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EFFECTS OF SALINITY ON THE GROWTH, SURVIVAL AND PROXIMATE COMPOSITION OF PANGAS, *PANGASIUS HYPOPHTHALMUS*

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Abstract: Climate change induced salinity intrusion has a global and local effect on the aquaculture production. Thai-Pangas (*Pangasius hypophthalmus)* has become one of the cheapest protein sources in Bangladesh because of its wide range of environment tolerance, excellent growth and survival rate. Present study was thus conducted to measure the effects of salinity on the growth performance and survival of pangas. For the determination of the effect of salinity on growth and survival, 15-day old fingerlings were reared in 0, 2, 4, 6, 8, 10, 12, 14 and 20‰ for 60 day at laboratory condition. All fish fingerlings in treatment with 20‰ salinity died within 6 hours of stocking while 62.5% mortality was found within 6 hours at 14‰ salinity. No mortality was detected in other treatment groups. Significantly higher specific growth rate was detected at 0, 2 and 4‰ salinity than that of 12 and 14‰ salinity. No significant change in food conversation ratio was found among treatments. No significant difference was observed on proximate composition between and within treatments. Water quality parameters include temperature, dissolved oxygen and pH were 27.23 ± 0.02 °C, 8.33 ± 0.05 mg/L and 8.05 ± 0.03, respectively throughout the experimental period. Thus, the present study suggests the suitability of pangas fingerlings at up to 4‰ saline water with desirable growth rate.

Key Words: Salinity intrusion, Thai Pangas fingerings, Feed conversion ratio, Water quality.

INTRODUCTION

Being anagro-based riverine country, Bangladesh is enriched with vast fisheries resources which contribute 3.5% to the GDP, 25.71% to the agricultural products and 1.5% to the export earnings (DoF 2018). A major portion of the protein demand comes from fish contributing about 60% in the diet of the Bengali people (DoF 2019). However, people of the lower income level cannot fulfill the demand of protein.

Bangladesh is going to be affected by global climate change and sea level rise. Millions of coastal inhabitants of Bangladesh will lose their livelihoods and heritage. Particularly, agricultural and aquaculture activities will be severely affected by several physico-chemical factors especially by saline water intrusion. Under this circumstances, it is better to find the ways how to adjust with the adverse climatic conditions. So, for the enhanced economic growth, researches in several agricultural sectors like aquaculture, horticulture, paddy culture are important to develop new and sustainable technologies to adjust with the saline challenged situation. Certain level of salinity has been shown to be positively correlated with growth of fish (Lemarie *et al.* 2004) where metabolism influences

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the proportion of energy intake allocated to growth (Sun *et al.* 2006), determination of optimum salinity might be useful in increasing pangas production.

Growth performance of fish largely depends on feed consumption and its assimilation and conversion into body tissues (Burel *et al.* 1996). However, several internal factors including endocrine system and environmental factors including salinity control the growth and food intake of fish. Salinity has been shown as one of the most significant environmental parameters influencing survival, growth and distribution of fish both in freshwater and marine habitat (Imsland *et al.* 2001). Salinity can directly impact on the survival of fish by decreasing feeding rate and by altering the energy cost for osmotic and ionic regulation (Boeuf and Payan 2001). Salinity, like other environmental factors specific to aquatic habitats, has provoked many studies on its influence on the growth of fish (Rubia *et al.* 2005). