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Effect of water acidification on growth performance of striped catfish, *Pangasianodon hypophthalmus*

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ABSTRACT

The present work aimed to use the acidification of water to improve some water quality parameters for rearing the fingerlings of striped catfish, *Pangasiandon hypophthalmus.* Two hundred of striped catfish juveniles (1.1±0.2 g) were stocked in 1000-L *Polypropylene tanks (PP)*for twelve weeks. In the control tanks, the water's pH was left unaltered throughout the entire study, allowing it to naturally fluctuate. In the acidification treatment, however, the pH of the culture water was purposely made slightly acidic (between 6.5 and 6.8) by daily addition of concentrated acetic acid (99% conc.). Acidification of water was significantly able to improve some of the water quality parameters as well as the final body weight, specific growth rate, and fish yield. Based on the findings, it can be inferred that the process of water acidification is a good, applicable, and cheap treatment method for the removal of the toxicity of ammonia in fish farming units with limited water exchange.

INTRODUCTION

The physiological well-being of aquatic organisms can be greatly impacted by the pH level of water. The acidic or alkaline nature of water can cause stress and hinder the proper development of farmed fish and shrimp. Fluctuations in water pH trigger mechanisms of ionic regulation in fish, as they strive to maintain a state of balance and overall health. Imbalances in blood and bodily fluids' acid-base levels can lead to changes in crucial metabolic factors in fish, including glycose, glycogen, and lactate concentrations**(Bolner *et al*., 2014; Garcia *et al*., 2014**). Typically, the recommended pH range for aquaculture is between 6.5 and 9.0 **(Boyd *et al.*, 2016)**. Nevertheless, certain fish species have a preference for acidic water conditions, including some ornamental fish species and the Pacu fish, *Colossoma macropomum* **(Aride *et al.*, 2007)**. On the other hand, there are also fish species, such as the Mozambique tilapia, *Oreochromis mossambicus*, that demonstrate tolerance to acidic environments **(Furukawa *et al.*, 2011)**.

Hence, there can be exclusions to the general rule regarding the suitability of water pH. Multiple authors have suggested that the ideal water pH for cultivating striped catfish is between 6.5 and 7.5. Another research conducted involved raising Nile tilapia fingerlings in tanks with complete daily water replacement, which led to minimal presence of harmful metabolites like ammonia and H_2S in the oligotrophic clear waters. Surprisingly, previous research demonstrated that Nile tilapia juveniles thrived remarkably well in acidic waters rich in organic matter, with a pH below 6 **(Rebouças *et al.*, 2015;2016)**. These studies even indicated that Nile tilapia could tolerate a transfer from pH 6-7 to pH 4.2 without encountering any issues.

Pangasianodon catfish is widely recognized as a highly successful aquaculture species in numerous countries. The main factors contributing to its popularity are its ease of cultivation, strong market demand, and ability to adapt to local climate conditions. **(Rahman, 2005; Rahman and Ali, 2012)**. The production of Pangasianodon has the potential to alleviate poverty for a large number of low-income individuals by generating improved employment chances through the establishment of activities connected to the market chain.

Pangasianodon fish are cultivated through various methods, including intensive culture with commercial feeds, semi-intensive culture with partial feeding, and extensive culture (without feeding) alongside tilapia and carp **(Ahmed *et al.*, 2010)**. the exceptional resistance to diseases, coupled with the ability to achieve high stocking densities and increased production yeild (averaging 40 tons/ha; **FAO, 2010**), has prompted the recommendation that *Pangasianodon* is an excellent choice for expanding aquaculture industry production in Egypt. This is principally beneficial for areas that are unfamiliar with farming other species and can help alleviate the challenges posed by population growth. Introducing Pangasianodon aquaculture to underutilized water resources in Egyptian coastal areas holds the potential to significantly improve dietary protein consumption for low-income families and create new sources of income and employment.

The present work was aimed to evaluate the effect of acidification of water on the water quality parameters and growth performance of striped catfish juveniles that farmed intensively with zero water exchange as a technique for removing the toxic effect of ammonia in aquaculture.

