http://www.ajol.info/index.php/tfb; DOI: https://dx.doi.org/10.4314/tfb.v28i2.5

INFLUENCE OF WATER AERATION LEVELS ON THE OPERCULAR RESPIRATORY BEATS AND SELECTED WATER QUALITY PARAMETERS OF HETEROCLARIAS FINGERLINGS UNDER LABORATORY CONDITIONS IN MINNA, NIGERIA

A.V. Ayanwale[1], S.M. Tsadu[2], S.L. Lamai[2], R.J Kolo[2], U. N. Keke[1] and Y. I. Auta[1]

[1] Department of Animal Biology, Federal University of Technology, Minna.
[2] Department of Water Resources Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Nigeria.
Corresponding author: a.adesola@futminna.edu.ng, +2348036532471

ABSTRACT

A twelve (12) week experiment was carried out to determine the influence of water aeration on the Opercular Respiratory Beats (ORB) and selected water quality parameters of 1,800 Heteroclarias fingerlings of average weight of 1.40 g under laboratory conditions. One hundred and fifty fingerlings were allotted in a complete randomized design into water aeration levels: 0.00(control), 6.00, 12.00 and 24.00 hours respectively as treatments and replicated thrice. The ORB and water quality parameters were determined weekly based on standard procedures .Water quality parameters investigated were not influenced by water aeration except the Dissolved Oxygen (DO) concentration in the control that was significantly ($p<0.05$) reduced. The respiratory beats (ranged from 51.60±5.94 to 53.17±3.77operculum beats per minutes) of fishes aerated within the investigated range of 6.00 – 24.00 hours were not significantly ($P>0.05$) different at the end of the 12th week. At the 2nd, 8th and 10th weeks, respiratory beats of the Heteroclarias fingerlings were not significantly ($P>0.05$) different among the treatments. However, in the 1st and 7th weeks respiratory beats were significantly ($P<0.05$) higher among the fishes not aerated (131.63±8.35operculum beats per minute) and those aerated (76.33±10.75 operculum beats per minute) for 6.00 hours. The ORB decreased with increase in fish size from week 1 to the end of the study. The research also showed that water aeration had no influence on the water quality parameters except DO of the controlled fingerlings. Water aeration had influence on ORB only at the 1st and 7th weeks of the experiment but no significant influence was recorded during the greater period of investigation. As a recommendation, fish farmers are advised to monitor the dissolved oxygen concentration daily in their ponds to ascertain when aeration is necessary. Findings of this research also remove the fears of maintenance cost of using Air pump.

Key words: water aeration, Heteroclarias, water quality, operculum respiratory beats, fish size.

INTRODUCTION

Aeration is the process of adding oxygen and decreasing dissolved carbondioxide or nitrogen gas to levels closer to atmospheric saturation in a pond with the use of mechanical aerators or through natural processes (Losordo *et al.,* 1999). .Sources of Dissolved Oxygen (DO) by aeration may be flow through riffles, rapids and waterfalls, inflow of turbulent water and photosynthesis by aquatic plants. DO can be depleted through respiration (from fish and aquatic plants), decay of organic matter, direct chemical oxidation, and out flow of water (Brown, 1985). An adequate supply of DO is important to fish during all stages of life. Aeration will results in increased levels of dissolved oxygen, because its helps to oxidize ammonia to nitrates and reduce the build-up of carbondioxide (Boyd, 1998). Fish ponds can be aerated with mechanical aerators such as fountain pond, venturi tube, diffusers, which will result in increased levels of dissolved oxygen. (Losordo *et al.,* 1999). Ventilatory responses in fish are mainly to increase the total amount of oxygen through water aeration and are also good indicators of stress situation in fish (Haughes, 1981). Boyd and Tucker (1998) reported that there are two ways fish ventilate their gills: buccal or opercula pumping (active ventilation) and ram ventilation (passive ventilation). The oxygen consumption by aeration or natural methods and ammonia excretion rates are affected by animals body size, activity, handling and an environmental condition such as temperature, the animal is exposed to (Crear and Forteath, 2000 and Ayanwale *et al.,* 2016).

