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Length-weight relationship and condition factor of Nile tilapia, *Oreochromis niloticus* fed farm-made and commercial tilapia diet

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Abstract
The length-weight relationship and condition factor are important parameters for assessing the growth-pattern, health and general well-being of fish. The length-weight relationship and condition factor of *Oreochromis niloticus* fed with farm-made tilapia diet (ARDECFEED), developed by the Aquaculture Research and Development Centre (ARDEC), Akosombo, Ghana and those of two commercial ones (RAANAN and COPPENS) in hapa-in-pond system for 140 days were investigated. The value of the regression co-efficient *b* obtained for the length-weight relationships suggests an isometric growth of the cultured fish in all the dietary treatments. The condition factor computed for *O. niloticus* in the dietary treatments were 2.01, 1.39 and 1.48 for ARDECFEED, RAANAN and COPPENS respectively. The cultured fish fed both the farm-made and commercial diets were in good condition and healthy. Hence, all the diets will be suitable for commercial production of *O. niloticus*.

Keywords: Commercial and farm-made tilapia diets, condition factor, length-weight relationship, Nile tilapia

1. Introduction
Annual global production of cultured Nile tilapia has continued to increase in most tropical, subtropical and temperate regions due to the fish's favourable culture characteristics [1, 2]. However, inadequate supply of certified quality feed and seed fish (fingerlings) has been a longstanding hurdle to the production of Nile tilapia especially in developing countries [3]. Some farmers have given up fish farming since they run into massive losses after stocking their ponds with low-quality fingerlings coming from poorly conditioned brood stocks in many hatcheries [4].

Knowledge of quantitative aspects such as length-weight relationship, condition factor, growth, recruitment and mortality of fishes are important tools for studying fish biology [5]. Condition factor reflects the physiological state of a fish in relation to its welfare [6], and from nutritional point of view, it indicates accumulation of fat and gonad development [7]. Condition factor also gives information when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source [8].

Poorly conditioned fishes are associated with negative allometric growth, which implies that the fish becomes more slender as it increases in weight whilst fishes with appropriate condition factor have isometric growth, which implies that the fish becomes relatively deeper-bodied as it increases in length. The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds and water quality [9]. Although water quality parameters such as temperature, pH, electrical conductivity and total ammonia are important, dissolved oxygen (DO) is more essential for growth and survival of a fish because it affects fish respiration as well as nitrite and ammonia toxicity [10]. Furthermore, fish are unable to assimilate the food consumed when DO is low [11].

In Ghana, most fish farmers are using commercial fish diets, particularly in intensive cage culture. Most of these diets are imported into the country and their prices are mostly affected by the exchange rate of the local currency (Ghana cedis, GHS) to the US dollar. Although, there is a major local producing company of commercial fish diets by brand name *Raanan*, its products are not easily affordable to farmers either, particularly small-scale fish producers. Hence, majority of these farmers have folded up. In an effort to support small-scale pond fish

farmers to remain in the fish farm business, the Aquaculture Research and Development Centre (ARDEC) of the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) has developed a farm-made grower tilapia diet known as ARDECFEED, using locally available ingredients.

Most commercial fish farmers, especially in developing countries do not relate the significance of fish condition factor to quality of diet fish is fed with. Although, the length-weight relationship and feeding habits of tilapia have been studied [10], this information is largely lacking in cultured *O. niloticus* fed with different diet types in Ghana. Hence, the current study was aimed at generating information on the length-weight relationship and the condition factor of *O. niloticus* fed with ARDECFEED and two commonly used commercial tilapia diets (RAANAN and COPPENS) in Ghana, with a view of determining whether all the diets are suitable for commercial production of *O. niloticus*, the most cultured fish in Ghana[12].

2. Materials and Methods

2.1. Study Area

This study was carried out at the Aquaculture Research and Development Centre (ARDEC) of Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR), Ghana (6^0 13′ N; 0^0 4′ E) at Akosombo in the Eastern Region of Ghana.

