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Effects of varied hours of aeration on the spawning success of African catfish (*Clarias gariepinus*)

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Abstract
Dissolved oxygen variation in fish ponds is a common problem. This is more critical at the early stage of the fish life when rate of metabolism is usually high and as such optimum water quality condition such as availability of sufficient dissolved oxygen is most required. An experiment was conducted to determine the effect of varied hours of aeration through water shower, on the spawning success of African catfish for the period of 10 weeks. The aeration treatments were T1 (0 hour of shower), T2 (4 hours of shower), T3 (6 hours of shower), T4 (8 hours of shower) and T5 (12 hours of shower). The experiment was laid out in a complete randomized design. Each treatment was replicated three times. Test for significant difference was carried out using Duncan Multiple range test. All test was carried out at 5% probability level. The effects of the five treatment were evaluated on hatchability, growth and survival rate. Data collected included egg hatching rate (%), bi-weekly weight gain and specific growth rates of hatchlings. There was significant difference ($P<0.05$) among treatments in terms of the egg hatching rate (30.12%, 54.76%, 60.44%,70.81% and 83.24% for T1, T2, T3, T4 and T5 respectively). The bi-weekly weight gain increased significantly from T1 to T5 (5.61, 7.67, 9.29, 12.93, and 17.03g respectively). Survival of hatchlings also increased significantly from T1 to T5(76.87, 76.60, 81.20, 84.80, and 88.80 respectively). The increase in hatching rate and growth performance was attributed to increased dissolved oxygen availability with increasing hours of aeration through shower. Increased dissolved oxygen content affected the fry appetite, feed consumption and utilization positively. These findings indicated that spawning success of African catfish can be greatly enhanced by 12 hours of water aeration through water shower. This could be used by hatchery operators in developing countries with limited resources for flow through system or water re-circulatory system.

Keywords: Hours of aeration, water shower, spawning success, *Clarias gariepinus*

1. Introduction
African catfish(*Clarias gariepinus*) is one of the widely cultivable fish in Nigeria due to its acceptability and its resistance to poor water quality [1].In recent past, fish fingerlings are sourced from the wild i.e. natural waters, However, due to the problems associated with wild fish seed, viz. seasonality in availability, uncertainty of species of fish seed collected, disease infestation and limited quality of harvestable fish seed, it is unreliable with respect to sustenance of commercial fish farming [2]

Artificial propagation of fish(spawning) is the most promising and reliable way of ensuring availability of good quality fish seed all year round and the sustainability of the aquaculture industry. It involves the use of natural or synthetic hormones to induce ovulation and spawning in farmed fishes [3]

In spite of the remarkable success on the hatching of African catfish (*Clarias gariepinus)*, the survival at fry stage is still a limiting factor [4] This can be attributed to lack of proper awareness and technicality involved in the principles of hatchery management. One of the sensitive areas of hatchery management is the water quality management which affects the success of fish seed production.

Water quality is the totality of physical, biological and chemical parameters that affects the growth and survival of culture organisms. These water quality parameters include water temperature, pH, dissolved oxygen content, dissolved carbon dioxide, total ammonia-nitrogen and total hardness [5]. (Ali *et al*. 2000).

Among various water quality parameters for a successful aquaculture practice, dissolved oxygen content in water is the most critical parameter. Oxygen is vital for all organisms living in water and having aerobic type of respiration [6]. Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of aquatic organisms.

The principal source of oxygen in water is atmospheric air and photosynthetic planktons [7]. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones due to low solubility of oxygen in water and solubility decreases with factors like- increase in temperature, low atmospheric pressure, high humidity, high concentration of submerged plants and plankton blooms. Oxygen derived from photosynthesis is produced during the day when there is sunlight captured by plants in the water. Oxygen level reduces at night via the respiration process by plants and animals, including fish [8]. When there is no light penetration, plants and phytoplankton cannot produce oxygen through photosynthesis thus decrease in the production of dissolved oxygen. This is common in the indoor hatchery where hatchlings are nursed in confined dark areas or enclosures.

The amount of oxygen required by fish depends on the metabolic rate of fish. Fish at early stage of life (hatchlings) are associated with higher metabolic rates and as such consume more oxygen than the larger fish. This makes the dissolved oxygen requirement for fish hatchling to be critical. In freshwater system, normally the level of dissolved oxygen is about 6ppm at 25^{0}C environment temperature [9]. This may be artificially increased using various means of aeration including showers or allowing water to fall from higher height into the culture facility to expose water to atmospheric air at larger surface area.

