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AN ASSESSMENT OF THE RELATIVE SUITABILITY OF GLASS AQUARIA, PLASTIC TANKS AND CLAY POTS IN THE HACHABILITY, SURVIVAL AND GROWTH OF *Clarias gariepinus*

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ABSTRACT

The relative suitability of Glass aquaria, Plastic tank and Clay pot in hatching eggs and rearing the fry of *Clarias gariepinus* was assessed over a period of 13 weeks. The study was conducted at the indoor hatchery of the Departmental of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. Eggs of *Clarias gariepinus* were fertilized, incubated and hatched in the various media. Percentage hatchability and fertilization were calculated to determine quality of the eggs. Relative performances of the resultant fry were assessed using Survival, growth (weight/length gain and SGR) and K-factor as indicators. A hundred and ten (110) fry were randomly selected; batch weighed and stocked in each culture media. The samples were distributed in triplicates of five (5) samples. Significantly higher percentages (75 %) of fertilization and hatching (90 %) were recorded in glass aquaria. The results also showed that fry in plastic tanks had the highest mean weight gain (2.69±1.73) and length gain (6.00±2.71) with significant difference ($p<0.05$). Similarly, the highest percentage SGR (4.34±1.82) was in fry reared in plastic tanks ($p>0.05$). However, percentage survival (58.47±3.92) was highest in clay pot culture facility with a significance ($p<0.05$). The condition factor on the other hand, revealed that Glass aquaria (K=1.10) and plastic tank (k=1.00) provided better rearing conditions and suitability for rearing *C. gariepinus* fry as against the clay pot (K=0.80). It was therefore concluded that, glass aquaria were the best for incubation and hatching of *C. gariepinus* larva, while plastic tank was better suited for rearing the fry and clay pot culture facility is better survival of fry.

Keywords: Culture enclosure, incubation, hatching rate and *C. gariepinus*

INTRODUCTION

For aquaculture to be highly successful in Nigeria there is need for good quality and cheap culturing facilities for fish culture which can also encourage small scale farmers in the field of aquaculture for sustainable production and also to meet the demand of fish. Scarcity of fish fingerlings is considered as the major problem mitigating the promotion and development of aquaculture in the country as desired fish seed are sometimes unavailable (Adewolu *et al.*, 2008). In order to achieve adequate seed supply, about one million tonnes of fish per annum is needed as stated by FAO (2004).That is, fingerlings production even at semi-intensive management level is required to supply at least two billion fingerlings annually (Atanda, 2007).

Human intervention is required in aquaculture practice in order to increase fish productivity and yields which will exceed those from the natural environment (Prince and Fatai, 2012). And also because the fish does not spawn spontaneously since the environmental factors such as the rise in water level and inundation of shallow areas do not occur in fish farm environment (Prince and Fatai, 2012).

Condition factors (K) commonly employed in fisheries studies to determine the well-being of fish species in relation to their environment. It is calculated as a function of the weight and the length relationship of the fish, to establish the health status of individual fish (Froese, 2006). As submitted by Anibeze, (2000), the value 1 (K=1) or above (K>1) and even up to 3 (K= 3), are indications a fish is in good health condition while K- value less than 1, indicates that a fish is not thriving well. Factors such as in adequate or non-availability of food, predation, competition, fishing intensity, change in physico-chemical parameters, spawning period, pollution and others could affect the condition of fish in the aquatic environment. (John and Nair, 1991).

C. gariepinus is a popular choice for aquaculture because of its fast growth rate, hardiness, tolerance to poor water condition, air breathing characteristics, attractive market price and ease of breeding in captivity. Similarly, its good taste has increased demand over other many fishes. One of the problems often encountered by the local fish farmers is the cost of establishing a fish holding facility. Fish pond which is the most

popular type of culturing facility requires a substantial amount of money for its establishment. This cost implication has been one of the retarding factors in the production of fish to meet the daily fish requirements by the masses, thus leading to shortage in the expectation from local supply. Furthermore, the low output and survival of hatchlings in other culturing facilities such as plastic tanks and glass aquaria has also been of concern for intending fish farmers, thus, the need for a cheaper and alternative culturing facility (Atanda, 2007).

