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Growth Performance and Proximate Composition of Oreochromis Niloticus (Trewavas) Fed Cobalt Chloride Incorporated Diet.

Ibim Adaba Tonye[1] AND Francis D. SIKOKI[2]
1. DEPARTMENT OF ANIMAL SCIENCE AND FISHERIES, FACULTY OF AGRICULTURE UNIVERSITY OF PORT HARCOURT. P.M.B. 5323 CHOBA, RIVERS STATE, NIGERIA
2. Hhggjj
* E-mail of the corresponding author: adabafishries@yahoo.com

Abstract
Indoor feeding trials were conducted for 49 days using juvenile tilapia (Oreochromis niloticus) with initial average weight ranging from 0.59gm to 0.65gm and initial average length ranging from 3.0cm to 3.25cm. they were fed cobalt chloride incoperated feed at 0% and 0.1% levels at 10% of their body weight.
Growth responses including specific growth rates, food conversion efficiency and carcass composition were studied. Results revealed that the cobalt chloride incoperated diet significantly ($P<0.05$) enhanced the growth. Though the food conversion efficiency and carcass composition were not significantly different between treated and untreated fish; the food conversion efficiency was much higher in the treated fish than the untreated fish specimens. It is therefore concluded that cobalt chloride has a growth enhancing property at 0.1% inclusion.
Keywords: Cobalt chloride, *Oreochromis niloticus*, Growth performance, Proximate composition

1. INTRODUCTION

As the world population increases, the demand for fish as a source of protein increases. The rapid attainment of market-size fish with appropriate proximate composition is of great practical and scientific significance.

Tilapia, *Oreochromis niloticus* are economically important, commercial pond fish in Nigeria, found in various salt and fresh water systems in Africa and other regions of the world and one of the most hardy fish species. They are widely accepted because of their palatable and highly nutritious flesh, valuable in high quality and quantity protein and polyunsaturated fatty acids, among other things (Guha, 1999). However, they easily exhibit stunted growth in culture systems, especially when faced with poor quality and quantity of feed.

Nutrition plays an important role in growth. Although the most limiting dietary component in the growth of fishes is protein, there are also the limiting nutrients. This mainly is due to the inability of fish to absorb certain minerals from the surrounding water (Cowey and Sergent, 1979). Natural feeds are known to lack some essential micro-nutrients necessary for growth and survival. Bowen (1982), reported that, food quality is proportional to its ability to support growth. Food quality influences growth especially among herbivorous and detritivorous fishes, to which tilapia belong.

Cobalt is considered a biologically essential element occurring in trace concentrations in plants, animals and in some micro-organisms (Johnson, 1976). It is a constituent of vitamin B_{12} (Cobalamine). Hammond and Beliles (1980), reported that, cobalt chloride is so important that one microgram of vitamin B is essential in the prevention of pernicious anemia, and that Cobalt salts are useful as catalyst in the production of numerous pigments. Dietary Cobalt also plays a role in the stimulation of production of vitamin B by gut bacteria in some organisms (Ftalver, 1976). Cobalt has been said to be essential for normal tissue metabolism and for the maintenance of health in man (Kuhnau, 1991). Kuhnau (1991) also stated that Cobalt as a component of Vitamin molecule takes part in essential steps of protein metabolism. According to Sikoki and h (1992), growth is dependent on a number of factors including metabolic state of the animal.

Cobalt chloride has been used by several workers to achieve growth in fishes. Korneeva (1976) used Cobalt chloride for enhancement of growth in Carp and Salmon. Anadu and Anthony; (1990), also reported that, *Tilapia zilli* fingerlings fed cobalt chloride in-cooperated diet had better growth rates and protein efficiency ratio than the control fish. Sen and Chaterjee (1976), reported that, cobalt chloride stimulates growth in fishes. They further stated that, the survival and growth of Indian carp fed cobalt chloride were significantly higher than those not fed diets containing Cobalt chloride and that, at an early stage in life it is possible to create a state of balance through the introduction of essential micro-nutrients in the culture medium it - will render the fish more resistant. Sukhoverkhov (1967) also reported that, the application of cobalt chloride in fish diet increased the food demand of Common carp (*Cyprinus carpio*). Sen (1972) observed that the survival and growth of Indian carp fry can be enhanced significantly by treatment with cobalt chloride. Das (1959, 1960,1976) and Das and Krishnamurtty

(1959) observed that minute quantities of Vitamin B complex can significantly enhance survival of embryonic and post embryonic Indian Carp.
However, there's paucity of information in the use of Cobalt chloride in enhancing the growth or carcass composition of Tilapia, *Oreohromis niloticus*.

The aim of this work therefore, is to determine the growth and carcass composition enhancing capacity of cobalt chloride in-cooperated diet, on cultured *Oreochromis niloticus*.

2. MATERIALS AND METHODS

2.1 Experimental Fish and Treatment

A total of 140 juvenile Oreochromis niloticus were obtained from the school fish farm. The fish weighed between 0.59gm to 0.65gm and ranged between 3.00cm and 3.25cm in length. They were then stocked randomly into four indoor concrete nursery tanks, which were previously filled with dechlorinated water. The stocking was at a rate of 35 fry/tank of 4in by 4m. The fish were fed for two days on free diet, prior to the commencement of the experiments in order for them to acclimatize properly.
Water was managed by, providing adequate aeration and cleaning of the nursery tanks was done daily by siphoning wastes/excess feed. The water in each tank was replaced weekly after cleaning the concrete tanks.

2.2 Cobalt Chloride Treatment

The Cobalt chloride used was obtained from Agrochemical stores. It was obtained in the form of pink anhydrous crystals.
In incoperating Cobalt chloride into the diet for the commencement of the feeding trials, 0.1gm/kg (feed) of Cobalt chloride was dissolved in 10 millilitres of water. This solution was later poured and thouroughly mixed into the diet.

2.3 Feed Formulation and Weighing

The feed was formulate based on the conventional method using the:pearson s square.
The gross composition of the diets as are shown in Table 1. below are white maize, fish meal, groundnut paste and vitamin premix including the Cobalt chloride

Table 1. Gross Composition of Feed for chromis nhloticus fry

Component	**Control diet (0%)**	**Cobalt chloride included diet (0.1%)**
White maize	51.00	51.00
Groundnut cake	22.95	22.95
Fish meal	22.95	22.95
Vitamin Premix	03.00	02.90
Cobalt chloride	0.0	0.10
Total	**100.00**	**100.00**

Diets were prepared by first mixing dry powdery ingredients, then adding a little moisture and blending them all together. Cobalt chloride solution was then added to the mixture in which it was required and kneaded through thoroughly. Both feed - mixs were pelleted into small pellets and sun-dried.
Dry pellets were crumbled to appropriate size before feeding to fish.
The feed were later fed to duplicate groups of fish for both the control and experimental treatments.
Feeding level was set at 10% of body weight per day and dispensed five times daily for six days a week. Ration levels were ref ixed in accordance with body weight after weekly batch weighing of fish in each tank.