MATERIALS AND METHODS

Striped catfish juveniles were obtained from a private hatchery (Shandoura village, Suez Governorate, Egypt) and transported to a private fish farm at El-Tall Al-Kabier, Ismailia Governorate, Egypt, where they were kept for 7 days in a Polypropylene (PP) tank (1000 L) for rearing acclimatization then fishes in all tanks were fed on four times daily with a commercial diet for fish containing 32% crude protein (Skretting®, Nutreco group of companies, Egypt) at 10% body weight daily.

At the begining of the study, four 1000-L PP tanks were stocked with a total of two hundred striped catfish fingerlings (1.1 ± 0.2 g), with 50 fish per tank, for a duration of twelve weeks. The fish were provided with appropriate commercial diets at four different feeding times: 10:00, 13:00, 15:00, and 18:00. The feeding rates ranged from 10% of their initial body weight to 5% of their final body weight. Mechanical aeration was consistently provided to each tank throughout the entire experiment. The excreted feces from fish removed from tanks using siphonation.Water exchange was not conducted, only occasional replenishment to maintain the initial water level. The study consisted of three replicates of fish that were subjected to water acidification treatment using acetic acid (CH_3COOH), and one control group. In the control tanks, the water's pH was left unadjusted, allowing it to naturally fluctuate throughout the study. In the acidification treatment, the culture water was acidified daily using a concentrated solution of Acetic Acid to achieve a pH range of 6.5 to 6.8 **(Table 1)**.

Table (1): The amount of daily added acetic acids in treated tanks to keep pH within the range of 6.5 to 6.8.

Day	Amount of UIA	Daily added acid (ml)	Day	Amount of UIA	Daily added acid (ml)	Day	Amount of UIA	Daily added acid (ml)
1	0.00	0.19	29	0.01	1.33	57	0.05	5
2	0.00	0.24	30	0.01	1.41	58	0.05	5.25
3	0.00	0.26	31	0.01	1.41	59	0.06	5.5
4	0.00	0.28	32	0.01	1.49	60	0.06	5.8
5	0.00	0.30	33	0.02	1.58	61	0.05	5.1
6	0.00	0.32	34	0.02	1.68	62	0.05	5.4
7	0.00	0.35	35	0.02	1.78	63	0.06	5.5
8	0.00	0.37	36	0.02	1.88	64	0.06	5.8
9	0.00	0.40	37	0.02	2.00	65	0.06	6
10	0.00	0.43	38	0.02	2.12	66	0.06	6.3
11	0.00	0.46	39	0.02	2.24	67	0.07	6.6
12	0.00	0.50	40	0.02	2.38	68	0.07	6.9
13	0.01	0.54	41	0.03	2.52	69	0.07	7.2
14	0.01	0.58	42	0.03	2.67	70	0.07	7.5
15	0.01	0.62	43	0.03	2.83	71	0.08	7.8
16	0.01	0.59	44	0.03	3.00	72	0.08	8
17	0.01	0.63	45	0.03	3.18	73	0.08	8.5
18	0.01	0.67	46	0.03	2.92	74	0.09	8.8
19	0.01	0.71	47	0.03	3.07	75	0.09	9.3
20	0.01	0.76	48	0.03	3.22	76	0.08	7.8
21	0.01	0.81	49	0.03	3.38	77	0.08	8
22	0.01	0.86	50	0.04	3.55	78	0.08	8.4
23	0.01	0.91	51	0.04	3.73	79	0.09	8.6
24	0.01	0.97	52	0.04	3.92	80	0.09	8.9
25	0.01	1.03	53	0.04	4.11	81	0.09	9.2
26	0.01	1.10	54	0.04	4.32	82	0.09	9.5
27	0.01	1.17	55	0.05	4.53	83	0.10	9.8
28	0.01	1.25	56	0.05	4.76	84	0.10	10
Total added acid								**300 ml**

UIA: Un–ionized ammonia

The acidic solutions was added to the tanks at 9:00 am per day. The pH level of the water at 08:30 was utilized to determine the quantities of acidic solutions employed on that particular day. The water condition in the culture tanks was assessed through regular observations of the following factors at 13:00 each day:

(1) Dissolved oxygen (DO) was determined using the Winkler method.
(2) The YSI 650 multi-parameter instrument (YSI, Yellow Springs, OH, USA) was used to measure temperature, specific conductance, and pH.
(3) Free CO_2 levels were assessed through titration with a Na_2CO_3 standard solution.
(4) Total ammonia nitrogen (TAN) was measured using the indophenol method.
(5) Un–ionized ammonia (UIA, NH_3) levels were estimated using Emerson's formula as described by **El-Shafai *et al.* (2004)**.

