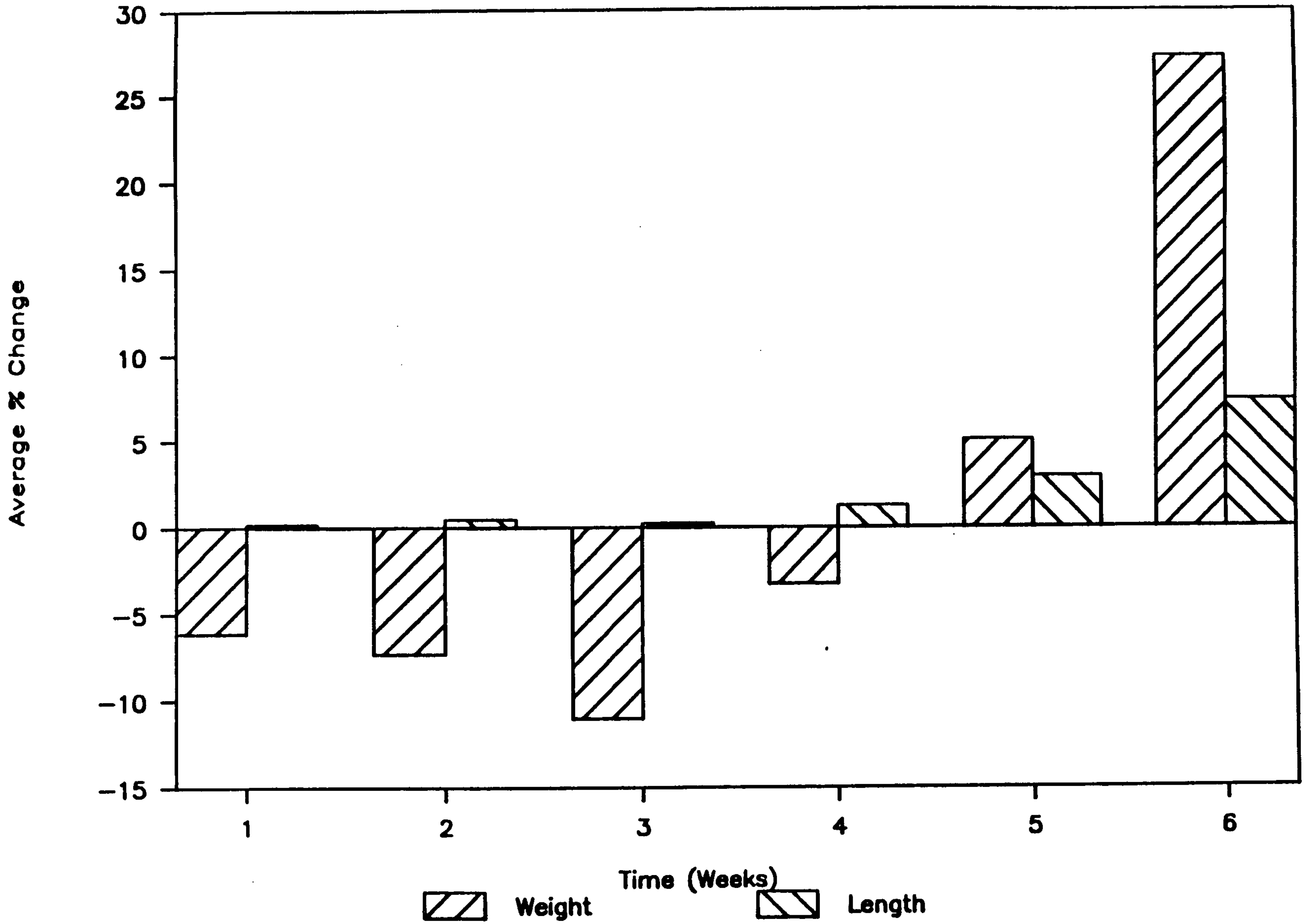


Figure 6

Group 1E

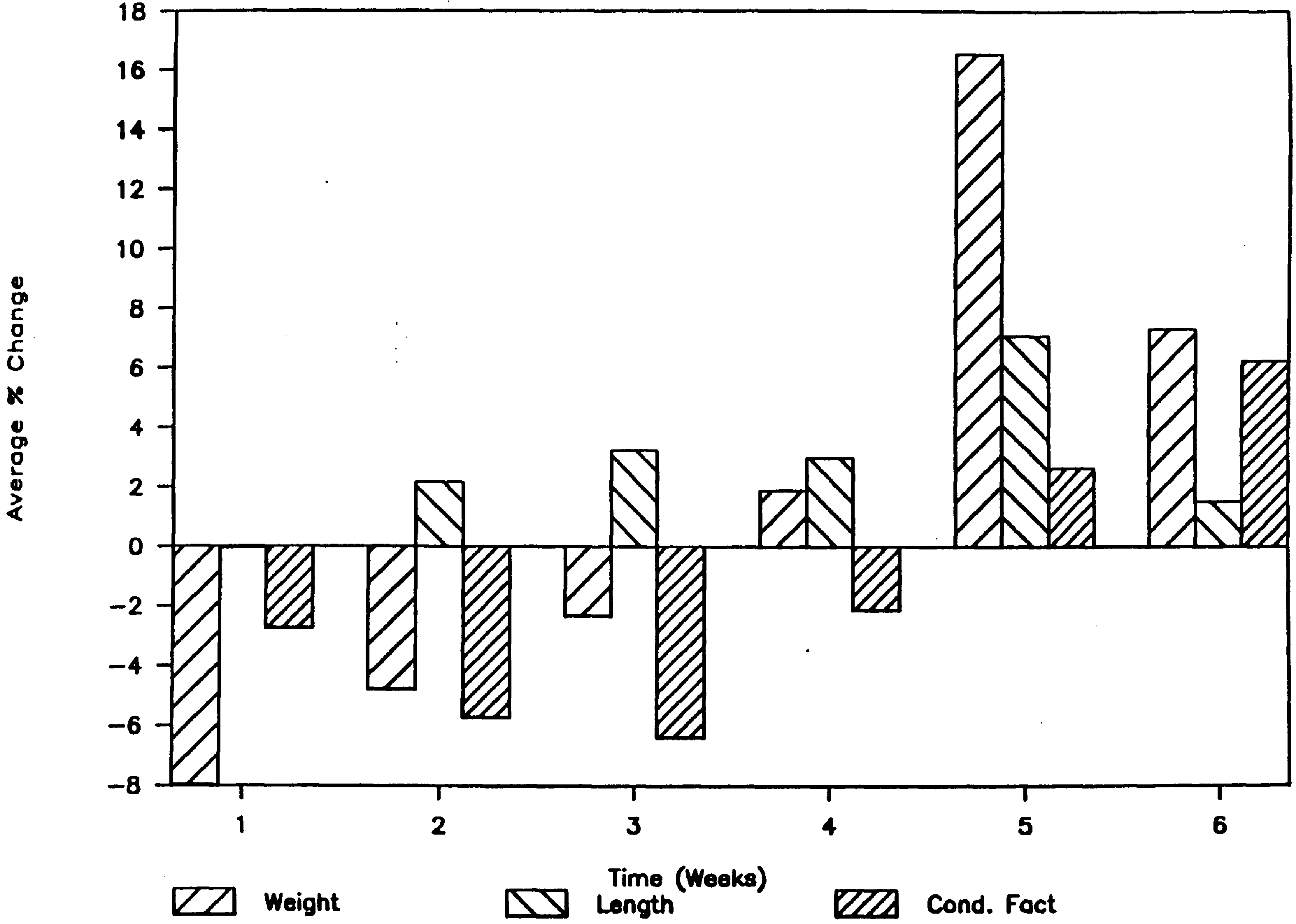


Figure 7

Group 1F

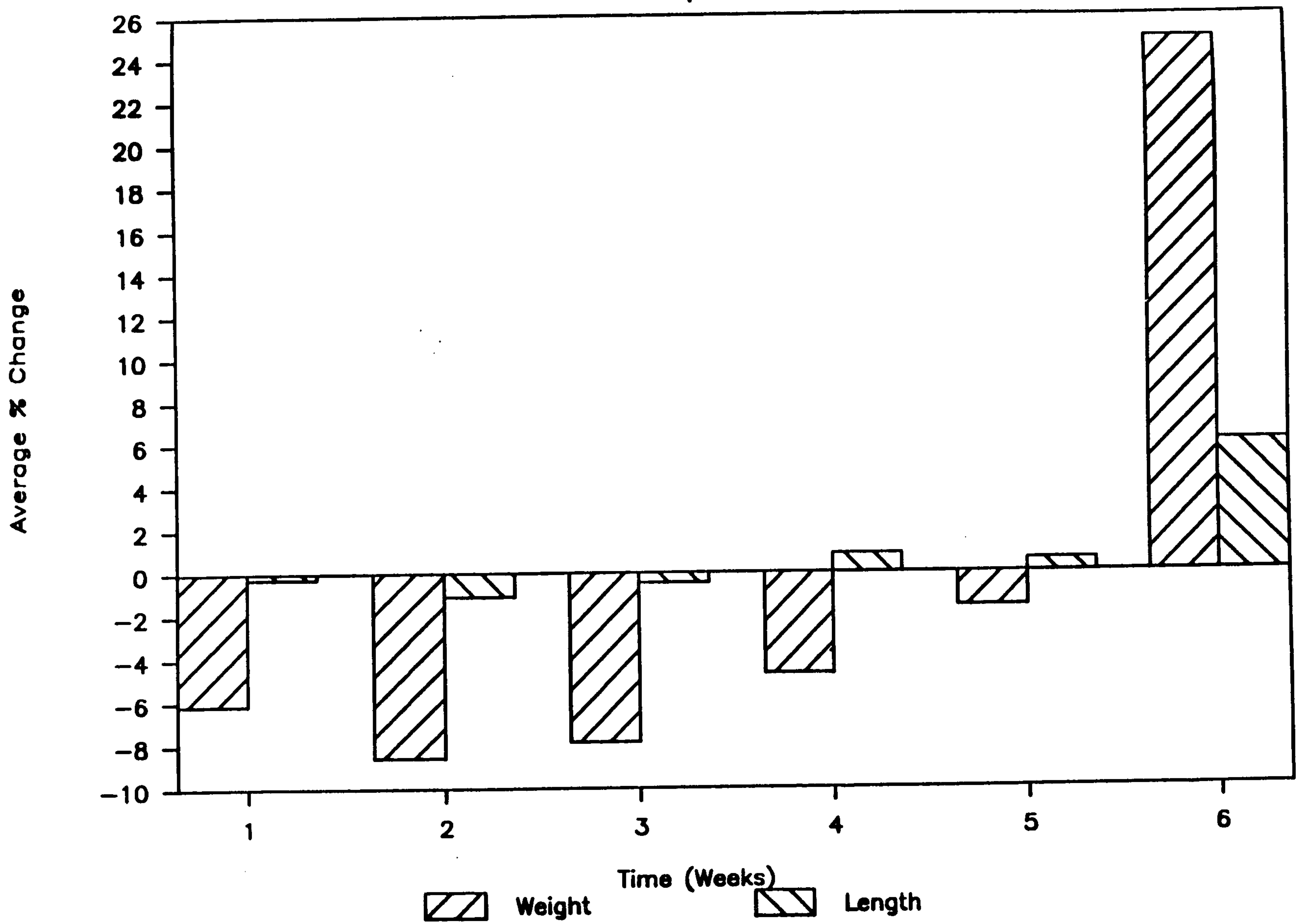
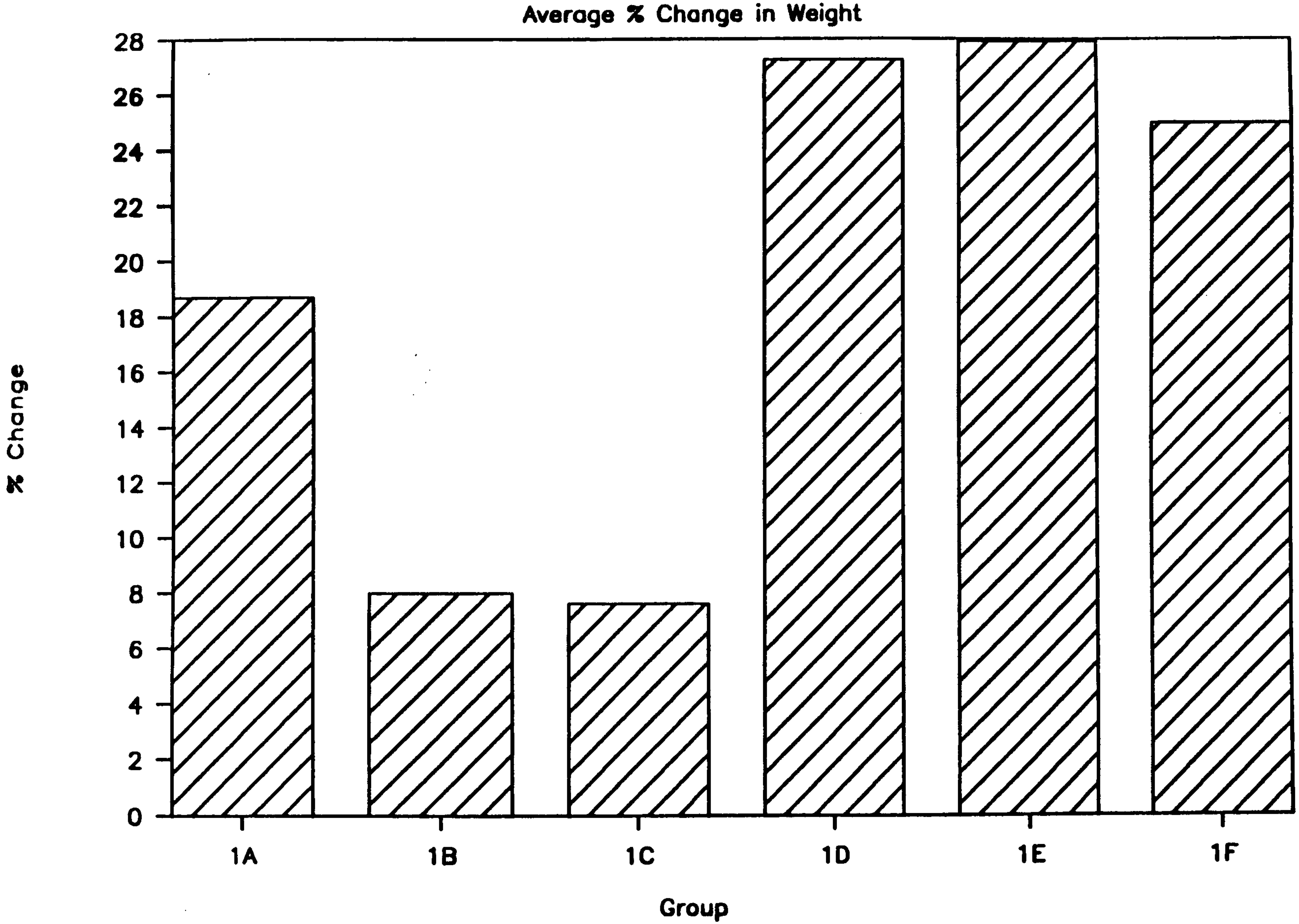
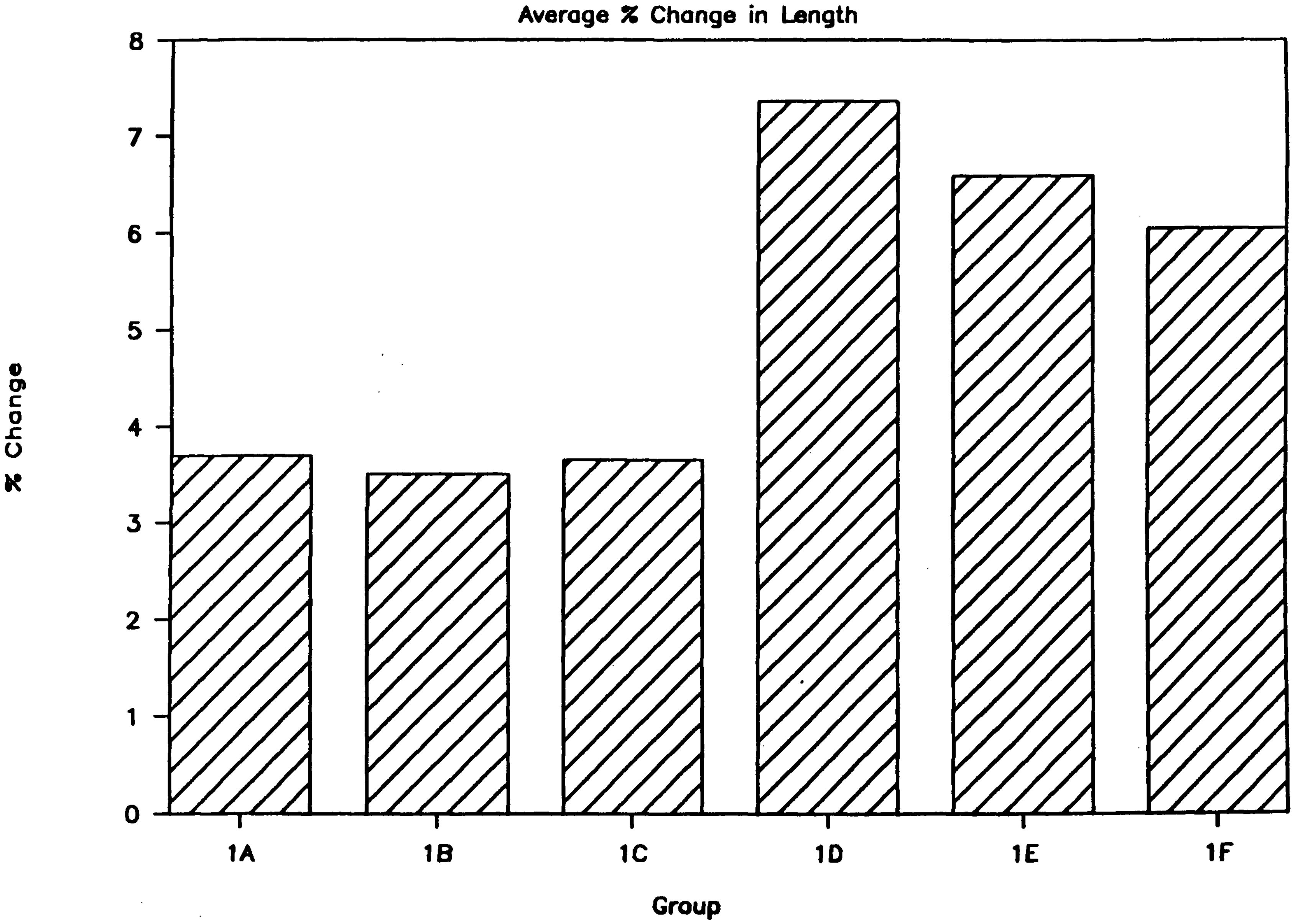


Figure 8



Average % Change in Weight
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
% Change
1A
1B
1C
1D
1E
1F
Group