The high mortality rate and low size of hatchlings often recorded in the use of plastic tanks and glass aquaria has been a set-back in meeting projected 1.3 million metric tonnes of fish demand (Ayinla, 2012). These problems could be associated with the environment of these culturing facilities which are far from the natural aquatic environment of fish. It is therefore necessary to intervene in the shortage of fish production by providing a mimicked environment to natural habitat through the use of culture enclosure for hatching and rearing.

There are several culturing facilities depending on the nature of the materials used for the production of such facility. Several criteria are often considered for the selection of materials to be used for the construction of culturing facilities. These factors include the ease of water circulation in such facility, toxicity of such facility to fish, smoothness of the facility to prevent skin abrasion and infection to the fish, ease of cleaning and sterilization (Timmons *et al.*, 2002). Also, the size of a particular holding facility depends on the type of fish species involved, stocking rates of fish, water quality and economic consideration (Olagunju *et al.*, 2007). According to De-Graaf *et al.* (1995), the importance of culturing facilities is enormous. This includes food security, preservation and storage and ornamental. Clay pots as fish culture enclosure is traditionally old and restricted to certain cultures and societies.

Clay pot has been identified and used as a holding facility for the rearing of hatchlings as it provides an environment similar to the fish natural environment since clay is a natural substance that contains silicate and other soil properties (Williams *et al.*, 1995).

One major advantage of clay pot as holding facility is its minimum maintenance requirement except of course, for keeping it filled with

clean water. Fish can be grown in plastic tanks of nearly every shape and size. Plastic tanks are majorly rectangular and circular or oval in shape. Circular or oval tanks with central drains are easier to clean and enable easy water circulation than their corresponding rectangular ones (Britz, 2007).In view of this, it is evident that information on the relative suitability of clay, glass and plastic materials as holding/rearing facilities is hard to come by. This study is therefore, an attempt to bridge the information gap in the suitability of these materials in fish culture via hatching, survival, growth performance and condition factor of *C. gariepinus* in clay pot, glass aquarium, and plastic tank as incubators and culture facilities so as to establish which would provide the best culture medium.

MATERIALS AND METHOD

The experiment was carried out at indoor hatchery of the Department of Water Resources, Aquaculture and Fisheries Technology fish farm, Bosso Campus, Federal University of Technology, Minna for eight (8) weeks. Four ripe and matured brooders (two males and females) of *Clarias gariepinus* weighing 800-1000 g and 48.30 cm length were purchased from a local fish farmer in Minna. The brooder fish were disinfected with 5% salt bath for 5 minutes as described by Haruna (2003) and then acclimatized for 1 week. Thereafter, brood fish were fed 40% crude protein commercial feed. The experimental samples were thereafter maintained under optimum temperature (27 °C – 32 °C), and good water quality management at optimum required limit for fresh water fish culture. After acclimatization, one each of the male and female were selected, the female was induced with Ovaprim hormone at 0.5ml/kg via intraperitoneal injection. After 9 hours of latency, the eggs were stripped into a dry and clean plastic bowl.

The male was sacrificed for milt. The milt was mixed with saline solution in a clean petri dish and added onto the eggs and stirred gently and thoroughly with a plastic spoon for about 2-3 minutes in order to fertilize the eggs. After fertilization, the eggs were divided into 3 batches, each weighed about 17.5g with about 3,000 eggs spread in a monolayer on kakabans in the incubators (glass aquarium: 60 x 30 x 30 cm; plastic tanks 42 x 33 x 25 cmand clay pots40 x30 cm for radius and height). Each facility was filled with 20 litres water. Incubation was monitored for about 48 h

under flow through system with aeration. Water quality parameters particularly dissolved oxygen (DO), temperature, conductivity and pH were recorded during incubation, hatching and rearing. DO was determined by Winkler – azide method as described by Golterman *et al.* (1978) and adopted by (Yisa, 2012). Temperature was measured using a common mercury – in- bulb thermometer (-10-110^{0}C range). Conductivity was measured using conductivity meter model JENWAY 4010 as described by Lind (1979) and adopted by Yisa and Izuoegu (2015) while pH was measured using pH meter KENT EH, model 7045/46. Percentage fertilization and hatchability were calculated using the formulae:

$$\textbf{Fertilization (\%)} = \frac{\text{NFE} \times 100}{\text{NEI}}$$

Where NFE= Number of Fertilized Eggs, NEI= Number of Eggs Incubated

$$\textbf{Hatchability (\%)} = \frac{\text{NHL} \times 100}{\text{NFE}}$$

Where NHL= Number of Hatched Larvae, NFE= Number of Fertilized Eggs

These were used to determine cumulative mean percentage fertility and hatching for the treatments. The 7 days old fry were reared in the incubation tanks for 4 weeks after which 110 fry were further randomly selected and stocked in each rearing tank and replicated three times. Rearing of the fry was done for another 8 weeks. Five (5) fry were randomly selected from each holding facility and then pooled weighed using Electronic Scale golden Mettler (USA) to determine the mean weight of the fry while transparent meter rule was used to determine the length.

The growth of each group of the experimental samples were estimated using the following formulae:

Weight gain (mg), **WG**= WF - WI;

Specific growth rate (%/day),

$$\textbf{SGR} = \frac{\text{WF} - \text{WI} \times 100}{\text{T}}$$

Where WF = final body weight of fish; WI = initial body weight of fish and T= time in days

Survival was estimated as:

$$\textbf{Survival (\%)} = \frac{\text{FNF} \times 100}{\text{INF}}$$

Where FNF= Final Number of Fish, INF= Initial Number of Fish.

Data Analysis

Data obtained from the experiment were subjected to One-way Analysis of Variance (ANOVA) using IBM SPSS Statistics 21 while multiple comparisons of the means were done using LSD. Linear regression of the length and weight of the samples was plotted via Microsoft Office Excel 2016 while the coefficient regression equation was used to determine the length-

'eight relationship on the linear raph.

ESULTS

able 1 presents the results of urvival and growth assessments f C. *gariepinus* fry raised in the ıree culture media. Samples eared in Plastic tank produced ıighest mean weight gain 2.69±1.73). The samples in glass ıquaria also differed significantly p>0.05) from samples in the other ıedia. The least mean weight gain (0.95±0.36) was however recorded in the clay pot.

Similarly, highest mean length gain was however recorded from samples reared in plastic tank (6.00±2.71). Samples in the Plastic Tanks also differed significantly (p>0.05) with samples in glass Aquaria and Clay pot. The least mean length gain was likewise recorded in samples reared in clay pot (1.88±1.09).

The highest % SGR (4.34±1.82) was again obtained in plastic tank which significantly differed (p>0.05) with samples in other media. Nevertheless, the least % SGR (3.54±1.61) was similarly recorded in the clay pot. However, the highest percentage survival (58.47±3.92) was recorded in samples of the clay pot which significantly differed (p>0.05) with those of the glass and plastic media.

Table2 presents the regression and correlation coefficients of the relationship between length and weight of *C. gariepinus* fry reared in the different culture facilities. The b-values indicated negative allometric growth pattern for the samples in glass aquarium (b = 0.97) clay pot (b = 1.16) and the plastic tank (b = 1.47) while the R^2 are in the order of 0.87, 0.61 and 0.79 for samples reared in glass aquaria, clay pot and plastic tank respectively. The above R squared values indicated that the model was good for samples in glass aquaria, fairly decent for those of the plastic tank while the clay pot was just above average in terms of fitness of predictability.

The condition factor values shown in the table indicated that the species thrived well in the Glass aquaria (K=1.10) and the plastic tank (K=1.00) as compared to the poor K-value for samples in the clay pot.

In Figure 1, the mean percentage fertility and hatching of *C. gariepinus* eggs incubated in different culture media are shown. The values revealed that the glass aquaria recorded highest percentages of fertility (75 %) and

hatching (90 %), Clay pot had the least percentage hatching (65 %) while plastic tank recorded 85 % percentage hatching.