2.2. Experimental system

Fish growth study was carried out in nine 5.0 x 2.0 x 1.2 m (i.e. length, width and height) mosquito netting hapas mounted in a 0.2 hectare earthen pond at ARDEC, Akosombo. The hapas were suspended to bamboo poles by means of nylon twine and the former were inserted in the bed of the pond. A monofilament nylon gill net of stretched mesh size 30.0 mm was sewn over the hapas as a cover and an opening was left at one end of the 2 m side so as to allow input and collection of fish during stocking, measurements and harvest. The cover net was to keep predatory birds from injuring or picking the experimental fish and also to prevent the fish from jumping out as they grow bigger. The pond was supplied with water from the Volta Lake to a mean height of about 1.4 ± 0.2 m.

Each hapa was separated from others by about 6 m distance to avoid easy drifting of contents of one system into another. About two-thirds (0.8 m) of the hapa heights were constantly submerged in the pond water by ensuring periodic topping up of the water when the level fell due mainly to evaporation and seepage.

2.3. Fish Culture

The ninth generation of monosex male *O. niloticus* known as the "Akosombo Strain" developed by CSIR-WRI at ARDEC, Akosombo through selective breeding was used in the study. The fish, with an initial mean weight of 22.8 ± 2.1 g were randomly divided into three groups of 20 fish (three treatments in triplicate) and stocked in the hapas, each of operational volume of about 8.0 m^3 at a density of 2 fish m^{-2} and fed at 4-3% body weight three times a day (8, 12 and 16 h) under three different dietary treatments. The diets were a farm-made type (ARDECFEED) produced at ARDEC, and two commonly used commercial tilapia diets in Ghana namely RAANAN and COPPENS for a 140-day growth period.

2.4. Fish Growth and Measurements

The standard length, total length and weight of all the fish in each hapa under each dietary treatment were measured fortnightly using fish measuring board (0.1 cm) and digital weighing balance (0.1 g) respectively. A bamboo pole was used at the opposite sides of the longer side of each hapa, starting from the bottom of the sewn end of the cover; the pole was drawn to confine the fish at the open end of the cover. All the fish were then netted and put into a large bowl containing pond water. The hapas were cleaned with pond water to ensure water circulation. The total number of fish was recorded. Each fish was gently blotted on a soft towel so as to remove excess water from the body. Then the standard length and total length were measured followed by the weight. Each fish was then returned into a bowl containing fresh pond water. After measuring the lengths and weights of all the fish in each hapa, they were put back into their respective hapas. The day after the 140 days, all the fish from each treatment was harvested, counted and measured individually to determine the final growth and survival.

2.5. Water Quality Parameters

Dissolved oxygen (DO), temperature and total ammonia were measured biweekly throughout the culture period. DO was measured with oxygen meter (YIS Environmental model no: DO 200) and pH with a pH meter (HANNA model no: HI 98128).water temperature was measured with a thermometer whilst total ammonia was measured using the direct nesslerization method.

2.6. Data Analysis

Length-weight relationships were calculated using the equation $W = aL^b$ [13]. The biweekly mean weight values obtained for each dietary treatment were considered as representatives of the various diets. The relationships between the length and weight of *O. niloticus* in each dietary treatment were calculated by the least squares method applied to the log transformed data for ARDECFEED, RAANAN and COPPENS diet as: $\log W = \log a + b \log L$, where 'W' is the body weight of the fish in grams, 'L' is the total length of the fish in centimetres, 'a' is the intercept of the regression curve and 'b' is the regression coefficient. Condition factor (K) was computed applying the formula: $K = 100W/L^3$ [14].