Figure 9



Average % Change in Length
% Change
0
1
2
3
4
5
6
7
8
1A
1B
1C
1D
1E
1F
Group

Figure 10

Specific Growth Rate

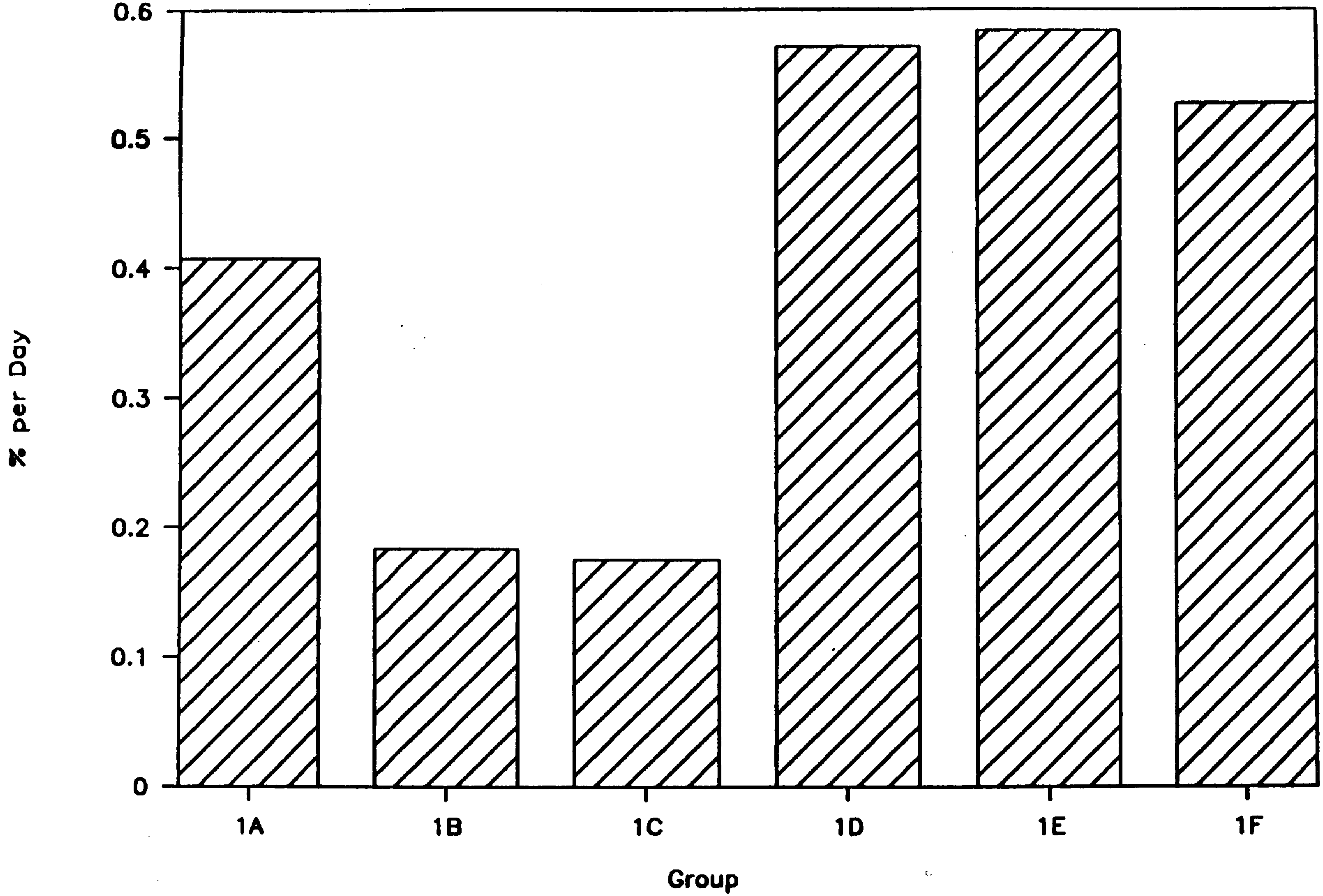
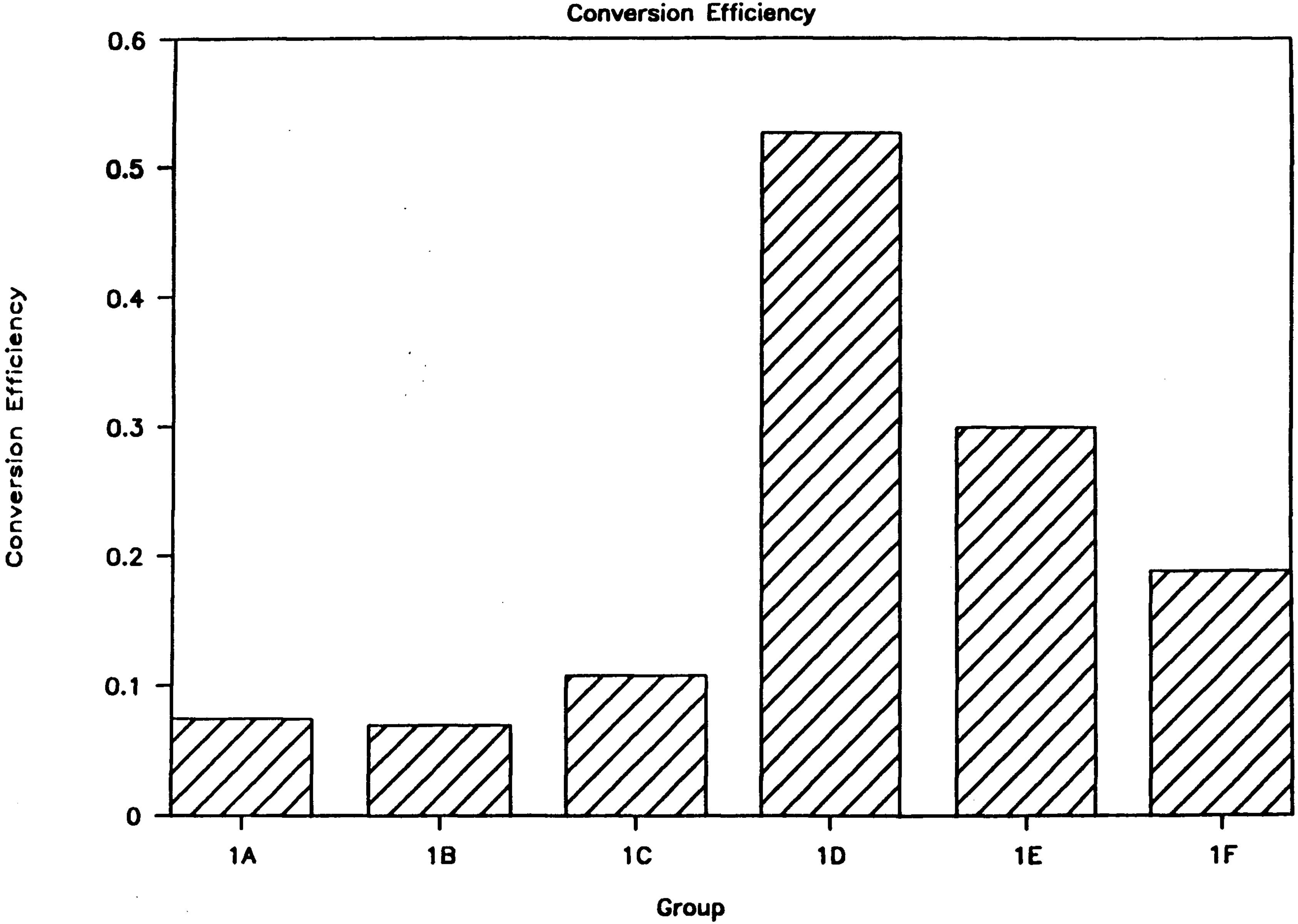


Figure 11



Conversion Efficiency
0.6
0.5
0.4
0.3
0.2
0.1
0
Conversion Efficiency
1A
1B
1C
1D
1E
1F
Group

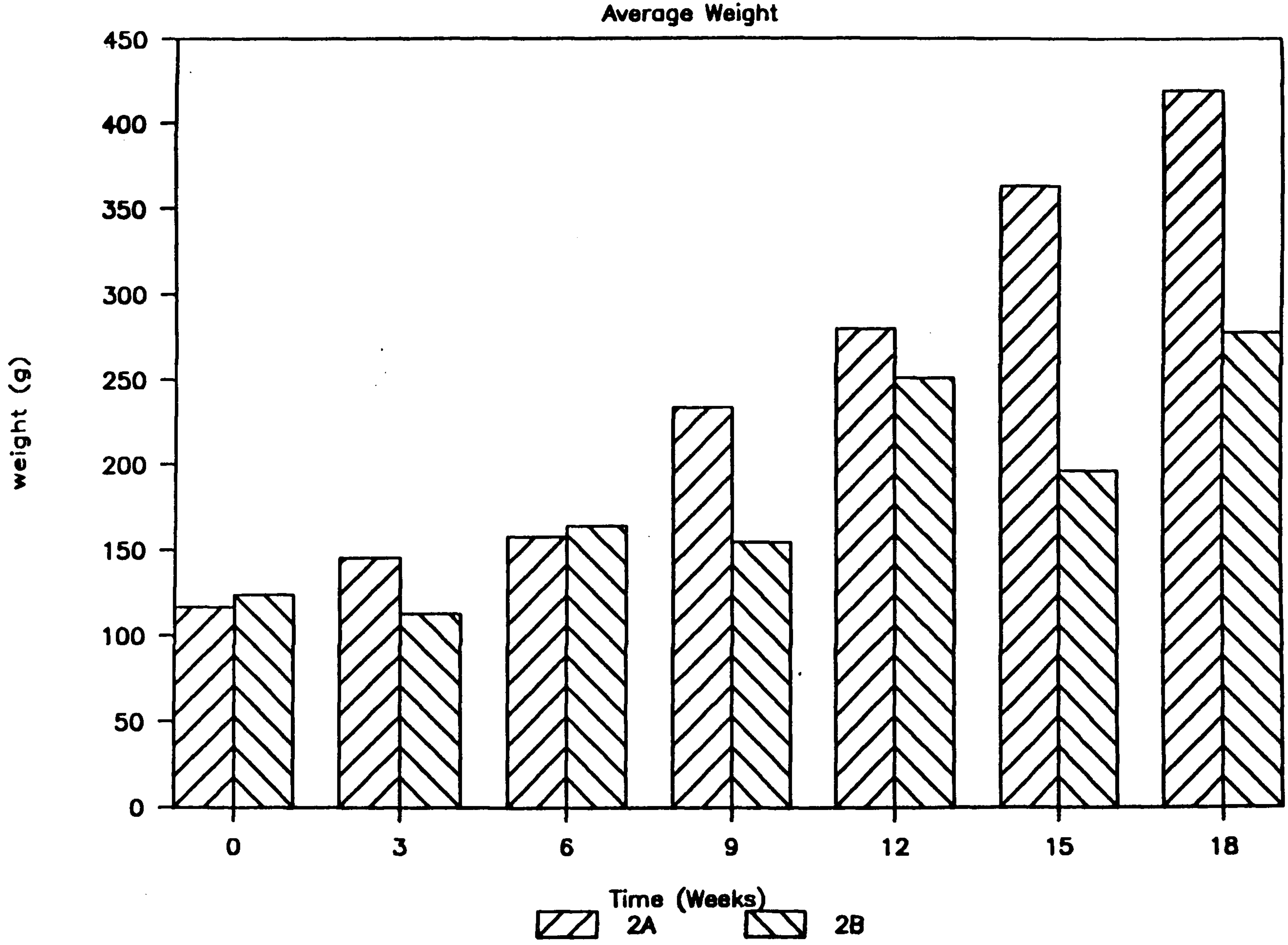
the average percentage weight change with time ($q = 30.1266$, $\alpha(45 \text{ d.f.}) < 0.05$). The large weight loss during the first week of starvation is typical of all experimental groups. The weight loss continues during the starvation period but at a reduced rate. In the first week of refeeding there is a moderate increase in average percentage weight gain of approximately eight percent. This gain is of the same order as that found in all experimental groups (Figs. 3,4,5,7). The gain during the second week is also approximately eight percent, typical of groups 1C, 1D, and 1F (Figs. 4,5,7). It is during the third week of refeeding (groups 1D, 1E, 1F, Figs. 5,7) that the greatest average percentage increases in weight and specific growth rate occur. Over this one week period the conversion efficiency for group D (Fig 5) was 1.289 and the specific growth rate was 4.04 percent per day.

The results of the second experiment are shown in Table III. The average weights of the control (2A) and experimental (2B) groups are shown in Fig. 12. There is no significance difference in the means initially ($t = 0.975837$, α (100 d.f.) >0.33), after three weeks ($t = 1.89186$, α (29 d.f.) >0.07) or after six weeks ($t = -0.36416$, α(58 d.f.) >0.72) though the control group had been fed 230 % more feed (Fig. 13). After nine weeks the experimental group was significantly smaller than the control ($t = 2.1933$, α(21 d.f.) < 0.04) but after refeeding (12 weeks) there was again no significant difference ($t = 0.786878$, α(29 d.f.) > 0.43) and the control had been fed 264 % more feed (Fig. 13). At weeks 15 and 18 the control group was significantly heavier than the experimental group ($t = 3.87415$, α (28 d.f.) $< .001$; $t = 3.67697$, α (32 d.f.) < 0.001 respectively) but 294% more feed. The differences in the

Table III: Summary of Results for Experiment 2

wk	wt.(%chg)		ln.(%chg)		con.fac.		C.E.		S.G.R.	
	2A	2B	2A	2B	2A	2B	2A	2B	2A	2B
3	16.7	-11.2	2.9	0.2	4.7	-11.6	0.16		1.05	
6	39.5	27.9	7.3	6.6	8.3	4.6	0.17	0.30	0.72	0.67
9	118.6	17.1	18.9	7.2	26.2	-5.4	0.32		1.06	
12	165.2	102.3	28.1	18.6	22.0	20.7	0.27	0.47	0.98	0.81
15	207.6	64.8	36.5	19.1	16.5	-2.8	0.24		0.98	
18	254.6	123.7	42.9	24.9	18.2	14.1	0.21	0.32	0.90	0.61

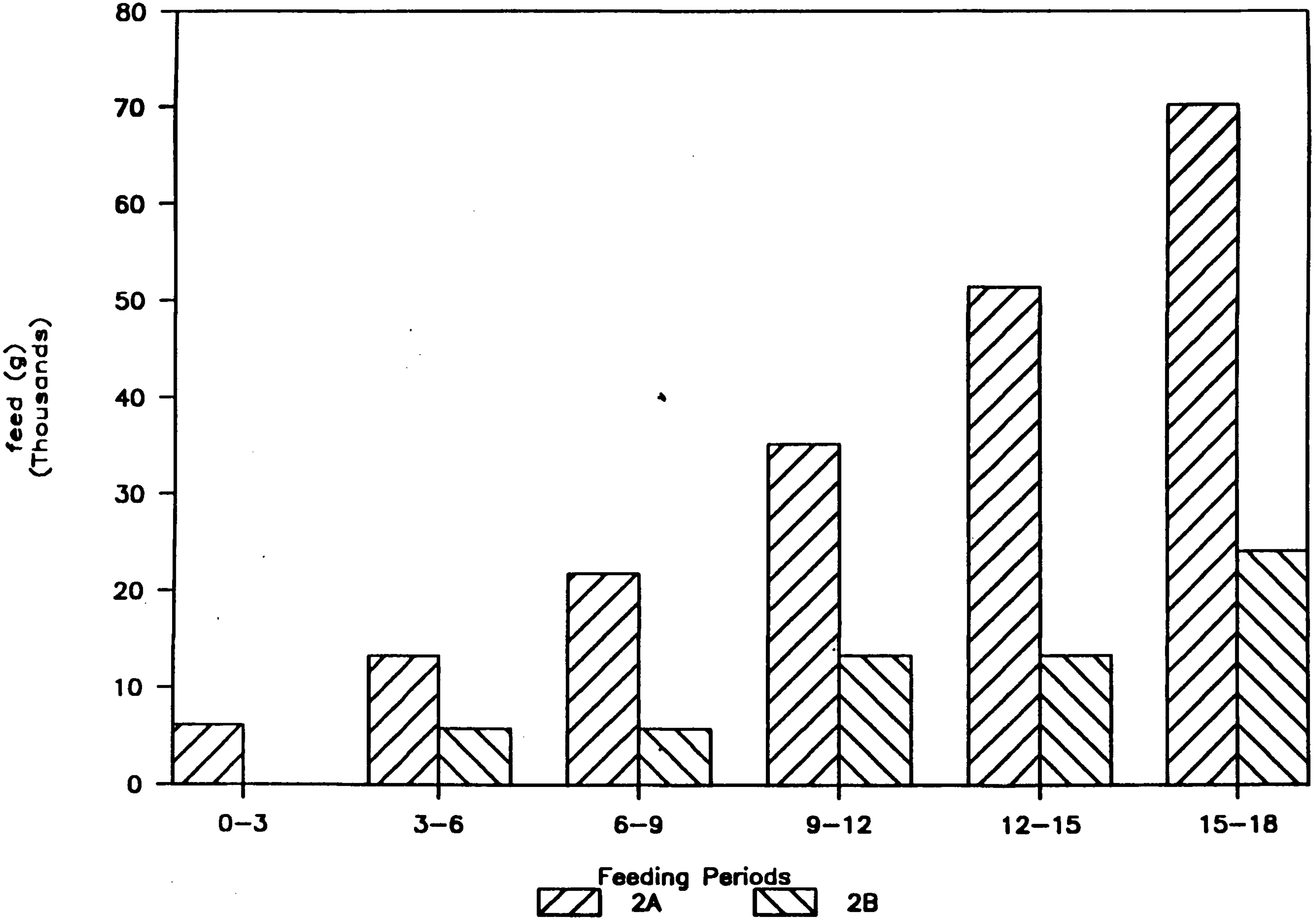
Figure 12



Average Weight
450
400
350
300
250
200
150
100
50
0
weight (g)
0
3
6
9
12
15
18
Time (Weeks)
2A
2B

Figure 13

Total Feed



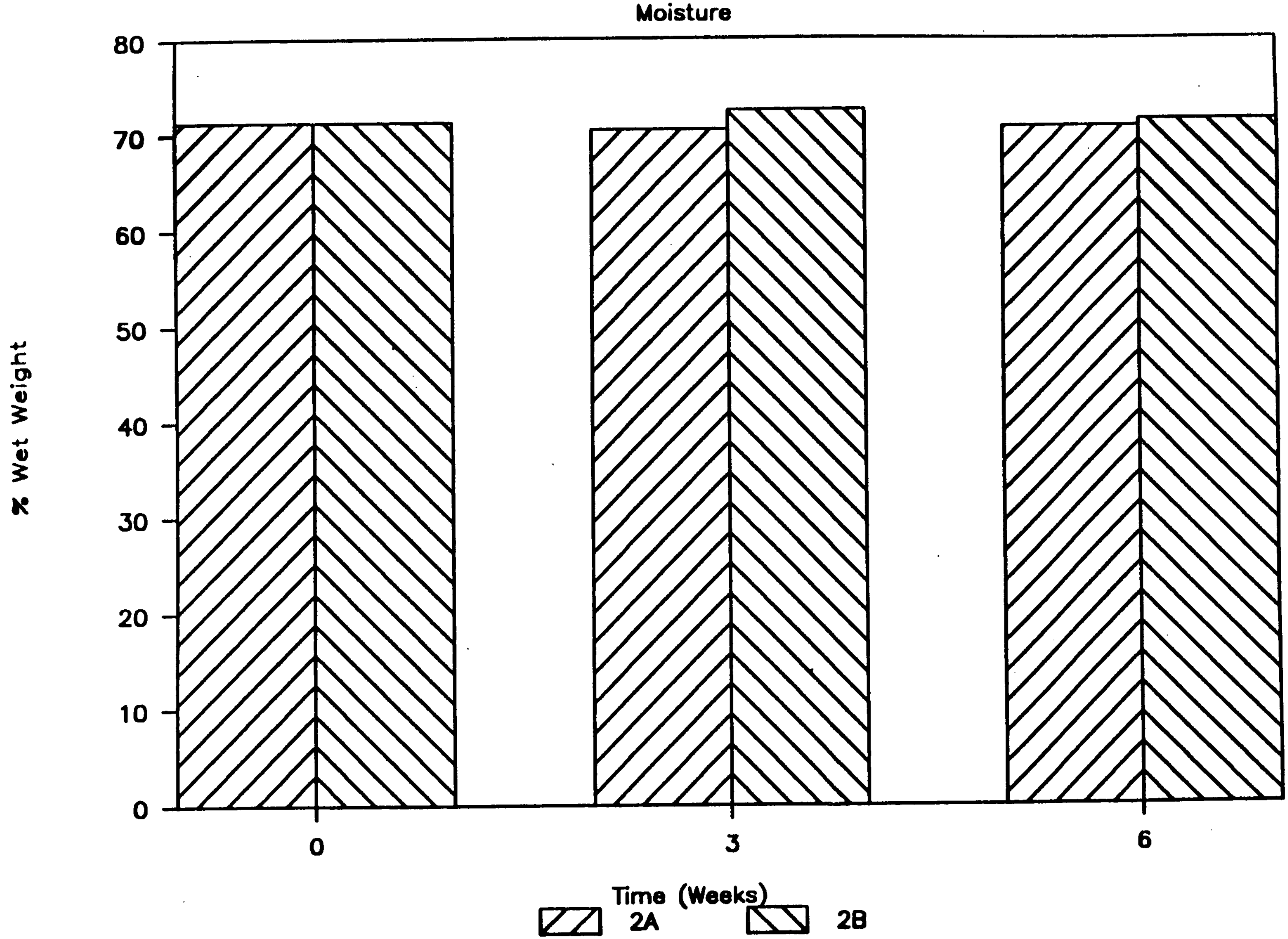
amount fed are reflected in the greater conversion efficiencies of the experimental group (Table III).

The carcass composition analysis results are shown in Table IV and Figs. 14 through 20. The only significant differences occurred in the samples taken after three weeks during which the experimental group had been starved and the control group fed. The experimental group was significantly higher in moisture ($t= -2.92$, $\alpha(8\ d.f.) <0.02$) (Fig. 14), and dry protein ($t = -3.96$, $\alpha(8\ d.f.) <0.005$) (Fig. 19) and lower in fat ($t = 3.21$, $\alpha(8\ d.f.)<0.02$) (Fig 15). After six weeks there were no significant differences between the control and experimental groups at $\alpha < 0.05$. The average percentage change in carcass composition (Fig. 21) illustrates the large changes in fat content with starvation. These average percentage changes were then used to calculate the body composition of a hypothetical 100 g trout in each of the control and experimental groups initially, after three weeks , and after six weeks of growth at the average percentage change in weight for each group (Table V). This shows that during the three weeks of starvation the weight loss in the experimental group consists mainly of water (6.86 g) and equal amounts of fat (2.09 g) and protein (2.19 g). In the following three week feeding period the experimental fish gained 39.10 g in weight of which 26.88g is water, 5.62 g is fat and 6.02 g is protein. After six weeks the control group fish is 11.60 g heavier of which 7.28 g is water, 2.16 g is fat and only 1.43 g is protein at a cost of 134.3 g more feed than the experimental fish received (based on 5% body weight per day feeding level for both groups).

