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Sex - dependent condition factor and index of preponderance of *Oreochromis andersonii* (Castelnau, 1861) Fed with artificial feed in fertilized ponds

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Abstract
A study was conducted to determine sex – dependent index of preponderance and condition factor of *Oreochromis andersonii* in fertilized fish ponds. Fish (0.52±0.093g; mean ± SD) were stocked in semi – concrete ponds at 4 fish/m^2 and were allowed to grow for 281 days. There was a negative allometry for both sexes since the 'b' factor was lower than 3 although females' (3.773±0.069) coefficient of condition (K) was significantly (P<0.05) lower than that of males (3.972±0.040). *Oreochromis andersonii* females showed a logarithmic relationship between the heart (y = 0.037ln(x) - 0.0836; R^2 = 0.407; P<0.05) and liver (y = 0.2214ln(x) - 0.1756; R^2 = 0.317; P<0.05) weights and body weight while in males there were linear relationship for both heart (y = 0.0213 + 0.0009x; R^2= 0.406, P<0.05), and liver (y = 0.0459 + 0.0097x; R^2= 0.40, P<0.05). A power relationship was observed between length – weight relationship for both sexes (female = y = 0.0001x$^{2.7672}$; R^2 = 0.943; P<0.05 and male = y = 0.0001x$^{2.7628}$; R^2 = 0.972; P<0.05). Stomach analysis revealed a higher index of preponderance for artificial feeds in males (55.73%) than females (52.52%). Females (47.48%) selected natural foods more than the males (44.27%) fish. However, the male (2.199±0.139%) fish had a significantly higher Relative Stomach Weight than females (1.592±0.147%). Growth indices favored males with both Specific Growth Rate (2.228±0.01% day^{-1}) and Body Weight Gain (157.589±3.422g) being significantly (P<0.05) higher than those of females (SGR % day^{-1}= 2.11±0.014; BWG = 117.804±3.987g). The culture of *O. andersonii* males should be promoted since they consume more of natural feeds and grow faster than the females. In rationing the feed, 2.2% of the total body weight should be considered for males production while 2.0% in mixed sex production at every feeding.

Keywords: Coefficient of condition, index of preponderance, *O. andersonii*, sex, growth

1. Introduction
Oreochromis andersonii (*Cichlidae*) is the most important indigenous fish species grown in Zambia. Its use estimated at 30.6% of the total production is just behind the exotic *O. niloticus* [1]. Probably this signifies the recent attention for this fish species in aquaculture research [2, 3]. However, it remains one of the species requiring further researches targeted at commercial traits. Feed is the essential input for culture of any aquatic species [4] as it accounts up to 60% of the total operational cost [5, 6]. The continuous increase in the cost of fish feed ingredients coupled with competition from the livestock industry even pose major production challenges in the future.

Although the culture of *O. andersonii* has been going on for decades in the country, several aquaculture practices including feeding regimes used are based on findings of other similar fish species such as *O. niloticus*. However, it is important to note that for a successful culture operation of any species, a good understanding of its food and feeding habits is an important pre-requisite in exploiting optimal feeding regimes. Understanding the food preferences of fish, gives an opportunity to direct effort in developing the feeds and rations that mostly suits the fish species in question.

The relative robustness, or degree of well-being, of a fish is expressed by "coefficient of condition" (also known as condition factor, or length-weight factor) which is a measure of various ecological and biological factors of the fish [7]. Although it is not sensitive, it is a very practical tool for fisheries and aquaculture biologists and managers to gauge the overall health of fish population [8]. Variations in a fish's coefficient of condition primarily reflect state of sexual maturity and degree of nourishment [9]. Therefore, it has been used to determine the physiological status of the fish and to identify possible variations between the units of stocks of the same fish species [10]. Furthermore, it can be used to compare population of fish living in the same feeding, climate and other conditions [11, 12, 10]. However, condition values may also vary with fish age, and in some species, with sex [9]. Although, there are some studies on length – weight relation of cichlids [13, 14], there has been no attempt to study the physiological and morphological parameters between sexes of *O. andersonii* using the condition factor or length – weight relationship.

