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Research Paper

Effect of pH on the growth performance and survival rate of *Clarias gariepinus* fry

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Abstract

The growth performance and survival rate of *Clarias gariepinus* fry subjected to various pH treatments was investigated. The tests were conducted in plastic baths of 3.5 litre capacity filled to 2 litre mark with freshly prepared experimental solution and labelled according to pH requirements for the test. Each bath was stocked with forty (40) fry of body length between 6.90mm and 7.03mm. They were exposed to the experimental solution for a period of fourteen (14) days for growth estimation. For survival rate, the test organisms were examined at 2hour intervals for probable death. The fry were fed during the time of this study using shell free *Artemia*, normally used as starter food at the onset of exogenous feeding. The length, measured as tip of the snout to the end of the caudal fin, was determined prior to stocking and at 2days interval, for the period of study. Every 24 hours the medium was checked for any change in pH and adjusted if any. The temperature of the culture media was averagely constant (26.5°C) and dissolved oxygen content remained approximately 6.0mg/l. Within 48hrs, average increase in length of between 0.16mm and 2.28mm was recorded in pH 5,6,7,8, and 9. There was no surviving fry on day 2 in pH 2,3,10,11 and 12 i.e. 100% mortality 24 hrs of stocking while pH4 recorded total mortality after 192hrs. Percentage survival in the other pH varied between 99.7% (in pH7 and pH8) and 51.67% (in PH5). Optimal growth of 92.03% was recorded in PH 7 while the median lethal pH (ML₅₀pH) is 4.3 and 9.2 for acidic and alkaline treatment respectively. Results from this study shows that reduced pH condition has a depressing effect on the growth rate of *Clarias gariepinus* fry. This suggests the need for constant monitoring of pH changes in water especially in fish farming operations.

Keywords: Growth, Survival, *Clarias gariepinus*, pH, Fry.

Introduction

The culture of *Clarias gariepinus* fry as seed for fish production is becoming increasingly essential as the fish is contributing to the food abundance and nutritional benefit to family health, income generation and employment opportunities^[1]. Fish contains large amounts of quality amino acids including lysine, methionine and tryptophan as well as substantial quantities of vitamins although poor in vitamins A and C^[2,3]. Over-fishing in many tropical countries has however resulted in scarcity of fish species in the wild highlighting the need to explore more avenues to satisfy the high demand for fish and fish products. Aquaculture is often recommended as a solution to the scarcity of fish protein. It has been recognized that the abiotic and biotic environment profoundly affect the distribution of animals in different habitats and the physical environment also embraces everything that is not directly associated with the presence of animals including fish. The life patterns and activities of

animals in a given ecological system are influenced by a number of factors which could be endogenous (body size, activity, reproductive cycle pattern, nutritional status), or exogenous (hydrogen ion concentration (pH), salinity, temperature, oxygen concentration and photoperiod, among others). The hydrogen ion concentration (pH) of a solution is among the many abiotic factors that affect the survival, growth, reproduction and distribution of aquatic animals. The similarity of the effects of the pH and carbon IV oxide (CO₂) tension on the oxygen-carrying capacity of the blood has also been noted^[4,5]. Thus, it is envisaged that increased pH is accompanied with increased rate of respiration.

It has been recognized that three distinct processes, namely, cell division, assimilation and cell expansion contribute to the physiological process of growth – a process which acts as an integrator of a variety of physiological end-products and which may be classified into reproductive and somatic phases. While the reproductive growth phase involves increase in the sizes of the reproductive structures, the somatic aspect entails increase in body size. In both processes growth is often determined by change in weight and/or length. Fish growth incorporates the larva, fry, fingerling and adult stages. Most researchers have focused on the acid and alkaline pH limits at which fish grow and reproduce rapidly because fishes have a narrow tolerance pH range^[6]. In a study, Boyd 1982^[7] noted that the acid and alkaline death points for fish are about pH 4 and pH 11, respectively. However, if waters are more acidic than pH 6.5 or more alkaline than pH 9.0 for long periods, reproduction and growth will diminish. Furthermore, during periods of rapid plant growth in ponds, pH values in these ponds have reached 12 or more and led to death.