Table IV: Carcass Composition: Average Values (%)

Week	Group	Moisture	Fat	Protein	Ash	other	Total
0	initial	71.24	8.54	17.20	2.02	1.00	100
3	2A	70.51	10.22	16.40	2.22	0.65	100
	2B	72.50	7.26	16.90	2.44	0.90	100
6	2A	70.64	10.20	16.12	2.40	0.64	100
	2B	71.36	9.44	16.44	2.38	0.38	100

Figure 14



Moisture
80
70
60
50
40
30
20
10
0
% Wet Weight
0
3
6
Time (Weeks)
2A
2B

48

Figure 15

Fat

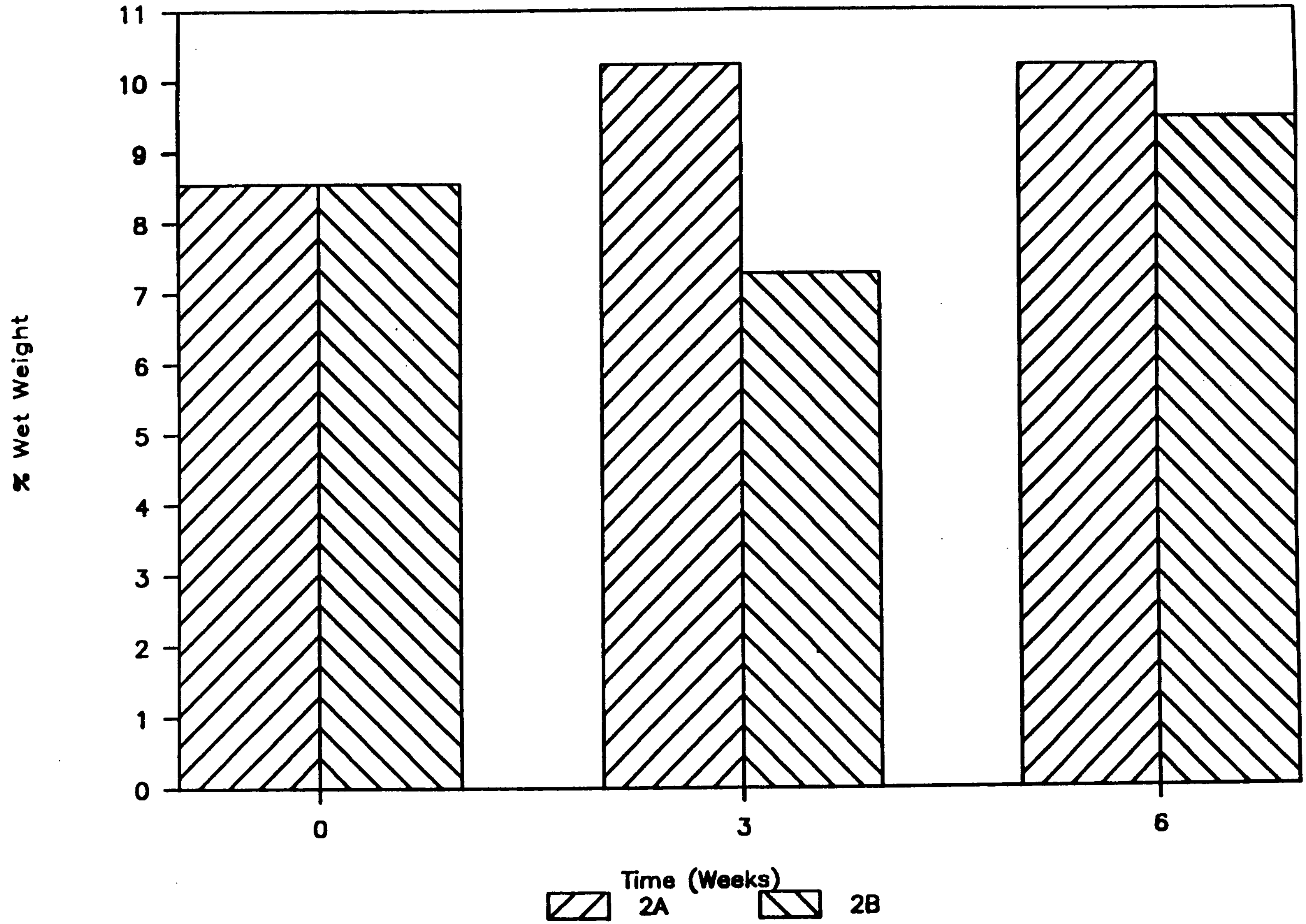
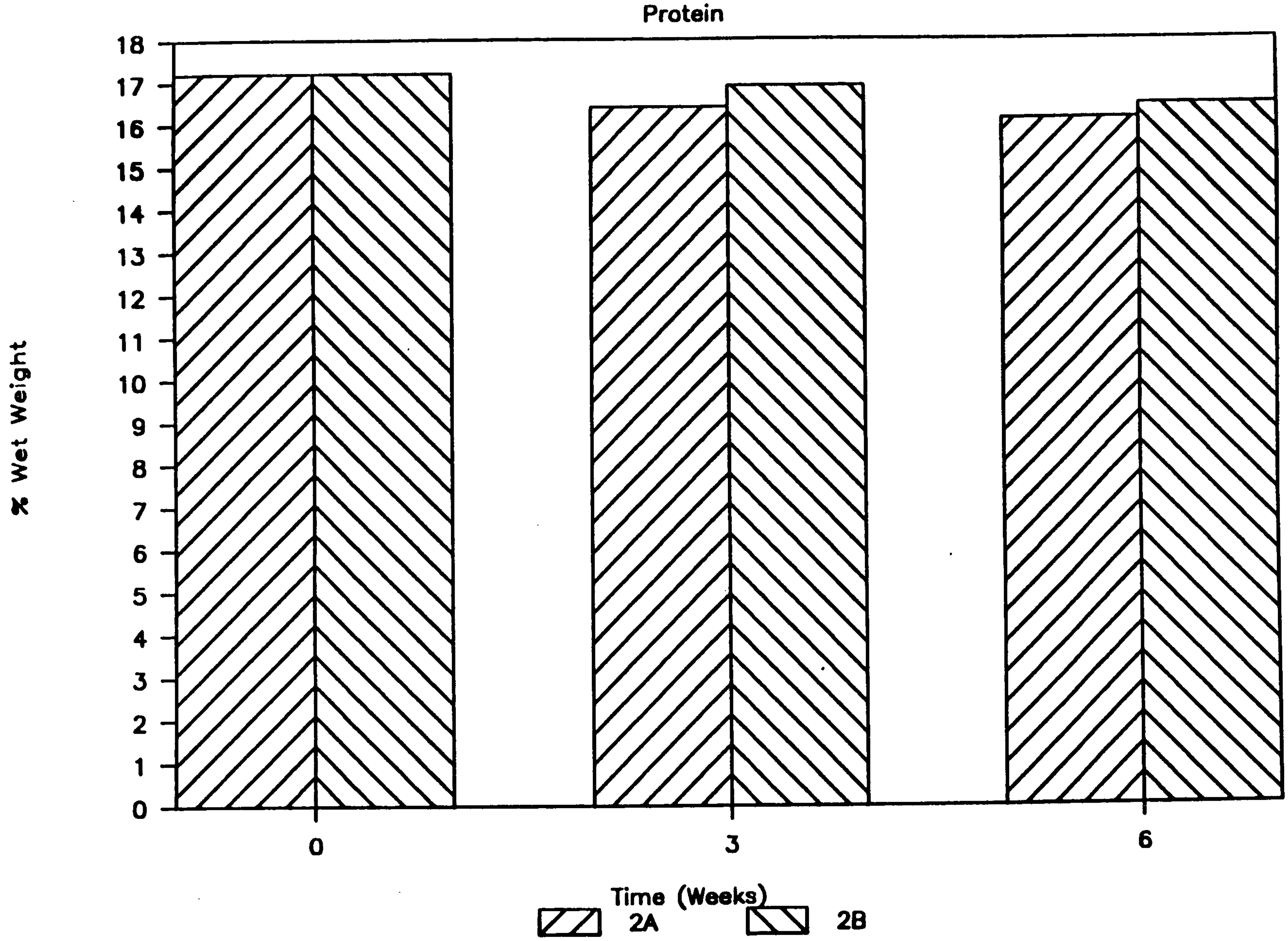


Figure 16



Protein
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
% Wet Weight
0
3
6
Time (Weeks)
2A
2B

50

Figure 17

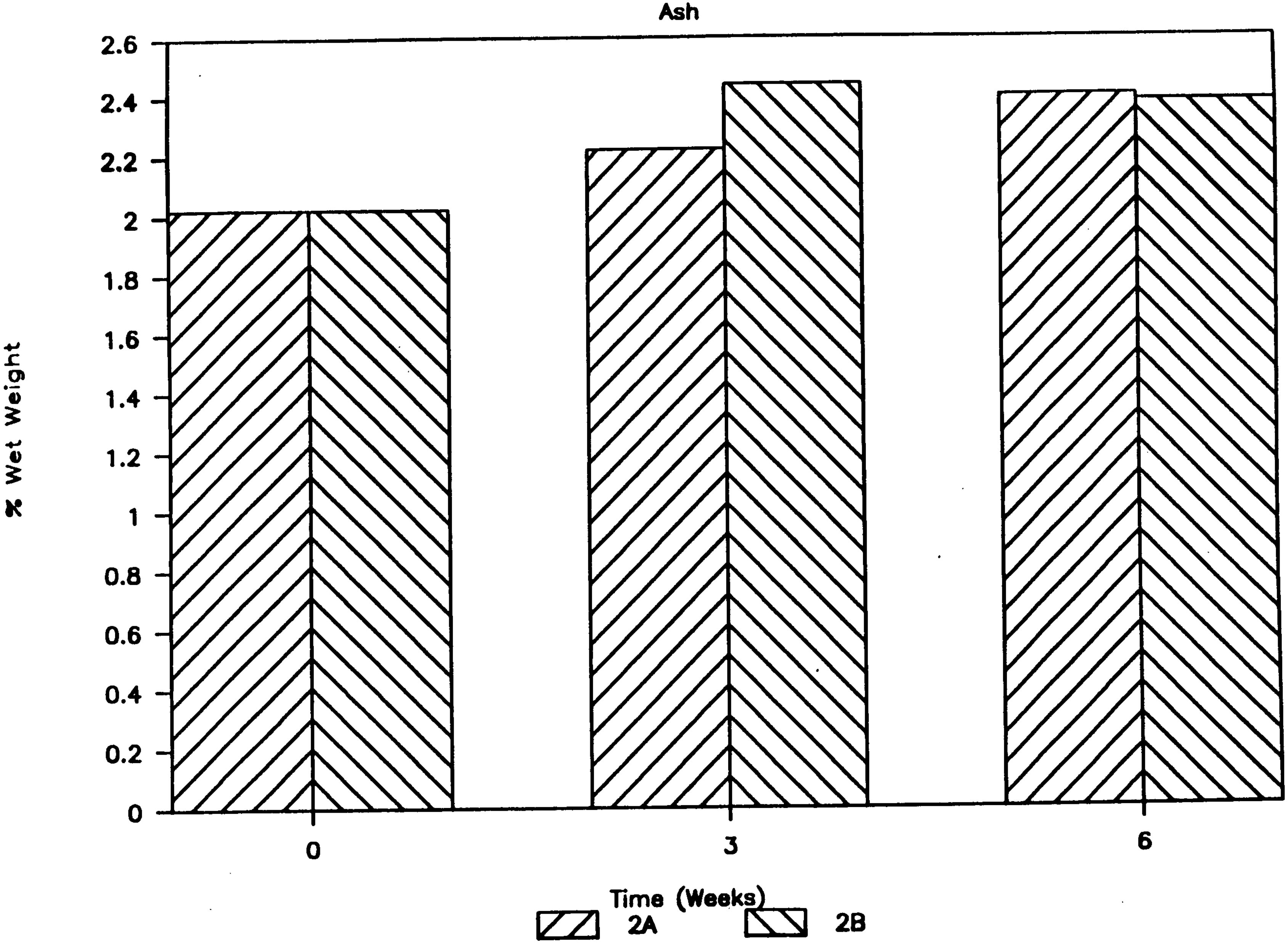

Ash
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
% Wet Weight
0
3
6
Time (Weeks)
2A
2B

Figure 18

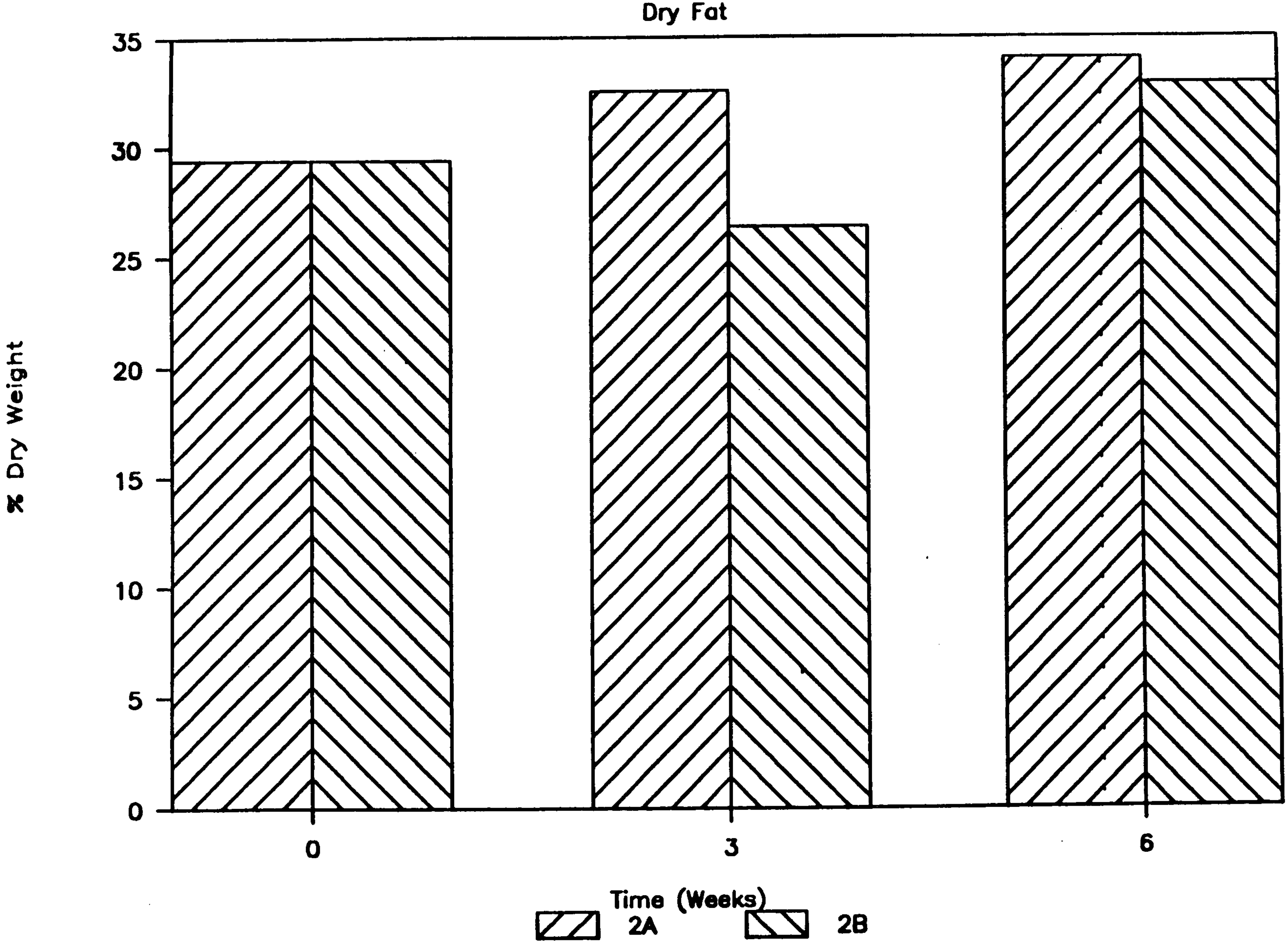
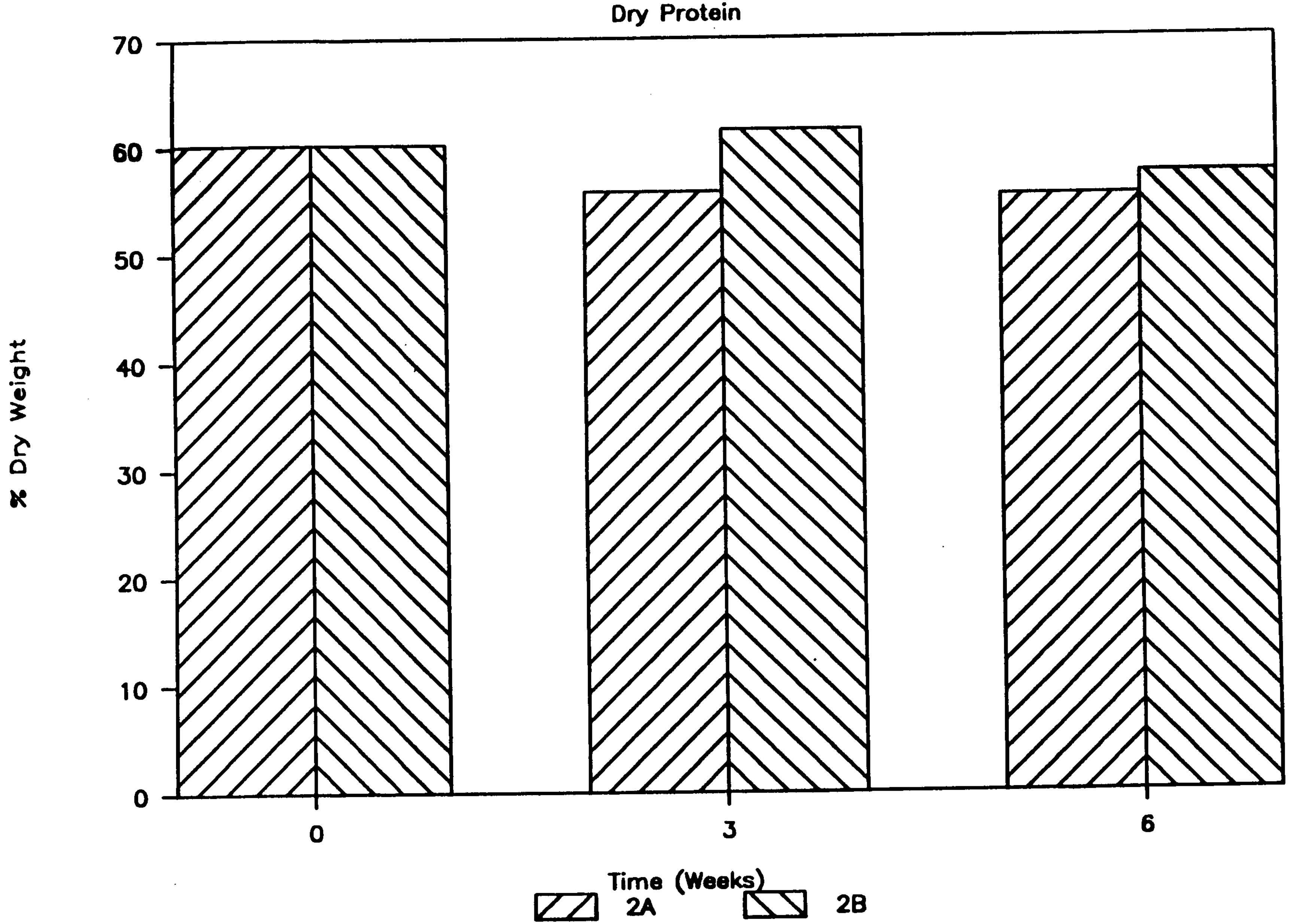