Gross indices such as hepato - somatic index or liver index (HSI) have been utilized as useful biomarkers to detect hazardous effects of the environmental stressors [15]. Therefore, it can be used as an indicator of fish health. Liver index is also an important coefficient in assessing the food value [10]. In their study they found increased HSI values due to increased dietary maltose levels.

This study investigated the amount of artificial feed consumed in relation to the natural foods found in fertilized fish pond. An attempt was made to identify the most preferred food between artificial feed and other food items by *O. andersonii* using a composite index called 'index of preponderance' which is based on both volume and occurrence of the food [16]. Furthermore, the length – weight relationship together with HSI and cardio-somatic indices (CSI) have been applied to determine the differences that may occur between the sexes of *O. andersonii* fed on the artificial feed to determine the value of the preferred food. Furthermore, the study investigated the growth differences between males and females.

2. Materials and Method

Four semi – concrete fish ponds (250m^2) were prepared by draining them completely. They were allowed to crack on the bottom and any pool of water was removed completely. Eight feeding tables measuring 1m x 1m were constructed and were erected in two ponds selected randomly with each pond having four feeding tables. The tables were located in all the corners and were 40 cm and 60cm from the bottom of the pond at the shallow end and deeper end respectively.

Soil samples were collected from all the ponds the upper, middle and deeper end of the pond and pH was determined using nitrophenal method. Hydrated lime ($Ca(OH)_2$ was applied at 0.1kg/m^2 by sprinkling in on the top of the bottom of the pond. Chemical fertilizer (D – compound) was applied at 5g/m^2 by putting the fertilizer in the sack suspended in the water. The ponds were filled with water up to 20 cm marks above the feeding tables. After seven days, the ponds were stocked with *O. andersonii* (0.52±0.093g; mean ± SD, standard deviation) at 4 fish/m^2. The experiment was terminated after 281 days.

Proximate analyses of the ingredients (soya bean and maize) were conducted according to AOAC [17] procedures. A 30% crude protein and 10% crude lipid was formulated using the Win Feed 2.8 (UK limited) software package. The formulated diet was used to feed the fish throughout the experiment based on 3% of the total fish live weight adjusted monthly after fish sampling. Fish was fed twice a day at 10 and 15 hours except on Sundays.

Table 1: Proximate analysis of the feed ingredients

Ingredient	Inclusion level (%)
Soya bean	56.41
Maize meal	40.79
Soya Gold oil	0.8
Vitamin C	1
*DCP	1
Analysis	
Dry matter (%)	89.206
Crude fibre (%)	6.841
Ash (%)	3.994
Crude fat (%)	10
Crude protein (%)	30
Carbohydrates (%)	39.169
Energy (Kcal/100g)	366.814

*Dicalcium phosphate ($CaHPO_4$)

Selected water quality parameters (water temperature, pH, nitrates and electrical conductivity) were collected using water checker (YSI) twice a week. The mean water temperature, pH, nitrates and conductivity were 21.1ºC, 6.4, 0.01 mg/L and 105.7µS/cm respectively during the experimental period.

At every sampling 10 fish (5 males and 5 females) were randomly sampled from the fish ponds and preserved in 10% formalin 30 minutes immediately after feeding. This was done in order to minimize the digestion of the feed and allow a good representation of the artificial feed consumed. At termination of the experiment, preserved fish were cleaned in water for 30 minutes to remove formalin and were dissected for the recovery of the gonads, liver, heart and stomach. The extracted organs and gonads were weighed on a digital Citizen analytical balance. Fish were also weighed and its standard length measured according to the procedure described by Skelton [18].

The stomach was emptied and its contents placed on a petri dish for the identification of the food on the Olympus microscope [19]. A sample of the feed was collected from the Petri dish and placed on a slide before a drop of water was added and then covered with a cover slip so as to identify different feed items found in the stomach. The type of feed (artificial feed or plankton) was recorded. The remainder of the feed in the petri dish was then put in a graduated measuring cylinder for its volumetric estimation after allowing the contents to settle for 5 minutes. In total 160 stomachs were observed.

