Population dynamics and size stratification in 75-day old *Clarias gariepinus juveniles*

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Summary

The greatest cause of economic losses in aquaculture has been traced to cannibalism and aggressive behaviour which have been more frequently exhibited by Catfish due to its omnivorous nature, as a result of disparity in sizes, sex ratio and/or stocking density. The aim of the aquaculturist is to produce fast growing fry and fingerlings of comparatively uniform sizes in order to avoid cannibalism in the hatchery. This study therefore aims to investigate population dynamics and size stratification within the Clarias population bred in artificial tanks.

The study was carried out at SEJ Farm Ventures in Torikoh, Badagry, Lagos State, Nigeria, located at latitude 6° 28.598' N and longitude 02° 54.440' E of the equator with an average annual rainfall and temperature of 1693mm 27.0°C respectively.

A total of 250, 75-day old juveniles were randomly sampled from the tank using a hand net and isolated for measurements. Data was collected on live body weight and linear body measurements which include Total Length (TL), Standard Length (SL), Head length (HL), Pre Dorsal Length (PDL), Dorsal Fin Length (DFL) Pre Anal Length (PAL) and Anal Fin Length (AFL). Two indices (length-weight relationship and Fulton's condition factors) were also computed based on the measures for predictive assessment of future performances and wellness of the fish.

The minimum and maximum fish weight recorded was 3.30g and 20.30g respectively with a range of 17.0g. The overall (n = 250) mean $\pm$ SE for body weight was 10.61$\pm$0.28g. The Sturge's formula was used to construct nine class intervals of 2.0g width each, with the grouping resulting in a disproportionate frequency distribution which statistically (P<0.0001) deviated from expected proportional frequencies across the nine sub-groups. Of all the variables measured, weight had the highest variability within the population with a CV of 41.88%, while other measures had CV of between 13.82% and 16.65%.

Although all measures recorded are within the normal distribution without an outlier value, it was observed that based on the mean body weight of the fish studied, only 6.4% are within the 95% Confidence Interval (CI) of the Mean, while 53.2% and 40.4% are respectively below and above the CI.

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The stratification and population structure provide a good discriminatory tool in separating the fish into fairly homogenous sizes for further rearing to minimize cannibalism and optimize profit.

Keywords: catfish, heterogeneity, body measurements, wellness, Nigeria

Introduction

Protein from animal sources are in short supply in Nigeria as a result rapid increase in human population (FAO, 2006), which has led to increase in the demand for fish, the cheapest and most available source of animal protein to supplement the needed animal protein intake. Fish remains the highest contributor of animal protein in Nigeria accounting for over 34% of all the animal protein sources in the country (Edwin *et al*., 2009).

Due to the reckless fishing methods and destruction of the natural environment, there is need to artificially propagate fish seeds. Thus, the culture of fish has become an innovative technology aimed at producing large quantity of fish as food for the ever-increasing human population in Nigeria. In order to meet the high demand for fish, aquaculture which is the rational rearing of fish in an enclosed and fairly shallow body of water remains the best option to bridge the wide gap between fish demand and domestic production in most countries of the world especially sub Saharan Africa (Dauda *et al*., 2013). Aquaculture, which could be practiced by artificial methods, most especially to produce fish on large-scale basis in and out of season to ensure regular supply all year round, constitute the major practicable means of providing enough quality seed for rearing in confined fish enclosure such as fish ponds, reservoirs and lake (Charo and Oirere, 2000).

Catfish (*Clarias gariepinus*, Burchell, 1822), one of the most commonly cultivated species of fish provides food for the populace and allows for improved protein nutrition because it has a high biological value in terms of high protein retention in the body, higher protein assimilation as compared to other protein sources, low cholesterol content and one of the safest sources of animal protein (Anoop et al., 2009). However, being omnivores, cannibalism and aggressive behaviour have been more frequently exhibited by this specie as a result of disparity in sizes, sex ratio and/or stocking density.