One of the suggested causes of fish death in very acidic water is failure to regulate their internal ion content associated with a reduction in ion uptake rates^[8], and inhibition of ammonia excretion attributed to reversal of the NH₃⁺ gradient across the gill^[9]. Both influx and efflux of sodium and chloride through the gills and kidneys are affected by this. Sodium influx rates appear to be largely dependent on pH. Empirical evidence has also shown that fish blood, muscle and cellular parameters are altered by pH^[10]. The pH tolerance range varies for different species. For example, the tolerance ranges are: for sticklebacks, pH 4.0 - 5.0, cichlids, 6.5 – 9.2, perch, 4.6 – 9.5, *Clarias gariepinus*, 6.5 – 8.0^[11].

According to Ogunji et al.^[12] a *Clarias gariepinus* fry feeds exogenously, gill and accessory organs are well developed, yolk sac is completely reabsorbed and the liver is conspicuous. The formation of all important organs had been initiated except the gonad and swim bladder, this normally occur after day 3 posthatch. Their ability to utilise live food at the onset of exogenous feeding has also been reported^[13,14]. However inability to get enough of the fry for Nigerian fish ponds poses a major problem to fish farmers. Although the fry are produced in large numbers in the hatcheries, poor survival of these larvae within the first month of life poses a big problem to hatchery operators^[15]. Several factors are responsible for this high mortality, one of which is the chemistry of the aquatic environment. Alterations in growth and survival rates of fish are amongst the most sensitive indicators of water chemistry change^[16]. The objective of this study was to determine the growth and survival performance of *Clarias gariepinus* fry and more specifically the optimum pH range that supports optimum growth rate.

Materials and Methods

The pH tolerance tests were carried out according to Alabaster et al. 1982^[17]. The test was conducted in the African Regional Aquaculture Centre (ARAC) at Aluu, Port Harcourt.

Experimental Fish

Fertilization, incubation and hatching of the eggs of the test fish were carried out in African Regional Aquaculture Centre (ARAC) Port Harcourt. The fish used for this study were fry of *Clarias gariepinus*. The gravid female and male *Clarias gariepinus* used in this work had been kept in the facilities of the African Regional Aquaculture Centre (ARAC) Port Harcourt.

Female *C. gariepinus* were chosen on the basis of ovarian biopsy of the Oocytes as described by Legendre 1986^[18]. Males were chosen on the basis of possession of pointed and hyperamic urino genital papillar^[19]. Hormone administration was carried out according to Woynarovich et al.^[20] between 15.00 and 17.00 hours with Carp pituitary suspension at a dose of 6mg/kg body weight and

at an induction temperature of 26.5°C. A total of four female *Clarias gariepinus* were injected. After latency period of about 10 hours, ovulated eggs were removed from the induced female *Clarias gariepinus* into dry receptacle by hand stripping. The stripped eggs were thoroughly mixed together with plastic spoon. Two *Clarias gariepinus* males were killed. Milt extracted from these males into 0.9% sodium chloride (NaCl) saline solution were pooled together and used in fertilizing the *Clarias gariepinus* eggs. Fertilization was enhanced by addition of freshwater to the mixture of eggs and milt. The fertilized eggs were incubated on bunched strands of polyethylene fibers (kakaban) placed in 4.35m diameter circular concrete tanks. The tanks were filled to 0.25m depth with clean water. The eggs hatched between 24 and 30 hours after incubation to produce the larvae. The larvae were not fed until day 3, because at this stage of development their yolk still serves as the only source of food^[21]. About 2000 larvae were collected for the study.

pH Treatments

Thirty-three (33) plastic containers of 3.5 litre volume were used for the study. 2 litre of dechlorinated tap water was poured into each container. To obtain the required pH values, HCl was added dropwise (for acidity) or Ca(OH)₂ solution added (for alkalinity) while the values were read using a pH meter ATC pH meter HI 8915^[17]. The pH values ranged between 2 and 12.

Stocking of Fish, Feeding and Fish Measurements

The bowls were stocked at a uniform distribution of 40 fry per bowl for 14 days (duration of study). Initial average length of the fry were determined before stocking. 1/3 of the experimental water was changed with fresh water daily to avoid water pollution, while the fry were fed to satiation using shell free *Artemia*. Fry of *Clarias gariepinus*, readily consumes artemia at the onset of feeding after yolk absorption as evidenced by Nyina-Wamwiza et al.^[22] who pointed out that at the onset of exogenous feeding, fry of the African catfish (*C. gariepinus*) are able to eat, digest, absorb, and metabolize nutrients since they have developed a sizeable mouth and digestive system. Feeding was done four times/day. The experiment was done in three (3) replicates for each pH treatment. Growth was measured at 2 days interval as body length, which is from the tip of the snout to the end of the caudal fin. This was done by the use of Venier Calipers and a pair of dividers. Mortality in each bowl was recorded daily.