2.1 Data analysis

In order to study the diet composition of *O. andersonii* in a fish pond, the following indices and methods were employed: Vacuity index (%), VI = 100*(number of empty stomachs/number of stomachs examined) and Percentage occurrence (O) = 100*(number of stomachs with artificial feed or plankton/number of stomachs examined). For evaluating the importance of all food items, the 'index of preponderance (IP)' method was employed; IP = (Vi*Oi/∑Vi*Oi)*100, Where, IP = Index of preponderance, Vi and Oi represent the percentage volume and occurrence of particular item of food (i) respectively.

Organ indices were also calculated: Gonadosomatic index (GSI) = ((weight of gonads (g)/weight of fish (g))*100), CSI = ((weight of heart (g)/weight of fish (g))*100), HSI = ((weight of liver (g)/weight of fish (g))*100) and Relative Weight Stomach (RSW %) = (weight of stomach (g)/weight of fish (g))*100). Furthermore, a condition factor (K) = ((weight of fish (g)/ (Standard length (mm))^3*100,000) was calculated too. Length – weight relationship was analysed by plotting the standard length (mm) on fish weight (g) and then applying a polynomial regression to determine the best fit.

In addition, the following growth indices were calculated: Body weight gain = final weight of fish-initial weight of fish and Specific growth rate (SGR(%day^{-1})) = ((*lnWf* - *lnWi)*/*t*)*100 where *lnWf* is the natural logarithm of final body weight, *lnWi* is the natural logarithm of initial body weight of the fish and *t* is the period of the experiment in days.

To compare growth, condition factor, GSI, CSI and HSI between the females and males, Independent sample T - test was employed. Before analysis, data were tested for normality using Shapiro – Wilk test and the homogeneity of variance using Levene's test for Equality of Variances. If significant (P<0.05) equal variances not assumed was used.

Correlation analyses were conducted to determine the direction and strength of the relationship between the organ measurements and fish weight. Regression analyses were performed only if the coefficient of correlation (r) was > 0.5.

Statistical Package for Social Scientist (SPSS) 15.0 (SPSS Inc) software was used for analysing the data. Microsoft excel was used in the production of figures and graphs. Untransformed data are presented to facilitate interpretation.

3. Results

Females had significantly higher (P<0.05) GSI than males while the HSI and CSI were not significantly different (P>0.05). Males were heavier for their length than females and the difference was significant (P<0.05). Females had a significant (P<0.05) lower RWS% than that of males (Table 2).

Oreochromis andersonii males showed stronger growth indices compared to female counterparts with both body weight gain and specific growth rate (SGR%day^{-1}) being significantly (P<0.05) higher for the former than the latter sex (Table 2).

Table 2: Reproductive and organ indices according to sex (mean ± SE)

Parameter	Females	Males	Combined
GSI (%)	0.941±0.0117^b	0.095±0.01^a	0.442±0.059
HSI (%)	1.070±0.055	0.942±0.041	0.992±0.0.033
CSI (%)	0.122±0.005	0.141±0.010	0.133±0.007
K	3.773±0.069^a	3.972±0.040^b	3.892+0.037
RSW (%)	1.592±0.147^a	2.199±0.139^b	1.960±1.310
Body weight gain (g)	117.804±3.987^a	157.589±3.422^b	141.387±2.924
SGR (%day^{-1})	2.11±0.014^a	2.228±0.01^b	2.181±0.009

Parameters with different superscript in a row for segregated sex are significant (P<0.05).

Correlation analyses showed a weak positive relationship between fish weight and amount of feed eaten for both males (r = 0.286, P<0.05) and females (r = 0.310, P<0.05). Due to a lower correlation coefficient, no regression analysis was performed. Fish weight was positively correlated with heart (females = 0.614, males = 0.57) and liver (females r = 0.67, males = 0.78) with bigger fish associated with bigger heart and liver.

Polynomial regression showed a logarithmic relationship for both heart (y= 0.037ln(x) - 0.0836; r = 0.64, P<0.05) and liver (y = 0.2214ln(x) – 0.1756, r = 0.56, P<0.05) and fish weight for females (Figures 1 and 2). However, males showed a linear relationship between fish heart (y = 0.0009x + 0.0213; r = 0.64, P<0.05) and liver (y = 0.0097x + 0.0459; r = 0.63, P<0.05) weights and fish weight (Figures 3 and 4).