Water aeration is the process of increasing or maintaining the oxygen saturation in both natural and artificial environments. Any procedure by which oxygen is added to water can be considered a type of water aeration. Using this as a criteria, there are various ways to aerate water. This falls into surface aeration and bottom aeration using aerators/pumps. However, aeration which is often carried out with the use of aerators requires electrical energy to power the aerator or pump water from one height to the other. Power supply is usually unstable, unreliable and expensive and as such difficult to ensure continuous aeration as this will involve considerable energy use and cost which will influence the economics of seed rearing. Thus the use water drops or shower falling into the pond or culture facility from a water holding facility such as storage tank may be useful.

A good aeration system provides many benefits such as increased production and performance, along with a healthy environment for the fish. Most importantly, fish kill can be prevented. In properly aerated pond water, beneficial pond bacteria are stimulated to efficiently break down and reduce the bottom layer. This controls odor and hydrogen sulfide that may be present otherwise. Another benefit is the reduction of algae blooms due to the lack of available nutrients for the algae. Aerators facilitate destratification, which improve the overall water quantity [10].

A number of studies have assessed the effect of aeration on the growth and survival of fishes. Aeration was found to improve the water quality and increase fish production in the white catfish [11]. Carps and tilapia yields were increased many folds by applying aeration [12, 13,] Higher production and survival of channel catfish in ponds with aeration has been reported by [14, 15]. also obtained 6 tons of catfish/acre with continuous aeration. [16] reported aeration to favor feed utilization and growth in common carps. [17] reported that fish cultured in an aerated tank had a significantly higher bi-weekly gain of 247g, than the ones cultured in a non-aerated tank having 217.3g.

Oxygen demand and requirement is higher in incubation and nursery pond because the demand for dissolved oxygen by smaller fishes (hatchlings) is higher than that of the adult fishes. Therefore, there is need to ensure continuous supply of dissolved oxygen in incubation and nursery ponds to meet their oxygen need. This is most important because mortality is higher at the early stage of fish life. Therefore, to increase success in spawning there is need to improve the water quality such as dissolved oxygen content of water using the least cost or cheaper means. In view of this, the present study is undertaken to ascertain the effects of varied hours of aeration using water shower on spawning success of African catfish

2. Materials and methods

2.1 Experimental set up and design

The experimental was made up of five treatments of water shower as a means of aeration namely, T1 (0 hour of aeration), T2(4 hours of aeration), T3(6 hours of aeration), T4(8 hours of aeration) and T5(12 hours of aeration). Each treatment was replicated thrice in a complete randomized design. The surface aeration method through the aid of shower heads was used for this study. It works with the principle of breaking up or agitating the water surface due the bubble effect created so that oxygen transfer can take place. The flow rate of the shower head was 0.79 liter of water per minute (0.79L/M). The experimental layout is as shown in Plate 1

Plate 1: Experiment set up

2.2 Spawning

This study was carried out at the experimental fish farm of the Department of Aquaculture and Fisheries Management, University of Benin, Benin City. Matured brood stocks were sourced from a reputable fish farm in Benin City. The broodstocks were acclimatized and kept separately, in a plastic holding tank to avoid violence and reduce stress. They were fed pelleted feed prior to spawning. Sexually matured male and female fish were selected and induced with vulin as described by [18]. The female fish was injected intramuscularly (Plate 2).

Plate 2: Hormonal injection of female broodstock

2.3 Estimation of the spawning success of African catfish
Hatching of eggs was notice between the 18-24 hour of incubation. Aeration of the spawning bowls started during incubation and this varied with the various treatments or hours of aeration. depending on the time frame allotted for it.

Hatching rate of egg was estimated as

$$\text{Hatching rate} = \frac{\text{No of eggs hatched}}{\text{Total number of eggs incubated}} \times 100$$ [19]

2.4 Management/nursing of hatchlings
Care of the larvae started immediately after hatching with regular flushing of water through shower at stipulated time frame for each treatment. For the first three days, the sac fry depended on its yolk sac for nutrients stored in it. And by the third day, the yolk sac was exhausted, after which the advanced fry were fed with artificial feed (Coppens) of 0.1mm size for the first week, 0.2mm for the next two weeks, then 0.5mm for the 4^{th} and 5^{th} weeks, and 0.8-1.2mm for the 6^{th} week.