Since the aim of the fish culturist is to produce fish that grows to table size using most minimal of inputs to maximise profit, it is necessary to know which cluster of fingerlings to pick as brood stock for the production of fast growing fry and fingerlings of comparatively uniform sizes and also avoid cannibalism in the hatchery. This study therefore aims to investigate growth dynamics and size stratification within the Clarias population bred in artificial tanks.

Material and methods

Study site

The study was carried out at SEJ Farm Ventures in Torikoh, Badagry, Lagos State, Nigeria. The farm is located at latitude of 6° 28.598’ N and longitude of 02° 54.440’ E of the equator. The average annual rainfall and average temperature in Lagos are 1693mm and 27.0°C respectively.

All measurements were taken at the farm and further analyses were conducted at the Department of Zoology and Environmental Biology, Lagos State University, Ojo Lagos, Nigeria.

Experimental units

The African catfish (*Clarias gariepinus*) broodstocks (one male and one female) used in the production of the new seed (hatchling) were from diverse lineage to avoid inbreeding. The hatchlings were raised to 75 days in artificial tanks under intensive management.

All hatchlings were subjected to the same experimental conditions and were fed thrice daily throughout the study period.

Data collection

A total of 250 juveniles were randomly sampled from the tank using a hand net and isolated for measurements. Each fish sampled was measured for the variables studied

Measurements

Data was collected on live body weight and linear body measurements. The weight of the fish was taken using professional digital scale sensitive to 0.01 grams. A flex graduated tape was used to obtain the linear body measurements (Figure 1).

Aside Body Weight (BW), seven morphometric measurements were taken on each fish, which include Total Length (TL), Standard Length (SL), Head length (HL), Pre Dorsal Length (PDL), Dorsal Fin Length (DFL) Pre Anal Length (PAL) and Anal Fin Length (AFL).

Computed indices

Based on the various measurements taken on individual fish, two distinct indices were computed to aid in the appraisal of the wellness of the fish and its potential for later growth and development.

Length weight relationship

Length-weight relationship was expressed as $W = aL^b$, the logarithm transformation of which gives the linear equation LogW =a + b logL, where W = Weight in gram, L = length in (cm), a = a constant being the initial growth index, and b = growth coefficient. Constant ‘a’ represents the point at which the regression line intercepts the y-axis and ‘b’ the slope of the regression line.

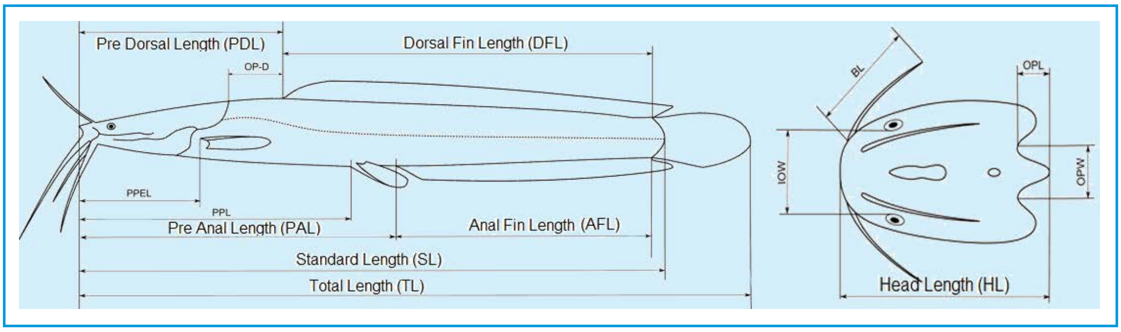

Figure 1. Diagram of Morphometric Measures Studied (Adapted from Agnese et al., 1997).

Condition factor

The condition factor (K) which is defined as the well-being of the fish was calculated. K is a useful index for monitoring of feeding intensity, age, and growth rates. The condition factor is to quantify the health of individuals in a population or to tell whether a population is healthy relative to other populations Stevenson and Woods (2006). The K was determined by:

$$K= W.100L^3$$

where W = length of fish in grams and L = Length of fish in centimeters.

Statistical analyses

A preliminary exploratory statistical analysis was conducted on each of the eight variables measured to test for normality and outlier values.

Based on the values obtained on body weight which is the most important attribute of fish in economic terms, the entire population was classified into nine (9) categories of fairly homogenous weights. This classification is based on Sturges (1926) rule of $K = 1+3.322(\log_{10} n)$ where K is the number of class intervals and n is the sample size. The classes are labelled A – I with each class having a width of 2.0g as follows; A (3.1 – 5.0), B (5.1 – 7.0), C (7.1 – 9.0), D (9.1 – 11.0), E (11.1 – 13.0), F (13.1 – 15.0), G (15.1 – 17.0), H (17.1 – 19.0) and I (19.1 – 21.0) respectively.

Descriptive statistical measures of all variables were obtained along with a multivariate correlation matrix for all variables. Due to the very correlation between weight and total length, a regression analysis was conducted to examine the length-weight relationship. A non-parametric was also done to evaluate the deviation of the disproportionate nine categories from an expected uniform sample sizes per category. A one way analysis of variance using group as the predictor variable was done for all variables and a Tukey test was conducted for further mean separation.

All statistical analyses were done using the Minitab 17® (2013) Statistical Software.

Results and discussion

The weight of fish in this study range between 3.30g and 20.30g with a mean $\pm$ SE of 10.61 $\pm$ 0.28g (Tables 1a and 1b). The nine class intervals have a width of 2.0g and the histogram with a fitted normal curve for both weight and total length is presented in Figure 2. Expectedly, all values increase as we go down the various groups with the first group having the least, while the last group had the highest values.

Only 6 percent of the fish studied have weights within 95% Confidence Interval of the entire population, while 53.2% and 40.8% were below and above the Confidence Interval respectively. This implies that variability in fish weight was more pronounced in the lower class intervals than the higher class intervals.

The differences between the groups for all measured variables were highly statistically significant ($P<0.01$) except for some measures in the heavier categories (Tables 1a and 1b) that were not statistically different ($P>0.05$) after a post-hoc test.

Table 1a. Mean p SE of some measured variables[1].

Group	N	Weight (g)	Total Length (cm)	Standard Length (cm)	Head Length (cm)
A	12	4.61±0.15^{i}	8.88±0.11^{h}	7.67±0.13^{g}	2.13±0.05^{g}
B	62	6.06±0.07^{h}	9.54±0.05^{g}	8.41±0.05^{f}	2.35±0.03^{d}
C	44	8.03±0.09^{g}	10.21±0.06^{f}	9.00±0.06^{e}	2.55±0.04^{e}
D	28	9.95±0.11^{f}	11.09±0.08^{e}	9.87±0.07^{d}	2.77±0.04^{d}
E	24	12.09±0.12^{e}	11.71±0.07^{d}	10.44±0.06^{c}	2.99±0.04^{c}
F	22	13.95±0.13^{d}	12.48±0.09^{c}	11.18±0.08^{b}	3.16±0.04^{bc}
G	30	16.16±0.09^{c}	12.97±0.08^{b}	11.61±0.11^{a}	3.32±0.04^{ab}
H	23	17.80±0.10^{b}	13.37±0.08^{a}	11.87±0.09^{a}	3.22±0.08^{b}
I	5	19.66±0.23^{a}	13.54±0.28^{ab}	12.14±0.23^{a}	3.64±0.05^{a}
Overall	250	10.61±0.28	11.11±0.10	9.86±0.09	2.78±0.03

[1]Means with different superscript within the same column differs significantly (P<0.05)

Group alone accounted for more than 70% of variability in measured variables with the highest effect recorded in fish weight (98.50%) and the least recorded in Head Length (74.73%).