Similarly, the amount of feed taken was strongly positively correlated with the weight of the stomach for both sexes (females = 0.866, P<0.05) with increased feed intake associated with increased weight of the stomach. Therefore, regression analyses were performed. Male fish showed a strong positive relationship with gonadal weight (r = 0.661, P<0.05). Females weight showed a weak positive relationship with gonad (r = 0.177, P>0.05).

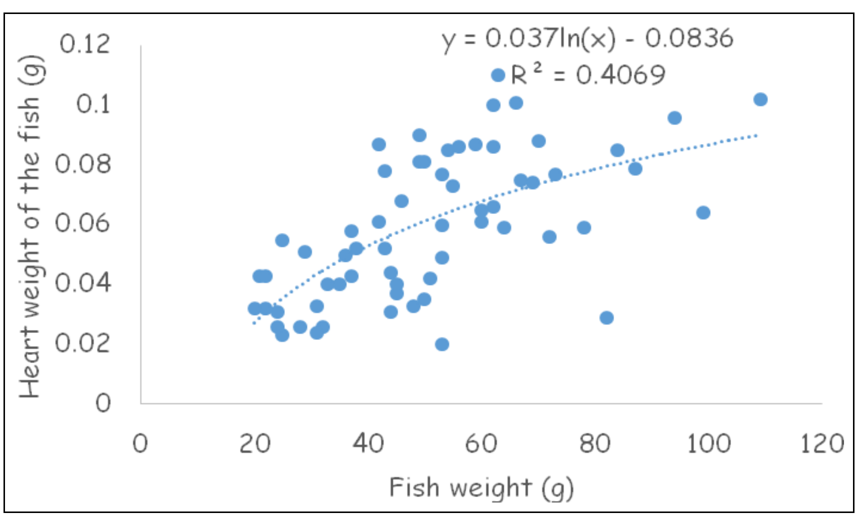

Fig 1: Relationship between the heart weight and fish weight in *O. andersonii* females

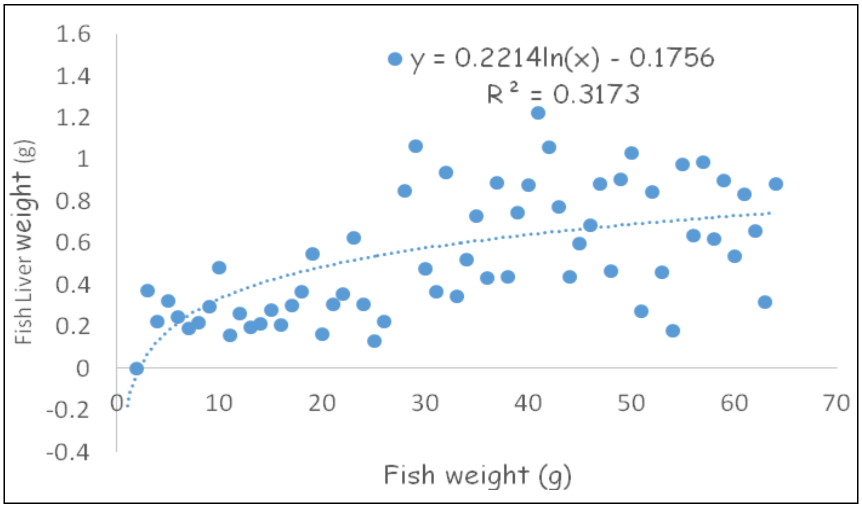

Fig 2: Relationship between the liver weight and fish weight in *O. andersonii* females