Figure 19



Dry Protein
70
60
50
40
30
20
10
0
% Dry Weight
0
3
6
Time (Weeks)
2A
2B

53

Figure 20

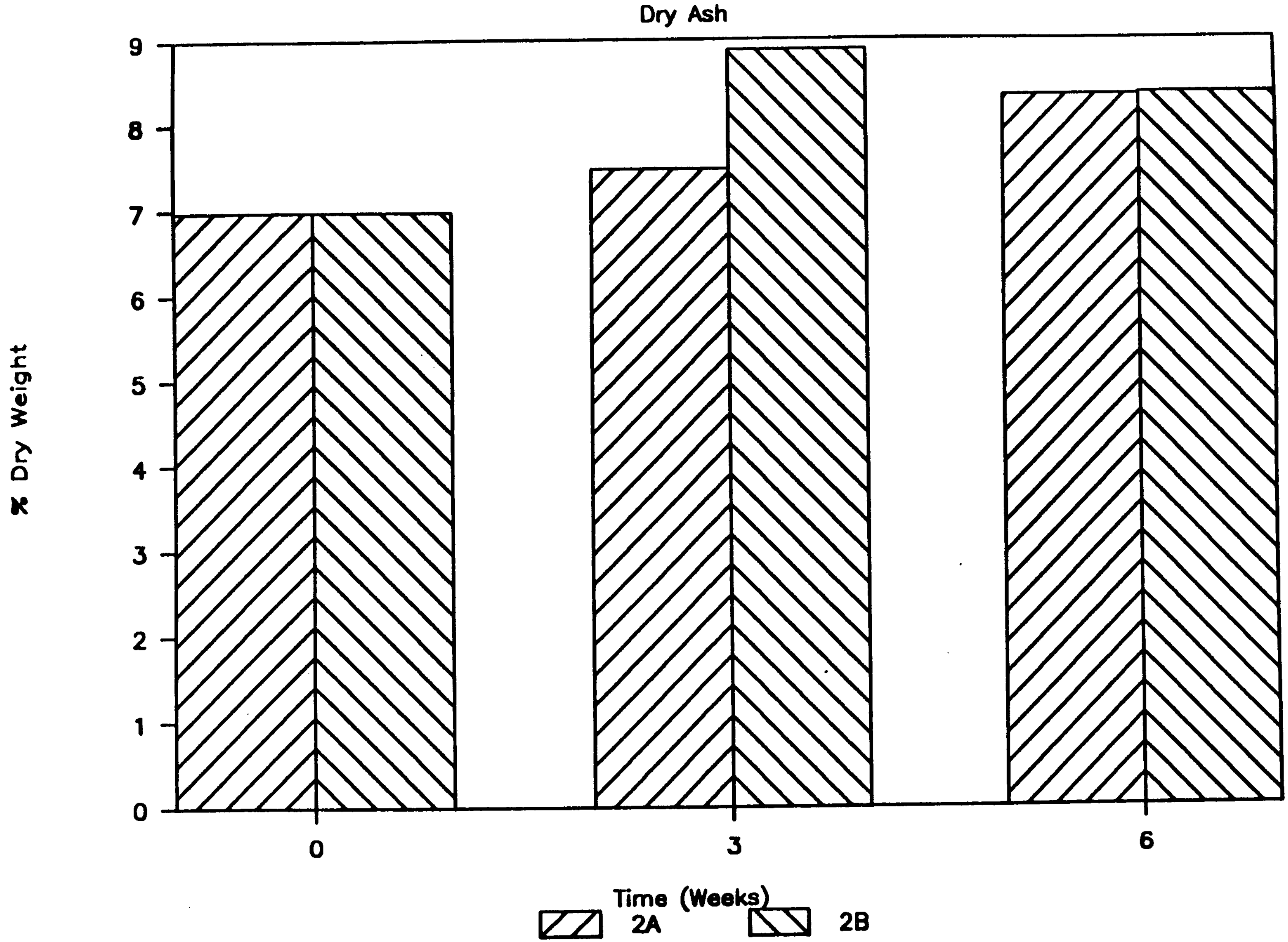


Figure 21

Carcass Compostion

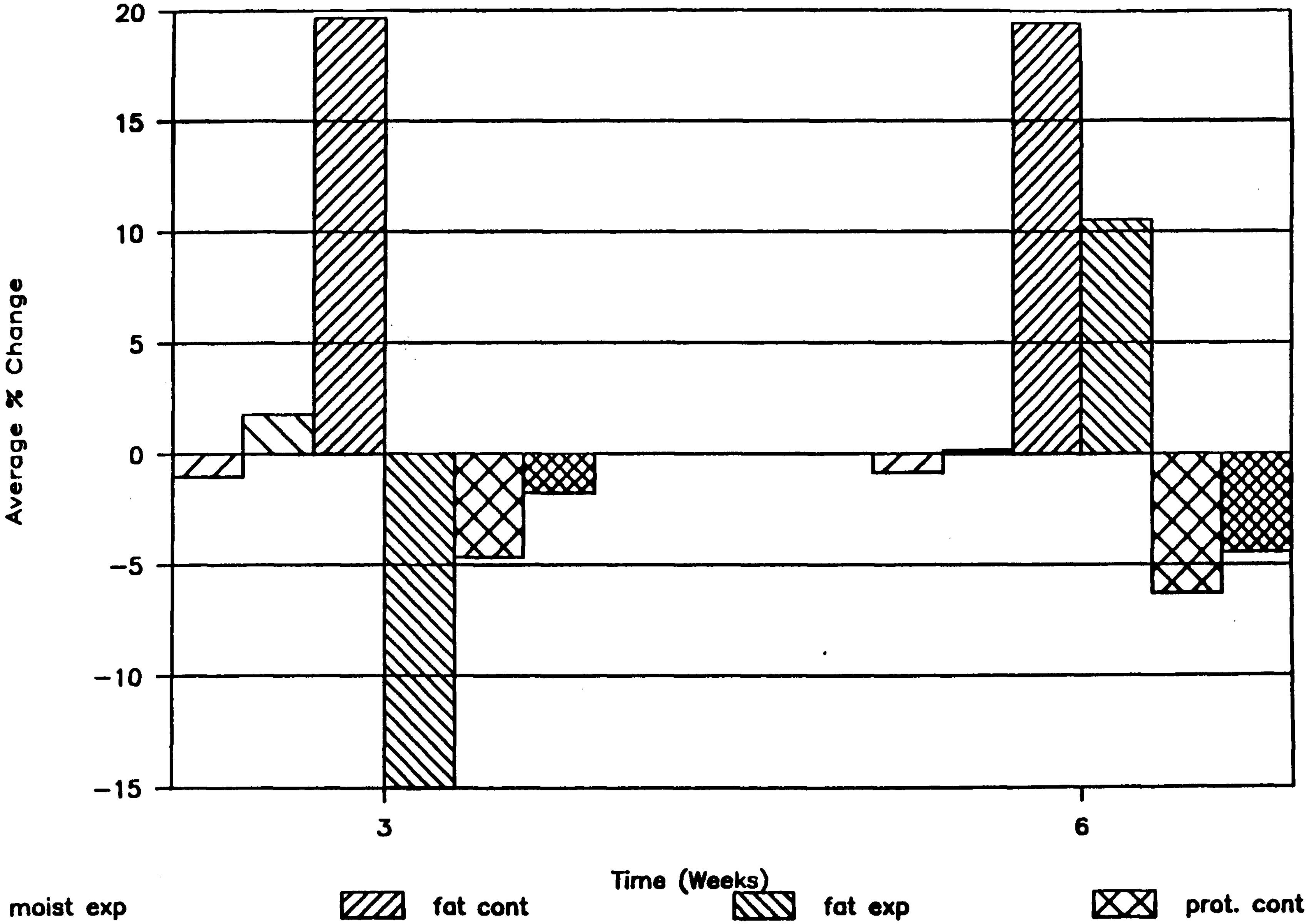


Table V: Changes in a 100 g fish

Week	Group	Moisture	Fat	Protein	Ash	Other	Total
0	Initial	71.24	8.54	17.20	2.02	1.00	100.0
3	2A	82.29	11.93	19.14	2.59	0.76	116.7
	2B	64.38	6.45	15.01	2.17	0.80	88.8
6	2A	98.54	14.23	22.49	3.35	0.89	139.5
	2B	91.26	12.07	21.03	3.04	0.49	127.9

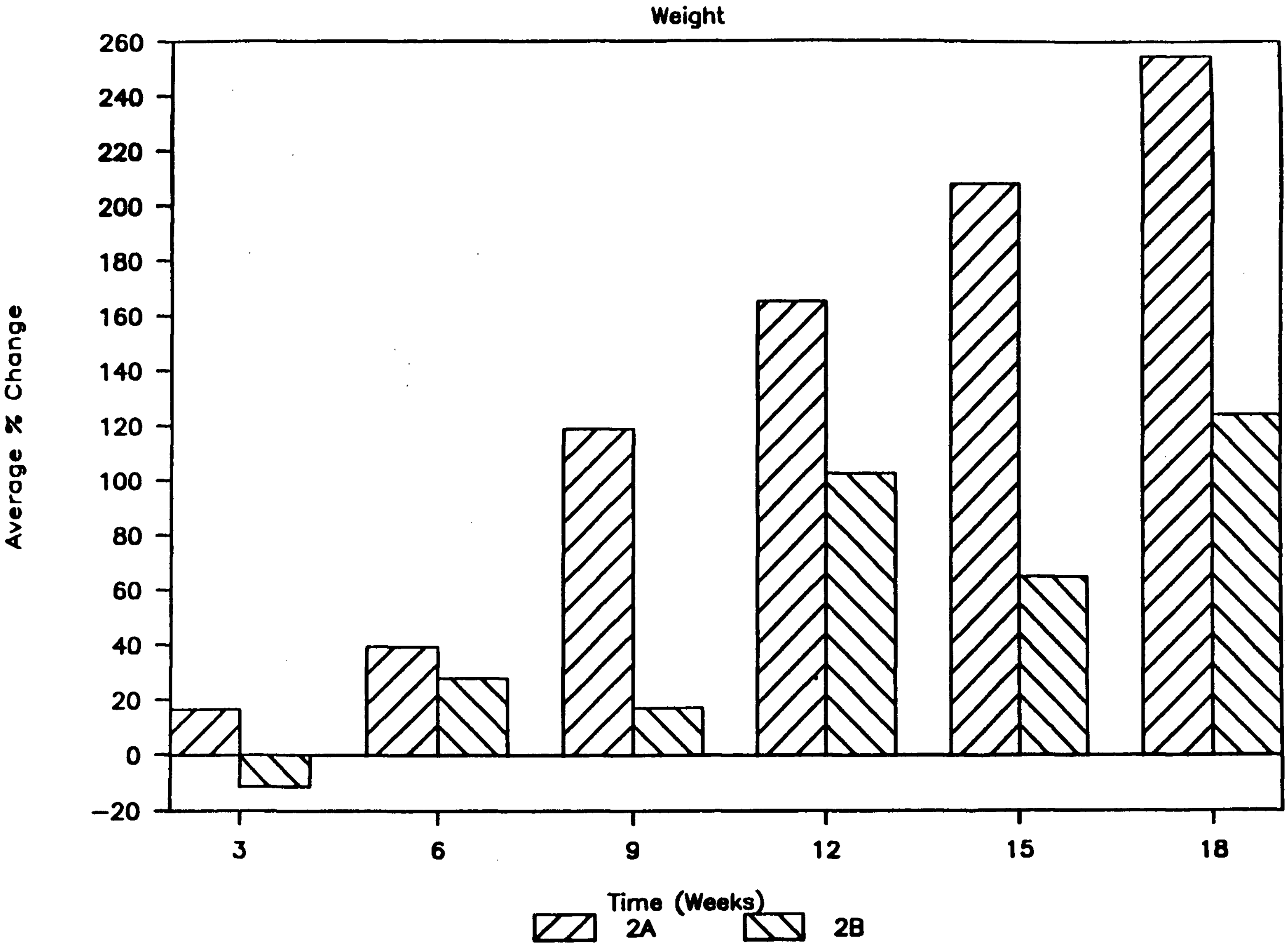
Discussion

Experiment 1 shows that the cycle period has a great effect on the C.G.R.. Groups 1D, 1E and 1F all showed greater average percentage weight (Fig. 8) and length (Fig. 9) gains, higher specific growth rates (Fig. 10) and better conversion efficiencies (Fig. 11) than the control or the two other cyclically fed groups, though the differences were not statistically significant at the $\alpha = 0.05$ level. Thus groups 1D, 1E and 1F did at least as well if not better than the controls though they were fed for half as long. The control group's specific growth rate (0.407 % per day) is comparable to that of other constantly fed groups in the literature (Houlihan and Laurent, 1987, Davidson and Goldspink, 1977, Elliott, 1975) which were fed to satiation. Experiment 1 shows that during starvation, the greatest weight loss occurs during the first week of starvation as was found by Dobson and Holmes (1984). This large initial loss is probably due to the emptying of the gut (Elliott, 1972). As starvation continues the carcass composition results show a decrease in fat and an increase in moisture (Tables IV and V, Fig.21). This reflects the utilization of the visceral fat deposits and muscle lipids (Parker and Vanstone, 1966, Smith, 1981; Weatherly and Gill, 1981, Jezoerska *et al*, 1982) and the replacement with water of the muscle lipids (Idler and Bitners, 1959). The starvation periods used here are shorter than those required to initiate significant protein utilization (Denton and Yousef, 1976, Elliott, 1975, Weatherly and Gill, 1981) although changes in the metabolic rate of the muscle tissues occur shortly after starvation begins (Loughna and Goldspink, 1984). The protein turnover rate is reduced during moderate starvation (Smith, 1981, Loughna and Goldspink, 1984). This reduction in protein metabolism may be the physiological mechanism underlying the C.G.R. and determining the ideal cycle periods for maximal growth and conversion efficiency. Upon starvation the basal metabolic rate drops and activity levels are reduced (Love, 1970, Love, 1980, Loughna and Goldspink, 1984). One of the main factors in reducing the basal metabolic rate is the reduction of the protein turnover rate in the white muscle tissue which comprises 70 percent of the fish's total wet body weight (Loughna and Goldspink, 1984). The protein turnover rate is determined by two factors, the degradation rate and the synthesis rate. In short term starvation both are reduced (Love, 1980, Smith, 1981, Loughna and Goldspink, 1984). As the starvation period increases the degradation rate increases in order to utilize the muscle tissue as an energy source through gluconeogenesis (Moon and Johnston, 1980). The very high growth rates associated with the C.G.R. would be possible if during the refeeding period the degradation rate remained low but the synthesis rate increased, allowing much more protein to be retained as growth. The inability of the shorter starvation periods (Groups 1B, 1C, Table II) to facilitate a greater C.G.R. may be the result of the protein turnover rate not having decreased sufficiently. The three week period could allow the synthesis and degradation rates to fall but not be long enough to cause the degradation rate to rise as the protein is not yet an energy source (Smith, 1981, Weatherly and Gill, 1981). This rise in the degradation rate may be the point at which a full recovery from the starvation period is not possible. The mechanics for the rapid growth in the last week of refeeding is not known. In rainbow trout rapid growth is normally achieved through the recruitment of new small muscle fibres, as opposed to increasing the diameter of existing ones (Weatherly *et al*, 1979, Weatherly *et al*, 1980a,b, Weatherly and Gill, 1984). The protein synthetic rates in trout are much lower than mammalian rates and a greater proportion of muscle tissue protein synthesis is retained as growth in fish epaxial muscle (Smith, 1981). This is due to the lower basal metabolic demands on the poikilothermic fish compared to the homeotherms (Smith, 1981). During starvation fish have much lower energy demands than mammals as they do not maintain a constant body temperature different than the environment.

The effect of ration level on the C.G.R. is minimal at the ration levels used in these experiments. The only effect that ration levels greater than three percent of body weight per day had was to decrease conversion efficiency (Table II, Fig. 11). This indicates that the fish fed at the higher ration levels were overfed. This is supported by observations made during the experiment that some of the feed in the higher ration level groups was washed out of the tanks and collected at the outflow. It was not possible to quantitatively measure this with the setup used for these experiments. All groups were fed all their ration at one time once per day. This would result in rapid filling of the gut and decrease residence time and assimilation efficiency during digestion (Jobling, 1981). If feeding were to be spread throughout the day even greater conversion efficiencies may be possible (Wurtsbaugh and Davis, 1977). Starvation periods of greater than seven days reduce the gastric evacuation rate and, the longer the starvation, the greater the reduction (Elliott, 1972). This reduced evacuation rate may increase assimilation efficiency during refeeding and contribute to the C.G.R. by making more energy available from the feed consumed.

The second experiment shows the effect of repetitive cycles on the C.G.R.. The control group showed a very high specific growth rate and conversion efficiency compared to the control in the first experiment and other sources in the literature. The experimental group showed great gains in average percentage weight during the three refeeding periods (39.1%, 85.2%, 58.9%, Table III, Fig. 22). A mechanical breakdown in the system severely reduced water quality during the last two weeks of the experiment. This is reflected in the reduced growth and conversion efficiency during the last three week period for both the control and experimental groups. The experimental group was more severely affected because it occurred during the final week of the feeding period when most of the compensatory growth occurs (Figs. 5,7). The average weights of the control and experimental groups were not significantly different after six or twelve weeks (Fig. 12) even thought the control had received 230% more feed at six weeks

Figure 22



Weight
Average % Change
260
240
220
200
180
160
140
120
100
80
60
40
20
0
−20
3
6
9
12
15
18
Time (Weeks)
2A
2B

and 260% more feed at 12 weeks (Fig. 13). The growth rate and conversion efficiency increased from the first cycle to the second and the average percentage increase in weight and length and the conversion efficiency were greater during the third cycle than the first (Table III). This indicates that the C.G.R. may increase with repetitive cycling.

The carcass composition analysis (Tables IV, V, Figs. 14 to 21) show that there is no significant difference between the experimental and control fish after six weeks in moisture, fat, protein or ash. The experimental group tended to have slightly more protein and less fat than the controls. This indicates that the compensatory growth response does not affect the tissue qualities of the fish.

The effect of fish size on the compensatory growth response can be inferred by comparing experiment 1 and the first six weeks of experiment 2. The average fish size in experiment 1 was 36.24 g while that for experiment 2 was 120.22 g. As fish increase in size their growth rate declines (Brett, 1979, Houlihan *et al*, 1986) but the results for experiment 1 and for the first 6 weeks of experiment 2 show very similar performance. Compensatory growth may increase the growth rate as well as the conversion efficiency in larger fish. The effect of fish size on the optimal cycle period is probably determined by the amount of lipid present to serve as the energy source during the starvation period and so determine the period before protein utilization occurs. Metabolic rate scales inversely with fish size (Wurtsbaugh and Davis, 1977).

Since the utilization of fat reserves is proportional to the metabolic rate it is probable that cycle period scales with fish size.

The results presented here indicate that the compensatory growth response can be utilized to grow fish of comparable size to fish fed daily with far less feed. Application of these techniques to commercial aquaculture operations could lead to a considerable saving in feed cost, the major operating expense of most fish farms (Dr. F. Ming, Pers.Comm).

Conclusions

The experiments show that equal or better growth rates can be achieved with less than half the feed through compensatory growth. The cycle period is critical. The three week cycles gave much higher average percentage changes in weight (27.24%, 27.91%, 24.91%) than either the control (18.68%) or the one (7.99%) and two (7.61%) week cycles. The results for average percentage change in length and specific growth rate show the same pattern.

Most of the compensatory growth occurred in the last week of the three week feeding period. Group 1D, which had a three week cycle period and a three percent of body weight per day ration level, produced a specific growth rate of over four percent at a conversion efficiency of 1.23 during the last week of its feeding period.

The ration levels tested, three, five and seven percent of body weight per day, did not affect the growth rate. The higher ration levels only decreased the conversion efficiency (0.527 for 3%, 0.299 for 5% and 0.188 for 7%). This indicates that groups fed at greater than 3% were overfed.

There were no significant differences between average weights of the control and experimental groups after six and twelve weeks though the control group had been fed 230 percent and 264 percent more feed respectively. After eighteen weeks the control group was significantly heavier than the experimental group but it had received 294 percent more feed.

Carcass composition analysis of moisture, protein, fat and ash show that compensatory growth has no significant effect on the overall body composition after a complete cycle.

The effect of compensatory growth is to increase the growth rate and conversion efficiency during the refeeding period if the starvation and refeeding periods have been long enough. Further research in this area should focus on the effect of independently varying the starvation and refeeding periods, including longer refeeding periods to determine when the increased growth rate due to compensatory growth rate falls to control levels. The underlying mechanisms of compensatory growth should also be examined by determining the changes in protein synthesis and degradation during compensatory growth. Histological studies to determine if muscle growth occurs through new fibre recruitment or increasing diameter of existing fibres would also be worthwhile.

References

Ayles, G.B., Bernard, D. and Hendzel, M. (1979). Genetic differences in lipid and dry matter content between strains of rainbow trout (*Salmo gairdneri*) and their hybrids. Aquaculture 18, 253-262.

Bennett, D., Morley, F.H.W., Clark, K.W. and Dudzinski, M.L. (1970). The effect of raising cattle and sheep together. Aust. J. Exp. Anim. Husb. 10, 694-709.

Bilton, H.T. and Robins, G.L. (1973). The effects of starvation and subsequent feeding on survival and growth of Fulton channel sockeye salmon fry (*Oncorhynchus nerka*). J. Fish. Res. Bd. Can. 30, 1-5.

Black, D. and Love, R.M. (1986). The sequential mobilization and restoration of energy reserves in tissues of Atlantic cod during starvation and refeeding. J. Comp. Physiol B. 156, 469-479.

Black, W.H., Queensberry, J.R. and Baker, A.L. (1940). Wintering steers on different planes of nutrition from weaning to 2 1/2 years of age. Tech. Bull. U.S. Dept. agric. 667, 20pp.

Bohman, V.R. (1955). Compensatory growth of beef cattle: the effect of hay maturity. J. Anim. Sci. 14, 249-255.

Brett, J.R. (1979). Environmental factors and growth. Pages 599-677 *in* W.S. Hoar, D.J. Randall, and J.R. Brett, eds. Fish physiology. 8. Academic Press, New York.

Brody, S. (1927). Growth and development, with special reference to domestic animals. Res. Bull. Mo. agric. Exp. Sta. 103, 40 pp.