3. Results

3.1. Length-Weight Relationship and Condition Factor

The results of the length-weight analysis at the end of the experiment are presented in table 1. The mean standard length of *O. niloticus* fed with ARDECFEED was 162.6 ± 8.9 cm whilst the mean weight was 140.3 ± 23.4 g. The mean standard length and weight of *O. niloticus* fed with RAANAN were 177.6 ± 13.7 cm and 187.6 ± 42.1 g respectively whilst those fed with COPPENS were 165.3 ± 8.7 cm and 148.3 ± 25.4 g respectively. The length-weight relationship among pairs of plotted data, determination coefficient values and the corresponding equations are demonstrated in Figures 1, 2 and 3 for ARDECFEED, RAANAN and COPPENS respectively.

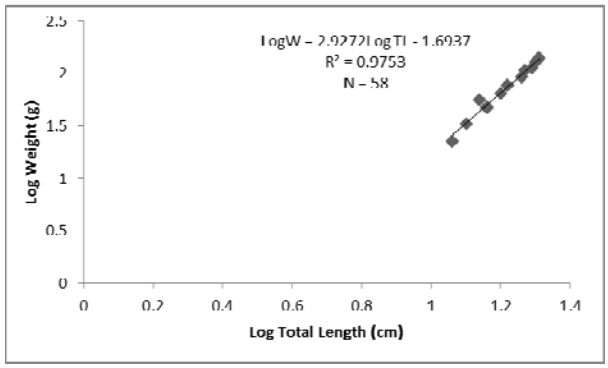

Fig 1: Length-Weight relationship of *O. niloticus* fed with ARDECFEED

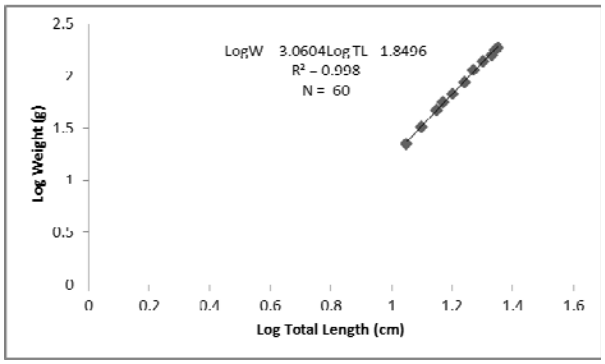

Fig 2: Length-Weight relationship of *O. niloticus* fed with RAANAN

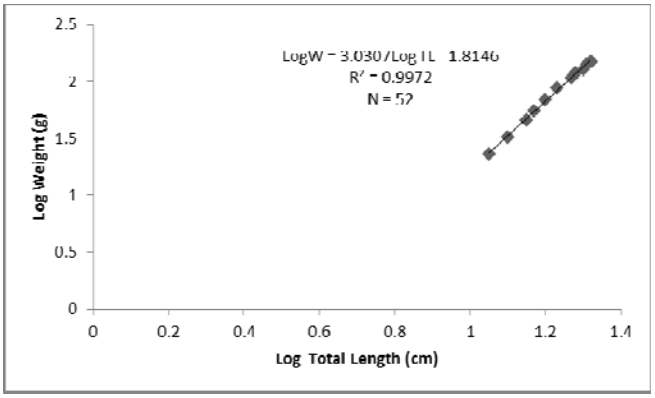

Fig 3: Length-Weight relationship of *O. niloticus* fed with COPPENS

Table 1: Length-weight relationship, regression coefficient and condition factor parameters of *O. niloticus* fed with ARDECFEED, RAANAN and COPPENS

Diet	N	Mean Length (±SD) (cm)		Mean Weight (±SD) (g)		a	b	K
		Initial	Final	Initial	Final			
ARDECFEED	58	11.4 ± 0.7	20.5 ± 23.4	23.0 ± 2.0	140.3 ± 23.4	-1.70	2.9	2.01
RAANAN	60	11.3 ± 0.5	22.4 ± 42.1	22.6 ± 2.3	187.6 ± 42.1	-1.85	3.1	1.39
COPPENS	52	11.3 ± 0.5	20.9 ± 25.4	22.7 ± 1.9	148.3 ± 25.4	-1.81	3.0	1.48