Results of water quality parameters measured during the experiment are presented in Table 3. The results reveals that higher dissolved oxygen values obtained were in the order of 3.6±0.31 and 2.80±0.28 for glass aquarium and plastic tank respectively with a significant difference ($p>0.05$) in glass aquarium alone. The least DO was therefore recorded in the clay pot. Similarly, the value of conductivity recorded was highest in glass aquarium (414.00±37.2) followed by the plastic tank (402.00±37.02) and the least was in the clay pot (398.00±36.40).The values of conductivity in the aquarium tank and the plastic tanks are significantly ($p>0.05$) higher than that of the clay pot.

Table 1: Growth, Survival and Mortality of *C. Gariepinus* Fry Reared in Three Different Culture Facilities for 8 Weeks

Parameter	Glass Aquarium	Clay Pot	Plastic Tank
Mean Initial Weight (g)	0.01±0.00^a	0.01±0.00^a	0.01±0.00^a
Mean Final Weight (g)	1.80±1.08^b	0.96±0.38^c	2.70±1.75^a
Mean Weight Gain (g)	1.79±1.06^b	0.95±0.36^c	2.69±1.73^a
Mean Initial length (cm)	0.50±0.00^a	0.50±0.00^a	0.50±0.00^a
Mean Final Length (cm)	5.50±2.08^b	4.94±1.61^c	6.50±2.38^a
Mean Length Gain (cm)	5.00±1.90^b	4.44±1.09^c	6.00±2.71^a
% Specific Growth Rate	4.04±1.81^a	3.54±1.61^b	4.34±1.82^a
% Survival	21.57±3.21^b	58.47±3.92^a	21.27±3.01^b

Superscript with the same letter in the same row are not significantly different at $p>0.05$

Table 2: The Length-Weight Relationship and Conditions factor of C. gariepinus fry reared in Glass Aquarium, Clay pot and Plastic Tank

Treatment	n	Mean Length (L) ± SD	Mean Weight (W) ± SD	a	b	r^2	Mean K ± SD
Glass Aquarium	110	5.50±2.08	1.80±1.08	2.7953	0.9731	0.871	1.10
Clay pot	110	2.38±1.61	0.96±0.38	1.1434	1.1649	0.6095	0.80
Plastic tank	110	6.50±2.38	2.70±1.75	2.8073	1.4732	0.7918	1.00

Table 3: Mean Water Quality Parameters of *C. gariepinus* Fry Reared in Three Different Culture Enclosure for 8 Weeks

CULTURE FACILITY	D O (mg·l)	T (°C)	pH	E.C. (µs/cm)
Glass Aquarium	3.61±0.31[a]	25.67±2.33[a]	8.9±1.42[a]	414.00±37.20[a]
Clay Pot	2.12±0.20[b]	25.00±2.01[a]	8.7±1.40[a]	398.00±36.40[b]
Plastic Tank	2.80±0.28[b]	25.67±2.32[a]	8.7±1.39[a]	402.00±37.02[a]

Superscript with the same letter in the same column are not significantly different at p>0.05

Key: T: Temperature; E. C.: Electrical Conductivity

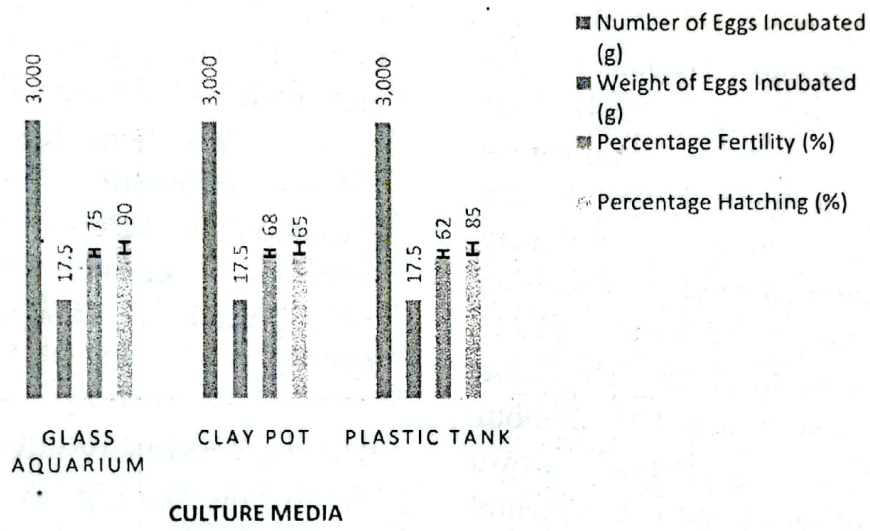

Figure 1: Number of Eggs Incubated and Mean Percentage Fertility and Hatching of *C. gariepinus* Fry Reared in Three Different Culture Media