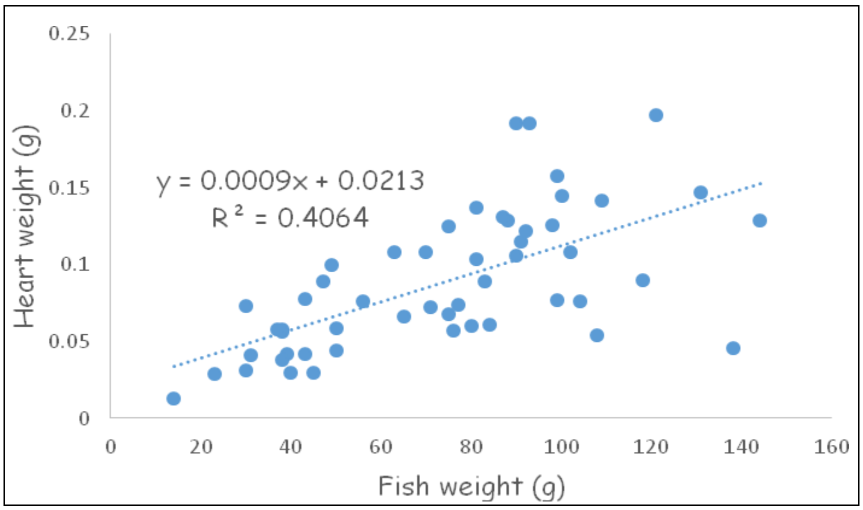

Fig 3: Relationship between the heart weight and fish weight in *O. andersonii* males

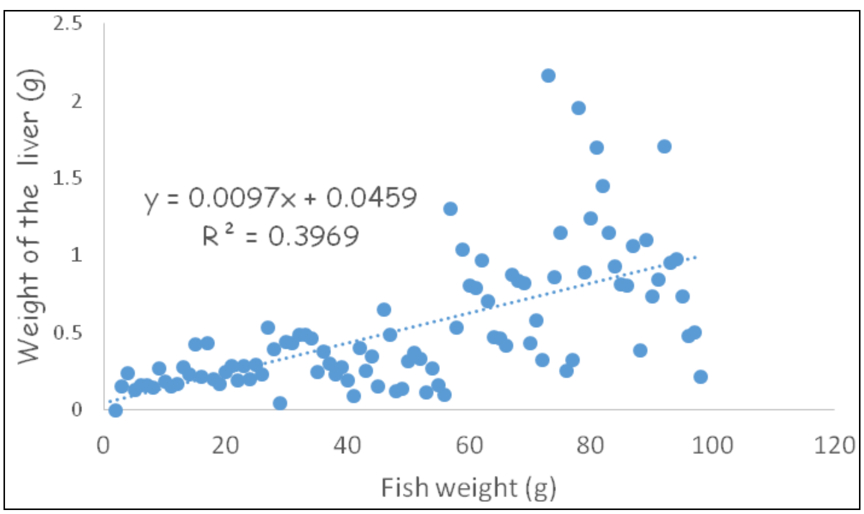

Fig 4: Relationship between the liver weight and fish weight in *O. andersonii* males

A power relationship was observed between the length – weight for both sexes (female = $y = 0.0001x^{2.7672}$; $R^2 = 0.943$; $P<0.05$ and male = $y = 0.0001x^{2.7628}$; $R^2 = 0.972$; $P<0.05$) (Figures 5 and 6).

