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%, 76.60% and 84.80% 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 hatching to be critical. In freshwater system, normally the level of dissolved oxygen is about 6ppm at 25°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 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 mature
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.

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 4th and 5th weeks, and 0.8-1.2mm for the
6th week.

Hatching rate of egg was estimated as

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

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.

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

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

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

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](image)

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 6.10C 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 [23], who noted that higher hatching 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 lower 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 [23] 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 T1 could 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
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 of *Clarias 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. 8-12 hours of water aeration should be adopted during the nursing of the fry in order to attain fast growth within the shortest time.

6. References

22. Stoeckel J, Neves R. Methods for hatching margined