DISCUSSION

The higher percentage hatching (90 % and 85 %) in glass aquarium and plastic tank might be attributed to their rectangular shape. Rectangular shape incubators are believed allow fertilized eggs to spread in a monolayer and remain still, hence, reducing mechanical damage which is common with jars such as clay pot. Similar observation was made by Viveen *et al.* (1986) and Lamai (2011).

The higher percentage survival recorded in clay pot might be attributed to material nature of

clay pot which mimics the natural environment as compared to the glass aquaria and plastic tanks which are foreign to the natural environment of fish. These observations agree with the report of Halver (1972) who stated that fish grow best in their natural environment than artificial. In addition, the thickness of the clay pot is likely to serve as a buffer against temperature fluctuation which is critical to the survival of fry. Furthermore, the low light penetration observed in the clay pot could possibly account for the highest survival (58.47±3.92) recorded therein. *C. gariepinus* tend to perform better in an average light intensity environment as similarly observed by Appelbaum and Kamler, (2000) and Mino *et al.* (2008). They also observed that in about 15- 20-hour darkness, *C. gariepinus* grows better. Although the experimental fish were randomly selected and distributed to the culture facilities (glass aquaria, clay pot and plastic tanks), the fry in the clay pots seems to be uniform in size which prevents sibling cannibalism as few or no shooters were noticed. This agrees with the report of Appelbaum and Arocklaraji (2010) that variation in size of fish can cause cannibalism.

The higher weight and length gains (2.69±1.73 and 6.00±2.71) recorded in plastic tanks was probably due to good response to feed by the fry and enough space and size as well shape of the tank as similarly observed by Yisa (2012) that good response of fish to feed increases its growth, appears robust and healthy. Similarly, the higher specific growth rate (SGR) of 4.34±1.82 that was recorded in plastic tanks could be adduced to similar reason as stated above. However, the low specific growth rate in clay pots could be attributed to low metabolism as a result of low temperature in the culture enclosure. This led to reduction in acceptance of dry compound diet and fry inactivity as reported by Balogun *et al.* (2004).

The high mortality after hatching or during rearing in the three culture facilities especially in glass aquarium (78.43±4.92) and plastic tank (78.73±4.02) could be partly due to transition from endogenous (yolk sac feeding) to exogenous feeding as similarly observed by Nlewadin andMadu (2004) as cited by Tsadu *et al.* (2009) and by Kolawole *et al.* (2011) and partly due to cannibalism by fast growers (shooters) among the hatchlings. This was because the carcasses of the dead fry were not always

found in the tanks hence assumed to have been cannibalized. Also Hecht and Appelbaum (1988) observed that young catfishes are cannibalistic.

The water temperatures measured were within the range (25.00±2.01 - 25.67±2.33) to culture warm water fishes as reported by Balogun *et al.* (2004). Dissolved oxygen was low, Adekoya *et al.* (2004) reported that this can cause discomfort to fish, slow down the growth and ultimately lead to death. Linear regression of the length and weight of *C. gariepinus* fry raised in the different facilities gave positive correlation coefficient values which indicates that length increases of the fry produced corresponding positive increases in weights of the respective samples. Exponents of regression ($b < 3.0$) shows negative allometric growth patterns of the species under the various culture media. It is a well-known fact that the functional regression "b" value represents the body form, and it is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and other factors such as sex, age etc (Benedict *et al.*, 2009). The implication is that, the body weights of the fishes increased with increase in body length, but the rate of increase in weight is less than the rate of increase in length. According to Adeyemi *et al.*, 2009, negative allometric growth pattern in fish implied that the weight increases at a lesser rate than the cube of the body length (Obasohan *et al.*, 2012). The coefficient determination (R-squared) values, which is the percentage of variability of the respondent variable explained by a linear model. This implies that, the model can be used to fairly predict the weight of the samples raised in the Glass aquaria and Plastic tank compared to those raise in the clay pot.