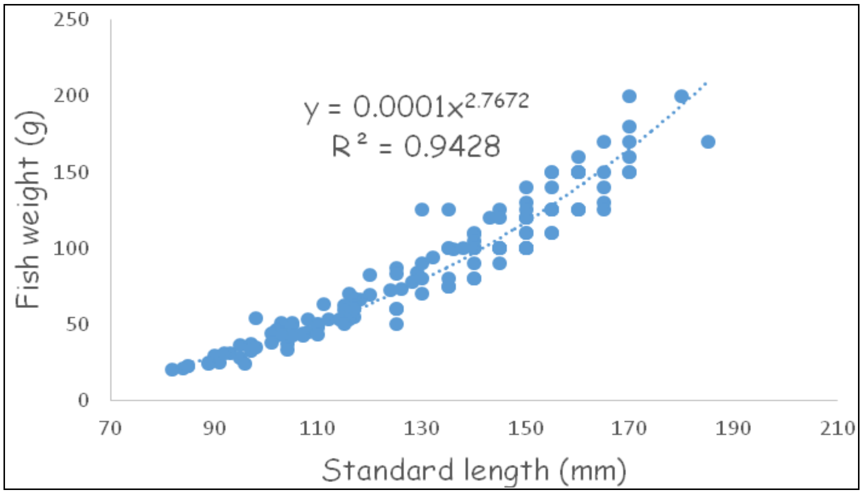

Fig 5: Length –weight relationship of the female *O. andersonii*

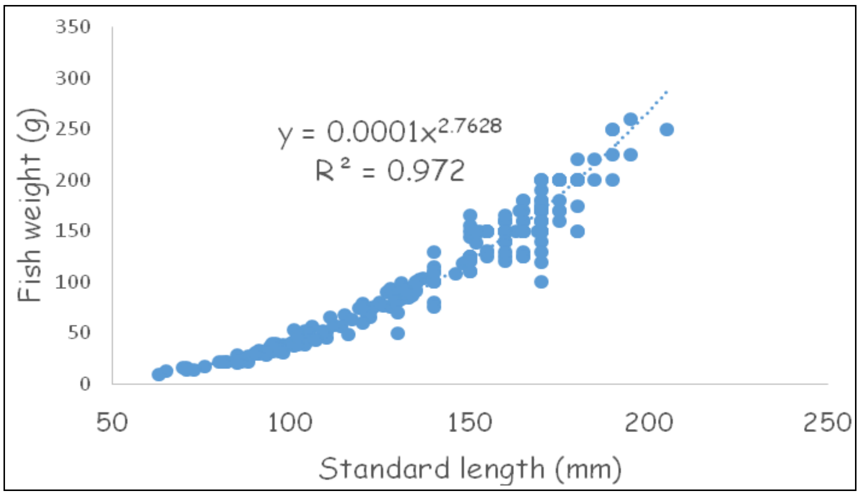

Fig 6: Length –weight relationship of the male *O. andersonii*

The index of preponderance showed that *O. andersonii* selected more artificial feed than natural feed. However, males selected more of the artificial feed (55.73%) than the females (52.52%) while the natural food was more preferred by females (47.48%) than males (44.27%) (Table 3).

4. Discussions

Knowledge of some quantitative aspects such as HSI in fishes is an important tool for the study of biological fundamentals, because measurement and analysis of these indices are very important in assessing food value or physiological status [20, 10]. Indirect indices such as condition factor assess the external health status of the fish. In the current study the HSI and CSI for both sexes did not differ significantly (P<0.05). However, the HSI values for female fish were higher than that of the male fish. This means that the livers for female fish were bigger than that of the male fish relative to their body sizes. One of the reasons for this could be due to the nutritional value of the food consumed by the fish. Ahmed *et al*. [21] found an increased levels of dietary carbohydrates resulted in an increased HSI values of *Cyprinus carpio communis.* This is because excess carbohydrates get deposited on the liver. On the contrary, Nandeesha *et al*. [22] found a lower HSI values on *C. carpio* fed with high levels of dietary protein. In the current experiment, the female fish consumed more of the natural food and less of the artificial feed than those of the males.

The K differed with males recording a significantly higher value than the females despite both showing positive allometry (K > 3), meaning fish became relatively stouter or deeper-bodied as they increased in length. When condition factor value is higher it means that fish has attained a better condition [14]. From the current experiment we can deduce that males tended to be in a better condition than females since the condition factor was significantly higher in the former than the latter sex.

A logarithmic relationship was observed in female fish weight, and liver and heart weight while a linear relationship was seen in males. The variance could be attributed to the reproductive growth in females as they mature early. The GSI was significantly higher in females than males for females. In the present study, there was a weak relationship between the fish weight and GSI while a strong positive correlation was found in males indicating a delay in maturity in males. There is evidence that *O. andersonii* females mature earlier than their males [23]. This probably is a reason why the heart and liver seem to grow disproportionately to fish weight later in life for females. This also shows that modelling of the quantitative measurements in this fish species should be done according to sex.

The length – weight relationship showed a power relation similar to that equation ($W = aL^b$ where w = weight of fish (g), L = Standard length (mm), a = rate of change of weight with length intercept and b = weight at unit length which is the slope) described by Pauly [24] on explaining the relationship between the standard length and weight. However, the component 'b' for both sexes was less than 3 meaning that there was a negative allomentry in both sexes [14]. The 'b' factors determined are not the same as those for K. This is expected as other authors [25] indicated that K is not a real representation of the length – weight relationship for a number of fish species. The disparity between K and 'b' was also observed by Nehemia *et al.* [14].