Cho, C.Y. and Slinger, S.J. (1980). Effect of water temperature on energy utilization in rainbow trout (*Salmo gairdneri*). *in* L.E. Mount, ed. Proc. 8th Symp. on Energy Metabolism, Cambridge, U.K. pp287-291. Butterworth. London.

Cho, C.Y., Bayley, H.S. and Slinger, S.J. (1975). An automated fish resperometer for nutrition studies. Proc. 28th Ann. Meeting of Can Conf. for Fish Res. Vancouver, B.C.

Cho, C.Y., Slinger, S.J. and Bayley, H.S. (1982). Bioenergetics of salmonid fishes: energy intake, expenditure and productivity. Comp. Biochem. Physiol. 73B, 25-41.

Clarke, E.R., Harman, J.P. and Forster, J.R.M. (1985). Production of metabolic and waste products by intensively farmed rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 27, 381-393.

Crichton, J.A. and Aitken, J.N. (1954). The economical rearing of dairy heifers. Proc. Nutr. Soc. 13, 10-37.

Davison, W and Goldspink, G. (1977). The effect of prolonged exercise on the lateral musculature of the brown trout (*Salmo trutta*). J. exp. Biol. 70, 1-12.

Denton, J.E. and Yousef, M.K. (1976). Body composition and organ weights of rainbow trout, *Salmo gairdneri*. J. Fish Biol. 8, 489-499.

Dobson, S.H. and Holmes, R.M.(1984). Compensatory growth in rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 25, 649-656.

Drew, K.R. and Reid, J.T. (1975a). Compensatory growth in immature sheep. I. The effects of weight loss and realimetation on the whole body composition. J. Agric. Sci. 85, 193-204.

Drew, K.R. and Reid, J.T. (1975b). Compensatory growth in immature sheep. II. Some changes in the physical and chemical composition of sheep half-carcass following feed restriction and realimentation. J. Agric. Sci. 85, 205-213.

Drew, K.R. and Reid, J.T. (1975c). Compensatory growth in immmature sheep. III. Feed utilization by sheep subjected to feed deprivation followed by realimentation. J. Agric. Sci. 85, 215-220.

Elliott, J.M. (1972). Rates of gastric evacuation in brown trout, *Salmo trutta* L. Freshwat. Biol. 2, 1-18.

Elliott, J.M. (1975). The growth rate of the brown trout, *Salmo trutta* L. fed on maximum rations. J. Anim. Ecology 44, 805-821.

Gill, H.S., Weatherly, A.H. and Bhesania, T. (1982). Histochemical characterization of myotomal muscle in the bluntnose minnow, *Pimphales notatus* Rafinesque. J. Fish Biol. 21, 205-214.

Graham, N.McC. and Searle, T.W. (1975). Studies of weaner sheep during and after a period of weight stasis. I. Energy and nitrogen utilization. Aust. J. Agric. Res. 26, 343-353.

Houlihan, D.F., McMillan, D.N. and Laurent, P. (1986). Growth rates, protein synthesis, and protein degradation rates in rainbow trout: effects of body size. Physiol. Zool. 59, 482-493.

Houlihan, D.F. and Laurent, P. (1987). Effects of exercise training on the performance, growth, and protein turnover of rainbow trout (*Salmo gairdneri*). Can. J. Fish. Aquat. Sci. 44, 1614-1621.

Hoyle, J., Gill, H.S. and Weatherly, A.H. (1986). Histochemical characterization of myotomal muscle in the grass pickerel, *Esox americanus vermiculatus* (LeSeuer), and the muskellunge, *E. masquinongy* (Mitchell). J. Fish Biol. 28, 393-401.

Idler, D.R. and Bitners, I. (1959). Biochemical studies on sockeye salmon during spawning migration. V. Cholesterol, fat, protein and water in the body of the standard fish. J. Fish. Res. Bd. Can. 16, 235-241.

Jezoerska, B., Hazel, J.R. and Gerking, S.D. (1982). Lipid mobilization during starvation in the rainbow trout, *Salmo gairdneri* Richardson, with attention to fatty acids. J. Fish Biol. 21, 681-692.

Jobling, M. (1981). Mathematical models of gastric emptying and the estimation of daily rates of food consumption for fish. J. Fish Biol. 19, 245-257.

Jobling, M. (1983). A short review and critique of methodology used in fish growth and nutrition studies. J. Fish Biol. 23, 685-703.

Johnston, I.A. (1981). Quantitative analysis of muscle breakdown during starvation in the marine flatfish *Pleuronectes platessa*. Cell Tissue Res. 214, 369-386.

Johnston, I.A. and Goldspink, G. (1973). Some effects of prolonged starvation on the metabolism of the red and white myotomal muscles of the plaice *Pleuronectes platessa*. Mar. Biol. 19, 348-353.

Keenan, D.M., McMannus, W.R. and Frur, M. (1969). Changes in body composition and efficiency of mature sheep during loss and regain of live weight. J. Agric. Sci. 72, 139-147.

Kindschi, G.A. (1988). Effect of intermittent feeding on growth of rainbow trout, *Salmo gairdneri* Richardson. Aquacult. Fish. Mgt. 19, 213-215.

Li, H.W. and R.W. Brocksen (1977). Approaches to the analysis of energetic costs of intraspecific competition for space by rainbow trout (*Salmo gairdneri*). J. Fish Biol. 11, 329-341.

Little, D.A. and Sandland, R.L. (1975). Studies on the distribution of the body fat in sheep during continuous growth and following nutrition restriction and rehabilitation. Aust. J. Agric. Res. 26, 363-374.

Loughna, P.T. and Goldspink, G. (1984). The effects of starvation upon protein turnover in red and white myotomal muscle of rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 25, 223-230.

Love, R.M. (1970). The Chemical Biology of Fishes. Academic Press, London, New York.

Love, R.M. (1980). The Chemical Biology of Fishes, 2. Academic Press, London, New York.

McCay, C.M., Maynard, L.A., Sperling, G. and Barnes, L.L. (1939). Retarded growth, lifespan, ultimate body size and age changes in the albino rat after feeding diets restricted in calories. J. Nutr. 18, 1-14.

McManus, W.R., Reid, J.T. and Donaldson, L.E. (1972). Studies of compensatory growth in sheep. J. agric. Sci., Camb. 79, 1-12.

Meyer, J.H. and Clawson, W.T. (1964). Undernutrition and subsequent realimentation in rats and sheep. J. Anim. Sci. 23, 214-224.

Miller, D.S. and Wise, A. (1976). The energetics of "catch up" growth. Nutr. Metabol. 20, 125-134.

Moon, T.W. (1983). Changes in tissue ion contents and ultrastructure of food-deprived immature American eels, *Anguilla rostrata* (LeSueur). Can. J. Zool. 61, 812-821.

Moon, T.W. and Johnston, I.A. (1980). Starvation and the activities of glycolytic and gluconeogenic enzymes in skeletal muscles and liver of the plaice, *Pleuronectes platessa*. J. Comp. Physiol. 136, 31-38.

Osborne, T.B. and Mendel, L.B. (1915a). The resumption of growth after long continued failure to grow. J. biol. Chem. 23, 439-454.

Osborne, T.B. and Mendel, L.B. (1915b). Protein minima for maintenance. J. biol. Chem. 21, 241-257.

Palsson, (1955). Progress in the physiology of farm animals, II, ch. 10. London: Butterworths.

Parker, R.R. and Vanstone, W.E. (1966). Changes in chemical composition of central British Columbia pink salmon during early sea life. J. Fish. Res. Bd. Can. 23, 1353-1384.

Pearson-Hughes, G., Alder, F.E. and Redford, R.A. (1955). The overwintering of beef steers. Emp. J. exp. Agric. 23, 145-157.

Refstie, T. (1980). Genetic and environmental sources of variations in body length and weight of rainbow trout fingerlings. Aquaculture 19, 351-357.

Searle, T.W. and Graham, N.McC. (1975). Studies of weaner sheep during and after a period of weight stasis. II. Body composition. Aust. J. Agric. Res. 26, 355-361.

Smith, M.A.K. (1981). Estimation of growth potential by measurement of protein synthetic rates in feeding and fasting rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 19, 213-220.

Smith, R.R., Rumsey, G.L. and Scott, M.L. (1978a). Net energy maintenance requirements of salmonids as measured by direct calorimetry: effect of body size and environmental temperature. J. Nutr. 108, 1017-1024.

Smith, R.R., Rumsey, G.L. and Scott, M.L. (1978b). Heat increment associated with dietary protein, fat and carbohydrate and complete diets in salmonids: comparative energetic efficiency. J. Nutr. 108, 1025-1032.

Stearns, G. and More, D.L.R. (1931). Growth in height and weight and retention of nitrogen, calcium and phosphorus during recovery from severe malnutrition. Amer. J. Dis. Child. 42, 774-780.

Swett, W.W. and Eckles, C.H. (1918). Some factors influencing the rate of growth and the size of dairy heifers at maturity. Res. Bull. Mo. Agric. Exp. Sta. 31, 56pp.

Thornton, R.F., Hood, R.L., Jones, P.N. and Re, V.M. (1979). Compensatory growth in sheep. Aust. J. Agric. Res. 30, 135-151.

Trzebiatowski, R., Filipiak, J. and Jakubowski, R. (1981). Effect of stock density on growth and survival of rainbow trout (*Salmo gairdneri* Rich.). Aquaculture 22, 289-295.

Walker, J.J. and Garrett, W.N. (1970). Shifts in the energy metabolism of male rats during their adaption to prolonged undernutrition and during their subsequent realimentation. *in* A. Shurch and C. Wenk, eds,Proc. 5th Symp. E.A.A.P.; Energy Metabolism of Farm Animals.

Watanabe, T. Takeuchi, T. and Ogino, C. (1979). Studies on the sparing effect of lipids on dietary protein in rainbow trout (*Salmo gairdneri*). Proc. World Symp. on Finfish Nutrition and Fishfeed Technology. Hamburg, Germany. 1, 113-125.

Waters, H.J. (1908). The capacity of animals to grow under adverse conditions. 29th Proc. Soc. Prom. agric. Sci., N.Y. p. 71

Waters, H.J. (1909). The influence of nutrition upon animal form.

30th Proc. Soc. Prom. agric. Sci., N.Y. p.70.

Weatherly, A.H. and Gill, H.S. (1981). Recovery growth following periods of restricted rations and starvation in rainbow trout *Salmo gairdneri* Richardson. J. Fish Biol. 18, 195-208.

Weatherly, A.H. and Gill, H.S. (1984). Growth dynamics of white myotomal muscle fibres in the bluntnose minnow *Pimephales notatus* Rafinesque and comparison with rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 25, 13-24.

Weatherly, A.H., Gill, H.S. and Rogers, S.C. (1979). Growth dymamics of muscle fibres, dry weight and condition in relation to somatic growth rate in yearling rainbow trout (*Salmo gairdneri*). Can. J. Zool. 57, 2385-2392.

Weatherly, A.H., H.S. Gill and S.C. Rogers (1980a). The relation between mosaic muscle fibres and size in rainbow trout (*Salmo gairdneri*). J. Fish Biol. 17, 603-610.

Weatherly, A.H., H.S. Gill and S.C. Rogers (1980b). Growth dynamics of mosaic muscle fibres in fingerling rainbow trout (*Salmo gairdneri*) in relation to somatic growth rate. Can. J. Zool. 58, 1535-1541.

Wilson, P.N. and Osbourne, D.F. (1960). Compensatory growth after undernutrition in mammals and birds. Biol. Rev. Camb. Phil. Soc. 37, 324-363.

Wurtsbaugh, W.A. and Davis, G.E. (1977). Effects of fish size and ration level on the growth and food conversion efficiency of rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 11, 99-104.

Zar, J.H. (1984). Biostatistical Analysis, Second Edition, Prentice-Hall, New Jersey, 718pp.

Appendix: Original Data

Group 1A, Initial Values
Dec. 6, 1987

Tag	Weight	Length	New Tag
236	36.15	13.8	
242	17.81	10.8	
243	27.4	12.8	
288	22.83	12.1	
292	18.8	11.3	469
297	17.85	10.6	
200	21.8	11.7	
201	17.65	10.7	
202	46.83	13.8	
204	24.74	12.5	
205	45.4	14.2	
206	44.68	15.1	
207	32.43	13.8	
209	19.45	11.1	515
211	28.08	13	
212	60.71	15	
213	30.91	13.3	
214	26.3	12.8	
215	30.9	13.4	
216	21.23	12	
217	12.05	9.8	
218	58.79	16.3	458
223	37.94	14.1	
224	30.1	13.7	
225	25.58	12.8	
227	29.16	13	
228	13.45	10.4	
230	24.85	11.9	
250	48.75	15.1	236
251	18.7	10.9	
254	19.43	10.8	
258	28.28	13.2	
259	12.91	9.5	
260	31.75	13.2	
262	33.5	13.9	
263	26.52	12.7	
267	12.98	10.2	
268	36.3	14	
282	38.8	14.6	
318	28.59	15.1	
avg	28.301	12.414	
sum	1160.3		
count	40		
feed	58.019	g/day	

Group 1A, Samples

Weight Length

Sample 1, Dec. 10, 1987

Tag	initial	sample	%	initial	sample	%
200	21.8	21.5	-1.37614	11.7	11.7	0
214	26.3	25.98	-1.21673	12.8	12.3	-3.90625
215	30.9	30.14	-2.45954	13.4	13.4	0
216	21.42	21.23	-0.88702	12	12.1	0.833333
217	12.05	12.51	3.817427	9.8	9.65	-1.53061
225	25.58	25.71	0.508209	12.8	12.7	-0.78125
228	13.45	13.88	3.197026	10.4	10.45	0.480769
258	28.28	29.22	3.323903	13.2	12.8	-3.03030
268	36.3	36.15	-0.41322	14	14	0
288	22.83	23.13	1.314060	12.1	12.1	0
	23.891	23.945	0.580795	12.22	12.12	-0.79343

Sample 2, Dec. 11

Tag	initial	sample	%	initail	sample	%
211	28.08	27.84	-0.85470	13	12.7	-2.30769
214	26.3	26.55	0.950570	12.8	12.5	-2.34375
216	21.42	21.31	-0.51353	12	12	0
217	12.05	12.95	7.468879	9.8	9.8	0
223	37.94	38.34	1.054296	14.1	13.6	-3.54609
228	13.45	13.5	0.371747	10.4	10.4	0
258	28.28	28.61	1.166902	13.2	12.7	-3.78787
260	31.75	31.58	-0.53543	13.2	13.2	0
268	36.3	36.29	-0.02754	14	13.9	-0.71428
288	22.83	21.35	-6.48269	12.1	12.1	0
	25.84	25.832	0.259847	12.46	12.29	-1.26997

Sample 3, Dec. 14

Tag	initial	sample	%	initial	sample	%
204	24.74	24.17	-2.30396	12.5	12.6	0.8
214	26.3	25.7	-2.28136	12.8	12.6	-1.5625
217	12.05	12.28	1.908713	9.8	9.8	0
224	30.1	30.4	0.996677	13.7	13.5	-1.45985
227	29.16	28.61	-1.88614	13	12.7	-2.30769
228	13.45	13.47	0.148698	10.4	10.4	0
258	28.28	28.13	-0.53041	13.2	12.8	-3.03030
260	31.75	31.16	-1.85826	13.2	13.2	0
267	12.98	12.88	-0.77041	10.2	10.3	0.980392
268	36.3	35.78	-1.43250	14	13.9	-0.71428
	24.511	24.258	-0.80089	12.28	12.18	-0.72942

Sample 4, Dec. 15

Tag	initial	sample	%	initial	sample	%
200	21.8	20.38	-6.51376	11.7	11.8	0.854700
204	24.74	24.62	-0.48504	12.5	12.5	0
207	32.43	32.22	-0.64754	13.8	13.4	-2.89855
212	60.71	67.79	11.66199	15	14.9	-0.66666
228	13.45	13.31	-1.04089	10.4	10.5	0.961538
258	28.28	27.92	-1.27298	13.2	13	-1.51515
260	31.75	31.04	-2.23622	13.2	13.3	0.757575
262	33.5	33.82	0.955223	13.9	13.8	-0.71942
267	12.98	12.71	-2.08012	10.2	10.4	1.960784
268	36.3	35.63	-1.84573	14	14	0
	29.594	29.944	-0.35050	12.79	12.76	-0.12651

Sample 5, Dec. 17

Tag	initial	sample	% chg	initial	sample	% chg
214	26.3	25.58	-2.73764	12.8	12.7	-0.78125
215	30.9	30.39	-1.65048	13.4	13.3	-0.74626
216	21.23	20.46	-3.62694	12	12	0
217	12.05	12.06	0.082987	9.8	9.7	-1.02040
223	37.94	36.43	-3.97996	14.1	13.8	-2.12765
225	25.58	24.78	-3.12744	12.8	12.8	0
227	29.16	28.32	-2.88065	13	12.9	-0.76923
258	28.28	27.84	-1.55586	13.2	12.9	-2.27272
262	33.5	33.96	1.373134	13.9	13.8	-0.71942
268	36.3	35.7	-1.65289	14	14	0
	28.124	27.552	-1.97557	12.9	12.79	-0.84369

Sample 6, Dec. 18, 1987

Tag	initial	sample	% chg	Initial	Sample	% chg
214	26.3	25.61	-2.62357	12.8	12.5	-2.34375
223	37.94	36.72	-3.21560	14.1	13.6	-3.54609
228	13.45	13.49	0.297397	10.4	10.5	0.961538
243	27.4	24.84	-9.34306	12.8	12.6	-1.5625
258	28.28	27.79	-1.73267	13.2	12.9	-2.27272
262	33.5	33.93	1.283582	13.9	13.7	-1.43884
267	12.98	12.57	-3.15870	10.2	10.3	0.980392
268	36.3	35.55	-2.06611	14	13.9	-0.71428
469	18.8	15.9	-15.4255	11.3	11.3	0
515	19.45	20.47	5.244215	11.1	11.1	0
	25.44	24.687	-3.07400	12.38	12.24	-0.99362

Sample 7, Dec. 22

Tag	initial	sample	% chg	initial	sample	% chg
202	46.83	57.01	21.73820	13.8	15.2	10.14492
207	32.43	35.07	8.140610	13.8	13.6	-1.44927
213	30.91	30.21	-2.26463	13.3	13.2	-0.75187
214	26.3	24.76	-5.85551	12.8	12.6	-1.5625
215	30.9	29.61	-4.17475	13.4	13.3	-0.74626
224	30.1	29.85	-0.83056	13.7	13.5	-1.45985
258	28.28	27.68	-2.12164	13.2	12.8	-3.03030
260	31.75	30.26	-4.69291	13.2	13.2	0
262	33.5	32.49	-3.01492	13.9	13.9	0
263	26.52	25.79	-2.75263	12.7	12.7	0
267	12.98	12.59	-3.00462	10.2	10.4	1.960784
268	36.3	34.96	-3.69146	14	13.9	-0.71428
318	28.59	27.988	-2.10563	15.1	13.1	-13.2450
	30.41461	30.636	-0.35619	13.31538	13.18461	-0.83489

Sample 8, Dec. 25

Tag	initial	sample	% chg	initial	sample	% chg
204	24.74	22.91	-7.39692	12.5	12.3	-1.6
206	44.68	71.05	59.01969	15.1	16.9	11.92052
217	12.05	11.28	-6.39004	9.8	9.7	-1.02040
223	37.94	35.7	-5.90405	14.1	13.7	-2.83687
236	36.15	42.54	17.67634	13.8	14.2	2.898550
258	28.28	27.94	-1.20226	13.2	12.8	-3.03030
260	31.75	29.66	-6.58267	13.2	13.1	-0.75757
262	33.5	31.41	-6.23880	13.9	13.8	-0.71942
469	18.8	17.2	-8.51063	11.3	11.2	-0.88495
515	19.45	24.99	28.48329	11.1	11.5	3.603603
	28.734	31.468	6.295392	12.8	12.92	0.757313

Sample 9, Dec. 29

Tag	initial	sample	% chg	initial	sample	% chg
204	24.74	22.81	-7.80113	12.5	12.4	-0.8
207	32.43	36.49	12.51927	13.8	13.7	-0.72463
211	28.08	26.96	-3.98860	13	12.4	-4.61538
212	60.71	79.18	30.42332	15	15.4	2.666666
217	12.05	11.53	-4.31535	9.8	9.7	-1.02040
224	30.1	29.03	-3.55481	13.7	13.4	-2.18978
227	29.16	26.92	-7.68175	13	12.8	-1.53846
258	28.28	27.53	-2.65205	13.2	12.7	-3.78787
260	31.75	29.62	-6.70866	13.2	13.2	0
262	33.5	31.21	-6.83582	13.9	13.6	-2.15827
	31.08	32.128	-0.05955	13.11	12.93	-1.41681