The frequencies of opercular ventilation beats have been reported to be used as measure of respiratory rates in fish (Lloyd, 1992). The increased opercula movement by the exposed fish may be the reflection of an attempt by the fish to extract more oxygen to meet the increased energy demand to withstand the rise in temperature but this too has a limit beyond which the activity stops resulting in the death of the fish (Murugaian *et al.,* 2008).

Therefore, the present study was carried out to investigate the influence of water aeration on the opercular respiratory beats and selected water quality parameters of Heteroclarias fingerlings under laboratory conditions.

MATERIALS AND METHODS

Experimental Site: The study was conducted at the Biology laboratory of the School of Life Sciences, Bosso Campus, Federal University of Technology, Minna, Niger State.

Source of the Experimental Fish: One thousand eight hundred weeks old Heteroclarias fingerlings with average weight of 1.40 g were purchased from a private fish farm in Lagos, Lagos state, Nigeria.

Acclimatization of the Fingerlings: The fingerlings were acclimatized in rearing tanks for a period of seven days to allow them to recover from transportation stress, fed on a commercial diet (Coppens) to satiation, morning and evening with water exchange (Ghanbari *et al.,* 2012 and Ayanwale *et al.,* 2014).

Experimental Set - Up: The experiment consisted of four treatments and each with three replicates. The diffused aeration method was used for the study (Poon *et al*., 2002). Treatment 1 was the control; while treatments 2, 3 and 4 were aerated for 6, 12 and 24 hours daily respectively. Twelve plastic indoor aquaria tanks 25 litres capacity (55x35x35cm^3) were filled with bore-hole water up to 20 cm level. The aeration of the water in the aquarium was maintained by a constant supply of air by the use of compressor operated electricity-powered air pump, with the aid of inverter as an alternative source of electricity in case of power outage (Odunze *et al*., 2006). The fingerlings were fed to satiation twice daily on a commercial diet-Coppens (Dong Han *et al*., (2005). Water exchange was done twice a week, and the experiment was conducted for a period of twelve weeks.
Determination of Selected Water Quality Parameters: Water temperature was determined weekly with mercury in bulb thermometer (10-110^{0}C range). Dissolved Oxygen, Biochemical Oxygen Demand (BOD), Hydrogen Ion Concentration (pH) and Ammonia (NH_3) were determined weekly based on standard methods (American Public Health Association, 1995).

Determination of Opercular Respiratory Beat Rate: Opercular respiratory beat rate was determined after the modification of Ambrose and Ambrose (1995) and those of Ayoola and Fredrick (2012). One fingerling from each of the experimental tanks was randomly and carefully removed with a hand net and placed gently in a beaker already filled with 250ml of rearing water of the fish. The fish were allowed to recover from stress incurred during handling before the opercular respiratory beat was counted individually per minute against each treatment using a stop watch. This procedure was repeated 10 times for 10 Heteroclarias fingerlings from each of the experimental tank. The experiment was conducted for a period of 12 weeks before termination.

Data Analysis: The data collected were analysed for significant differences ($P < 0.05$) by the analysis of variance (ANOVA) using a Computer Statistical Package for Social Sciences (SPSS). Duncan Multiple Range Test (Duncan, 1955) method was used to separate the means where there were statistically significant differences ($P < 0.05$).

RESULTS AND DISCUSSION

The results of selected water quality parameters of the water medium in which the Heteroclarias fingerlings were exposed to different water aeration levels are shown in Table 1. The water temperature (22.37±0.61^{0}C) of the fingerlings exposed to 24.00 hours of aeration was significantly ($P<0.05$) reduced when compared with those of other water aeration levels (12.00-0.00 hours) and ranged from 24.61±0.60 to 26.34 ±0.67^{0}C.The dissolved oxygen concentration (4.00 ±0.47mg/L) consumed by the fingerlings cultured in non-aerated water (control) was also significantly lower ($P<0.05$) when compared with those of higher water aeration duration (6.00-12.00 hours) ranged from 4.55 ± 0.53 to 4.92 ± 0.61 mg/L.Similarly, the biochemical oxygen demand concentration (0.95± 0.54mg/L) was also significantly ($p< 0.05$) lower when compared with those of higher

