EFFECT OF pH ON THE GROWTH PERFORMANCE OF *Heterobranchus bidorsalis* (♂) X *Clarias gariepinus* (♀) HYBRID JUVENILES

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ABSTRACT

Twelve plastic basins each filled with 6 litres of dechlorinated tap water at pH 6, 7 (control), 7.5 and 8 such that each pH treatment was replicated three times in a Latin square design were used for the study. The tanks were randomly stocked with 10 four-week-old Clarias gariepinus (♀) x Heterobranchus bidorsalis (♂) hybrid juveniles (mean weight 3.32 ± 0.05 g) and fed 30.25% crude protein diets for five weeks. Fish growth was measured by weighing the juveniles every week and the weight differences, specific growth rate (SGR) and food conversion ratio (FCR) determined. Fish raised at pH treatment 7.0 recorded significantly higher weight gain (P < 0.05) than other pH treatments. Weight gain of fish raised at pH 6.0 was however not different (P > 0.05) from that of fish raised on pH 8.0 treatment. There was significant difference (P < 0.05) in the SGR of the juveniles raised at pH 6 and pH 8. There was no significant difference (P > 0.05) between the SGR of fish raised at pH 7 and pH 7.5 but there was significant difference between the SGR of fish raised at pH 7 and fish raised at other treatments. Fish showed reduced growth when raised at pH 6 and pH 8 and positive growth when raised at pH 7 and 7.5 though there was no significant difference (P > 0.05) in FCR of fish cultured at all pH treatments. Our results showed that the optimal pH range for raising the hybrid catfish juveniles was between 7.0 – 7.5 pH.

Keywords: *Heterobranchus bidorsalis* x *Clarias gariepinus* hybrid, Optimal pH range

INTRODUCTION

As the primary sources of animal protein became depleted, more expensive and usually beyond the rich of a substantial number of people, especially in developing countries of the world, fish became increasingly one of the less expensive and readily available sources of dietary animal protein (Kapetsky, 1981). Besides, 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 (Lovell, 1989; Benitez, 1999). 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. The physical environment also embraces everything that is not directly associated with the presence of other animals including fish. The life patterns and activities of animals in a given ecological system are also 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 (CO_2) tension on the oxygen-carrying capacity of the blood has also been noted (Cameron and Randall, 1972; Lagler *et al*., 1977). 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 (De Silva and Anderson, 1995). In a study, Boyd (1982) 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. 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 of pH.

Empirical evidence has also shown that fish blood, muscle and cellular parameters are altered by pH (Brown and Sadler, 1989).

Research observations have shown that *Clarias gariepinus* species do not grow as large and as quickly as *Heterobranchus bidorsalis*. On the other hand, *Heterobranchus* species do not possess the high survival rates of *Clarias gariepinus* (Madu *et al*., 1999), hence the strong urge in aquaculture for hybrid of *Clarias gariepinus* (♀) and *Heterobranchus bidorsalis* (♂) commonly called *Heteroclarias* in which the characteristics of *Heterobranchus bidorsalis* is dominant. *Heteroclarias* is voracious and capable of interbreeding.

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 (Gaunder, 2005). The objective of this study was to determine the growth performance of the *Heteroclarias* juveniles and more specifically the optimum pH range that supports optimum growth rate.

MATERIALS AND METHODS

Experimental Fish: Prior to the collection of the experimental fish, 12 plastic basins (12 L capacity), were bought, washed and filled with dechlorinated tap water. Artificial diet was formulated and prepared from artificial ingredients (Table 1) as described by Eya and Mgbenka (1990). The standard diet was dried at 60° C for 2 days, finely reground and stored in airtight container prior to feeding to fish. Two hundred and ten four-week-old *Heteroclarias* (mean weight 3.32 ± 0.05 g) produced in the Fisheries and Hydrobiology wet laboratory within the Zoological garden, University of Nigeria, Nsukka were used for the study. The juveniles were divided into 10 plastic culture tanks each filled with 6 litres of water and acclimatized for two weeks. After acclimatization, using a randomized Latin square design, the catfish were then divided into 12 plastic fish experimental tanks comprising four treatment groups replicated three times and 10 juveniles per tank. During the period of acclimation, the juveniles were fed the reground formulated catfish diet (Table 1) at 4% body weight twice daily. During a five-week experimental period, the water temperature was measured with mercury-in-glass thermometer 5 cm below the surface. To minimize the risk of fungal and algal growth, the culture tanks were cleaned weekly and covered with plastic mosquito nettings held in place by plastic rubber bands to prevent the fishes from jumping out. The remaining catfishes were kept in a reservoir tank to serve for replacement in cases of mortality. The pH of the tap water prior to pH dilutions was measured with a hand-held pH meter (ExStick^{TM} pH Meter, Expects Instrument Corp., USA) and was 7.0. This served as control.