Sample 10, Jan. 1

Tag	initial	sample	% chg	initial	sample	% chg
204	24.74	22.68	-8.32659	12.5	12.5	0
206	44.68	77.48	73.41092	15.1	17.6	16.55629
215	30.9	29.55	-4.36893	13.4	13.2	-1.49253
217	12.05	11.43	-5.14522	9.8	9.8	0
224	30.1	28.68	-4.71760	13.7	13.4	-2.18978
225	25.58	25.03	-2.15011	12.8	12.6	-1.5625
260	31.75	29.47	-7.18110	13.2	13.3	0.757575
268	36.3	35.1	-3.30578	14	14.1	0.714285
458	58.79	67.29	14.45824	16.3	15.8	-3.06748
469	18.8	17	-9.57446	11.3	11.3	0
	31.369	34.371	4.309932	13.21	13.36	0.971584

Sample 11, Jan 5, 1988

Tag	initial	sample	% chg	initial	sample	% chg
207	32.43	38.24	17.91551	13.8	13.8	0
217	12.05	11.28	-6.39004	9.8	9.8	0
224	30.1	28.63	-4.88372	13.7	13.4	-2.18978
227	29.16	27.38	-6.10425	13	12.8	-1.53846
254	19.43	30.11	54.96654	10.8	12.3	13.88888
260	31.75	29.68	-6.51968	13.2	13.2	0
262	33.5	31.57	-5.76119	13.9	13.7	-1.43884
263	26.52	25.42	-4.14781	12.7	12.5	-1.57480
318	28.59	28.39	-0.69954	15.1	12.9	-14.5695
458	58.79	68.81	17.04371	16.3	16.2	-0.61349
	30.232	31.951	5.541951	13.23	13.06	-0.80360

Sample 12, Jan. 8, 1988

Tag	initial	sample	% chg	initial	sample	% chg
211	28.08	48.09	71.26068	13	12.8	-1.53846
217	12.05	11.3	-6.22406	9.8	9.7	-1.02040
223	37.94	40.4	6.483921	14.1	14	-0.70921
224	30.1	28.61	-4.95016	13.7	13.4	-2.18978
227	29.16	26.8	-8.09327	13	12.8	-1.53846
236	36.15	51.57	42.65560	13.8	15	8.695652
254	19.43	29.48	51.72413	10.8	12.4	14.81481
258	28.28	26.93	-4.77369	13.2	12.8	-3.03030
263	26.52	25.87	-2.45098	12.7	12.6	-0.78740
318	28.59	28.68	0.314795	15.1	12.9	-14.5695
	27.63	31.773	14.59469	12.92	12.84	-0.18731

Sample 13, Jan. 15

Tag	initial	sample	% chg	initial	sample	% chg
206	44.68	82.31	84.22112	15.1	18.2	20.52980
211	28.08	27.53	-1.95868	13	12.7	-2.30769
212	60.71	89.11	46.77977	15	16.1	7.333333
217	12.05	11.18	-7.21991	9.8	9.7	-1.02040
225	25.58	24.51	-4.18295	12.8	12.8	0
227	29.16	26.53	-9.01920	13	12.8	-1.53846
230	24.85	48.91	96.82092	11.9	14	17.64705
258	28.28	26.39	-6.68316	13.2	12.8	-3.03030
260	31.75	29.29	-7.74803	13.2	13.2	0
268	36.3	34.77	-4.21487	14	13.9	-0.71428
	32.144	40.053	18.67949	13.1	13.62	3.689904

Group 1B, Initial Values
Dec. 4, 1987

Tag	Weight	Length	New Tag
210	30.61	13.4	
233	31.2	13.1	
234	30.44	13.1	261
235	34.38	13.8	
237	39.68	14	
238	23.78	12	
239	20.22	11.1	
240	35.5	14.1	
241	19.49	11.1	
244	20.61	11.2	
281	19.06	11.4	
284	34.16	13.5	
285	24.85	12.5	
286	55.97	15.1	
287	20.24	11.9	
289	37.75	14.9	
290	20.81	11.5	
291	42.28	13.4	
301	35.24	14.5	
307	33.75	13	
308	24.43	11.7	
309	40.55	13.4	
321	21.5	11.6	
324	13.9	10	
328	18.38	10.6	
331	77.32	15.4	
334	21.35	11.7	
335	30.9	13.2	
336	37.08	13.8	
337	19.69	11.5	
338	22.78	11.6	
354	49.3	14.8	
367	25.53	12.4	258
369	19.29	11.1	
374	12.31	10	
383	23.62	12.1	
384	26.19	12.5	
385	54.75	15.5	
386	80.05	16.1	521
387	32.59	12.8	
count	40		
avg	31.538	12.76	
sum	1261.5		
feed	63.076	g/day	

Group 1B, Samples

Weight / Length

Dec. 8, 1987

Tag	Weight Initial	Weight Sample	%	Length Initial	Length Sample	%
281	19.06	18.3	-3.98740	11.4	11.3	-0.87719
284	34.16	32.35	-5.29859	13.5	13.6	0.740740
285	24.85	23.92	-3.74245	12.5	12.7	1.6
289	37.75	38.57	2.172185	14.9	14.8	-0.67114
301	35.24	34.47	-2.18501	14.5	14.1	-2.75862
307	33.75	32.23	-4.50370	13	13.2	1.538461
308	24.43	25.37	3.847728	11.7	12	2.564102
331	77.32	61.43	-20.5509	15.4	15.4	0
336	37.08	37.43	0.943905	13.8	13.8	0
374	12.31	12.37	0.487408	10	9.9	-1
	33.595	31.644	-3.28169	13.07	13.08	0.113635

Dec. 11, 1987

Tag	Weight Initial	Weight Sample	%	Length Initial	Length Sample	%
210	30.61	30.53	-0.26135	13.4	13.1	-2.23880
238	23.78	21.91	-7.86375	12	11.7	-2.5
261	30.44	30.35	-0.29566	13.1	13.2	0.763358
281	19.06	18.05	-5.29905	11.4	11.5	0.877192
289	37.75	38.17	1.112582	14.9	14.7	-1.34228
291	42.28	35.82	-15.2790	13.4	13.6	1.492537
301	35.24	34.17	-3.03632	14.5	14.1	-2.75862
336	37.08	36.78	-0.80906	13.8	13.9	0.724637
384	26.19	25.92	-1.03092	12.5	12.7	1.6
387	32.59	32.29	-0.92052	12.8	12.8	0
	31.502	30.399	-3.36831	13.18	13.13	-0.33819

Dec. 15, 1987

Tag	Weight Initial	Weight Sample	%	Length Initial	Length Sample	%
238	23.78	25.06	5.382674	12	11.9	-0.83333
261	30.27	13.3	-56.0621	13.1	13.3	1.526717
281	19.06	18.98	-0.41972	11.4	11.4	0
285	24.85	23.82	-4.14486	12.5	12.6	0.8
289	37.75	36.92	-2.19867	14.9	14.9	0
309	40.55	46.18	13.88409	13.4	13.7	2.238805
331	77.32	70.4	-8.94981	15.4	15.9	3.246753
383	23.62	22.95	-2.83657	12.1	12	-0.82644
384	26.19	25.35	-3.20733	12.5	12.6	0.8
387	32.59	32.18	-1.25805	12.8	13	1.5625
	33.598	31.514	-5.98103	13.01	13.13	0.851499

Dec. 18, 1987

Tag	Initial	Sample	%	Initial	Sample	% chg.
210	30.61	49.65	62.20189	13.4	13.3	-0.74626
261	30.44	30.17	-0.88699	13.1	13.2	0.763358
281	19.06	19.31	1.311647	11.4	11.4	0
286	55.97	65.28	16.63391	15.1	16.1	6.622516
289	37.75	36.55	-3.17880	14.9	14.8	-0.67114
301	35.24	32.92	-6.58342	14.5	14.2	-2.06896
308	24.43	24.22	-0.85959	11.7	11.9	1.709401
374	12.31	12.45	1.137286	10	10	0
383	23.62	23.28	-1.43945	12.1	12	-0.82644
521	80.05	54.41	-32.0299	16.1	16.4	1.863354
	34.948	34.824	3.630647	13.23	13.33	0.664580

Dec. 22, 1987

Tag	Initial	Sample	%	Initial	Sample	%
210	30.61	29.1	-4.93302	13.4	13.5	0.746268
235	34.38	33.92	-1.33798	13.8	13.9	0.724637
238	23.78	25.84	8.662741	12	12.1	0.833333
281	19.06	18.8	-1.36411	11.4	11.4	0
285	24.85	22.99	-7.48490	12.5	12.8	2.4
286	55.97	57.65	3.001608	15.1	16.4	8.609271
289	37.75	36.18	-4.15894	14.9	14.8	-0.67114
301	35.24	32.58	-7.54824	14.5	14.1	-2.75862
328	18.38	19.18	4.352557	10.6	10.9	2.830188
354	49.3	49.32	0.040567	14.8	15.6	5.405405
	32.932	32.556	-1.07697	13.3	13.55	1.811934

Dec. 25, 1987

Tag	Initial	Sample	%	Initial	Sample	%
258	25.53	22.82	-10.6149	12.4	12.7	2.419354
261	30.44	29.5	-3.08804	13.1	13.1	0
281	19.06	18.46	-3.14795	11.4	11.5	0.877192
286	55.97	55.85	-0.21440	15.1	16.4	8.609271
289	37.75	35.72	-5.37748	14.9	14.7	-1.34228
301	35.24	32.45	-7.91713	14.5	14.2	-2.06896
309	40.55	43.8	8.014796	13.4	14.8	10.44776
328	18.38	18.89	2.774755	10.6	10.9	2.830188
354	49.3	48.29	-2.04868	14.8	15.6	5.405405
383	23.62	22.63	-4.19136	12.1	12	-0.82644
	33.584	32.841	-2.58104	13.23	13.59	2.635148

Dec. 29, 1987

Tag	Initial	Sample	%	Initial	Sample	%
210	30.61	28.43	-7.12185	13.4	13.2	-1.49253
235	34.38	34.66	0.814426	13.8	13.9	0.724637
237	39.68	38.23	-3.65423	14	14.2	1.428571
238	23.78	28.71	20.73170	12	12.2	1.666666
285	24.85	22.48	-9.53722	12.5	12.8	2.4
289	37.75	35.32	-6.43708	14.9	14.8	-0.67114
291	42.28	42.62	0.804162	13.4	14	4.477611
308	24.43	23.15	-5.23945	11.7	11.8	0.854700
336	37.08	35.31	-4.77346	13.8	13.9	0.724637
374	12.31	11.98	-2.68074	10	10	0
	30.715	30.089	-1.70937	12.95	13.08	1.011314

Jan. 1, 1988

Tag	Initial	Sample	%	Initial	Sample	%
210	30.61	28.69	-6.27245	13.4	13.4	0
235	34.38	34.35	-0.08726	13.8	13.8	0
237	39.68	38.02	-4.18346	14	14.4	2.857142
281	19.06	20.1	5.456453	11.4	11.6	1.754385
285	24.85	22.74	-8.49094	12.5	12.7	1.6
289	37.75	35.02	-7.23178	14.9	14.8	-0.67114
308	24.43	23.68	-3.06999	11.7	11.9	1.709401
309	40.55	59.44	46.58446	13.4	14.9	11.19402
354	49.3	59.24	20.16227	14.8	15.8	6.756756
383	23.62	22.5	-4.74174	12.1	11.9	-1.65289
	32.423	34.378	3.812552	13.2	13.52	2.354768

Jan. 5, 1988

Tag	Initial	Sample	% chg	Initial	Sample	% chg
210	30.61	28.23	-7.77523	13.4	13.2	-1.49253
235	34.38	33.56	-2.38510	13.8	14	1.449275
238	23.78	29.6	24.47434	12	12.6	5
261	30.44	29.58	-2.82522	13.1	13.3	1.526717
285	24.85	23.2	-6.63983	12.5	12.6	0.8
289	37.75	35.28	-6.54304	14.9	14.8	-0.67114
308	24.43	23.46	-3.97052	11.7	11.8	0.854700
309	40.55	53.71	32.45376	13.4	15.2	13.43283
331	77.32	82.01	6.065700	15.4	17	10.38961
336	37.08	35.1	-5.33980	13.8	13.9	0.724637
383	23.62	22.45	-4.95342	12.1	11.9	-1.65289
	34.98272	36.01636	2.051053	13.28181	13.66363	2.760109

Jan. 8, 1988

Tag	Initial	Sample	%	Initial	Sample	%
210	30.61	28.43	-7.12185	13.4	13.4	0
237	39.68	37.06	-6.60282	14	14.4	2.857142
261	30.44	29.72	-2.36530	13.1	13.2	0.763358
281	19.06	19.65	3.095487	11.4	11.5	0.877192
284	34.16	42.91	25.61475	13.5	14.8	9.629629
289	37.75	22.91	-39.3112	14.9	12.7	-14.7651
331	77.32	79.72	3.103983	15.4	17.1	11.03896
336	37.08	34.72	-6.36461	13.8	13.9	0.724637
383	77.32	82.01	6.065700	12.1	12	-0.82644
521	80.05	61.8	-22.7982	16.1	17.1	6.211180
	46.347	43.893	-4.66841	13.77	14.01	1.651055

Jan. 15, 1988

Tag	Initial	Sample	%	Initial	Sample	%
210	30.61	28.41	-7.18719	13.4	13.2	-1.49253
237	39.68	37.38	-5.79637	14	14.2	1.428571
261	30.44	29.42	-3.35085	13.1	13.3	1.526717
281	19.06	20.52	7.660020	11.4	11.6	1.754385
285	24.85	22.88	-7.92756	12.5	12.6	0.8
289	37.75	34.55	-8.47682	14.9	14.8	-0.67114
307	33.75	52.38	55.2	13	15.1	16.15384
308	24.43	22.99	-5.89439	11.7	11.7	0
309	40.55	65.75	62.14549	13.4	15.7	17.16417
383	23.62	22.08	-6.51989	12.1	11.9	-1.65289
	30.474	33.636	7.985242	12.95	13.41	3.501112

Group 1C, Initial Values
Dec. 10, 1987

Tag	Weight	Length	New Tag
205	39	14.5	461
222	50.35	14.6	
226	24.18	12.2	
231	22.21	11.7	
257	20.39	11.2	
264	15.13	10.5	
315	18.13	11	
317	28.65	13.1	
319	29.74	12.9	
320	29.52	12.8	
322	45.34	14.4	
323	28	12.6	
325	28.85	11.8	
327	64.12	15.8	
329	22.77	12.3	
330	21.52	11.3	
332	29.44	12.9	
333	18.98	11.7	
350	75.1	15.6	
351	38.82	14.4	
352	23.25	11.2	
353	26.75	12.5	
358	59.2	15.5	
361	30.87	13.3	
363	13.45	10.1	
364	27.4	13.1	
365	41.95	14	
366	27.5	11.4	
368	24.3	12	
370	28.91	12.9	
371	78.62	16.2	
372	35.25	14	
373	20.45	11.6	
375	26.37	12.3	
376	35.67	13.7	
377	32	13.4	
378	11.98	9.5	
379	23.34	12.6	
380	21.6	11.5	
381	27.82	13.2	
382	24.55	12.6	
count	41		
avg	31.49926	12.77804	
sum	1291.47		
feed	64.5735	g/day	

Group 1C, Samples

	Weight			Lenght		
Dec. 14, 1987						
Tag	Initial	Sample	%	Initial	Sample	%
222	50.53	45.33	-10.2909	14.6	14.9	2.054794
322	45.34	45.33	-0.02205	14.4	14.5	0.694444
329	22.77	22.28	-2.15195	12.3	12.3	0
332	29.44	28.84	-2.03804	12.9	12.9	0
351	38.82	39.85	2.653271	14.4	14.5	0.694444
353	26.75	26.83	0.299065	12.5	12.5	0
358	59.2	54.97	-7.14527	15.5	15.8	1.935483
371	78.62	75.37	-4.13380	16.2	16.5	1.851851
372	35.25	35.01	-0.68085	14	14	0
376	35.67	35.25	-1.17746	13.7	13.8	0.729927
	42.239	40.906	-2.46880	14.05	14.17	0.796094
Dec. 17, 1987						
Tag	Initial	Sample	%	Initial	Sample	%
319	29.74	29.772	0.107599	12.9	12.9	0
329	22.77	21.92	-3.73298	12.3	12.3	0
332	29.44	27.86	-5.36684	12.9	12.5	-3.10077
353	26.75	26.01	-2.76635	12.5	12.6	0.8
358	59.2	52.57	-11.1993	15.5	15.8	1.935483
365	41.95	38.86	-7.36591	14	14.2	1.428571
371	78.62	71.88	-8.57288	16.2	16.6	2.469135
376	35.67	34.78	-2.49509	13.7	13.8	0.729927
379	23.34	23.21	-0.55698	12.6	12.5	-0.79365
381	27.82	27.44	-1.36592	13.2	13.1	-0.75757
382	24.55	23.72	-3.38085	12.6	12.6	0
	36.35	34.36563	-4.24505	13.49090	13.53636	0.246465
Dec. 21, 1987						
Tag	Initial	Sample	% chg	Initial	Sample	% chg
222	50.35	53.58	6.415094	14.6	14.9	2.054794
257	20.39	19.71	-3.33496	11.2	11.6	3.571428
320	29.52	28.87	-2.20189	12.8	12.5	-2.34375
329	22.77	21.7	-4.69916	12.3	12.2	-0.81300
353	26.75	26.11	-2.39252	12.5	12.7	1.6
358	59.2	50.02	-15.5067	15.5	15.8	1.935483
371	78.62	69.41	-11.7145	16.2	16.4	1.234567
372	35.25	33.77	-4.19858	14	13.9	-0.71428
381	27.82	27.29	-1.90510	13.2	13	-1.51515
382	24.55	24.01	-2.19959	12.6	12.6	0
	37.522	35.447	-4.17380	13.49	13.56	0.501007

Dec. 24, 1987

Tag	Initial	Sample	% chg	Initial	Sample	% chg
257	20.39	19.1	-6.32663	11.2	11.7	4.464285
319	29.74	28.84	-3.02622	12.9	12.8	-0.77519
329	22.77	20.98	-7.86122	12.3	12	-2.43902
332	29.44	27.53	-6.48777	12.9	12.8	-0.77519
353	26.75	25.6	-4.29906	12.5	12.6	0.8
365	41.95	36.69	-12.5387	14	14.3	2.142857
372	35.25	33.31	-5.50354	14	14	0
379	23.34	22.58	-3.25621	12.6	12.6	0
381	27.82	26.59	-4.42127	13.2	13.1	-0.75757
382	24.55	23.47	-4.39918	12.6	12.6	0
	28.2	26.469	-5.81198	12.82	12.85	0.266015

Dec. 28, 1987

Tag	Initial	Sample	% chg	Initial	Sample	% chg
320	29.52	28.89	-2.13414	12.8	12.7	-0.78125
322	45.34	49.91	10.07940	14.4	14.8	2.777777
329	22.77	21.25	-6.67545	12.3	12.1	-1.62601
332	29.44	27.08	-8.01630	12.9	12.7	-1.55038
350	75.1	74.59	-0.67909	15.6	16.1	3.205128
353	26.75	25.62	-4.22429	12.5	12.5	0
358	59.2	58.69	-0.86148	15.5	16.1	3.870967
372	35.25	34.02	-3.48936	14	14	0
379	23.34	23.38	0.171379	12.6	12.5	-0.79365
381	27.82	26.53	-4.63695	13.2	13.1	-0.75757
	37.453	36.996	-2.04663	13.58	13.66	0.434499

Dec. 31, 1987

Tag	Initial	Sample	% chg	Initial	Sample	% chg
222	50.35	69.63	38.29195	14.6	15.5	6.164383
319	29.74	28.74	-3.36247	12.9	13	0.775193
332	29.44	26.95	-8.45788	12.9	12.8	-0.77519
351	38.82	39.15	0.850077	14.4	14.6	1.388888
365	41.95	49.46	17.90226	14	14.6	4.285714
372	35.25	36.35	3.120567	14	14.1	0.714285
376	35.67	34.47	-3.36417	13.7	13.8	0.729927
379	23.34	23.6	1.113967	12.6	12.5	-0.79365
381	27.82	26.71	-3.98993	13.2	13.2	0
382	24.55	23.58	-3.95112	12.6	12.6	0
	33.693	35.864	3.815325	13.49	13.67	1.248954

Jan. 4, 1988

Tag	Initial	Sample	% chg	Initial	Sample	% chg
205	39	37.46	-3.94871	14.5	14.5	0
222	50.35	67.17	33.40615	14.6	15.8	8.219178
319	29.74	28.79	-3.19435	12.9	13	0.775193
320	29.52	30.4	2.981029	12.8	12.8	0
351	38.82	40.99	5.589902	14.4	14.8	2.777777
353	26.75	25.28	-5.49532	12.5	12.7	1.6
358	59.2	67.21	13.53040	15.5	16.6	7.096774
364	27.4	28.85	5.291970	13.1	13	-0.76335
365	41.95	54.11	28.98688	14	14.9	6.428571
372	35.25	37.73	7.035460	14	14.2	1.428571
376	35.67	34.52	-3.22399	13.7	13.9	1.459854
381	27.82	26.85	-3.48670	13.2	13.1	-0.75757
382	24.55	23.19	-5.53971	12.6	12.7	0.793650
	35.84769	38.65769	5.533308	13.67692	14	2.235279