aeration duration (24.00 to 12.00 hours) ranged from 1.42± 0.41 to1.45± 0.48Mg/L. Table 1 also indicated that there were no significant differences (P>0.05) in the ammonia concentration (range = 0.26 ± 0.05 to 0.28 ± 0.05 mg/L) and water pH (7.29 ± 0.34 to 7.58 ± 0.49) of the fingerlings cultured in all the treatments.

TABLE 1

Mean Water Quality Parameters Measured During Experiment on Influence of Different Water Aeration Levels on Heteroclarias Fingerlings

Duration of Aeration (Hrs)	Temperature (°C)	DO (mg/l)	Ammonia (mg/l)	pH	BOD (mg/l)
0.00	26.34±0.67^{b}	4.00±0.47^{a}	0.28±0.05^{a}	7.29±0.34^{a}	0.95±0.54^{a}
6.00	25.48±0.64^{b}	4.55±0.53^{ab}	0.26±0.05^{a}	7.40±0.35^{a}	1.28±0.41^{ab}
12.00	24.61±0.60^{ab}	4.92±0.61^{b}	0.27±0.06^{a}	7.53±0.44^{a}	1.45±0.48^{b}
24.00	22.37±0.61^{a}	4.78±0.48^{b}	0.26±0.05^{a}	7.58±0.49^{a}	1.42±0.41^{b}

Values are Mean ± Standard deviation, Values followed by the same superscript(s), in the same column, are not significantly different at (P >0.05) tested by DMRT.

The result of mean respiratory rates of Heteroclarias fingerlings exposed to different aeration levels for a period of 12 weeks are highlighted in Table 2. The respiratory rate (ranged from 51.60±5.94 to 53.17±3.77operculum beats per minutes) of fishes aerated within the investigated range of 6.00 – 24.00 hours were not significantly (P>0.05) different at the end of the 12th week. During the 2nd, 8th and 10th weeks, respiratory rates of the Heteroclarias fingerlings were not significantly (P>0.05) different among the treatments. But, in the 1st and 7th weeks however, respiratory rates were significantly (P<0.05) higher among the fishes not aerated (131.63±8.35operculum beats per minute) and those aerated (76.33±10.75 operculum beats per minute) for 6.00 hours. For all treatments, including the control, respiratory rates of the fishes reduced steadily with weeks and by the 12th week such respiratory rates were less than half the rates during the 1st and 2nd weeks of exposure of the fingerlings to different daily continuous aeration levels. Generally, there was a decrease in the opercular respiratory beats of the experimental fingerlings as the fish size increased. Water aeration had no influence on the selected water quality parameters because they were all within the range documented for fish growth in the tropics (Ayanwale *et al*., 2016). This finding was also in agreement with the common management practice of most fish farmers who does not operate mechanical aerators but depend on natural processes as sources of DO. In addition, the farmers were able to maintain water quality parameters through constant exchange of water, avoidance of excess feeding and planting of shading tree crops (Ayanwale *et al*., 2012 and Ayanwale *et al*., 2016). The similar responses observed in the opercular respiratory beats of the fingerlings at the 2nd, 8th and 10th and also at 12th weeks between 6.00- 24.00 hours of water aeration; might be because the animals carried out the same metabolic activities.

TABLE 2

Mean Respiratory Rates (number of operculum beats per minute) of Heteroclarias Fingerlings Exposed to Different Aeration Levels for a 12 Weeks Period.