2.5 Determination of growth parameters
The following growth parameters were estimated;
i) Bi-weekly weight gain was estimated by taking randomly the weight of 10% of the total population of the fry in each replicate. Weight was determined by using a sensitive compact scale, Model CS 2000 HAUS.
ii) Specific growth rate (g/day): The SGR was calculated as

$$SGR = \frac{\log_e W_2 - \log_e W_1}{\text{Rearing period in days}}$$

Where W_2= final weight of the fry, W_1= initial weight of the fry and $\log_e$= natural log to the base e as described by [20].

2.6 Determination of survival rate
The experimental bowls was monitored daily to remove dead fry and the survival rate was calculated as; [21]

$$\text{Survival rate (SR \%)} = \frac{\text{Total number of fry at the end of the rearing period}}{\text{Total number of fry at the beginning of the rearing period}} \times 100$$

2.7 Data collection and analysis
The data obtained was subjected to analysis of variance (ANOVA) to determine significant differences among treatments and the treatment means was separated by Duncan's Multiple Range Test (DMRT) at 5% probability level.

3. Results
The results of the effect of varied levels of aeration on the spawning success of African catfish, growth performance and water quality is shown in Table 1. The results showed that reproductive performance (hatching rate), growth performance (bi-weekly weight gain, survival and SGR) and water quality parameters were significantly different among the treatments with values of 30.12%, 54.76%, 60.44%, 70.81% and 83.24% for for the hatching rate, 5.61g, 7.67g, 9.29g. 12.93g and 17.03g for the bi-weekly weight gain, 76.87%, 76.6%, 81.3%, 84.8% and 88.8% for survival, 0.03, 0.03, 0.04, 0.04 and 0.17 for specific growth rate for T1, T2, T3, T4 and T5 respectively. These parameters increased with increasing hours of aeration of culture water using water shower.

Table 1: Spawning Success, growth performance and water quality parameters of *C. gariepinus* fry exposed to various hours of aeration

Parameters	Treatments				
	T1	T2	T3	T4	T5
Hatching Rate (%)	30.12e	54.76 d	60.44c	70.81b	83.24a
Bi-weekly weight gain(g)	5.61e	7.67d	9.29c	12.93b	17.03a
SGR	0.03b	0.03b	0.04b	0.04b	0.17a
Survival (%)	76.87e	76.6d	81.3c	84.8b	88.8a
Water Temp(oC)	25.62a	24.86b	24.3c	23.1 d	22.5e
Water pH	4.79e	4.84d	5.27c	5.66b	6.1a

NB: Means with different alphabetic remarks are significantly different at 5% probability level.
Horizontal comparison only
T1= 0 hour, T2=4 hours, T3=6 hours, T4=8 hours and T5=12 hours

The pattern of growth over time is shown in fig.1 which indicated a weight increase from week 2 to week 10 and general weight increase with increasing rate of aeration.

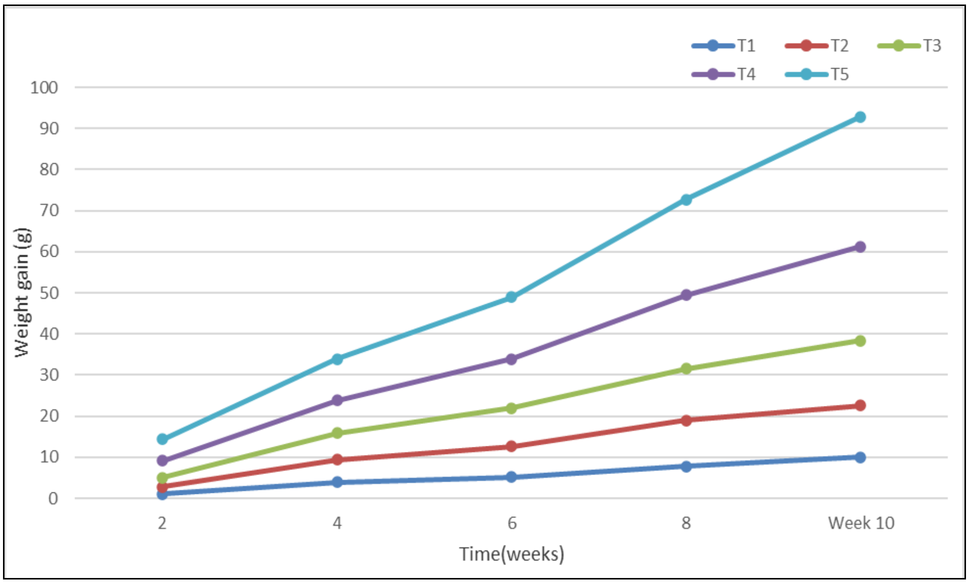

Fig 1: Weight gain of Clarias gariepinus fry under varied hours of aeration through water shower over time