2.4 Proximate Analysis

Samples of five whole fish of known weights randomly picked from each tank were analyzed for proximate composition. This was carried out prior to the onset of the feeding trial, fourth and seventh week of the feeding trial.

The properties analyzed were crude protein, moisture and fat (ether extract).
Crude protein was analyzed using the modified micro-kjedahl method (A.0.A.C; 1980). This method involved three main steps; Digestion, Distillation and Titration.

Digestion involves taking a known weight of fish sample from each tank; macerating thoroughly and putting it in a digestion flask. Later l0mls of distilled water was added followed by 2Omls sulphuric acid to initiate digestion. This was later accelerated by adding one Kjedhal digestion tablet (selenium tablet). The digestion flask was then fixed onto a digestion apparatus and heated over a heating mantle for about three hours to produce a clear solution. This solution was then diluted up to 5omls and then stored in a 5Oml—volumetric flask.

Distillation immediately followed by adding lOmls of a mixture of 2% boric acid and 4 drops of indicator (bromocresol purple and methyle red) into an Erlenmeryer volumetric flask and fixed into the receiving end of the micro-kjedhal steam distillation apparatus. Through the funnel end of the apparatus, 5Omls of the digested sample and lOmls of sodium hydroxide solution were added and distilled.

As the ammonia in the sample is liberated, it is trapped by the boric acid indicator which gradually turned the reddish pink boric acid and indicator content into emerald green colour. The distilaltion was stopped when the volume of the boric acid indicator almost doubled the original volume.

Titration was finally done by titrating the distillate against a 0.025 CM) (Hcl) hydrocloric acid, producing a light red coloured end product.

Percent crude protein (% C.P) was then calculated by using formular;

$$(\%C.P) = \frac{Ts — Tb \times 0.014 \times 0.025 \times D \times 100 \times 6.25}{W \times L}$$

Where Ts = Titre of sample
Tb = Titre of blank
0.014 = Nitrogen constant per 1,000 ml (weight of nitrogen (gm)
0.025 = Molarity of acid used
D = Vol. after Digestion (5Oml)
W = Weight of sample used (gm)
L = Aliquot volume of sample used (5ml)
6.25 = Protein conversion factor
100 = Percentage conversion factor

The titre value obtained was used to calculate the nitrogen content of the aliquot distilled and then expressed as a percentage. The percentage nitrogen was multiplied by a conversion factor (6.25) to convert to crude protein.
Moisture content was determined as described by Nwokoye (1983). Fish samples were weighed using sauter analytical balance and then oven-dried at l10C for 24 hours to a constant weight. The samples were cooled in a desicator and re-weighed. Loss in weight was equal to moisture content of the original sample. The dry matter was then expressed as a percentage of the wet weight and the percentage moisture calculated by difference.

Lipid content was determined by the Ether Soxhlet extraction method (A.0.A.C (1970). A 250 millimetre round bottom flask was washed and ovendried at 105Cc. The flask was then allowed to attain a balanced room temperature after which it was weighed to a constant weight. Weighed fish sample was then mascerated and put into a filter paper and put into a lipid extraction thimble, which was dropped into a Soxhlet extractor. These were then connected to the previously weighed flask to which l2Oml of extraction solvent, petroleum spirit was added and heated. The ether siphoned over through the sample and back into the sample at regular intervals. This refluxing continued for six (6) hours. About l5mls of petroleum spirit and lipid were left in the flask. The flask/oil was removed from the heater and dried in the hot oven air at 95Cc for 12 hours. This drying excercise was to remove residual petroleum spirit and traces of water from the flask, leaving lipid only.

The flask with the lipid was then cooled and weighed to constant weight. The difference in the original weight of the flask and the flask/lipid weight was then regarded as the lipid weight. This was then multiplied by a 100 to express as a percentage. The lipid content was expressed as a percentage of the original weight of sample.

The calculation is as follows for percent ether;

$\frac{M_3 - M_2}{M_1} \times 100$

Where:
M1 (gm) = weight of sample taken
M2 (gm) = weight of empty flask
M3 (gm) = weight of flask and redidue (oil)

2.5 Growth Determination

Growth was estimated using growth parameters such as weight, length, specific growth rate (SGR) and food conversion efficiency (FCE). Weight and length of fish were determined at the onset of the experiment and thereafter, at every 7-day interval, until the termination of the experiment. Fish weight was recorded in grams. The measurement was taken by cropping all fish in each experimental tank into a beaker of constant quantity of water with known weight. The beaker was thereafter re-weighed and the difference in weight was recorded as the collective weight of fish in each tank. Average fish weight was then determined by dividing the total fish weight by the total number of fish present. Length was measured and recorded in centimetres (cm). Length determination was by measuring all fish in each tank using a metre rule. The total measurements were then added and divided by the total number of fish in that tank, to give the average fish length.

The growth rate was expressed as specific growth rate (SGR). Mean specific growth rate were calculated every 7-day interval. SGR was expressed as percent per day (%/day). It was calculated using the formula

$$SGR\ (\%/day) = \frac{LogesW_2 - LogeW_1}{T_2 - T_1} K\ 100$$

(After Jauncey & Ross; 1982)
Where;
W_1 = Weight at time T_1
W_2 = Weight at time T_2
Loge = Natural log

Food Conversion efficiency (FCE) was also calculated weekly based on the weight gain and food intake of fish, using the following formula

$$FCE = \frac{\text{Weight gain(gm)}}{\text{Food intake (gm)}}$$

(After Jauncey & Ross, 1982)

2.6 Statistica1Analsis
A one-way analysis of variance and a two-way analysis of variance (randomized block design) were used to test if there was significant difference in length increment, weight gain, specific growth rate (SGR), Food Conversion Efficiency (FCE) and proximate composition.
Chi-square goodness of fit test was used to evaluate if the observed treatment results differed significantly from the control results.
Correlation analysis was also performed when necessary.

3. RESULTS

3.1 Proximate Composition
Proximate composition of fish feed is shown in table 4.1 below. It reveals that crude protein had the highest value of 30.0% followed by ether extract with 6.45% and then moisture with 4.0% and 5.0% in control and treated fish respectively.

Table 2: Proximate composition of the test and control diets

Component	Amount (%) in Diet	
	0% Cocl2	0.1% Cocl2
Crude protein	30.1	30.1
Ether extract	6.45	6.45
Moisture		5.0
Dry matter	50.10	48.20

The proximate composition of fish tissues at the onset, fourth and seventh weeks are shown in table 2.