Water Quality Monitoring

Water temperature records in each container were taken twice daily, morning (8.00am -9.00am) and evening (5.00pm – 6.00pm) using mercury- in-tube thermometer. Dissolved oxygen (DO) content was determined using Jenway DO meter (model 3050, England). Dissolved oxygen and pH measurements were taken every morning (8.00am -9.00am).

Data analysis

Growth and survival values were subjected to analysis of variance (ANOVA) and treatment means were compared with each other for significant differences ($p < 0.5$).

Results

Growth Performance and Mortality

Table 1 shows the growth responses of the frys at the various pH treatments. Highest percentage increase in length (92.03%) was recorded in pH 7 while 77.38% and 56.85% increase were recorded against pH 5 and 9 respectively. Table 2 shows the percentage mortality and survival with their corresponding pH treatments. 100% mortality was recorded in pH 2,3,10,11 and 12 twenty-four (24) hours post stocking while pH 4 recorded 100% mortality after 192 hours. Data obtained in Figure 1 shows the median lethal pH (ML 50 pH) for acidic treatment as pH 4.3 while for alkaline treatment, ML 50 pH was 9.2.

Table 1: Growth responses of *Clarias gariepinus* Fry at the various pH treatments

pH treatment	TL0 (mm)	TL1 (mm)	TL2 (mm)	TL3 (mm)	TL4 (mm)	TL5 (mm)	TL6 (mm)	TL7 (mm)	% Increase
2	6.90 ±0.01	-	-	-	-	-	-	-	-
3	6.97 ±0.01	-	-	-	-	-	-	-	-
4	6.97 ±0.02	0.66 ±0.01	1.60 ±0.10	0.24 ±0.00	0.18 ±0.01	-	-	-	-
5	7.03 ±0.01	0.88 ±0.00	2.28 ±0.01	0.34 ±0.01	0.66 ±0.01	0.72 ±0.01	0.38 ±0.00	0.18 ±0.00	77.38
6	6.90 ±0.01	1.80 ±0.01	1.00 ±0.01	0.80 ±0.01	0.66 ±0.01	0.82 ±0.01	0.90 ±0.01	0.37 ±0.00	92.02
7	7.03 ±0.00	1.54 ±0.01	1.00 ±0.01	1.20 ±0.01	0.66 ±0.01	1.04 ±0.00	0.48 ±0.02	0.55 ±0.01	92.03
8	7.03 ±0.01	0.60 ±0.01	1.40 ±0.00	0.40 ±0.02	1.28 ±0.00	0.76 ±0.00	0.45 ±0.01	0.41 ±0.01	75.39
9	6.93 ±0.01	0.60 ±0.00	2.00 ±0.01	0.34 ±0.00	0.34 ±0.01	0.30 ±0.01	0.16 ±0.01	0.20 ±0.02	56.85
10	6.97 ±0.10	-	-	-	-	-	-	-	-
11	6.97 ±0.02	-	-	-	-	-	-	-	-
12	6.90 ±0.01	-	-	-	-	-	-	-	-

Key
 TL = Total Length
 TL0 = Mean original Length (at stocking)
 TL1 = Mean Length increase after 2days
 TL2 = Mean Length increase after 4days
 TL3 = Mean Length increase after 6days
 TL4 = Mean Length increase after 8days
 TL5 = Mean Length increase after 10days
 TL6 = Mean Length increase after 12days
 TL7 = Mean Length increase after 14days

Table 2: Percentage Mortality and Survival of *Clarias gariepinus* Fry in the different pH treatments

pH treatment	Mean no. exposed	Mean time of exposure	Mean no. of mortality	Mean no. of survival	Mean % mortality	Mean % survival
2	40	14days	40.0	0	100	0
3	40	14days	40.0	0	100	0
4	40	14days	40.0	0	100	0
5	40	14days	2.33	37.67	5.83	94.17
6	40	14days	1.33	38.67	3.33	96.67
7	40	14days	0.33	39.67	0.83	99.17
8	40	14days	0.33	39.67	0.83	99.17

9	40	14days	19.33	20.67	48.33	51.67
10	40	14days	40.0	0	100	0
11	40	14days	40.0	0	100	0
12	40	14days	40.0	0	100	0