The result in Table 1 also showed improvement in water quality with increase in water pH and dissolved oxygen level with increasing hours of aeration with shower with values of 4.74oC, 4.84 oC, 5.27oC, 5.66oC and 6.1oC for water Temperature; 2.65mg/l, 3.1mg/l, 3.15mg/l, 3.6mg/l and 3.7mg/l of dissolved oxygen for T1, T2, T3, T4 and T5 respectively.

4. Discussion

4.1 Hatching rate

Hatching rate increased with increasing hours of aeration (Table1). The highest hatching rate was recorded in T5. This may be due to the increased water aeration during the incubation period. This result is similar to the findings of [22], who noted that higher hatchling rates were achieved when the eggs were constantly kept in motion.

In this study, the hatching rate was relatively low in T1, and this was because no form of aeration was carried out here. This result agreed with the findings of [23] who recorded low hatchability rate as a result of low dissolved oxygen levels resulting in dead eggs or deformed fry. Increase in dissolved oxygen level culture water was achieved with increase in hours of aeration (Table 1).

4.2 Growth rate

The result of the bi-weekly weight gain (Table 1) showed a general increase in growth with increasing hours of aeration. This result is similar to the findings of [24] who reported that 12 hours of aeration had a higher weight gained at harvest. The fast growth rate recorded can be traced to the increasing D.O content which affects the fry appetite, feed consumption and utilization [25], while the low growth observed in T1could be as a result of low D.O reducing fry appetite and digestibility.

The significant increase in indices of growth performance except specific growth rate (SGR) of the fry exposed to 12 hours of aeration was in conformity with the works of [26, 27]. They reported that fry exposed to oxygen saturation expressed high appetite, better feed intake, better utilization and unstressed environment which ultimately leads to better growth performance.

Water aeration had no influence in the specific growth rate (SGR) of the *C. gariepinus fry*, from T1-T4 during the experiment. This finding was in agreement with the reports of [28] who observed no influence in the SGR of Atlantic Halibut Juveniles exposed to different oxygen levels (60-140%) which was approximately 2-4mg/l of DO concentration recorded in the study.

4.3 Survival rate

The advantages of aeration on the survival of all fingerlings were clearly demonstrated from the significant higher levels in aerated bowls, showing a linear relationship with the duration of aeration. The survival rate of the fish during this experiment was higher in T5 (88.80%), followed by T4 (84.80%) T3 and T2 having a survival rate of 81.20% and 76.60% respectively, with the least survival rate occurring in T1 (73.31%).

Although higher survival of fry in the culture systems with aeration as additional input is a known fact [29, 30, 31, 32], the present study showed interesting results with regards to 8hr and 12hr in T4 and T5 respectively.

Higher survival of the fingerlings in aerated groups was likely to contribute to relatively greater deterioration of the water quality owing to the use of more feed and release of faecal matter, this is in line with the findings of higher survival of rohu with provision of aeration [32] while the prevalence of low dissolved oxygen content as evident from the study might have led to low survival rate in the control and mortality of fingerlings that may have occurred during the study might have resulted mainly from cannibalism [33] and space effects.

4.4 Water quality parameters

The physical and chemical properties of culture water determine the quality of water, growth and wellbeing of the fry. The dissolved oxygen level obtained in this study were within the required levels recommended for a successful fish reproduction and in agreement with [34] except the fall in dissolved oxygen (2.85-3.79mg/l) compared to the 6mg/l recommended by FAO but this can be attributed to the enclosed indoor hatchery used for the study.