C. gariepinus did well in the Glass aquaria as well as the Plastic tank as compared to the Clay pot. This could be an indication of the conditions of these facilities for fry rearing as indicated by John and Nair (1991) that a fish is thriving well when the K-value is equal to or greater than 1.

CONCLUSION

Inferring from the outcome of this study, it was concluded that glass aquarium is the best for incubation and hatching facility for *C. gariepinus*. However, it was concluded that the plastic Tank on the other hand, was the best rearing facility for the species while clay pot was best as holding

facility for *C. gariepinus* at fry stage as shown in their survival.

REFERENCES

Adekoya, B. B., Olunuga, O.A., Ayansanwo, T. O. and Omoyinmi, G.A.K. (2004). Hand book on Manual of the second annual Fish seminar and training workshop held at Ogun State Agricultural Development Programme (OGADEP), Abeokuta, Published by Fisheries Society of Nigeria (FISON), Ogun state chapter. 19-25pp.

Adewolu M. A., Adeniji C. A. and Adejobi A. B. (2008). Feed utilization, growth and survival of *Clarias gariepinus* (Burchell,1822) fingerlings cultured under different photoperiods. *Journal of Aquaculture* (4), 64-67.

Anibeze, C. I. P. (2000). Length-weight and relative condition of *Heterobranchuslongifillis* from Idodo River, Nigeria. NAGA, *The ICLARM Quarterly*, 23:34-35.

Appelbaum, S. and Arocklaraji, A.J. (2010). Sibling cannibalism in juvenile Asian sea bass (*Latescalcarifer*) reared under different photoperiods, *Journal of Aquaculture* 3(5), 384-394.

Appelbaum, S., Kamler, E. (2000). Survival, growth, metabolism and behaviour of *Clarias gariepinus* (Burchell, 1822) early stages under different light conditions.*Journal of Aquaculture*, 22, 269–287.

Atanda, A.N. (2007). Fresh Water Fish Resource in Nigeria. Assessment of Fresh Water Fish Seed Resources for Sustainable Aquaculture F.A.O Fishery Technical Paper No 501, Rome FAO 628, 361 -380.

Ayinla, A. O. (2012). Growth and survival of trial of Africa catfish species, *Clarias gariepinus* (Burchell, 1822) and *Heterobrachusbidorsalis*, reared on *Moinadubia* in comparison with other first feed sources. *Journal of Aquaculture* 49 (34), 209-221.

Balogun, J.K., Abdullahi, S. A., Auta, J. and Ogunlade, O.P. (2004). Feed conversion protein efficiency, digestibility and growth

performance of *Oreochromis niloticus* fed *Delonixregia* seed meal, 2004 *Proceedings of National Conference of Fisheries Society of Nigeria*, 823-829.

Benedict, O. O., Yemi A. S. and Isaac T. O. (2009).Length-weight Relationship, Condition Factor and Sex Ratio of Forty-Six Important Fishes in a Tropical Flood River. *Research Journal of Fisheries and Hydrobiology*, 4 (2): 65-72.

Britz, P.J. (2007). A Study on the Status of Aquaculture Production and Trade in South Africa. *Journal of Zoology*, 227, 43-62.

De-Graaf, G.J., Galemoni, F. and Banżoussi, B. (1995). The Artificial Reproduction and Fingerling Production of the African Catfish, *Clarias gariepinus* (Burchell, 1822) in protected and unprotected ponds.*Aquaculture Research*, 26, 233-242.

Food and Agriculture Organisation (2004). *World Aquaculture Supply of Catfish and Tilapia.* FAO Fisheries Report No 733. FAO, Rome. 46.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22:241-253.

Golterman, H.L., Clymo, R.S. and Ohnstad, M.A.M. (1978). In: T. A., Yisa, S. L. Lamai,S.M. Tsadu and R. J. Kolo (2002). Effects of incision variation length on *Heterobranchusbidorsalis* male spawners to extract milt for induced breeding. *American Journal of Experimental Agriculture*. 10 (2), 1-7.

Halver, J. E., (1972). *Fish Maturation*. Academic Press, New York, 222.