(6) Nitrite levels were determined using the sulfanilamide method.
(7) Total alkalinity was measured through titration with an H_2SO_4 standard solution.
(8) Total hardness was assessed through titration with an EDTA standard solution.
(9) H_2S levels were determined by titrating total sulfide (TS) with a standard $Na_2S_2O_3$ solution, and H_2S concentration was estimated according to **Boyd (2000)**.

All water quality measurements were conducted according to the guidelines of **APHA (2000)**.

Growth performance:

The analyzed growth performance variables were the followings: survival (%), final body weight (g), specific growth rate (% day^{-1}; SGR = [Ln (final weight) – Ln (weight initial)]$^{-1}$ days of culture) x 100), fish yield (g m^{-3} day^{-1}), daily weight gain (g day^{-1}; DWG = weight gain / days of culture) and feed conversion ratio (FCR = feed consumed/body weight gain).

Statistical analysis:

Differences of all recorded and estimated values of water quality parameters and growth performance of striped catfish fingerlings in all tanks were analyzed using T test with 95% confidence limits. These analyses were carried out using the statistical software SPSS 18.0 (2002).

RESULTS AND DISCUSSION

Water quality parameters

Water acidification did not have a significant impact on the temperatures and dissolved oxygen concentrations in the water, as indicated by the data presented in **Table (2)**. The average water temperatures in control and treated tanks at 13:00 were 29.1 ± 3.2°C and 29.3 ± 3.5°C respectively. The average concentration of DO in water was 5.5 ± 1.2 mg L^{-1} in control tank and 5.4 ±1.5 in the treated tanks. The treatment of water with acidification resulted in an elevation of free CO_2 concentrations in the tanks, with an average value of 20.8 mg L^{-1}. On the other hand, the untreated (or control tank) water had lower concentrations of this parameter (**Table 2**). According to **Danley *et al.* (2005)**, fish may experience stress when exposed to free CO_2 concentrations exceeding 20 mg L^{-1} in water. Despite this, the striped catfish fingerlings were unaffected by the acidification as they attained a higher final body weight exclusively in the acidified tanks (82.14± 2.1 g; **Table 3**).

The conductivity of water increased with the acidification treatments. The level of water acidification directly correlated with a decrease in the total alkalinity of the water, as demonstrated by the data presented in **Table (2)**. The average total alkalinity (TA) of water was 51 ± 3 mg L^{-1} $CaCO_3$ eq. for the acidified treatments while it was 155 ± 12 mg L^{-1} $CaCO_3$ eq. in control tanks. In the current study, Although the pH of water was intentionally regulated to specific levels, the presence of low total alkalinity (TA) did not have any impact on the pH of the water.

The acidification of water resulted in an elevation of total hardness (TH). The tanks with acidified water had the highest TH, measuring 200±15 mg L^{-1} $CaCO_3$, while the control tank recorded the lowest TH of 85±11 mg L^{-1} $CaCO_3$. According to **Boyd *et al.* (2016)**, the recommended TH for aquaculture production ranges from 40 to 300 mg L-1 $CaCO_3$. Consequently, the TH values in all tanks remained within the suitable range.

The average TAN concentrations were high in treated tanks 17.4 ± 1.7 mg L^{-1} than that found in the control tank. According to **Boyd (2001)**, TAN concentrations exceeding 3-4 mg L^{-1} are considered toxic to warm-water aquaculture organisms in waters with a pH above 8.5-9.0. However, in the present study, the highest TAN concentration observed was significantly lower than the critical levels reported in the literature **(Shalaby *et al.*, 2019)**. Additionally, due to the acidification of the water, the concentrations of NH_3 in the water were nearly undetectable.

The acidification of water had no notable impact on the nitrite concentrations in comparison to the control tank, as indicated in **Table (2)**. Notably, the concentrations of nitrite were already at zero levels in the control tank. **Yanbo *et al.* (2006)** established the 96-hour LC_{50} nitrite concentration for Nile tilapia at 28.2 mg L^{-1}. Consequently, the safe concentration of nitrite for tilapia in freshwater is 0.3 mg L^{-1}, which corresponds to 1% of the 96-hour LC_{50} **(Yanbo *et al.*, 2006)**.