The ability of water to hold oxygen decreases as the water temperature increases, so water temperature must stay low enough to avoid fish kill. Fry were observed to aggregate at the corner during episodes of low oxygen levels. A similar observation was reported by [35]. The lower value of dissolved oxygen concentration available to the controlled fingerlings indicated that absence of water aeration might reduce Dissolved oxygen level in the controlled fingerlings. To support the above submission, it was documented that aeration will always increase levels of dissolved oxygen because its helps to oxidize ammonia to nitrates and reduce the build-up of carbon dioxide (www.ag.auburn.edu/fish)

Temperature still fell within the range of 22-35^{0}C tolerance for optimum growth rate in the tropics [36] while water pH improved with increasing hours of aeration. Generally, water aeration increased and improved with increasing hours of aeration thus providing better water condition and wellbeing of the culture fish.

4.5 Conclusion
The result of this study re-established the fact that aeration is an important input during spawning and nursing of fry procedure. Furthermore, this study revealed that, 8-12 hour aeration is required in order to ensure greater yield in the success of the spawning and nursing *C. gariepinus* due to the higher oxygen requirement. The use of water shower as a means of aeration may be used by the developing societies with inadequate resources for flow through system or water re-circulatory system.

5. Recommendation
Based on the findings of this research, the following recommendations are made:

1. Hatchery operators should ensure that the water inlets are with showerhead rather than the normal inlets to ensure that the D.O level is constantly increased.
2. During the incubation, water aeration of 12 hours should be adopted to ensure high hatchability rate.
3. 8-12hours of water aeration should be adopted during the nursing of the fry in order to attain fast growth within the shortest time.

6. References

1. Okunsebor SA, Ayuba AO. Growth performance and survival of fry fed on live feeds *Branchionus Calyciflorus*, *ceriodaphnia reticulate* and shell free Artemia. PAT. Livestock Research for Rural Development. 2011; 7(2):108-115.
2. Nwokoye CO, Nwaba LA, Eyo JE. Induced propagation of African clariid catfish *Heterobranchusbidorsalis* (Geoffrey Saint Hillarie, 1809) using synthetic and homoplastic hormone. African journal of Biotechnology. 2007; 6:2687-2693.
3. Olubiyi OA, Ayinla OA, Adeyemo AA. The effects of various doses of ovaprin on reproductive performance of the African catfish *Clarias gariepinus* (Burchell) *Hetero Branch Longicollis (*valenciennes). African Journals of Applied Zoology and Environmental Biology. 2005; 7:101-105.
4. Nguenga D, Forbin I, Teugles GG, Ollevier F. Predation capacity of tadpoles (Buforegularis)using African catfish *Hetero Branch Longicollis* larvae: impact of prey characteristic on vulnerability to predation. Aquaculture Research. 2000; 31:931-936.
5. Ali A, Ashraf A, Ayub M, Abide ZA, Khan MN. Water quality profile of fish farms in various ecological zones of Punjab. Pakistan Journal of Fisheries. 2000; 1:81-88.
6. Timmons MB, Summerfelt ST. Culture tank Engineering. Proceeding of AES workshop, Orlando, Florida, U.S.A. January. 2001; 23:2-14.
7. Bhatnagar A, Gary SK. Water quality management in aquaculture, International Journal of Environmental Science. 2006; 3(2)1342-1357.
8. Francis-floyd R. Dissolved oxygen for fish production fact sheet FA-27, Department of Fisheries and Aquatic Sciences, Florida co-operative extension service, Institute of Food and Agricultural science, University of Florida, 1992.
9. Najiah M, Wendy W, Ruhli H, Wei LS, Leong LK, Nooransikin H. Bakten dainIk Penerbitan University Malaysia Terengganu, 2008.
10. (Natural Environmental systems, LLC) NES. Pond aeration is critical for pond's success. Online at, 2011. http://www.naturalenviro.com/Article.php?ArticleSKU=pondae ration.
11. Loyacano HA. Effects of aeration in earthern ponds on water quality and production of white catfish; Aquaculture. 1974; 3:261-271.
12. Marek M, Sarig S. Preliminary observations of super-intensive fish culture in the Berth-Swan valley in 1969-1970; Bamidgeh. 1971; 23:93-99.
13. Rappaport U, Sarig S. The results of tests in intensive growth of fish at the Gunosar (Israel) station ponds in 1974; Bamidgeh. 1975; 27:75-82.
14. Hollerman WD, Boyd CE. Nightly aeration to increase production of channel catfish; American. Fisheries. Society. 1980; 109:446-452.
15. Plemmons B, Avault JW. Jr., Six tons of catfish per acre with constant aeration; La. Agric. 1980; 23:6-8.
16. Singh SB, Ghosh SR, Reddy PVGK, Dey RK, Mishra BK. Effect of aeration on feed utilization by common carp fingerlings; Journal of Inland Fisheries India. 1980; 12:64-69.
17. Okonji VA, Osayi SE, Imokhuede DA. Effect of Aeration on the Growth Performance of *Clariasgariepinus* in Concrete Tank. Journal of Agriculture and Environment, Retrieved from, 2012. https:// Scholar google.com.
18. Egwanomhe M, Okonji VA, Aniorji H. Effect of size of female broodstock on fry survival and condition factors of Clariabranchus (*Clarias gariepinus* ♀ X *Heterobranchus bidorsalis* ♂) International Journal of Fisheries and Aquatic Studies. 2017; 5(4):118-121.
19. Lambert Y. Why Should We Closely Monitor Fecundity in Marine Fish Population? Journal of Northwest Fisheries Science. 2008; 41:930-1106.
20. DongHan S, Xie wu L, Xiaoming Z, Yunxia Y. Effect of light intensity on growth, survival and skin color of juvenile Chinese longsnout catfish. Aquaculture, 2005, 248-299.
21. Adewolu MA, Ogunsanmi AO, Yunsa A. Studies on growth performance and feed utilization of two clariid catfish and their hybrid reared under different culture system. European Journal of Scientific Research. 2008; 23(2):252-260.
22. Stoeckel J, Neves R. Methods for hatching margined