Jan. 7, 1988

Tag	Initial	Sample	% chg.	Initial	Sample	% chg.
222	50.35	67.14	33.34657	14.6	15.9	8.904109
320	29.52	30.5	3.319783	12.8	12.8	0
322	45.34	53.52	18.04146	14.4	15.6	8.333333
353	26.75	25.31	-5.38317	12.5	12.6	0.8
358	59.2	64.59	9.104729	15.5	16.7	7.741935
365	41.95	50.81	21.12038	14	15.1	7.857142
372	35.25	38.92	10.41134	14	14.3	2.142857
376	35.67	34.48	-3.33613	13.7	13.9	1.459854
381	27.82	26.51	-4.70884	13.2	13.1	-0.75757
382	24.55	23.12	-5.82484	12.6	12.6	0
	37.64	41.49	7.609127	13.73	14.26	3.648165

Jan. 14, 1988

Tag	Initial	Sample	% Chg	Initial	Sample	% Chg
226	24.18	23.28	-3.72208	12.2	12.2	0
257	20.39	18.86	-7.50367	11.2	11.7	4.464285
319	29.74	28.57	-3.93409	12.9	13	0.775193
320	29.52	29.18	-1.15176	12.8	12.8	0
322	45.34	51.12	12.74812	14.4	15.6	8.333333
329	22.77	21.84	-4.08432	12.3	12.2	-0.81300
332	29.44	27.09	-7.98233	12.9	12.8	-0.77519
365	41.95	46.05	9.773539	14	15.3	9.285714
379	23.34	23.68	1.456726	12.6	12.6	0
381	27.82	26.31	-5.42774	13.2	13.1	-0.75757
	29.449	29.598	-0.98276	12.85	13.13	2.051274

Jan. 21, 1988

Tag	Initial	Sample	% Chg	Initial	Sample	% Chg
222	50.35	62.62	24.36941	14.6	16	9.589041
257	20.39	18.3	-10.2501	11.2	11.6	3.571428
319	29.74	28.35	-4.67383	12.9	12.8	-0.77519
320	29.52	28.89	-2.13414	12.8	12.7	-0.78125
329	22.77	21.62	-5.05050	12.3	12.3	0
332	29.44	26.78	-9.03532	12.9	12.7	-1.55038
353	26.75	24.92	-6.84112	12.5	12.6	0.8
364	27.4	27.8	1.459854	13.1	13.1	0
372	35.25	36.14	2.524822	14	14.1	0.714285
461	39	38.52	-1.23076	14.5	14.6	0.689655
	31.061	31.394	-1.08617	13.08	13.25	1.225757

Group 1D, Initial Values
Dec. 15, 1987

Tag	Weight	Length	New Tag
255	28.9	12.2	
447	60.47	15.5	
558	55.65	13.8	
559	65.95	15.7	
560	60.63	14.8	
561	25.25	12.4	
562	28.62	12.6	
563	97.72	17.5	
565	74.23	15.9	
566	36.6	13.8	
567	40.21	14.8	
568	47.4	14.1	
569	74.91	16.2	
570	24.4	12.4	564
571	39.7	13.3	
572	76.69	16.2	
573	29.01	12.2	
574	69.03	16.3	
575	28.32	12.3	
576	77.96	16.4	
577	23.58	10.9	
579	79.24	16.3	
582	30.9	13.6	
583	69.11	16.5	534
584	50.49	14.3	
585	14.28	10.5	
586	29.65	13.2	
587	23.78	12.3	
588	24.18	12.3	
589	109.14	18.4	
590	38.14	14.3	
591	38.8	13.1	
592	25.48	12.9	
593	26.18	12.5	
594	20.82	11.2	
595	62.22	15.1	
596	31.61	13.7	
597	22.9	11.5	
598	26.72	13.4	
599	38.3	12.6	501
500	27.18	13.3	
503	27.18	11.9	
504	36.65	13.3	
509	53.98	14.8	
523	33.08	13.3	
528	27.69	12.2	
count	46		
avg.	44.19413	13.82173	
sum	2032.93		
feed	60.9879	g/day	

Group 1D, Samples

	Weight			Length		

Sample 1, Dec. 25, 1987.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
501	38.3	34.73	-9.32114	12.6	12	-4.76190
523	33.08	33.97	2.690447	13.3	13.2	-0.75187
565	74.23	65.29	-12.0436	15.9	16.3	2.515723
583	69.11	60.81	-12.0098	16.5	16.7	1.212121
588	24.18	24.03	-0.62034	12.3	12.2	-0.81300
589	109.14	99.86	-8.50284	18.4	18.3	-0.54347
591	38.8	34.68	-10.6185	13.1	13.6	3.816793
593	26.18	25.88	-1.14591	12.5	12.5	0
597	22.9	20.93	-8.60262	11.5	12	4.347826
598	26.72	26.45	-1.01047	13.4	13	-2.98507
	46.264	42.663	-6.11849	13.95	13.98	0.203711

Sample 2, Jan. 1, 1988.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
501	38.3	33.82	-11.6971	12.6	12.3	-2.38095
523	33.08	33.5	1.269649	13.3	13.4	0.751879
558	55.65	47.2	-15.1841	13.8	13.2	-4.34782
560	60.63	51.9	-14.3988	14.8	15.4	4.054054
566	36.6	35.99	-1.66666	13.8	13.8	0
574	69.03	61.35	-11.1255	16.3	16.9	3.680981
576	77.96	67.73	-13.1221	16.4	16.9	3.048780
588	24.18	23.55	-2.60545	12.3	12.2	-0.81300
594	20.82	20.15	-3.21805	11.2	11.2	0
596	31.61	31.15	-1.45523	13.7	13.8	0.729927
	44.786	40.634	-7.32036	13.82	13.91	0.472383

Sample 3, Jan. 8, 1988.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
255	28.9	24.16	-16.4013	12.2	12.2	0
504	36.65	33.41	-8.84038	13.3	13.5	1.503759
509	53.98	49.4	-8.48462	14.8	14.9	0.675675
528	27.69	25.29	-8.66738	12.2	12.4	1.639344
558	55.65	45.81	-17.6819	13.8	13.5	-2.17391
577	23.58	18.78	-20.3562	10.9	10.9	0
586	29.65	28.5	-3.87858	13.2	13.2	0
589	109.14	95.83	-12.1953	18.4	18.6	1.086956
597	22.9	20.25	-11.5720	11.5	11.9	3.478260
598	26.72	26.12	-2.24550	13.4	12.9	-3.73134
	41.486	36.755	-11.0323	13.37	13.4	0.247874

Sample 4, Jan. 15, 1988.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
528	27.69	28.91	4.405922	12.2	12.6	3.278688
534	69.11	75.38	9.072493	16.5	16.7	1.212121
564	24.4	24.45	0.204918	12.4	12.3	-0.80645
574	69.03	65.35	-5.33101	16.3	17.2	5.521472
575	28.32	27.58	-2.61299	12.3	12.4	0.813008
576	77.96	67.72	-13.1349	16.4	17.1	4.268292
586	29.65	28.6	-3.54131	13.2	13.2	0
589	109.14	95.39	-12.5984	18.4	18.8	2.173913
594	20.82	19.82	-4.80307	11.2	11.1	-0.89285
598	26.72	25.61	-4.15419	13.4	13	-2.98507
	48.284	45.881	-3.24926	14.23	14.44	1.258311

Sample 5, Jan. 22, 1988.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
500	27.18	27.36	0.662251	13.3	13.3	0
528	27.69	36.58	32.10545	12.2	13	6.557377
559	65.95	73.84	11.96360	15.7	16.7	6.369426
570	24.4	23.78	-2.54098	12.4	12.4	0
574	69.03	76.16	10.32884	16.3	17.5	7.361963
576	77.96	77.28	-0.87224	16.4	17.2	4.878048
579	79.24	87.15	9.982332	16.3	17.5	7.361963
587	23.78	22.53	-5.25651	12.3	12.3	0
588	24.18	22.75	-5.91397	12.3	12.1	-1.62601
592	25.48	25.48	0	12.9	12.7	-1.55038
	44.489	47.291	5.045876	14.01	14.47	2.935237

Sample 6, Jan. 29, 1988.

Tag	initial	sample	% diff.	Initial	Sample	% chg.
255	28.9	37.72	30.51903	12.2	13	6.557377
503	25.02	34.65	38.48920	11.9	12.6	5.882352
504	36.65	55.69	51.95088	13.3	14.6	9.774436
509	53.98	80.27	48.70322	14.8	16.5	11.48648
534	69.11	90.03	30.27058	16.5	17.7	7.272727
558	55.65	60.12	8.032345	13.8	14	1.449275
565	74.23	93.46	25.90596	15.9	17.7	11.32075
576	77.96	87.67	12.45510	16.4	17.7	7.926829
584	50.49	66.91	32.52129	14.3	16	11.88811
587	23.78	22.25	-6.43397	12.3	12.3	0
	49.577	62.877	27.24136	14.14	15.21	7.355835

Group 1E, Initial Values
Dec. 6, 1987

Tag	Weight	Length	New Tag
219	19.91	11.1	
220	26.8	12.9	508
221	19.41	11	
229	11.38	10.1	
252	30.08	12.6	
253	44.89	14.3	
256	24.65	12.1	
265	44.4	14.9	502,524
266	35.25	14.2	
269	30.38	13.5	
270	63.7	15.5	
271	36.12	14.5	
272	73.8	15.8	
273	26.98	12.9	
274	66.68	16.4	
275	61.92	16	
276	29.23	12.8	
277	23.09	12.4	
278	48.54	15	
279	39.81	13.6	
280	56.38	15.1	
283	28.22	12.8	
300	43.1	14.5	
302	18.64	11.1	
303	24.92	13.1	449
304	35.24	13.4	
305	20.9	11.8	
306	40.08	14.1	406
310	21.4	11.8	
311	31.29	13.9	
313	28.55	12.4	
314	20.18	11.8	
316	41.41	14.6	
326	36.52	13.6	
355	75.4	16.8	
356	25.98	12.9	
357	23.59	12.4	
359	44.75	14.3	
360	64.02	16	421
362	40.95	13.6	
count	40		
avg	36.9635	13.54	
sum	1437.59		
feed	71.8795	g/day	

Group 1E, Samples

Weight — Length

Dec. 25, 1987: Sample 1

Tag	Initial	Sample	%	Initial	Sample	% chg.
271	36.12	34.02	-5.81395	14.5	14.3	-1.37931
277	23.09	22.25	-3.63793	12.4	12.3	-0.80645
283	28.22	27.95	-0.95676	12.8	13.1	2.34375
300	43.1	42.48	-1.43851	14.5	14.4	-0.68965
310	21.4	20.18	-5.70093	11.8	11.6	-1.69491
316	41.41	40.38	-2.48732	14.6	14.5	-0.68493
326	36.52	39.44	7.995618	13.6	14.3	5.147058
355	75.4	89.05	18.10344	16.8	18.2	8.333333
502	44.4	44.85	1.013513	14.9	14.7	-1.34228
508	26.8	24.29	-9.36567	12.9	12.8	-0.77519
	37.646	38.489	-0.22885	13.88	14.02	0.845140

Jan. 1, 1988: Sample 2

Tag	Initial	Sample	%	Initial	Sample	% chg.
253	44.89	50.71	12.96502	14.3	15.5	8.391608
256	24.65	26.22	6.369168	12.1	12.8	5.785123
272	73.8	79.95	8.333333	15.8	17.1	8.227848
273	26.98	25.32	-6.15270	12.9	12.8	-0.77519
275	61.92	68.82	11.14341	16	16.7	4.375
283	28.22	26.94	-4.53579	12.8	13.1	2.34375
304	35.24	37.59	6.668558	13.4	14.1	5.223880
316	41.41	39.93	-3.57401	14.6	14.4	-1.36986
357	23.59	22.38	-5.12929	12.4	12	-3.22580
406	40.08	41.46	3.443113	14.1	14.3	1.418439
	40.078	41.932	2.953080	13.84	14.28	3.039478

Jan. 8, 1988: Sample 3

Tag	Initial	Sample	%	Initial	Sample	% chg.
256	24.65	26.09	5.841784	12.1	12.7	4.958677
270	63.7	68.71	7.864992	15.5	16.7	7.741935
278	48.54	55.64	14.62711	15	16	6.666666
304	35.24	37	4.994324	13.4	14.3	6.716417
311	31.29	30.3	-3.16395	13.9	13.4	-3.59712
355	75.4	84.6	12.20159	16.8	18.3	8.928571
357	23.59	22.36	-5.21407	12.4	12.2	-1.61290
362	40.95	47.52	16.04395	13.6	14.7	8.088235
406	40.08	41.41	3.318363	14.1	14.4	2.127659
421	64.02	62.59	-2.23367	16	16.2	1.25
	44.746	47.622	5.428042	14.28	14.89	4.126813

Jan. 15, 1988: Sample 4

Tag	Initial	Sample	%	Initial	Sample	% chg.
269	30.38	29.3	-3.55497	13.5	13.4	-0.74074
270	63.7	75.32	18.24175	15.5	17.1	10.32258
274	66.68	83.28	24.89502	16.4	17.8	8.536585
277	23.09	23.22	0.563014	12.4	12.3	-0.80645
283	28.22	30	6.307583	12.8	13.2	3.125
302	18.64	22.07	18.40128	11.1	11.4	2.702702
304	35.24	40.88	16.00454	13.4	14.3	6.716417
311	31.29	30.11	-3.77117	13.6	13.3	-2.20588
326	36.52	41.89	14.70427	13.6	14.7	8.088235
406	40.08	41.89	4.515968	14.1	14.5	2.836879
	37.384	41.796	9.630730	13.64	14.2	3.857532

Jan. 22, 1988: Sample 5

Tag	Initial	Sample	%	Initial	Sample	% chg.
271	36.12	35.81	-0.85825	14.5	14.6	0.689655
272	73.8	102.09	38.33333	15.8	17.9	13.29113
274	66.68	87.22	30.80383	16.4	18.3	18.3
283	28.22	33.86	19.98582	12.8	13.4	13.4
302	18.64	26.42	41.73819	11.1	11.7	5.405405
304	35.24	47.18	33.88195	13.4	14.9	11.19402
311	31.29	30.31	-3.13199	13.9	13.5	-2.87769
359	44.75	66.08	47.66480	14.3	16	11.88811
449	24.92	33.98	36.35634	13.1	14.3	9.160305
467	11.38	11.14	-2.10896	10.1	10	-0.99009
	37.104	47.409	24.26650	13.54	14.46	7.946085

Jan. 29, 1988: Sample 6

Tag	Initial	Sample	%	Initial	Sample	% chg.
269	30.38	28.92	-4.80579	13.5	13.5	0
271	36.12	38.01	5.232558	14.5	14.5	0
274	66.68	98.08	47.09058	16.4	18.5	12.80487
277	23.09	28.53	23.55998	12.4	12.6	1.612903
283	28.22	37.12	31.53791	12.8	13.5	5.46875
311	31.29	30.37	-2.94023	13.9	13.5	-2.87769
316	41.41	41.61	0.482975	14.6	14.6	0
357	23.59	23.88	1.229334	12.4	12.4	0
467	11.38	11.09	-2.54833	10.1	10.2	0.990099
502	44.4	67.31	51.59909	14.9	15.8	6.040268
	33.656	40.492	15.04380	13.55	13.91	2.403920

Group 1F, Initial Values
Dec. 17, 1987

Tag	Weight	Length	New Tag
505	39	13.9	
507	29.75	13	
509	16.45	10.9	
510	33.52	13.5	
511	38.65	13.7	
512	51.24	15.5	
513	44.58	14.2	
514	29.361	14.1	
516	39.02	14.6	
517	83.6	17.3	
518	40.64	14.3	
519	40.12	13.3	525
520	64.66	15.7	
526	29.31	12.8	
527	27.5	12.5	
529	48.35	15	
530	106.54	18.9	
531	19.55	11.8	413
532	58.65	15.8	424
533	39.92	14.2	
536	88.28	17.9	
537	26.42	12.3	417
538	16.08	10.3	
539	34.48	13.4	
540	31.82	13.3	
541	43.95	14.6	
542	34.46	12.6	
543	20.61	11.6	
544	58.98	15.5	
545	46.7	14.1	
546	18.3	11.3	
547	54.59	15.8	
548	22.08	12	
549	67.71	16.5	
550	56.75	14.7	
551	110.28	19.1	
552	21.8	11.9	
553	42.29	14.8	
554	51.38	14	
555	35.69	13.7	
556	28	12.4	
557	31.32	12.7	
578	71.68	16.3	
580	35.3	13.7	
581	17.6	10.3	

Group 1F, Samples

	Weight			Length		

Dec. 25, 1987: Sample 1

Tag	Initial	Sample	% change	Initial	Sample	% chg.
424	58.65	54.01	-7.91133	11	15.9	44.54545
507	29.75	29.5	-0.84033	13	12.9	-0.76923
509	16.45	16.8	2.127659	10.9	10.9	0
513	44.58	38.42	-13.8178	14.2	14.2	0
516	39.02	38.92	-0.25627	14.6	14.4	-1.36986
519	40.12	34.68	-13.5593	13.3	13.6	2.255639
526	29.31	28.01	-4.43534	12.8	12.9	0.78125
546	18.3	18.06	-1.31147	11.3	11.1	-1.76991
551	110.28	98.15	-10.9992	19.1	18.5	-3.14136
557	31.32	28.06	-10.4086	12.7	12.8	0.787401
	41.778	38.461	-6.14122	13.29	13.72	4.131937

Jan. 1, 1988: Sample 2

Tag	Initial	Sample	%	Initial	Sample	% chg.
417	26.42	25.09	-5.03406	12.3	12.3	0
507	29.75	29	-2.52100	13	13	0
509	16.45	15.65	-4.86322	10.9	10.8	-0.91743
511	38.65	29.8	-22.8978	13.7	13.5	-1.45985
512	51.24	45.55	-11.1046	15.5	15.3	-1.29032
527	27.5	24.42	-11.2	12.5	12.4	-0.8
542	34.46	29.4	-14.6836	12.6	12.3	-2.38095
546	18.3	17.85	-2.45901	11.3	11.2	-0.88495
552	21.8	20.55	-5.73394	11.9	11.8	-0.84033
555	35.69	33.81	-5.26758	13.7	13.4	-2.18978
	30.026	27.112	-8.57649	12.74	12.6	-1.07636

Jan. 8, 1988: Sample 3

Tag	Initial	Sample	%	Initial	Sample	% chg.
413	19.55	18.92	-3.22250	11.8	11.6	-1.69491
424	58.65	52.88	-9.83802	15.8	15.9	0.632911
513	44.58	37.09	-16.8012	14.2	14.2	0
516	39.02	39.03	0.025627	14.6	14.5	-0.68493
518	40.64	39.38	-3.10039	14.3	14.3	0
520	64.66	54.9	-15.0943	15.7	15.6	-0.63694
527	27.5	24.51	-10.8727	12.5	12.5	0
541	43.95	38.49	-12.4232	14.6	14.7	0.684931
546	18.3	17.6	-3.82513	11.3	11.1	-1.76991
553	42.29	40.82	-3.47599	14.8	14.6	-1.35135
	39.914	36.362	-7.86279	13.96	13.9	-0.48202

Jan. 15, 1988: Sample 4

Tag	Initial	Sample	%	Initial	Sample	% chg.
413	19.55	18.46	-5.57544	11.8	11.6	-1.69491
505	39	37.78	-3.12820	13.9	13.9	0
507	29.75	28.62	-3.79831	13	13.9	6.923076
516	39.02	39.5	1.230138	14.6	14.7	0.684931
517	83.6	84.12	0.622009	17.3	17.4	0.578034
520	64.66	55.69	-13.8725	15.7	16	1.910828
527	27.5	24.89	-9.49090	12.5	12.6	0.8
530	106.54	97.28	-8.69157	18.9	19.3	2.116402
544	58.98	59.66	1.152933	15.5	15.2	-1.93548
546	18.36	17.35	-5.50108	11.3	11.2	-0.88495
	48.696	46.335	-4.70530	14.45	14.58	0.849791

Jan. 22, 1988: Sample 5

Tag	Initial	Sample	%	Initial	Sample	% chg.
507	29.75	28.02	-5.81512	13	12.9	-0.76923
509	16.45	15.15	-7.90273	10.9	10.7	-1.83486
513	44.58	48.61	9.039928	14.2	14.7	3.521126
516	39.02	38.95	-0.17939	14.6	14.7	0.684931
542	34.46	31.08	-9.80847	12.6	12.5	-0.79365
546	18.3	17.88	-2.29508	11.3	11.2	-0.88495
548	22.08	22.28	0.905797	12	11.9	-0.83333
551	110.28	109.28	-0.90678	19.1	19.2	0.523560
553	42.29	40.58	-4.04350	13.7	13.9	1.459854
555	35.69	37.55	5.211543	12.7	13.3	4.724409
557	31.32	37.71	20.40229			
	39.29	38.938	-1.57938	13.41	13.5	0.579784