The acidification of water led to an elevation in the concentrations of H_2S in the water, as shown in **Table (2)**. The average H_2S concentrations in the acidified tanks were 0.65 ± 0.7 mg L^{-1}, whereas the control one recorded a lower concentration of 0.14 mg L^{-1}. Exposure to H_2S levels ranging from 0.1 to 0.5 mg L^{-1} has been known to cause significant biochemical and physiological damage in channel catfish **(Hargreaves & Tomasso, 2004)**. However, despite the higher H_2S levels observed in the current study, there was no significant impact on the growth of striped catfish fingerlings. This suggests that striped catfish fingerlings are resilient to H_2S exposure.

Table (2): Water quality parameters in striped catfish outdoor tanks after twelve weeks of farming (mean ± SD).

Parameter/treatment	Treatment		*P* value
	Control	Acid treatment	
Temperature (°C)	29.1±3.2	29.3±.3.5	0.196
pH	7.8±0.5	6.7±0.2	<0.01
Conductivity (S/m)	920±35	1200±52	<0.01
Total alkalinity (mg L^{-1})	155±12	51±3	<0.001
Total hardness (mg L^{-1})	85±11	200±15	<0.01
Dissolved Oxygen (mg L^{-1})	5.5±1.2	5.4±1.5	0.928
Carbon Dioxide (mg L^{-1})	11±0.6	18.9±1.1	<0.001
TAN (mg L^{-1})	1.5±0.3	17.4±1.7	<0.001
NH_3 (mg L^{-1})	0.07±0.02	0.01±0.007	<0.01
NO_2^- (mg L^{-1})	0.05±0.01	0.1±0.03	0.139
Total sulfide (mg L^{-1})	1.1±0.3	2.4±0.5	<0.05
H_2S (mg L^{-1})	0.14±0.05	0.65±0. 7	0.274

Growth performance analysis:

Significant differences were found in all growth performance parameters and survival rate at the end of experiment. Fish which reared in acidified treatments displayed the highest final weight with 82.14±2.1 g, weight gain (81 g), average DWG (0.96 g /day, SGR with 5.19%. Significant differences were observed in all growth parameters between the acidified tanks and the control one and accepted mortalities were found in all farmed tanks **(Table 3** and **Fig. 1**).

Table (3): Growth performance (mean ± SD) of striped catfish juveniles after twelve weeks of rearing.

Parameters	Control	Treatment Acidification treatments	*P* value
Survival rate (%)	92	95.4±1.66	**<0.05**
Initial Body Weight (g)	1.1±0.3	1.1±0.2	**1.00**
Final Body Weight (g)	70.84±5.5	82.14±2.1	**<0.05**
Weight gain (g)	69.74±5.25	81.04±2.01	**<0.001**
Average daily weight gain (g)	0.83±0.06	0.96±0.02	**<0.05**
Specific growth rate (% day^{-1})	4.96±0.7	5.19±0.5	**0.629**
Food conversion ratio	1.62±0.3	1. 42±0.2	**0.01**

The impact of pH on freshwater organisms, particularly fish, has been extensively studied **(Katz, 1969; Alabaster & Lloyd, 1980)**. The pH of water affects various physiological functions of aquatic organisms, including ion exchange and respiration. Most aquatic organisms can function normally within a relatively wide pH range, typically spanning from 6 to 9 pH units. However, there is no definitive pH range that universally guarantees the well-being of all freshwater aquatic life, as adverse effects can occur outside this range. The acceptable pH range for aquatic life, especially fish, depends on several other factors such as prior pH acclimatization, water temperature, dissolved oxygen concentration, and the concentrations and ratios of different cations and anions **(McKee & Wolf, 1963)**.

Wilkie & Wood (1991) observed that if the pH falls below the tolerance range, death can occur due to disruptions in the balance of sodium and chloride ions in the fish's blood and the inhibition of ammonia excretion through the gills during high pH situations. However, it is also noted that the relationship between growth rate and hydrogen-ion concentration is not clearly understood, and the presence of other ions like sodium, calcium, and chloride in the water can have modifying effects on growth rate.