Males ate and preferred more artificial feed than the females while the opposite was observed with natural foods. This is because the index of preponderance was higher in males (55.73%) than females (52.52%) for artificial feed. However, females (47.48%) consumed more of the natural food than the males (44.27%). From an aquaculture point of view, male *O. andersonii* is preferable because of the utilization of the provided artificial feeds although females would benefit more from natural food as a result of fertilization than the males. This is because the objective of feeding fish is to provide all the necessary nutrients for optimal growth. Since the feed accounts for up to 60% of the operational cost it is imperative that the feeds being administered are consumed by the fish so as to utilize the nutrients in the feed efficiently. However, the RSW (%) also favoured males since they could consume up to 2.2% compared to females (1.6%) with this being significant ($P<0.05$). This means that males can eat up to 2.2% of the total body weight compared to females 1.6%. This probably gives another environmental pointer why males performs better in terms of growth. Therefore, feeding regimes should be tailored to sex as males eat more than females. This scenario was also observed by Barreto *et al.* [26] in *O. niloticus* where male fish had an increased feed intake after fasting.

In most tilapiine species males grow faster and bigger than females. This sex dirmophism has been observed in *O. mossambicus* [27] and *O. niloticus* [26, 28, 29]. The same has been observed in the current experiment on *O. andersonii* with males exhibiting higher SGR (%day^{-1}) and body weight gain of about 25% superiority. This justifies the need to culture males only in this species if productivity has to be positively exploited.

5. Conclusion

Under artificial feeding condition male *O. andersonii* tend to be in a better condition than the female species. Furthermore, the study clearly shows that the males consume larger quantities of artificial feeds than their female counterparts. However, the female *O. andersonii* consume more of natural food than the males. In rationing the feed, 2.2% of the total body weight should be considered in male's production while 2.0% in mixed sex production at every feeding. The present study clearly provides evidence of sex dimorphism in *O. andersonii* under culture conditions. Males were superior (25%) in growth compared to females, probably due to a higher intake of artificial feed, apart from a genetic superiority.

6. Acknowledgement

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7. References

1. Department of Fisheries. Fisheries Department Annual Report for 2012. DOF, Chilanga, Zambia., 2013.
2. Bbole I, Katongo C, Deines AM, Shumba O, Lodge DM. Hybridisation between non – indigenous *Oreochromis niloticus* and *Oreochromis* species in the lower Kafue River and its potential impacts on fishery. Journal of ecology and Natural Environment. 2014; 6:215-225.
3. Deines AM, Bbole I, Katongo C, Feder JL, Lodge DM. Hybridisation between native *Oreochromis* species and introduced Nile tilapia *O. niloticus* in the Kafue River, Zambia. African Journal of Aquatic Science. 2014, 1-12.
4. Baskar S, Narasimhan N, Swamidass GD, Ravichelvan R, Sukumaran M, Anandaraj T. Food and Feeding Habits of *Penaeus monodon* (Fabricius) from Mallipattinam Coast in Thanjavur District, Tamil Nadu, India. International Journal of Research in Biological Sciences. 2013; 3:1-4.
5. Virk P, Saxena PK. Potential of Amaranthus seeds in supplementary feed and its impact on growth in some carps. Bioresource Technology 2003; 86:25-27.
6. Madalla N. Novel Feed Ingredients for Nile Tilapia (*Oreochromis niloticus* L.). PhD Thesis, Institute of Aquaculture, University of Stirling, Stirling, Scotland, 2008.
7. Mac Gregoer JS. Relation between fish condition and population size in the sardine (*Sardinops cacrulea*). U.S. Fishery Wild Service, Fish Bulletin 1959; 60:215-230.
8. Lenhardt M, Jarić I, Cakić P, Cvijanović G, Gačić Z, Kolarević J *et al.* Seasonal changes in condition, hepatosomatic index and parasitism in sterlet (*Acipenser ruthenus L.*). Turkish Journal of Veterinary and Animal Science. 2009; 33:209-214.
9. Williams JE. The Coefficient of Condition of Fish. Manual of Fisheries Survey Methods II., 2000.
10. Ighwela KA, Ahmad AB, Abol – Munafi AB. The selection of viscerosomatic and hepatosomatic indices for the measurement and analysis of *Oreochromis niloticus* condition fed with varying dietary maltose levels. International Journal of Fauna and Biological Studies. 2014; 1:18-20.
11. Oni SK, Olayemi JY, Adegboye, JD. The comparative physiology of three ecologically (Rupel). *Synodonts schall*. Block and Schneider and *Tilapia zilli* (Gervais). Journal of Fish Biology. 1983; 22:105-109.
12. Lizana MDLAP, Ambrosia, AM. Condition factor in nine species of fish of the Characidae family in the Upper Parana River floodplain, Brazil. Journal of Biology. 2002; 62:113-124.
13. Anene A. Condition factor of four Cichlid species of a man-made Lake in Imo State, Southeastern Nigeria. Turkish Journal of Fisheries and Aquatic Sciences 2005; 5:43-47.
14. Nehemia A, Maganira JD, Rumisha C. Length-Weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. Agriculture and Biology Journal of North America. 2012; 3:117-124.
15. Sadekarpawar S, Parik P. Gonadosomatic and