Jan. 29, 1988: Sample 6

Tag	Initial	Sample	%	Initial	Sample	% chg.
413	19.55	20.43	4.501278	11.8	11.8	0
507	29.75	27.58	-7.29411	13	13	0
514	29.61	62.98	112.6984	14.1	15.5	18.3
520	64.66	70.39	8.861738	15.7	16.5	13.4
525	40.12	45.9	14.40677	13.3	13.9	4.511278
527	27.5	29.89	8.690909	12.5	12.8	2.4
533	39.92	58.81	47.31963	14.2	15.1	6.338028
543	20.61	21.72	5.385735	11.6	11.9	2.586206
554	51.38	69.11	34.50759	14	15.5	10.71428
555	35.69	42.82	19.97758	13.7	14	2.189781
	35.879	44.963	24.90555	13.39	14	6.043957

Group 2A: Initial Values
July 19, 1988

Tag	Weight	Length
650	123.68	19.4
651	136.81	20.1
610	66.91	15.7
652	151.62	20.2
653	48.12	14.3
654	97.59	17.5
655	100.01	18.8
656	163.8	20.7
657	134.52	20.8
658	109.22	18.5
659	126.22	19.6
660	56.92	15
661	97.63	18.2
662	147.68	20.7
664	181.35	22.5
665	184.72	22.2
666	115.5	19.4
667	179.18	21.4
668	189.11	21.7
669	71.59	15.7
670	120.05	19.2
671	128.78	20.2
672	108.75	18.2
673	130.6	20.1
674	107.57	18.5
675	81.95	16.9
676	76.47	16.5
678	68.77	15.4
679	142.6	20.3
680	128.98	19.7
681	72.65	17
682	132.24	19.6
683	104.82	18.7
684	135.05	19.7
685	139.38	19.9
686	49.72	14.5
687	115.3	18.8
688	93.98	17.1
689	169.92	21.5
690	143.57	20.3
691	76.61	16.6
692	112.18	19.4
693	173.22	20.9
694	120.68	19.8
695	106.15	18.2
696	113.47	19.2

Tag	Weight	Length
697	69.72	16.5
698	100.11	18.2
699	61.12	15.6
700	130.5	19.4
701	127.78	19.8
702	165.88	21.2
avg:	116.6052	18.796
sum:	5830.26	
feed (5%)	291.513	

Group 2B: Initial Values
July 19, 1988

Tag	Weight	Length
600	115.23	18.7
602	159.11	21.4
603	119.26	19.3
604	118.1	19.3
605	75.33	16.7
606	120.17	19.1
607	165.6	21.5
608	78.51	16.5
609	183.65	22.5
611	50.24	14.9
612	95.42	17.5
613	123.52	19.7
614	117.75	19.1
615	49.2	13.4
617	125.35	19.9
618	146.45	20.4
619	137.5	20.5
620	112.35	17.6
621	174.09	21.3
622	144.05	20.1
623	115.68	18.6
625	155.77	20.2
626	120.21	19.1
627	125.45	18.8
628	131.05	19.8
629	126.83	18.9
630	110.63	18.5
631	171.16	21.8
632	42	13.3
634	143.95	20.6
635	106.73	18.2
636	106.1	18.8
637	107.25	18.6
638	123.21	19.3
639	97.17	17.6
640	93.02	17.6
641	100.52	17.8
642	133.25	20
643	109.64	18
644	113.31	19.8
645	103.23	18
646	183.01	22.5
647	130.62	19.3
648	112.72	18.7
649	168.18	21.2

Tag	Weight	Length
750	124.81	19.3
751	162.59	21.1
752	157.83	21.6
753	160.98	21.4
754	143.28	19.5
avg:	123.8212	19.146
total:	6191.06	
feed (5%)	309.553	

Experiment 2: Sample 1
August 10, 1988

Group 2B Tag #	Initial	Weight Sample	% change	initial	length sample	% diff
604	118.1	108.48	-8.14563	19.3	19.2	-0.51813
605	75.33	59.78	-20.6425	16.7	16.8	0.598802
606	120.17	109.58	-8.81251	19.1	19.3	1.047120
608	78.51	57.31	-27.0029	16.5	17	3.030303
613	123.52	111.08	-10.0712	19.7	19.5	-1.01522
614	117.75	107.35	-8.83227	19.1	19.2	0.523560
618	146.45	132.15	-9.76442	20.4	20.2	-0.98039
621	174.09	151.91	-12.7405	21.3	21.1	-0.93896
636	106.1	98.58	-7.08765	18.8	18.8	0
637	107.25	97.61	-8.98834	18.6	18.7	0.537634
639	97.17	88.29	-9.13862	17.6	17.6	0
640	93.02	85.42	-8.17028	17.6	17.8	1.136363
646	183.01	160.05	-12.5457	22.5	22.4	-0.44444
668	189.11	171.65	-9.23272	21.7	21.8	0.460829
751	162.59	150.7	-7.31287	21.1	21	-0.47393
avg	126.1446	112.6626	-11.2325	19.33333	19.36	0.197567

Group 2A Tag #	Initial	weight Sample	% change	initial	length sample	% diff
655	100.01	92.83	-7.17928	18.8	18.5	-1.59574
657	134.52	124.25	-7.63455	20.8	20.6	-0.96153
662	147.68	244.53	65.58098	20.7	22.8	10.14492
666	115.5	117.65	1.861471	19.4	19.7	1.546391
670	120.05	104.77	-12.7280	19.2	18.9	-1.5625
674	107.57	165.2	53.57441	18.5	20	8.108108
676	76.47	93.46	22.21786	16.5	17	3.030303
678	68.77	60.08	-12.6363	15.4	15.5	0.649350
685	139.38	199.24	42.94733	19.9	21.1	6.030150
689	169.92	242.13	42.49646	21.5	22.8	6.046511
690	143.57	200.54	39.68099	20.3	21.8	7.389162
692	112.18	101.91	-9.15492	19.4	19.4	0
693	173.22	155.42	-10.2759	20.9	20.7	-0.95693
694	120.68	213.61	77.00530	19.8	21.6	9.090909
695	106.15	95.25	-10.2684	18.2	18.5	1.648351
701	127.78	117.81	-7.80247	19.8	19.6	-1.01010
avg	122.7156	145.5425	16.73030	19.31875	19.90625	2.974834

Group 2A: sample 2
August 31, 1988

tag	init. wt	sample wt	% dif	init ln.	sample ln	% diff
652	151.62	305.77	101.6686	20.2	24.4	20.79207
653	48.12	57.85	20.22028	14.3	14.9	4.195804
656	163.8	216.82	32.36874	20.7	22.7	9.661835
657	134.52	89.51	-33.4597	20.8	17.2	-17.3076
660	109.22	69.48	-36.3852	18.5	15.8	-14.5945
661	97.63	99.62	2.038307	18.2	17.7	-2.74725
664	181.35	355.7	96.14006	22.5	26.7	18.66666
666	115.5	175.82	52.22510	19.4	21.2	9.278350
670	120.05	106.32	-11.4369	19.2	18.9	-1.5625
671	128.78	219.31	70.29818	20.2	22.9	13.36633
672	108.75	229.8	111.3103	18.2	22	20.87912
675	81.95	89.51	9.225137	16.9	17.2	1.775147
676	76.47	116.09	51.81116	16.5	18	9.090909
677	130.32	149.55	14.75598	20.4	21.1	3.431372
678	68.77	78.82	14.61393	15.4	16.8	9.090909
680	128.98	117.33	-9.03240	19.7	19.6	-0.50761
681	72.65	165.58	127.9146	17	21.5	26.47058
682	132.24	128.28	-2.99455	19.6	19.7	0.510204
683	104.82	162.91	55.41881	18.7	20.3	8.556149
685	139.38	257.28	84.58889	19.9	23.2	16.58291
686	49.72	48.44	-2.57441	14.5	14.5	0
687	115.3	109.51	-5.02168	18	18.8	4.444444
688	93.98	110.62	17.70589	17.1	18.1	5.847953
689	169.92	330.38	94.43267	21.5	24.9	15.81395
691	76.61	99.62	30.03524	16.6	17.7	6.626506
692	112.18	112.48	0.267427	19.4	19.5	0.515463
694	120.68	304.68	152.4693	19.8	24.3	22.72727
697	69.72	83.28	19.44922	16.5	17	3.030303
698	100.11	187.58	87.37388	18.2	21.2	16.48351
Avg	110.4531	157.86	39.49748	18.54827	19.92413	7.279936

Group 2B: sample 2
August 31, 1988

tag	init. wt	sample wt	% dif	init ln.	sample ln	% diff
600	115.23	172.11	49.36214	18.7	20.8	11.22994
602	159.11	192.88	21.22431	21.4	22.6	5.607476
603	119.26	165.58	38.83951	19.3	21.1	9.326424
606	120.17	142.09	18.24082	19.1	20.2	5.759162
607	165.6	247.35	49.36594	21.5	24	11.62790
609	183.65	160.2	-12.7688	22.5	22.2	-1.33333
614	117.75	158.3	34.43736	19.1	20.5	7.329842
615	49.2	56.16	14.14634	13.4	14.3	6.716417
617	125.35	176.35	40.68607	19.9	21.9	10.05025
620	112.35	148.38	32.06942	17.6	19.1	8.522727
622	144.05	125.05	-13.1898	21.1	19.9	-5.68720
623	115.68	108.08	-6.56984	18.6	18.6	0
626	120.21	169.06	40.63721	19.1	20.8	8.900523
627	125.45	184.98	47.45316	18.8	20.9	11.17021
629	126.83	186.77	47.26011	18.9	21.1	11.64021
631	171.16	180.21	5.287450	21.8	21.9	0.458715
634	143.95	129.78	-9.84369	20.6	20.5	-0.48543
635	106.73	133.58	25.15693	18.2	19.3	6.043956
637	107.25	142.4	32.77389	18.6	20.2	8.602150
638	123.21	156.35	26.89716	19.3	21.4	10.88082
640	93.02	150.28	61.55665	17.6	19.8	12.5
641	100.52	104.21	3.670911	17.8	18.1	1.685393
644	113.31	163.87	44.62095	19.8	21.4	8.080808
645	103.23	154.08	49.25893	18	19.3	7.222222
646	183.01	244.3	33.48997	22.5	24.4	8.444444
648	112.78	114.08	1.152686	18.7	18.7	0
628	131.05	164.72	25.69248	19.8	21.4	8.080808
750	124.81	157.31	26.03958	19.3	20.5	6.217616
751	162.59	201.35	23.83910	21.1	22.2	5.213270
752	157.83	227.66	44.24380	21.6	23.5	8.796296
753	160.98	273.85	70.11429	21.4	23.9	11.68224
Avg	128.8812	164.2377	27.90790	19.51935	20.79032	6.589802

	initial	% change	sample total	ration
ration (5%)	6191.06	27.9079	7918.854	395.9427

Experiment 2: Sample 3
Sept. 21, 1988

Group 2A

Tag #	Weight initial	sample	% change	Length initial	sample	% change
654	97.59	246.87	152.9664	17.5	21.7	24
661	97.63	227.02	132.5309	18.2	23	26.37362
666	115.5	252.63	118.7272	19.4	23.2	19.58762
676	76.47	145.72	90.55838	16.5	19.2	16.36363
679	142.6	244	71.10799	20.3	22.7	11.82266
681	72.65	135.81	86.93737	17	19.6	15.29411
685	139.38	336.49	141.4191	19.9	24.4	22.61306
691	76.61	118.79	55.05808	16.6	18.3	10.24096
694	120.68	405.71	236.1866	19.8	26.4	33.33333
696	113.47	136.25	20.07579	19.2	19.6	2.083333
699	61.12	108.14	76.93062	15.6	17.2	10.25641
700	130.5	444.98	240.9808	19.4	26.1	34.53608
Avg.	103.6833	233.5341	118.6233	18.28333	21.78333	18.87540

Group 2B

Tag #	Weight initial	sample	% change	Length initial	sample	% change
617	125.35	159.37	27.14000	19.9	21.9	10.05025
622	144.05	126.25	-12.3568	20.1	20.1	0
625	155.77	215.8	38.53758	20.2	22.7	12.37623
627	125.45	158.78	26.56835	18.8	20.6	9.574468
628	131.05	162.91	24.31133	19.8	21.2	7.070707
629	126.83	155.57	22.66025	18.9	20.7	9.523809
630	110.63	125.58	13.51351	18.5	19.6	5.945945
635	106.73	117.08	9.697367	18.2	19.4	6.593406
641	100.52	99.78	-0.73617	17.8	18.3	2.808988
751	162.59	164	0.867212	21.1	22.3	5.687203
752	157.83	217.81	38.00291	21.6	23.6	9.259259
757		136.31			19.1	
Avg.	131.5272	154.8118	17.10959	19.53636	20.94545	7.171843

Feeding Amounts

	initial	total	feed/day (g)
Tank 5 (5%)	5830.26	12746.30	637.3153
Tank 7 (5%)	6191.06	7250.324	362.5162

Experiment 2: Sample 4
Oct. 12, 1988

Group 2A

Tag #	Weight initial	sample	% change	Length initial	sample	% change
654	97.59	314.88	222.6560	17.5	24.1	37.71428
655	100.01	151.16	51.14488	18.8	21	11.70212
661	97.63	327.15	235.0916	18.2	25.3	39.01098
662	147.68	483.52	227.4106	20.7	28.4	37.19806
666	115.5	313.58	171.4978	19.4	25.3	30.41237
669	71.59	157.33	119.7653	15.7	19.8	26.11464
670	120.05	210.61	75.43523	19.2	22.1	15.10416
680	128.98	234.91	82.12901	19.7	22.6	14.72081
681	72.65	220.65	203.7164	17	22.3	31.17647
683	104.82	338.38	222.8200	18.7	25.7	37.43315
687	115.3	167.47	45.24718	18.8	21.1	12.23404
688	93.98	204.05	117.1206	17.1	20.6	20.46783
692	112.18	271.69	142.1911	19.4	24.2	24.74226
697	69.72	186.54	167.5559	16.5	20.9	26.66666
698	100.11	316.65	216.3020	18.2	24.8	36.26373
700	130.5	578.28	343.1264	19.4	28.9	48.96907
Average	104.8931	279.8031	165.2006	18.39375	23.56875	28.12066
S.D.	21.25444	114.2811	78.43601	1.286209	2.646157	10.73070

Group 2B

Tag #	Weight initial	sample	% change	Length initial	sample	% change
612	95.42	201.65	111.3288	17.5	21.3	21.71428
614	117.75	229.78	95.14225	19.1	22.3	16.75392
625	155.77	361.22	131.8931	20.2	25.1	24.25742
629	126.83	255.6	101.5296	18.9	22.8	20.63492
630	110.63	201.63	82.25616	18.5	21.6	16.75675
631	171.16	318.61	86.14746	21.8	25	14.67889
635	106.73	201.45	88.74730	18.2	21.2	16.48351
640	93.02	253.05	172.0382	17.6	23	30.68181
641	100.52	165.73	64.87266	17.8	20.3	14.04494
642	133.25	259.98	95.10694	20.1	23.1	14.92537
643	109.64	209.65	91.21670	18.1	21.2	17.12707
644	113.31	237.98	110.0255	19.8	23.6	19.19191
750	124.81	239.03	91.51510	19.3	22.7	17.61658
751	162.59	280.91	72.77200	21.1	23.9	13.27014
752	157.83	379.05	140.1634	21.6	26.1	20.83333
757		219.35			20.8	
Average	125.284	250.9168	102.3170	19.30666	22.75	18.59806
S.D.	24.63195	57.11309	26.80272	1.374756	1.625576	4.394011

Feeding	initial	% change	Total	feed/day (g)
Tank 5	5830.26	165.2	15461.84	773.0924
Tank 7	Starvation Period			

Experiment 2: Sample 5
November 2, 1988

Group 2A

Tag #	Weight initial	sample	% change	Length initial	sample	% change
655	100.01	173.37	73.35266	18.8	22.4	19.14893
659	126.22	253.05	100.4832	19.6	24.4	24.48979
661	97.63	405.77	315.6201	18.2	27.6	51.64835
666	115.5	383.55	232.0779	19.4	27.2	40.20618
667	179.18	586.28	227.2016	21.4	29.8	39.25233
671	128.78	463.44	259.8695	20.2	29.4	45.54455
679	142.6	428.88	200.7573	20.3	27.7	36.45320
680	128.98	291.21	125.7791	19.7	25.1	27.41116
681	72.65	286.31	294.0949	17	25.3	48.82352
687	115.3	183.91	59.50563	18.8	22.2	18.08510
688	93.98	258.87	175.4522	17.1	22.3	30.40935
689	169.92	573.35	237.4234	21.5	31.1	44.65116
694	120.68	669.85	455.0629	19.8	31.4	58.58585
696	113.47	260.15	129.2676	19.2	23.5	22.39583
697	69.72	229.02	228.4853	16.5	23.1	40
Average	118.308	363.134	207.6289	19.16666	26.16666	36.47369
S.D.	29.54218	149.5474	100.2556	1.437435	3.133191	11.98323

Group 2B

Tag #	Weight initial	sample	% change	Length initial	sample	% change
605	75.33	135.14	79.39731	16.37	20.4	24.61820
614	117.75	191.06	62.25902	19.1	22.8	19.37172
619	137.5	235.51	71.28	20.5	24.6	20
627	125.45	225.68	79.89637	18.8	23.1	22.87234
629	126.83	213.21	68.10691	18.9	23	21.69312
630	110.63	176.08	59.16116	18.5	21.9	18.37837
631	171.16	272.55	59.23697	21.8	25.4	16.51376
632	42	59.25	41.07142	13.3	15.4	15.78947
639	97.17	137.62	41.62807	17.6	20.3	15.34090
642	133.25	210.87	58.25140	20.1	23.4	16.41791
644	113.31	203.38	79.48989	19.8	23.9	20.70707
645	103.23	207.38	100.8912	18.1	22.6	24.86187
648	112.72	153.81	36.45315	18.7	21	12.29946
751	162.59	225.81	38.88308	21.1	24.2	14.69194
752	157.83	308.31	95.34309	21.6	26.4	22.22222
757		182.27			20.9	
Average	119.1166	196.1206	64.75660	18.95133	22.45625	19.05189
S.D.	32.12609	56.29581	19.37769	2.092070	2.489972	3.678371

Feeding	initial	% change	Total	feed/day (g)
Tank 5	5830.26	207.6	17933.87	896.6939
Tank 7	6191.06	64.8	10202.86	510.1433

Experiment 2: Sample 6
November 23, 1988

Group A

Tag #	Weight initial	sample	% change	Length initial	sample	% change
656	163.8	402.52	145.7387	20.7	27.6	33.33333
662	147.68	534.92	262.2156	20.7	31	49.75845
666	115.5	415.19	259.4718	19.4	28.5	46.90721
670	120.05	329.11	174.1441	19.2	25.4	32.29166
671	128.71	504.98	292.3393	20.2	30.3	50
676	76.47	313.45	309.8993	16.5	24.6	49.09090
679	142.6	471.91	230.9326	20.3	28.3	39.40886
680	128.98	314.38	143.7432	19.7	25.3	28.42639
681	72.65	344.91	374.7556	17	26.4	55.29411
685	139.38	586.31	320.6557	19.9	29.2	46.73366
687	115.3	202.32	75.47267	18.38	22.5	22.41566
688	93.98	290.31	208.9061	17.1	22.8	33.33333
689	169.92	606.79	257.1033	21.5	31.6	46.97674
694	120.68	710.39	488.6559	19.8	32.1	62.12121
697	69.72	261.39	274.9139	16.5	24.4	47.87878
Average	120.3613	419.2586	254.5965	19.12533	27.33333	42.93135
S.D.	30.11348	140.4963	97.95022	1.582377	3.030438	10.54467

Group B

Tag #	Weight initial	sample	% change	Length initial	sample	% change
605	75.33	182.31	142.0151	16.7	21.7	29.94011
614	117.75	272.58	131.4904	19.1	24	25.65445
617	125.35	318.79	154.3199	19.9	25.7	29.14572
619	137.5	319.68	132.4945	20.5	25.6	24.87804
627	125.45	301.11	140.0239	18.8	23.9	27.12765
628	131.05	282.11	115.2689	19.8	23.8	20.20202
629	126.83	318.51	151.1314	18.9	24.4	29.10052
631	171.16	330.67	93.19350	21.8	26.9	23.39449
635	106.73	248.68	132.9991	18.2	22.9	25.82417
636	106.1	174.68	64.63713	18.8	21.5	14.36170
639	97.17	187.55	93.01224	17.6	21.3	21.02272
641	100.52	195.18	94.17031	17.8	21.5	20.78651
642	133.25	263.91	98.05628	20	24.5	22.5
644	113.31	273.28	141.1790	19.8	25.3	27.77777
648	112.72	216.29	91.88254	18.7	22.1	18.18181
750	124.81	263.78	111.3452	19.3	24.1	24.87046
752	157.83	428.11	171.2475	21.6	27.5	27.31481
753	160.98	455.13	182.7245	21	28.8	37.14285
757	112.35	235.11	109.2656	17.6	21.9	24.43181
Avg	122.9573	277.2347	123.7082	19.25789	24.07368	24.92935
S.D.	22.61857	74.01842	29.82537	1.342548	2.121529	4.866129

Feeding	initial	% change	Total	feed/day (g)
Tank 5	5830.26	254.6	20674.10	1033.705
Tank 7	6191.06	123.7	13849.40	692.4700 (Starvation)