madtorn eggs. Journal of Aquaculture. 2000; 62:42-47.
23. Bromage NR. Propagation and stock improvement. In: Shepherd, J, Bromage, N(Eds)Intensive Fish farming. Blackwell, Oxford, Uk, 1988, 103-153.
24. Pawar NA, Jena JK, Das PC, Bhatnagar DD. Influence of duration of aeration on growth and survival of carp fingerlings during high density seed rearing. Aquaculture. 2009; 290:263-268.
25. Hepher B. Nutrition of pond fishes. Cambridge University Press; New York, 1988, 420p.
26. Pichavant K, Person-Le-Ruyet J, Le Bayou N, Severe A, Le Roux A, Bcouf G. Comparative effects of long-term hypoxia on growth, feeding and oxygen consumption in juvenile turbot and European sea bass. Journal Fish Biology. 2001; 59:875-883.
27. Nordgarden U, Oppedal F, Taranger GL, Hemre GJ, Hanseen T. Seasonally changing metabolism in Atlantic salmon (salmosalarl). Aquaculture Nutrition. 2003; 9:287-289.
28. Mallya YJ. The effect of dissolved oxygen on fish growth in aquaculture. The United Nations University. Fisheries training programme, Final project, 2007.
29. Vijayann MM, Verghese TJ. Effect of artificial aeration on growth and survival of Indian major carps. Proceedings of the Indian Academy of Sciences. (Anim. sci.). 1986; 95(4):371-378.
30. Aravindakshan PK, Jena JK, Ayyappan S, Muduli HK, Suresh Chandra. Evaluation of aeration intensities for rearing of carp fingerlings. Journal of Aquaculture. 1997; 5:63-69.
31. Jena JK, Aravindakshan PK, Mohanty UK. Evaluation of growth and survival ofIndian major carp fry in aerated vis-à-vis non-aerated ponds under differentstocking densities. Indian Journal of Fishes. 2005; 52:197-205.
32. Jena JK, Aravindakshan PK, Singh WJ. Nursery rearing of Indian major carp fryunder different stocking densities. Indian Journal of Fishes. 1998; 45(2):163-168.
33. Wasiu AO, Ofelia GO. Embryonic and larval developmental stages of African catfish *Heterobranchusbidorsalis* (Geoffroy Saint Hilaire, 1809) Teleostei, Clariidae). Springerplus. 2014; 3:677.
34. FAO. Artificial Reproduction and Pond Rearing of the African Catfish Clariasgariepinus in Sub-Saharan Africa. A Handbook. Food and Agriculture Organization of the United Nations, Rome, Italy. 1996; ISBN-13: 9789251039182, 73p.
35. Abdulla AF, Romaire RP. Effect of timing and duration of aerationon water quality and production of channel catfish Journal of Applied Science. 1996; 6(1):1-9.
36. Howerton R. Best management practices for Hawaiian aquaculture. CTSA. 2001; 148:7-31.