pH Dilutions: For stock solution for acid, 2% hydrochloric acid was prepared by measuring 2 ml concentrated hydrochloric acid and 98 ml of distilled water into a beaker, mixed thoroughly with a clean glass rod and stored in a reagent bottle. For the base, 0.01M sodium hydroxide (NaOH) was prepared by weighing 0.4 g of sodium hydroxide granules and dissolving in 100 ml of distilled water. This served as control. Various pH readings employed were 6, 7, 7.5 and 8. To get pH 6, drops of the 2% hydrochloric acid were added to get the most stable reading of 6. To get pH greater than 7.0, drops of 0.01M sodium hydroxide were added to obtain the most stable reading as displayed by the pH meter.

Growth of the Hybrid Juveniles: The growth was measured by weighing the juveniles every week for the 5 weeks that the study lasted. Weight differences were determined. Also estimated were specific growth rate (SGR) and food conversion ratio (FCR) (De Silva and Anderson, 1995), thus: $SGR = In(W_2) - In(W_1) / t_2 - t_1 \times 100$ where W_1 – Initial weight (g), W_2 = Final weight (g), t = time (days), ln = natural log. FCR = mass of feed offered to fish (g)/ increase in weight of fish (g).

Statistical Analysis: The data collected were analysed for significant differences ($P \leq 0.05$) by the analysis of variance (ANOVA) using a computer Statistical Package for Social Sciences (SPSS). Determined differences were partitioned by the least significant difference (LSD) and the Duncan's New Multiple Range Test (DNMRT).

RESULTS

The effect of various pH on the growth performance of *H. bidorsalis* (♂) x *C. gariepinus* (♀) hybrid juveniles is shown in the weight gain and loss corresponding to the different pH values (Table 2). During the experimental period which lasted for five weeks, the water temperature ranged from 23.9° C – 29.4° C. The pH of the water at the same period prior to treatment ranged from 6.87 – 7.00. At the end of the culture period, pH treatment 7.0 (control) recorded significantly higher weight gain or loss ($P < 0.05$) than other treatments (Table 2). The weight difference of juveniles of fish raised at pH 6.0 was however not different ($P > 0.05$) from that of fish on pH 8.0 treatment. pH treatment 7.5 also indicated weight gain, while pH 6.0 and 8.0 showed weight reductions.

The specific growth rate of the hybrid catfish juveniles at the different pH treatments showed that the juveniles at pH 7.5 treatments had higher mean specific growth rate (2.90 ± 0.47 g/d) when numerically compared with the hybrid catfish fed at pH 7.0 (1.63 ± 0.31 g/d) and other pH treatments (Table 3). There was significant difference ($P < 0.05$) in the SGR of the juveniles fed at pH 6 and pH 8. There however was no significant difference ($P > 0.05$) between the SGR of fish fed at pH 7 and pH 7.5. The food conversion ratio of the hybrid catfish juveniles at different pH treatments (Table 4) indicate that the catfish in pH treatment 7.0 (0.17 ± 0.04) showed greater but non-significant ($P > 0.05$) ability to convert food energy for growth when compared with other pH treatments.

Table 1: Composition (%) of the standard diet with estimated percent crude protein content

Ingredient	% ingredient	Estimated % crude protein in ingredient	Estimated % crude protein
Yellow corn	35.0	9.8	3.43
Soybean meal	50.5	40.0	20.20
Fishmeal	10.0	57.0	4.62
Blood meal	3.0	60.0	2.00
Vitamin and mineral premix (Vitalyte)[1]	1.2	-	-
Vitamin C	0.3	-	-
Total:	100.00		30.25
Proximate composition			
Ash	10.70		
Crude protein	29.95		
Fats	11.60		
Fibre	15.25		
Moisture	14.60		
Nitrogen free extract	17.90		

[1]*Vitamin and mineral premix provided the following constituents diluted by cellulose (mg/kg of diet): Vitamin, A; Vitamin, B_2; Vitamin, B_6; Vitamin, B_{12}; Vitamin, C; Vitamin, D_3; Vitamin, E, Vitamin, K; Panthothenic acid, 5,350; Lysine, 15,000; Methionine, 10,000; Lactose, 1,000; Potassium chloride, 87,000; Sodium chloride, 50,000; Sodium sulphate, 212,000; Magnesium sulphate, 12,000; Copper sulphate, 12,000; Zinc sulphate, 12,000.*

Table 2: Weight gain and loss of hybrid *Heterobranchus bidorsalis x Clarias gariepinus* juveniles reared at different pH values