Table 3: Proximate Composition of Fish at Weeks Zero (0) Four (4) and seven (7)

Week	Treatment	MeanWeights(gm)	Parameter (%)		
			Crude protein	Crude fat	moisture
0	C (Control A(Treatment	0.59 0.65	13.0 I3.5	17.2 19.5	76.0 77.0
4	C A	0.69 0.90	14 14	12.4 11.0	74.0 76.0
7	C A	0.73 1.18	12.3 15.0	7.7 9.0	73.0 73.0

It shows that the moisture content, fat content and protein content of the control fish ranged from 73.0% to 76.0%, 7.7% to 17.2% and 12.3% to 13.0% respectively. to 19.5% and 13..5% to 15.0% for moisture, fat and protein contents The corresponding values for the untreated fish ranged between 73.0% to 77.0%, 9.0% respectively. However, the differences in values of protein, moisture and fat content between the treated and untreated fish were not statistically significant; although there's a gradual increase in the crude protein content of the treated fish as against that of the control which showed a gradual decline (Fig. 1)

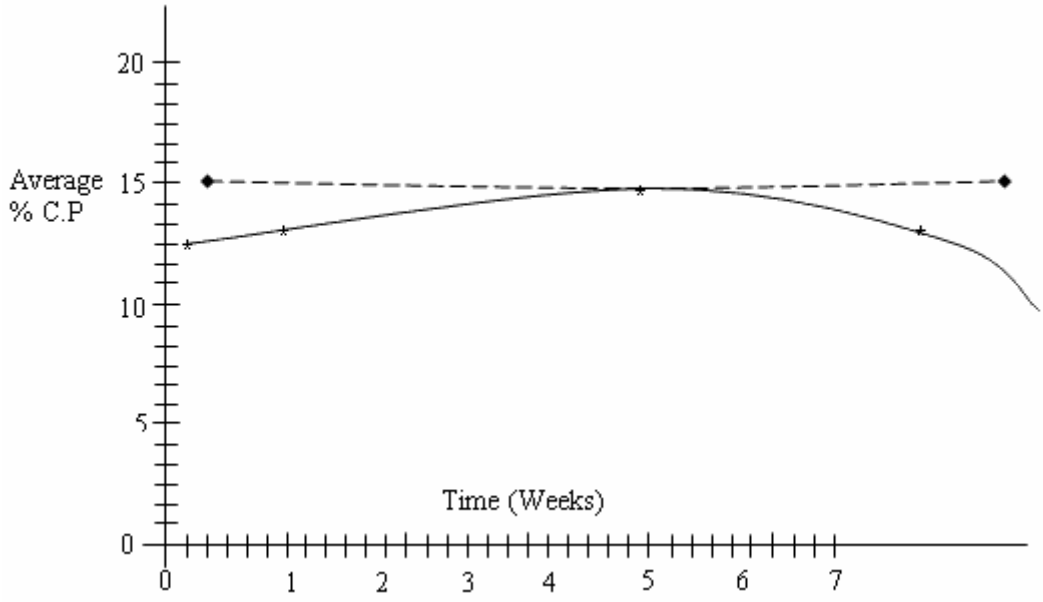

Fig. 1: The Percentage Crude Protein %C.P of Treated Fish A and untreated Fish Control (c) during the 49 Day Feeding Trial.

3.2 Growth Response

Data on growth response of tilapia Oreochromis niloticus based on the mean length and mean weight measurements of both control and treated fish during the 7-ween feeding trials are presented in tables 4.3 and 4.4 respectively.

Table 4: Change in Mean Fish Length (cm)

TREATMENT	WEEKS 0 1 2 3 4 5 6 7
C (control fish)	3.0 3.10 3.22 3.28 3.32 3.36 3.39 3.41
C (control fish)	3.25 3.45 3.72 3.92 4.10 4.27 4.44 4.60

Table 5: Change in Mean Fish Weight (gm)

These results show that there was a gradual increase in mean weight and length of both the treated and untreated in mean were significantly higher (P<0.05) in the treated fish.

TREATMENT	WEEKS 0 1 2 3 4 5 6 7
C (control fish)	0.59 0.61 0.64 0.69 077 0.89 1.05 1.14
A (control fish)	0.65 0.70 0.77 0.87 1.05 1.33 1.73 2.23