3.2. Water Quality Analyses

The range and mean values obtained for the selected water quality parameters for the various dietary treatments are shown in Table 2. Temperature ranged from 27.58 to 29.83, DO ranged from 3.50 to 5.40, pH ranged from 6.95 to 7.47, Nitrite ranged from 0.001 to 0.111, Total Ammonia ranged from 0.51 to 0.61 and Alkalinity from 52.0 to 73.0. The mean values were 28.90 ± 0.02, 4.53 ± 0.15, 7.22 ± 0.05, 0.008 ± 0.003, 0.35 ± 0.01 and 61.0 ± 0.08 for Temperature, DO, pH, Nitrite, Total Ammonia and Alkalinity respectively. There were no significant differences (ANOVA, $p > 0.05$) among water quality parameters within and among the various dietary treatments.

Table 2: Range and mean values (± Standard Deviation) of water quality parameters recorded in the various dietary treatments during the period of study

Parameter	Range	Mean (± SD)
Temperature	27.58-29.83	28.90 ± 0.02
DO	3.50-5.40	4.53 ± 0.15
pH	6.95-7.47	7.22 ± 0.05
Nitrite	0.001-0.111	0.008 ± 0.003
Total ammonia	0.51-0.61	0.35 ± 0.01
Alkalinity	52.0-73.0	61.0 ± 0.8

4. Discussion

4.1. Length-Weight Relationship

Length-weight relationship of fish varies depending upon the condition of life in aquatic environment and it is an important tool that gives information on growth and its pattern of animals [6]. The present work revealed that *O. niloticus* followed the cube law completely in all the dietary treatments. Statistical analysis of the length-weight relationship showed that *O. niloticus* fed both the farm-made and commercial diets showed isometric growth. The values of *b* in this study were 2.9, 3.1 and 3.0 for fish fed with ARDECFEED, RAANAN and COPPENS respectively. These values were within the range of 2 - 4 recommended as appropriate for fresh water fishes and an ideal fish maintain the shape $b = 3$ [8, 15-17]. These results are comparable with the findings of other researchers who worked on other species of tilapia. Values of 2.7-3.0 were recorded for *O. urolepis* in fresh water floodplain lakes in Ruwe ponds [18], whilst 2.7 and 3.2 were observed in *T. zillii* for wet and dry seasons respectively [19]. The values of *b* obtained by these researchers are in agreement with the findings of this study. Values of *b* above 3 are possible in some conditions such as stress free environments [20]. The length-weight relationship was found to be in a linear form conforming to the general formula expressing the relationship between the length and weight of fishes.

4.2. Condition Factor of the Cultured *O. niloticus*

The condition factor (K) of *O. niloticus* fed with ARDECFEED, RAANAN and COPPENS were 2.01, 1.39 and 1.48 respectively. The *K* values of *O. niloticus* in all the dietary treatments were greater than 1. A condition factor higher than 1.0 suggests good fish health condition and indicates an isometric growth, which is desirable in fish farming [21]. There may be differences in the condition factor due to sex [10]. This was not applicable to the results of the present study as monosex male *O. niloticus* were utilized in all the dietary treatments. The fish from all the treatments were in good condition and healthy. This suggests that all the fish diets used in this study will be suitable for commercial production of *O. niloticus*.

4.3. Water Quality Parameters

There were no significant differences (ANOVA, $p > 0.05$) in water quality parameters among the production hapas and all recorded values were within the desired ranges for tilapia. The good water quality parameters recorded in all the dietary treatments coupled with food availability and feeding characteristics could account for the high *b* values obtained in the present study.

5. Conclusion

The length –weight relationship and condition factor values of *O. niloticus* in this study indicate isometric growth. Hence, the cultured *O. niloticus* using ARDECFEED, RAANAN and COPPENS were in good condition and healthy, and all the diets will be suitable for the commercial production of *O. niloticus*.

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