Hepatosomatic indices of freshwater fish *Oreochromis mossambicus* in response to plant nutrient. World Jornal of Zoology. 2013; 8:110-118.
16. Natarajan AV, Jhingran AV. Index of preponderance—a method of grading the food elements in the stomach analysis of fishes. Indian Journal of Fisheries. 1961; 8:54-59.
17. AOAC (Association of Official Analytical Chemists). Methods of Analysis of the Association of Official Analytical Chemists. Association of Official Analytical Chemists, Inc., Arlington., 2002.
18. Skelton P. A Complete Guide to the Freshwater Fishes of Southern Africa. Struik, Cape Town, South Africa., 2001.
19. Utsugi K, Mazingaliwa K. Field Guide to Zambian Fishes, Planktons and Aquaculture, JICA, Zambia., 2002.
20. Brown ML, Murphy BR. Seasonal dynamics of direct and indirect condition indices in relation to energy allocation in largemouth bass *Micropterus salmoides*. Ecology of Freshwater Fish. 2004; 13:23-36.
21. Ahmad M, Qureshi TA, Singh AB. Effect of dietary protein, lipid and carbohydrate contents on the viscera composition and organ Indices of *Cyprinus carpio communis* fingerlings. African Journal of Biotechnology. 2012; 11(33): 8361-8366.
22. Nandeesha MC, Gangadhara B, Varghese TJ, Keshavanath P. Growth response and flesh quality of common carp, *Cyprinus carpio* fed with high levels of earthworm meal. Journal of Asian Fish Science. 2002; 15:235-239.
23. Kefi AS. Influence of dietary soya beans (*glycine max* (l.) merr.) protein and lipid combination, and androgen (17 α– methyl testosterone) levels on the growth and reproduction of *Oreochromis andersonii* (Castelnau, 1861). PhD thesis, Bunda College of Agriculture, University of Malawi, Lilongwe, Malawi., 2014.
24. Pauly D. Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical paper (234), FAO, Rome, Italy., 1983.
25. Bolger TPL, Connoly PL. The suitable of suitable indices for the measurement analysis of fish condition. Journal of Fish Biology. 1989; 34:171-182.
26. Barreto RE, Moreira PSA, Carvalho RF. Sex – specific compensatory growth in food-deprived Nile tilapia. Journal of Medical and Biological Research. 2003; 36:477-483.
27. Bhatta S, Iwai T, Miura T, Higuchi M, Maugars G, Miura C. Differences between male and female growth and sexual maturation in tilapia (*Oreochromis mossambicus*). Kathmandu University Journal of Science, Engineering and Technology 2012; 8: 57-65.
28. Lowe-McConnell R**.** Observations on the biology of *Tilapia nilotica* Linné in East African waters. Revue de Zoologie et de Botanique Africaines 1958; 57: 129-170.
29. Toguyeni A, Baroiller JF, Fostier A, Le Bail PY, Khün ER, Mol KA, Fauconneau B. Consequences of food restriction on short term growth variation and plasma circulating hormones in *Oreochromis niloticus* in relation to sex. General and Comparative Endocrinology. 1996; 103: 167-175.