Duration of Aeration (Hours)	Weeks 1	2	3	4	5	6	7	8	9	10	11	12
0.00 (Control)	131.63 ±8.35^{c}	104.3 ±1.49^{a}	96.73 ±4.03^{a}	95.77 ±8.79^{a}	82.93 ±0.73^{b}	76.27 ±3.14^{b}	70.03 ±2.52b^{c}	56.40 ±1.44^{a}	54.53 ±5.08^{a}	49.73 ±3.74^{a}	44.17 ±1.44^{a}	46.23 ±1.04^{a}
06.00	126.23 ±10.24^{b}	104.23 ±3.72^{a}	95.90 ±8.24^{a}	97.40 ±3.81^{a}	95.37 ±3.83^{c}	74.40 ±3.32^{ab}	76.33 ±10.75^{c}	58.63 ±1.37^{a}	58.83 ±5.04^{c}	52.67 ±3.92^{a}	54.73 ±5.52^{b}	51.60 ±5.94^{ab}
12.00	118.63 ±1.00^{a}	108.60 ±0.43^{a}	98.26 ±2.19^{a}	106.30 ±3.98^{b}	82.10 ±7.30^{b}	70.27 ±3.53^{a}	67.03 ±8.25^{b}	59.50 ±4.36^{a}	59.50 ±3.15^{c}	54.43 ±2.49^{a}	53.03 ±2.99^{b}	52.40 ±8.64^{b}
24.00	121.57 ±2.47^{a}	107.8±2.33^{a}	107.60 ±2.75^{b}	107.77 ±2.60^{b}	73.00 ±2.05^{a}	71.47 ±1.19^{a}	57.70 ±2.55^{a}	56.47 ±3.35a	52.83 ±1.72^{a}	53.83 ±650^{a}	52.63 ±3.80^{b}	53.17 ±3.77^{b}

Values are Mean ± Standard deviation, Values followed by the same superscript(s), in the same column, are not significantly different at (P >0.05) tested by DMRT

This finding was in consonance with the works of Crear and Forteath (2000) who reported that respiratory rates in fish were affected by animal body size, activity and environmental conditions. The sudden increase in the ORB in controlled and fishes aerated for 6.00 hours in the 1st and 7th weeks suggest respiratory distress. This is because the rearing water became slightly warmer and thus had less DO (Materna, 2001). Therefore, increase in the ORB or movement by the fingerlings might be an attempt to get more oxygen from the water to meet the increased energy demand, and also primary sudden stress for oxygen demand (Murugaian *et al.,* 2008; Sreeya and Lipton, 2012). However, the reduction in the ORB from the commencement to the end of the study may be attributed to fish size and activities (Ayoola and Fredrick, 2012).The author also added that opercular respiratory beats or rate decreased with increase in growth or fish size.

The research revealed that water aeration had no influence on the water quality parameters except DO of the controlled fingerlings. Water aeration had influence on ORB only at the 1st and 7th weeks of the experiment but no significant influence was recorded during the greater period of investigation.

The fish farmers are advised to monitor the dissolved oxygen (DO) concentration daily in their ponds to ascertain when water aeration is necessary. These findings also remove the fears of maintenance of cost of air pump or water aerators.

ACKNOWLEDGEMENTS

This study was part of a Research Project funded by the TETFUND Institution based research intervention (TETFUND/FUTMINNA/2014/26 Federal University of Technology, Minna, Nigeria.

REFERENCES

Ambrose, H.W. & Ambrose, K.P. (1995). *A Hand Book of Biological Investigation,* (5th Ed.), Winston-Salem, NC, Hunter Textbooks Incorporation.

American Public Health Association (APHA, 1995). Standard Methods for the Examination of Water and Wastewater (19th Eds.). APHA, Washington, DC, Lewis publisher.

Ayanwale, A V., Tsadu, S. M., Lamai, S. L, Kolo, R.J., Patrick, O.S. & Abdulhakeem, A. (2016). Influence of Temperature and pH on Critical Water Quality Parameters of Laboratory reared Culture Media of the Economically Important Heteroclarias Fish Fingerlings. *NSUK Journal of Science and Technology,* **6 (2),** 7-11, ISSN 1597-5527.

Ayanwale, A. V., Minnin, M. A., & Olayemi, I. K. (2012). Physico-chemical Properties of Selected Fish Pond in Nigeria: Implications for Artificial Fish Culture. *Biomed Central, BIOLOGY* 3(10):WMC003751.