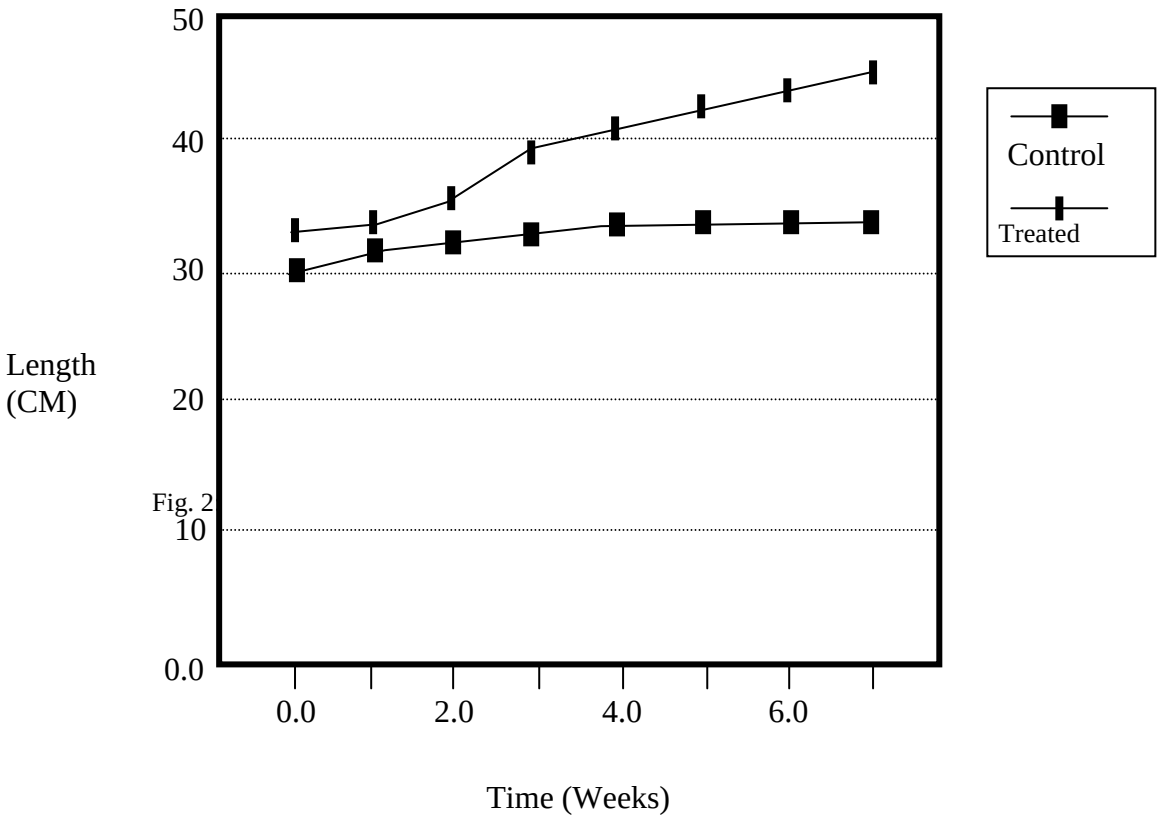

Fig. 2

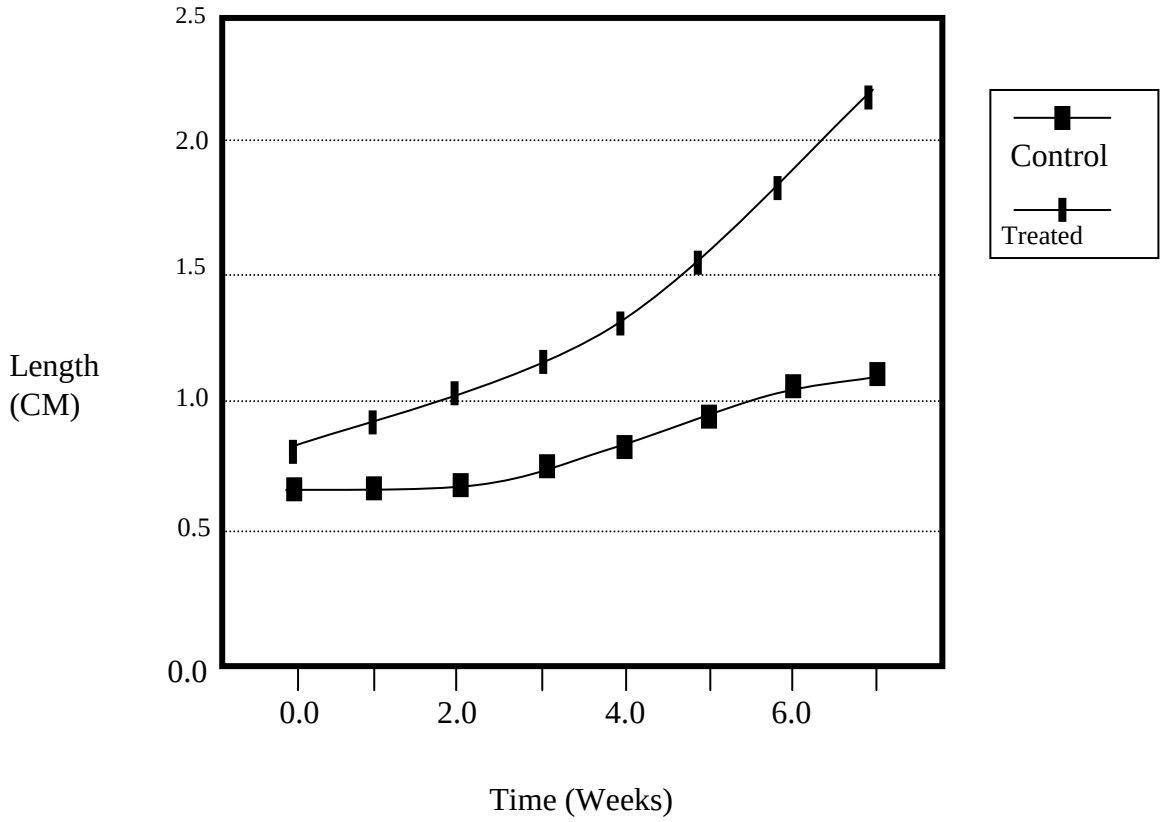

Fig. 2: Changes in Mean Fish Weight with time

As shown in Table 5, the recorded weight gain of the treated fish exceeded the weight gain of the control fish. This was revealed by the rapid weight gain of the treated fish from an initial weight of 0.65gm to a final weight of 2.25gm as opposed to the initial weight of 0.59gm of the treated fish which rose to a final weight of 1.14gm within the 7-week experimental period. This rapid weight gain was also evident between the weeks and the increases were significantly ($P<0.05$) different between the treated and untreated fish samples. This rapid increase in weight can be seen in Figure 3.

In week-l, the treated fish gained 0.05gm as against 0.02gm for the untreated fish. In week-3, the weight gain of treated fish rose rapidly to 0.10gm, doubling that of week-i whereas the weight gain of the control fish at the same week-3 was only 0.05gm.

Finally, the weight gain of the treated fish at the end of week- 7 went up to 0.50gm as against 0.14gm for the control fish.
Length changes are shown in Table 4. It shows that the treated fish performed better than the control fish. This is evident in Figure 2.
The length of the control fish rose from 3.00cm to 3.28cm and 3.41cm between weeks 0, 3 and 7 as opposed to the length changes 3.25cm, 3.92cm and 4.60cm for the treated fish samples during the same period.
The length increments between these periods were more vividly observed to be 0.2, 0.18 and 0.i6 at weeks 1, 4 and 7 for the treated fish, while it was 0.1, 0.4 and 0.02 for weeks 1, 4 and 7 respectively for the control fish.