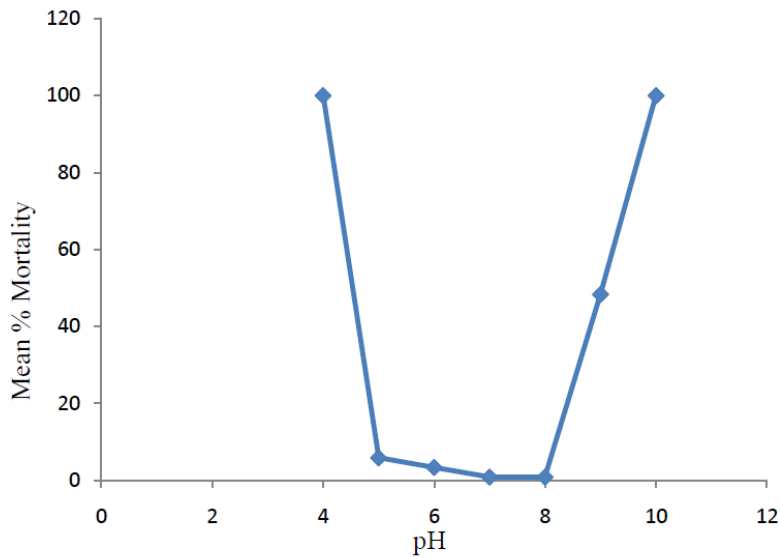


Figure 1: Mean % Mortality against pH

Water Quality Records

Dissolved oxygen content of the medium was approximately 6.0 mg/l throughout the study. The temperature also remained approximately constant at 26.5°C.

Discussion

Weatherly^[23] described fish growth as the end product and an integrator of the reactions involving the intrinsic and extrinsic factors (including the aquatic medium) in which the fish finds itself. According to Ivoke et al.^[24], specific features of the catfish environment are of primary importance in determining the growth and survival of the species in varying degrees. Naturally, most organisms possess well-defined range of pH tolerance.

Mortality of the fry especially in extreme pH of 4 and in pH 10 recorded in this study could be attributed to internal respiration practiced by the fry whereby there is a direct contact between the solution and the internal organs of the fish which led to the immediate destruction of the fry 24hrs post-stocking in pH10 and 192hrs post-stocking in pH4. Similar study conducted on *Clarias gariepinus* hatchlings^[16] confirms the ability of *C. gariepinus* hatchlings to tolerate extreme pH of 4 and 10. This is achieved due to cutaneous respiration carried out by the hatchlings which minimizes their contact with the toxic solution. Meanwhile Boyd^[7] and Gaunder^[11] had observed that the acid and alkaline death points for fish are about pH 4 and 11 respectively with reproduction and growth diminishing with increasing acidity or alkalinity.

The median lethal pH of 4.3 and 9.2 recorded for the fry in acidic and alkaline treatment respectively when compared to data obtained for bluegill sunfish (*Lepomis machrochinus*)^[25], rainbow trout and roach^[26], and goldfish^[27] confirms the firmness of *Clarias gariepinus* even as fry. Data obtained shows that the acidic and alkaline environment had a depressing effect on the growth rates of the fry especially at the extreme pH of 4 and 10, but within the tolerated range i.e. between pH5 and pH9, the optimum pH range for best growth is between pH6 and 7 (Table 1). The reduced growth rate in pH treatments 5.0, 8.0 and 9.0 recorded in this study (Table 1) could be attributed to imbalance in homeostasis since low or high pH that is not directly lethal only affects fish growth and reproduction

[28]. Also, Wilkie [29] observed that if the pH falls below the tolerance range death would ensue as a consequence of the disturbance of the balance of sodium and chloride ion in the blood of the fish and the inhibition of ammonia excretion through the gills during high pH situations. Nevertheless it is also reported that the relationship between growth rate and hydrogen-ion concentration is unclear [17] and the presence of other ions such as sodium, calcium and chloride in a water body can exert a modifying effect on the growth rate. The study shows that extreme pH has a deleterious effect on the growth and survival of *Clarias gariepinus* fry, the mode of toxicity being the precipitation of mucus on the gills epithelium or the precipitation of protein with the epithelial cells. This therefore calls for the monitoring and maintaining of the chemistry of water especially where these pond fish are reared so that it is within survival limit for *Clarias gariepinus* fry.

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