Ayanwale, A.V, Tsadu, S.M, Kolo, R.J., Lamai, S.L., Falusi, F. M. & Baba, B. M. (2014). Influence of Temperature on Survivorship and growth performance of Heteroclarias fingerlings under laboratory conditions. *Advance in Agriculture and Biology* **1(3),** 135 – 139.

Ayoola, O.A & Fredrick, A.C. (2012). Effects of the Shape of Culture Tanks on Production of the African Catfish *Clarias gariepinus* Juveniles. *Journal of Agriculture and Social Research*, **12(1),** 1-18.

Boyd, C. E. (1998). Pond water aeration systems, *Aquaculture Engineering* Vol. **18(1),** 9-40.

Boyd, C.E. & Tucker, C.S. (1998). *Pond Aqaculture Water Quality Management*, Boston, MA, Kluwer Academic Publishers, pp 700.

Brown, G.W. (1985). *Forestry and Water Quality, Corvallis*: College of Forestry, Oregon State University Publisher, OSU Bookstores, Inc. 142

Crear, B.J. & Forteath, G.N.R. (2000). The Effect of Extrinsic and Intrinsic Factors on Oxygen Consumption by the Southern Rock Lobster, Tasus Edwadsii. *Journal of Experimental, Marine Biology and Ecology,* **252,** 129-147.

Dong Han, S. Xie Wu, L., Xiaoming, Z. & Yunxia, Y. (2005). Effect of Light Intensity on Growth Survival and Skin Colour of Juvenile Chinese Longsnout Catfish (*Leiocassis longirostris* Gunther). *Aquaculture*, **248,** 299-306.

Duncan, D. B. (1955). New multiple and multiple F-test. *Biometric,* **11,** 1-42

Ghanbari, M., Mansoureh, J., Konrad, J.D. & Wolfgang, K. (2012). Long-Term Effects of Water pH Changes on Hematological Parameters in the Common Carp (*Cyprinus carpio* L.). *African Journal of Biotechnology*. **11(13),** 3153-3159

Haughes, M. (1981). Effects of a Low Oxygen and Pollution on the Respiratory System of Fish. *In*: Pickering, A. D. (Eds.), Stress and Fish. New York, Academic Press, pp. 121-146.

Lloyd, R. (1992). *Pollution and Freshwater Fish, Fishing News Book.* U.S.A., Blackwell Scientific Publications Inc.

Losordo, T.M., Masser, M.P. & Rakocy, J. (1999). Recirculating aquaculture tank production systems: A review of component options. *Srac Publication* **(453),** 12.

Materna, E. (2001). *Temperature Interaction, United States Environmental Protection Agency Issue Paper 4.* Prepared as part of Epa region 10, temperature water quality criteria guidance development project. pp 1-33.

Murugaian, P., Ramamurthy, V. & Karmegam, N. (2008). Effect of temperature on the behavioural and physiological responses of catfish, *Mystus gulio* (Hamilton) *Journal of Applied Sciences Research,* **4(11),** 1454-1457.

Odunze, F.C., Lamai, S.L & Oladimeji, A.A. (2006). *Preliminary studies on the effects of varying levels of aeration on the growth and physiological processes of cultured Clarias gariepinus fingerlings.* Editorial team: U.I. Enin, E.I. Chukwu, P.O. Ajah, D.A. Ama-Abasi, F.M. Nwosu. Proceedings of the 21st Annual Conference of the Fisheries Society of Nigeria (FISON). pp 233-239. Calabar.

Poon, W.L., Hung, C.V. & Randau, D.J. (2002). *The effect of aquatic hypoxia on fish*. Department of Biology and Chemistry, City University of Hong Kong, Kowloon, Hong Kong, Sar, China (Epa/600/R02/097).

Sreeya, G.N. & Lipton, A.P. (2012). Physiological responses of the cyprinid, *Puntius ticto* hamilton acclimated to different temperatures. *Journal of Theoretical and Experimental Biology*, **8(3 & 4),** 133-139.