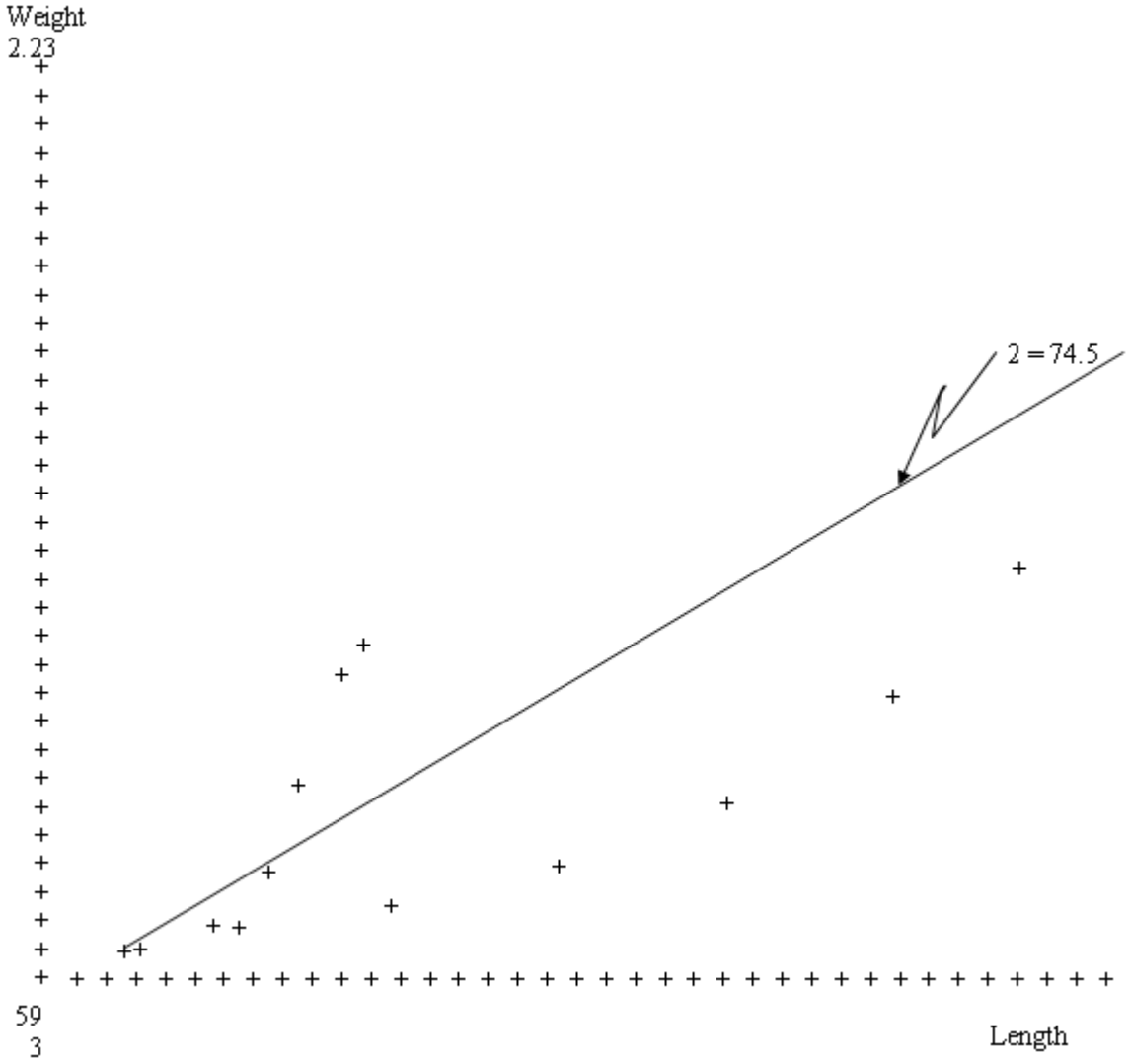

Fig 4: Coversion between fish length and weight regression equation (shown on matter plot).
Intercept = -1.8454578852012. Slope = 0.78224669139235
R = 0.8633, + squared = 0.7453

As shown in figure 2, increase in mean length was more rapid from the 3rd week. The length increments dropped for both treated and untreated fish as is shown in Table 4.3. However, mean length increment was higher for the treated fish than the control fish. The length increment for the control fish at weeks 3, 5 and 7 were 0.06cm, 0.04cm and 0.02cm as opposed to 0.2cm, 0.17cm and 0.16cm for the treated fish. The differences in length changes within the weeks was also found to be significantly different ($P<0.05$) between the treated and the untreated fish groups.

As shown in figure 4, for every gain in weight, there was a subsequent increase in length.
Both length and weight were found to be highly positively correlated among the treated and untreated fish groups.

3.3 Specific Growth Rate (SGR) and Food Conversion Efficiency (FCE)

The increase in Mean Specific Growth Rate (SGR) and Food Conversion Efficiency (FCE) values of the treated fish are far higher than the increase in these parameters (SGR and FCE) for the control fish. These increases are reflected in the mean length and weight changes in Tables 4.3 and 4.4.

Table 4.5 Weekly Variations in Food Conversion Efficiency (FCE)

Week	Treatment	(FCE)
1	C A	0.09685 0.02198
2	C A	0.01586 0.03226
3	C A	0.02520 0.041894
4	C A	0.03865 0.06674
5	C A	0.05195 0.08602
6	C A	0.06914 0.11139
7	C A	0.04902 0.086237

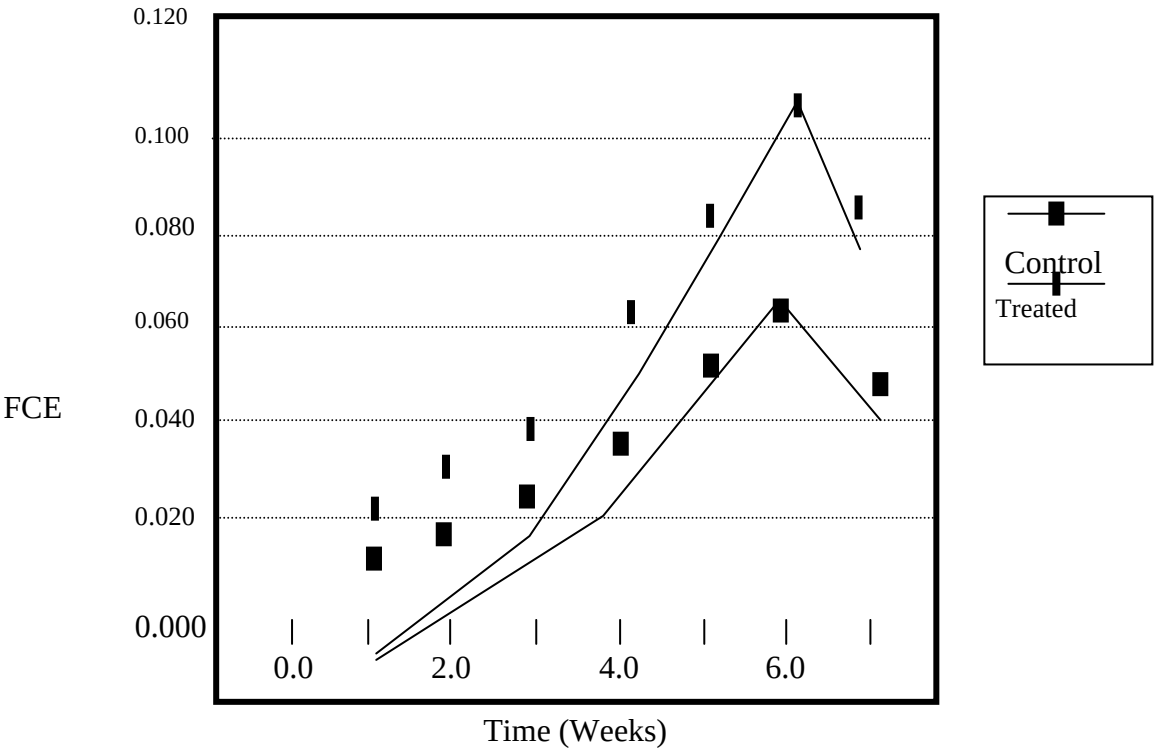

Fig. 5: Weekly variation in food conversion efficiency

Food Conversion Efficiency (FCE) values for both the treated fish and control fish are given in Table 4.5. A close look at this table 4.5 shows that after every 7-day interval during the feeding trials, the food conversion efficiency (FOE) increased for both the treated and untreated fish although the difference was not statistically

significant. However, all fish fed Cobalt chloride incoperated feed had better food conversion efficiency, as against the FOE of the control fish. This is evident in Figure 5. This increase was obvious from the end of the first week and in subsequent weeks. The FCE at the end of the first week was 0.02198 for the treated fish and 0.09685 for the control fish. There were further increases recorded uptill the 6th week, at which time the FOE values were 0.06914 and 0.11139 for the control fish and treated fish respectively. However, by the 7th week there was a noticeable drop in the FOE values for both the treated and the control fish, but the FCE values for the treated fish was still higher with a value of 0.086237 as against 0.04902 for the control fish.