Haruna, A. B. (2003). *Aquaculture* in the tropics: Theory and Practice. Kano: Alhassan Publishers.

Hecht, T. and Appelbaum, S. (1988). Growth of Israeli sharptooth catfish (*Clarias gariepinus*) during the primary nursing phase. *Aquaculture*, 63: 195-204.

John, K. C. and Nair, N. B. (1991). Relative condition factor in Nandusnachus (Hamilton). Fisheries Technology, 28: 103-105.

Kolawole, O. M., Ajayi, K. T., Olayemi, A. B. and Okoh, A. I. (2011). Assessment of water quality in Asa River (Nigeria) and its indigenous *Clarias gariepinus* fish. *International Journal of Environment*. 8 (11), 4332-4352.

Lamai, S. L. (2011). The African Catfish Culture for the 21st Century. Inaugural Lecture Series 22 delivered on 17th November, 2011at Carverton Lecture Theatre, Federal University of Technology, Minna, Niger State. P.17.

Lind, O.T. (1979). Hand book of common methods in Limnology. 2nd Edition, London press 185pp.

Mino, S. A., Metillo, E. B. and Tobias, E. G. (2008). Effects of photoperiod on egg hatching and growth and survival of larvae fed with different diets in the Asian catfish, *Clarias macrocephalus*(Gunther) and the African catfish, *Clarias gariepinus* (Burchell, 1822). *Journal of Aquaculture*, 91, 431–438.

Nlewadin, A. A. and Madu, O.C. (2004). Growth response and survival of F1 Hybrid fry of *Heterobranchuslongifilis* and *Clarias gariepinus* reared in glass aquaria and plastic basins. *Proceedings of the 19thAnnual Conference of Fisheries Society of Nigeria* (FISON), 29th November, - 3rd December, 2004. 334-340.

Obasohan, E. E., Obasohan, E. E., 1imasuen, J. A. And 1isidahome, C. E. (2012). Preliminary studies of the length-weight relationships and condition factor of five fish species from Ibiekuma stream, Ekpoma, Edo state, Nigeria. E3 *Journal of Agricultural research and development*. 2(3). pp. 061-069.

Olagunju, F.I., Adesiyan, I.O. and Ezekiel, A.A. (2007). Economic Viability of Catfish production in Oyo State, Nigeria. *Journal of Human Ecology*, 21(2), 121-124.

Prince, E. N. and Fatai, G. O. (2012). Comparative Reproductive and Growth Performance of *Clarias gariepinus* (Burchell, 1822) and Its Hybrid Induced with Synthetic Hormone and Pituitary Gland of *Clarias gariepinus*. *Journal of Aquaculture*, 13, 3-27.

Timmons, M.B., Ebeling, J.M., Wheaton, F.W., Summerfelt, S.T., and Vinci, B.J. (2002).*Recirculating Aquaculture Systems*. 2nd Northeastern Regional Aquaculture Center Publication No. 01-002.

S. M. Tsadu, A, Yisa and Ogubude, O. S. (2009). Effects of Net Hapa on the Survival of *Clarias gariepinus* (Burchell, 1822) Fry from Different Broodstock Sizes. *Journal of Aquatic Sciences* 24 (1), 12-15.

Viveen, W.J.A.R., Richter, C.J.J., Van Oardt, P.G.W.J., Jassen, J.A.L., Huisman,E.A. (1986). Practical manual for culture of the African catfish, *Clarias gariepinus*. Joint Publication. Ministry for Foreign Affairs, Netherlands; Dept. of Zoology University of Utrecht, The Netherlands. 94pp.

Williams B. W., Cuvelier, M. E. and Berset, C. (1995). Use of free radical method to evaluate antioxidant activity. *LebensmWiss Technology*; 28:25-30.

Yisa, T. A. (2012). Induced Breeding of *Clarias gariepinus* and *Heterobranchusbidorsalis* Using Non-Conventional Methods of Abdominal Incision and Stripping of Males. PhD Thesis, Federal University of Technology, Minna.

Yisa, T. A. and Izuoegu (2015). Determination of some Physico-chemical Parameters of Dan-Zaria Dam in Niger State, Nigeria. Continental *Journal of Environmental Sciences* 9 (2) 1-11.