The very high positive correlation amongst the variables (Table 2) is indicative of the strength of relationship between the variables and calls for caution in modelling for weight in order to avoid multicollinearity in the model. All the pairwise correlations are high, direct (positive) and are highly significant (P<0.01).

The disproportionate subclass sizes recorded across the nine groups was statistically significant (P<0.01) with the largest deviation recorded in groups A, B, C and I (Figure 3). While groups A and I fell short of expected frequencies, groups B and C contributed far beyond and above the expected frequencies accounting for almost 64% of the

Table 1b. Mean p SE of some measured variables[1].

Group	N	Pre Dorsal Length (cm)	Dorsal Fin Length (cm)	Pre Anal Length (cm	Anal Fin Length (cm)
A	12	2.55±0.04^{h}	4.85±0.08^{g}	3.99±0.05^{g}	3.39±0.06^{g}
B	62	2.76±0.02^{g}	5.35±0.03^{f}	4.34±0.03^{f}	3.77±0.03^{f}
C	44	3.00±0.02^{f}	5.79±0.04^{e}	4.68±0.04^{e}	4.03±0.04^{e}
D	28	3.24±0.03^{e}	6.28±0.05^{d}	5.10±0.07^{d}	4.31±0.04^{d}
E	24	3.45±0.03^{d}	6.71±0.06^{c}	5.47±0.05^{c}	4.56±0.05^{c}
F	22	3.64±0.04^{c}	7.15±0.05^{b}	5.81±0.05^{b}	4.84±0.05^{b}
G	30	3.83±0.03^{b}	7.43±0.06^{a}	6.14±0.05^{a}	5.06±0.04^{a}
H	23	4.01±0.05^{a}	7.58±0.06^{a}	6.17±0.09^{a}	5.20±0.04^{a}
I	5	4.20±0.08^{a}	7.74±0.12^{a}	6.48±0.10^{a}	5.28±0.11^{a}
Overall	250	3.26±0.03	6.30±0.06	5.13±0.05	4.34±0.04

[1]Means with different superscript within the same column differs significantly (P<0.05).

Table 2. Correlation amongst variables studied[1].

	Total length	Standard length	Head length	Pre dorsal length	Dorsal fin length	Anal fin length	Pre anal length
Weight	0.9696	0.9590	0.8503	0.9438	0.9561	0.9246	0.9432
Total Length		0.9847	0.8705	0.9485	0.9636	0.9296	0.9516
Standard Length			0.8812	0.9456	0.9630	0.9220	0.9522
Head Length				0.8902	0.8687	0.8055	0.8787
Pre Dorsal Length					0.9251	0.9069	0.9169
Dorsal Fin Length						0.9210	0.9398
Anal Fin Length							0.8535

[1]All correlations are highly statistically significant (P<0.01).

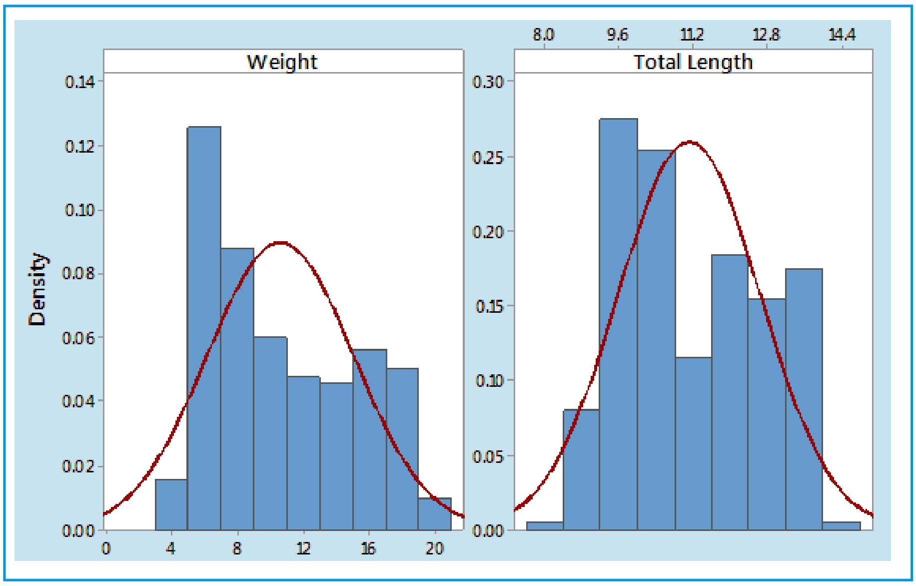

Figure 2. Histogram of weight (g) and total length (cm) across the nine groups.