The Specific Growth Rate (SGR) for the treated and untreated fish groups are represented in Tables 4.6 and 4.7 and Figures 6 and 7.

Table 4.6 Weekly specific Growth Rate (SGR) for Length of Fish (%/day)

Week	Treatment	SGR (%/day)
1	C A	3.88285 7.76571
2	C A	4.65942 10.48371
3	C A	2.38971 7.76571
4	C A	1.55314 6.98914
5	C A	1.55314 6.60085
6	C A	1.16485 6.60086
7	C A	0.77657 6.21257

Table 4.7 Weekly Specific Growth Rate (SGR) for Weight (%/day)

Week	Treatment	SGR (%/day)
1	C A	0.77657 1.94142
2	C A	1.6485 2.718
3	C A	] 1.94142 3.88285
4	C A	3.10628 6.98914
5	C A	4.65942 10.8720
6	C A	6.21257 15.53142
7	C A	5.436 19.41428

The specific growth rate (SGR) also showed the same pattern of increases in both treated and untreated fish as shown in the length and weight specific growth rate values in Table 4.6 and 4.7 respectively. It is obvious from the tables that the SGR for length and weight of treated fish were significantly different ($P<0.05$) from those of the control fish. The differences were noticed all through the duration of the feeding trials. Unlike the SGR for weight which increased steadily, the SGR for length increased graduallyuntil the third week of the feeding trials, after which there was a gradual drop (Table 4.6). The SGR for weight showed increasing values from 0.77657 at week 1, to 5.436 at the end of

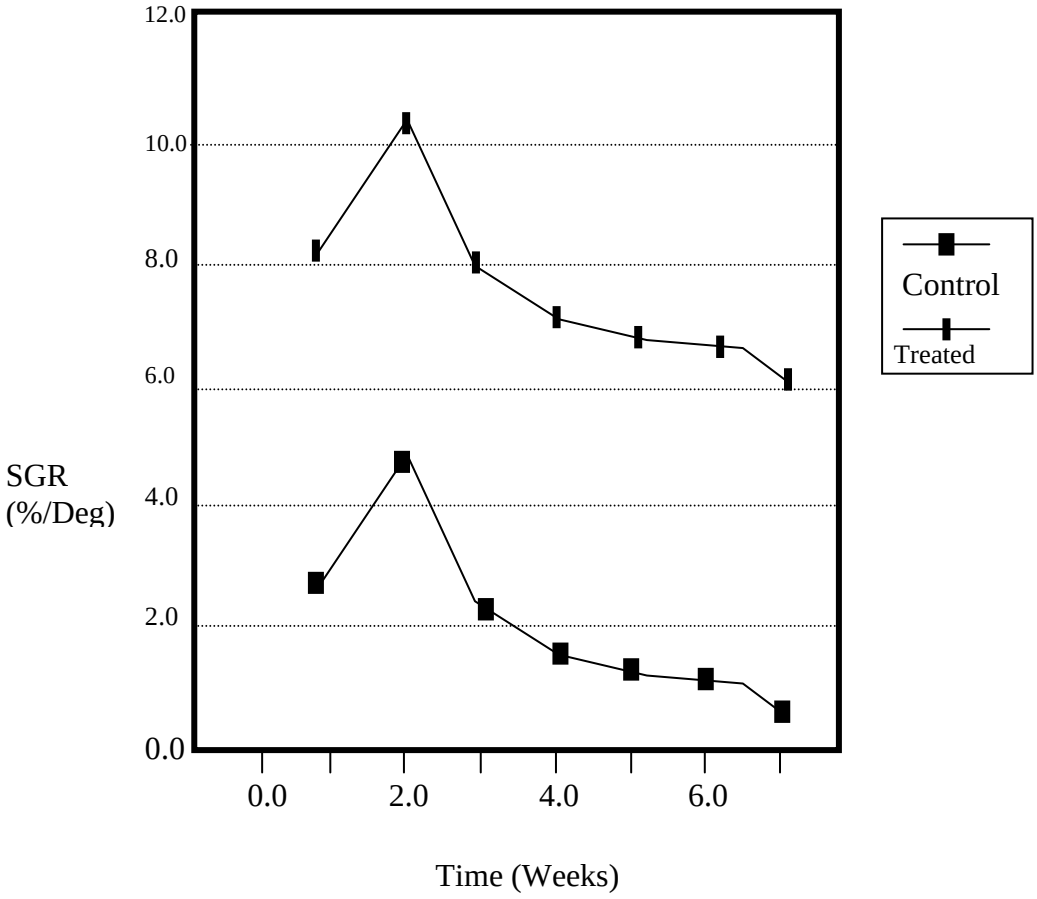

Fig. 6: Specific growth rate of fish (by length)

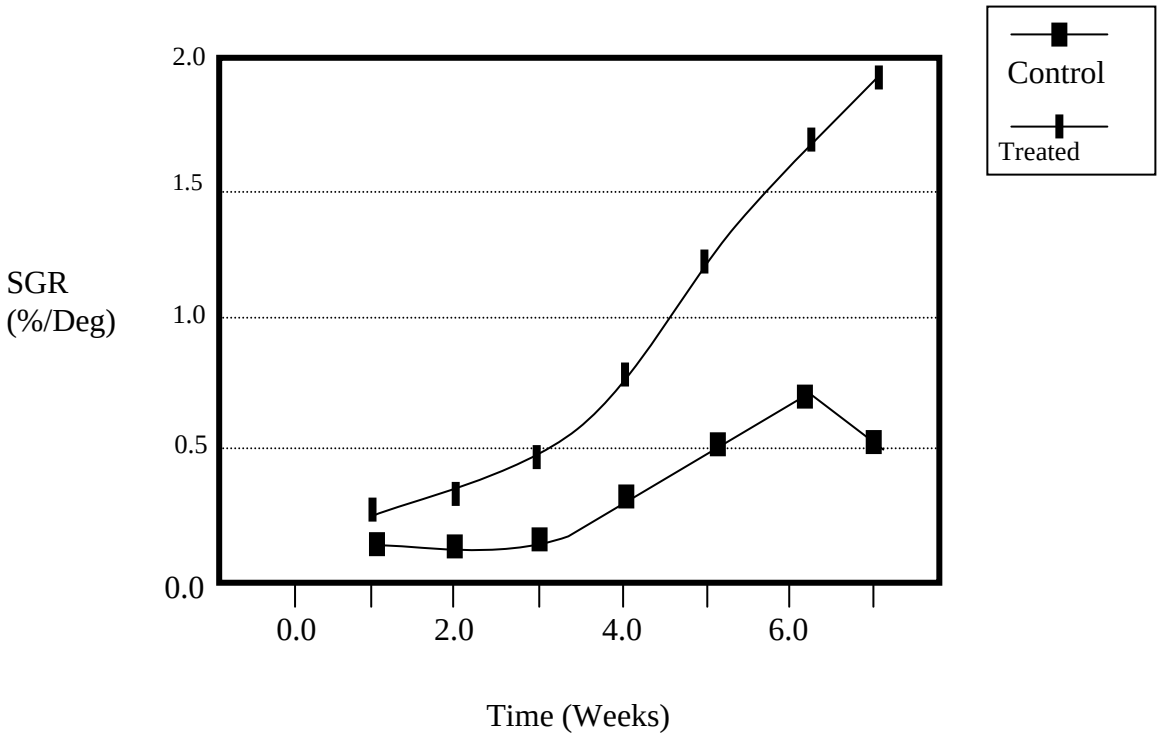

Fig. 2: Specific growth rate of fish (by weight)

week 7 for the control fish; and 1.94142 at week 1 to 19.414 at week 7 for the treated fish. The SGR for length dropped steadily for both control and treated fish after the 2nd week. However, the SGR (length) values for the treated fish was significantly higher (P<O.05) than that of the untreated fish (Fig. 4.6).

4. DISCUSSION AND CONCLUSION

4.1 Proximate Composition

Data on proximate composition revealed that there was no significant difference between the treated and untreated fish groups in all the parameters investigated (protein, fat and moisture). This might have been due to the short duration of the experiments. It is therefore suggested that the experiment be allowed for a minimum of 14 weeks for a probable realization of the full effect of cobalt chloride treatment on the crude protein content. This suggestion is as a result of the fact that cobalt chloride has been stated to enhance the synthesis of muscular protein and assimilation of nitrogen (Sen and Chaterjee, 1976).
However from the results obtained the moisture, protein and fat analysis produce similar values for both the treated and untreated fish groups. These values are normal values obtainable in nature. This is supported by Guh (1991) who stated that the protein content of fish is usually in the region of 13% to 20%. The fat content varies depending on whether the fish has white or red muscles. (FAO, 198l). Most fish contain high proportion of fat, some nearly 20% fat (Guha 1991). Water being the main constituent of fish is typically 80% in lean fish and 70% in fatty fish (FAO, 1981).

4.2 Growth Response

Data presented in this study indicated significant enhancement of growth among the Areated fish groups during the 7-week duration of the feeding trials.
From the weekly values of mean increase in weight and length (table 4.3 and 4.4) it can be seen that there was a generally positive growth response to Cobalt chloride in the treated fish. No dewformation and sudden deaths were observed during the feeding trials showing harmless effect of extra or supplementary concentration of cobalt chloride up to 0.1 mg/kg feed. Kornueva (1976) used cobalt chloride in carp and salmon culture and observed that there was a significantly high growth of the fish. Sen and Chaterjee (1976) also observed significant increase in growth when they fed Indian carp with cobalt chloride incoperated diets.

4.3 Specific Growth Rate (SGR) and Food Conversion Efficiency (FCE)

The mean specific growth rate for length and weight and the FCE of the treated fish groups exceeded those of the control fish groups. Infact, the mean specific growth rate for both length and weight of the treated fish significantly exceeded those of the control fish. The food conversion effiency (FCE) was higher in fish groups fed treated diet though the difference was not statistically significant. This high FCE can be attributed to the presence of cobalt chloride in the experimental diet.

Hammond and Beliles (1980), stated that cobalt chloride is essential in the normal metabolic activities of fishes and that it also enhances the synthesis of muscular protein and assimilation of nitrogen. The chlorine ions found in cobalt chloride are also known to activate digeative enzymes (Lagher, Bardach, Miller and Passino; 1977). Although the FCE of the treated fish was always higher than that of the control fish, there was a drop in the FCE of the control fish groups at the 6th week followed by a drop in the FCE of the treated fish groups at the seventh week. This can be attributed to the fact that, increase in age resulted in a consequent decrease in FCE and that the efficiency of food utilization for growth is higher in the embryo and early larval stages of fish than those in the adult fishes (Sikoki and Eneh) The growth rates by length and weight showed very positive response in the treated fish groups. Anadu; Anozie; and Anthony, A.D; also observed higher growth rates with T. zilli when cobalt chloride incoperated diet were administered to them for 12 weeks. This also suggests that cobalt chloride may be able to sustain higher growth rate for a longer period, beyond the seven weeks given for the feeding trials in the study.

However from the 5th week there was a gradual decline in SGR for length followed by a decrease in the SGR of weight for the control groups on the 7th week. This is likely to be as a result of increase in age, which led to a gradual decrease in food conversion efficiency and growth rate. But even with the decrease observed, the FCE,

specific growth rate and weight and length increment values for the fish groups fed cobalt chloride incoperated diet were higher than the values for the control groups.

4.4 Conclusion

The incorporation of cobalt chloride in fish diet, result in significantly enhancing growth and improving food conversion efficiency, over the untreated *Oreochromis niloticus* fry. This finding will go a long way to improve culturing operations as it will aid in solving the growth problems of the tilapia *Oreochromis niloticus* both in the wild or in the ponds.
The fish can henceforth achieve market - size faster and there will also be a reduce in the cost of production of the fish during culture practice.

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APPENDIX

Appendix 1

Appendix 1a: Formula used for calculating Specific Growth Rate (SGR) is;

$$SGR\ (\%/day) = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$

Where W_1 = Weight at time T_1

W_2 = Weight at time T_2

(After Jauncey and Ross 1982)

Appendix 1b: Formula used for calculating Food conversion Efficiency (FCE) is;

$$F.C.E. = \frac{\text{Weight Gain (gm)}}{\text{Food Intake (gm)}}$$

(After Jauncey and Ross 1982)

Appendix 2

Appendix 2a: Formula used for calculating chi-square values is;

$$X^2 = \sum \frac{(0-E)^2}{E}$$

Where x^2 = chi square

0 = Observed

E = Expected

Appendix 2b: Correlation Coefficient, "r" was calculated using the formula

$$r = \frac{\sum xy - \frac{(\sum x \sum y)}{n}}{\sqrt{(\sum x^2 - \frac{(x)^2}{n}(\sum y^2 - \frac{(\sum y)^2}{n}}}$$

The significance of the r value ($p < 0.05$) was tested using the formula

$$t\ (0.05, n-2df) = r\sqrt{\frac{n-2}{1-r^2}}$$

Appendix 2c: Analysis of Variance Table for Proximate Composition of Fish;

A (Period) ANOVA

Average Moisture Content

Analysis of Variance for AV.%MCT

Source	DF	SS	MS	F	P
WEEK	2	12.333	6.1667	7.40	0.069
Error	3	2.500	0.8333		
	5	14.833	2.9667		

Average Fat

Analysis of Variance for AV.%FAT

Source	DF	SS	MS	F	P
WEEK	2	103.630	51.815	34.78	0.008
Error	3	4.470	1.490		
Total	5	108.100	21.620		

Average Crude Protein

Analysis of Variance for AV.%C.P

Source	DF	SS	MS	F	P
WEEK	2	0.5633	0.2817	0.22	0.811
Error	3	3.7700	1.2567		
Total	5	4.3333	0.8667		

MEANS

WEEK	N	AV.%MCT	AV.%FAT	AV.%C.P
0	2	76.500	18.350	13.250
4	2	75.000	11,700	14.000
7	2	73.000	8.350	13.650

B: Treatment ANOVA

Analysis of Variance for Average % Moisture Content

Source	DF	SS	MS	F	P
TREATMENT	1	1.500	1.500	0.45	0.539
Error	4	13.333	3.333		
Total	5	14.833	2.967		

Analysis of Variance for Average % Fat Content

Source	DF	SS	MS	F	P
TREATMENT	1	0.807	0.8067	0.03	0.871
Error	4	107.293	26.8233		
Total	5	108.100	21.6200		

Analysis of Variance for Average % Crude Protein

Source	DF	SS	MS	F	P
TREATMENT	1	1,707	1,7067	2.60	0.182
Error	4	2.627	0.6567		
Total	5	4.333	0.8667		

MEANS

TREATMENT	N	AV.%MCT	AV.%FAT	AV.%C.P
1	3	74.333	12.433	13.100
2	3	75.333	13.167	14.167

Appendix 2d: Analysis of Variance for Changes in Mean Length (cm)

Weekly Changes in Length (cm)
NUMBER OF CASES:8 NUMBER OF VARIABLES: 2

RANDOMIZED BLOCKS ANOVA

TREATMENT	MEAN	N
1	.798	8
2	1.166	8

BLOCK	MEAN	N
1	.620	2
2	.655	2
3	.705	2
4	.780	2
5	.910	2
6	1.110	2
7	1.390	2
8	1.685	2
GRAND MEAN	.982	16

SOURCE	SUM OF SQUARE	D.F.	MEAN SQAURE	F RATIO	PROB.
TREATMENT	.544	1	.544	8.502	.0225
BLOCK	2.075	7	.296	4.634	.0303
ERROR	.448	7	.064		
TOTAL	3.067	15			

Appendix 2e: Analysis of Variance Table for Changes in Mean Weight (gm)

Weekly changes in mean weight (gm)

NUMBER OF CASES: 8 NUMBER OF VARIABLES: 2

RANDOMIZED BLOCKS ANOVA

TREATMENT	MEANS	N
1	3.260	8
2	3.969	8
BLOCK	3.125	2
1	3.125	2
2	3.275	2
3	3.470	2
4	3.600	2
5	3.710	2
6	3.815	2
7	3.915	2
8	4.005	2
GRAND MEAN	3.614	16

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
TREATMENT	2.009	1	2.009	36.014	5.416E-04
BLOCK	1.336	7	.191	3.421	.0635
ERROR	.391	7	.056		
TOTAL	3.736	15			

Appendix 2f: Correlation between Fish Length and Weight

NUMBER OF CASES: 16 NUMBER OF VARIABLES: 2

	Length	Weight
1	3.00	.59
2	3.25	.65
3	3.10	.61
4	3.45	.70
5	3.22	.64
6	3.72	.77
7	3.28	.69
8	3.92	.87
9	3.32	.77
10	4.10	1.05
11	3.36	.89
12	4.27	1.33
13	3.39	1.05
14	4.44	1.73
15	3.41	1.14
16	4.60	2.23

REGRESSION ANALYSIS

NUMBER OF CASES: 16 NUMBER OF VARIABLES: 2

INDEX	NAME	MEAN	STD.DEV.
1	Length	1.6144	.4991
DEP.VAR.:	Weight	.9819	.4522

DEPENDENT VARIABLE: Weight

VAR.	REGRESSION COEFFICIENT	STD.ERROR	T(DF=14)	PROB.
Length	.7822	.1222	6.401	.00002
CONSTANT	-1.8455			

STD.ERROR OF EST. = .2362

r SQUARED = .7453

r = .8633

ANALYSIS OF VARIANCE TABLE

SQUARE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
REGRESSION	2.2861	1	2.2861	40.972	1.652E-05
RESIDUAL	.7812	14	.0558		
TOTAL	3.0672	15			

Appendix 2g: Analysis of Variance Table for Specific Growth Rate for Length

NUMBER OF CASES: 7 NUMBER OF VARIABLES: 2

RANDOMIZED BLOCKS ANOVA

test analysis for SGR length - cm.

TREATMENT	MEAN	N
1	2.274	7
2	7.488	7

BLOCK	MEAN	N
1	5.824	2
2	7.572	2
3	5.048	2
4	4.271	2
5	4.077	2
6	3.883	2
7	3.495	2
GRAND MEAN	4.881	14

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
TREATMENT	95.155	1	95.155	481.964	5.837E-07
BLOCK	24.187	6	4.031	20.418	9.478E-04
ERROR	1.185	6	.197		
TOTAL	120.526	13			

Appendix 2h: Analysis of Variance Table for Specific Growth Rate by Weight

NUMBER OF CASES: 7 NUMBER OF VARIABLES: 2

RANDOMIZED BLOCKS ANOVA

test analysis for SGR - (%weight per day)

TREATMENT	MEAN	N
1	2.328	7
2	8.764	7

BLOCK	MEAN	N
1	1.359	2
2	1.941	2
3	2.912	2
4	5.048	2
5	7.766	2
6	10.872	2
7	12.425	2
MEAN	6.046	14

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO	PROB.
TREATMENT	103.425	1	103.425	9.086	.0236
BLOCK	233.149	6	38.858	3.414	.0804
ERROR	68.297	6	11.383		
TOTAL	404.871	13			

Appendix 2i: Analysis of Variance Table for Variation in Food Conversion Efficiency

NUMBER OF CASES: 7 NUMBER OF VARIABLES: 2

RANDOMIZED BLOCKS ANOVA

TREATMENT	MEAN	N
1	.100	7
2	.064	7

BLOCK	MEAN	N
1	.016	2
2	.024	2
3	.034	2
4	.053	2
5	.069	2
6	.090	2
7	.288	2
GRAND MEAN	.082	14

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F.RATIO	PROB.
TREATMENT	4.6141E-03	1	4.6141E-03	.350	.5759
BLOCK	.107	6	.018	1.356	.3604
ERROR	.079	6	.013		
TOTAL	.191	13			