Uzoka *et al.* (2012) reported that extreme pH levels have a detrimental effect on the growth and survival of African catfish (*Clarias gariepinus*) fry, possibly due to the precipitation of mucus on the gill epithelium or the precipitation of protein within the epithelial cells. In tilapia, feed conversion ratio (FCR) increased when pH levels deviated from pH 7, likely due to reduced feed consumption at low pH. **Scott *et al.* (2005)** found that FCR achieved at pH 9 was significantly higher (P≤0.05) than at pH 7 and 8, with values of 3.3, 2.7, and 2.9, respectively. **Ivoke *et al.* (2007)** reported better FCR and protein efficiency ratio (PER) at pH 7.0 to 7.5 in hybrid catfish, indicating efficient utilization of the given feed for somatic growth. **Sapkale *et al.* (2013)** also reported improved FCR at pH 7.5 in common carp (*Cyprinus carpio*). The pH readings in all tanks during the current study were within the accepted range of striped catfish as that stated and reported by **Hassan *et al.* (2021)**.

Based on **Fig. (1)**, it can be inferred that the acidified treatment tanks with a pH slightly below 7 exhibited the highest average individual body weights of striped catfish.This is in agreement with the findings of many authors for tilapia fishes **(El-Shafai *et al.*; 2004, Xu *et al.*, 2005 ; El-Sherif & El-Feky, 2009; Basyuni *et al.*,2023)**. In control tank, a higher pH values were recorded throughout the period of study which may be attributed to weak growth performance of striped catfish juveniles due to the increasing of ammonia excreation.

The findings of **Saha *et al.* (2002); Scott *et al.* (2005)** and **El-Sherif & El-Feky (2009)** supported the same conclusion. They observed that as pH increased, ammonia excretion also increased, while growth decreased. This decrease in growth was attributed to a decrease in feed consumption, which aligns with the results of the present study.

Atle *et al.* (2003, 2004) and **El-Shafai *et al.* (2004)** reported that the best SGR were at pH 7 and 8 and with no significant difference (P≥0.05) between them. The feed conversion ratios (FCR) were low for acidified treatments in comparisons with control one. This in agreement with **Scott *et al.* (2005)** who found the FCR was high at extremes pH for tilapia fingerlings.

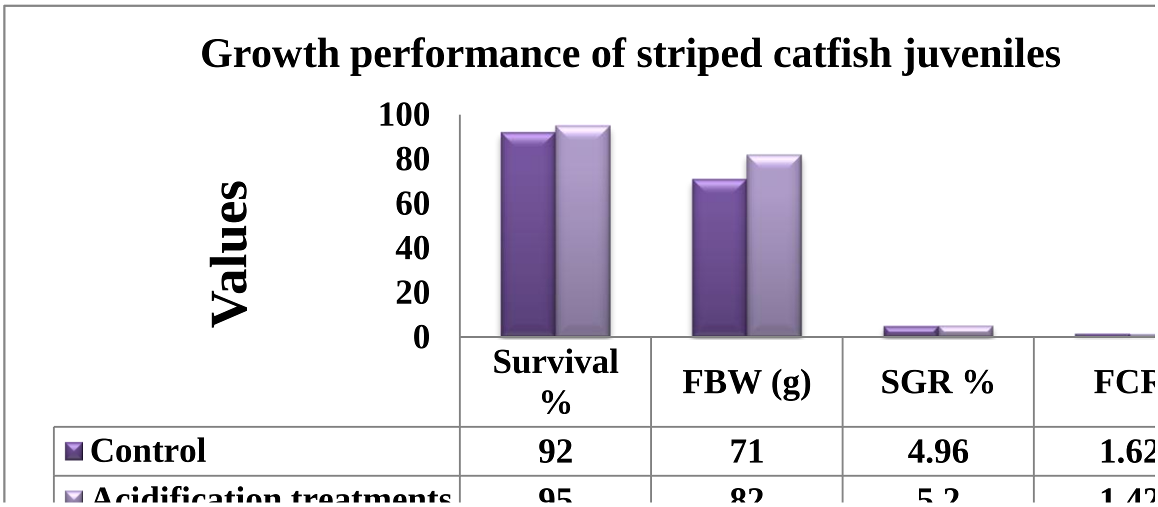

Fig. 1: Growth performance of striped catfish juveniles in all tanks

CONCLUSION

The current study concluded that the acidification of water at specific level can improve some of water quality parameters in reared units and give advantages in growth performance of striped catfishes as long as pH values were within optimum or accepted levels.

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