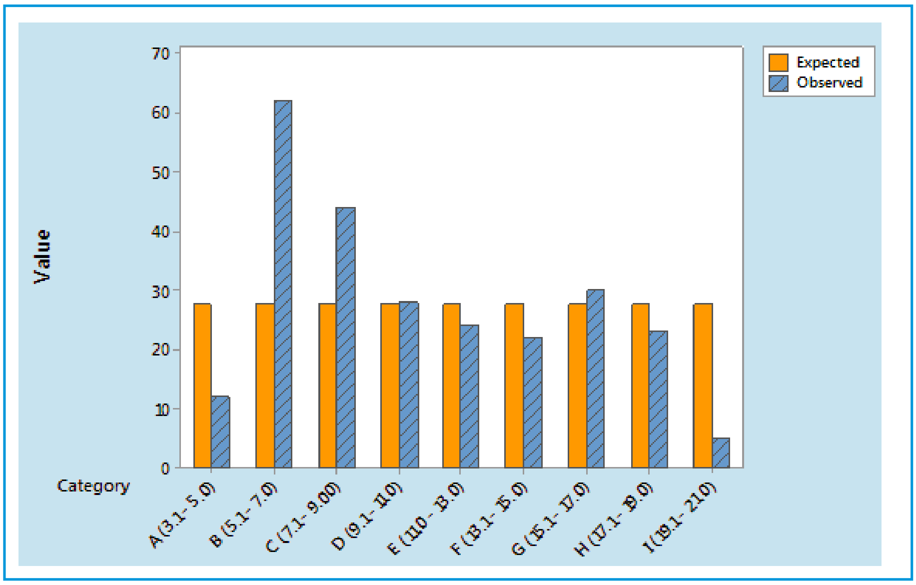

Figure 3. Chart of observed and expected values across the nine weight groups.

deviation from expected values. This is an indication that the growth rate within that population is non-uniform and as such the sizes are highly heterogenous which consequently poses a big threat to the growth and development of the small sized fish and encourage cannibalism within the tank.

The length-weight relationship in the study revealed the a and b values to be -2.18 and 3.04 respectively indicating a positive allometric growth with an r^2 of 0.94 which is close to reports of Torres (1992). The condition factor (K) ranges between 0.66 and 0.80 across the nine groups with an overall mean value of 0.73, implying that the larger fishes had higher values compared to the fishes in the lower groups. This is indicative of the fact that the larger fishes are performing better metabolically compared to the smaller fishes despite the fact that all were reared under similar conditions and corroborated the work of Keyombe *et al* (2015).

Conclusions and recommendation

The following can be concluded from this study:

- The weight of fish sampled in this study varied widely between 3.30g and 20.30g with coefficient of variation of 41.88 percent and a mean of 10.61g.
- Majority of the fish (53.2 %) has weight below 95 percent confidence interval of the mean weight, implying that less than half of the fish are at or above mean weight.
- There is very high positive and significant correlation between all variables studied, implying that any of the variable can be used to predict or model another variable.
- The length-weigh relationship indicated a positive allometric growth (b = 3.04) with an average condition factor (K) of 0.73.
- The population structure in the study is inimical to profitable fish rearing as it encourages cannibalism and/or under-development of the weaker groups.

It is therefore recommended that the fish be separated into groups of fairly homogenous sizes for further rearing to minimize cannibalism and optimize profit.

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