Treatment	Weight of fish (g)					
	Week 0	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
pH 6.0	7.03 ± 1.35	4.43 ± 0.05	4.17 ± 0.08	3.73 ± 0.30	3.47 ± 0.43	3.17 ± 0.58
pH 7.0	6.10 ± 0.34	6.96 ± 0.21	7.33 ± 0.02	7.47 ± 0.50	7.73 ± 0.18	8.06 ± 0.35
pH 7.5	5.23 ± 0.48	5.70 ± 0.25	6.07 ± 0.06	6.40 ± 0.11	6.70 ± 0.26	7.06 ± 0.44
pH 8.0	6.13 ± 0.96	4.77 ± 0.28	3.97 ± 0.12	3.77 ± 0.33	3.77 ± 0.22	3.36 ± 0.43

Table 3: Specific growth rate (g/d) of hybrid (*Heterobranchus bidorsalis* x *Clarias gariepinus*) juveniles raised at different pH for five weeks

Ph	Week 1	Week 2	Week 3	Week 4	Week 5	Mean
6.0	-6.57 ± 1.19	-7.57 ± 0.69	-9.00 ± 0.03	-10.04 ± 0.60	-11.43 ± 1.24	-9.94 ± 0.75
7.0	0.54 ± 0.54	1.26 ± 0.18	1.54 ±0.04	2.11 ± 0.24	2.69 ± 0.53	1.63 ± 0.31
7..5	1.29 ± 0.81	2.18 ± 0.36	3.00 ±0.05	3.60 ± 0.35	5.43 ± 0.77	2.90 ±0.47
8.0	-3.57 ± 1.50	-6.14 ±0.22	-6.86 ±0.15	-7.71 ± 0.57	-8.57 ±1.00	-6.57 ± 0.69

Table 4: Food conversion ratio of hybrid (*Heterobranchus bidorsalis* x *Clarias gariepinus*) juveniles raised at different pH for five weeks[1].

pH	Week 1	Week 2	Week 3	Week 4	Week 5	Mean
6.0	-0.03 ± 0.00	-0.03 ± 0.00	-0.02 ± 0.00	-0.02 ± 0.00	-0.02 ± 0.07	-.024 ± 0.00
7.0	0.37 ± 0.10	0.16 ± 0.00	0.13 ± 0.02	0.10 ± 0.03	0.07 ± 0.05	.166 ± 0.04
7..5	0.16 ± 0.04	0.09 ± 0.00	0.07 ± 0.01	0.06 ± 0.01	0.05 ± 0.02	.086 ± 0.02
8.0	-0.06 ± 0.10	-0.03 ± 0.00	-0.03 ± 0.00	-0.03 ± 0.00	-0.02 ± 0.01	-.034 ± 0.02

[1]*There is no significant difference (P > 0.05) in feed conversion efficiency for the juveniles raised at different pH.*

While the hybrid catfish in pH treatment 7.5 were next in converting their feed to energy needed for growth, the fish in pH treatments 6.0 and 8.0 were relatively poor feed-energy for growth transformation. The non-significant difference (P > 0.05) in feed conversion ratio of the juveniles fed at different pH implies that the juveniles apparently transformed the feed to energy with values close to each other at the different pH values.

DISCUSSION

Weatherly (1990) 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.

It has been established that 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 or pH tolerance. The results of the study indicate that *Heterobranchus bidorsalis* (male) x *Clarias gariepinus* (female) hybrid juveniles would have their tolerance pH range at 6.0 to 8.0 since death was not observed at this pH range, and an optimum pH range of 7.0 to 7.5 as maximum growth performance was recorded within this range (Fig. 1). The results obtained are in conformity with those of Boyd (1982) and Gaunder (2005) who 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 reduction in weight in pH treatments 6.0 and 8.0 recorded in the study (Table 4) could be attributed to imbalance in homeostasis since low or high pH that is not directly lethal only affects fish growth and reproduction (Kimmel, 1993). Also, Wilkie and Wood (1991) 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.

The weekly growth performance (Table 2) indicate that at pH 7.5 the catfish added satisfactory amount of growth compared to the optimal amount added by fish at the control treatment (pH 7.0). While the optimum pH for this fish is pH 7.0, a satisfactory range is pH 7.0 to 7.5. The results for the food conversion ratio (another parameter used to determine growth performance) show that catfish in pH treatment 7.0 had the highest food conversion ratio (Table 4). This indicates that the catfish in pH treatment 7.0 had greater ability to convert their food to energy necessary for growth since their environment was devoid of acid and base. In other words, the growth of the catfish which is largely dependent on their ability to convert food to energy for growth is, to a large extent, dependent on the pH of their surrounding medium.

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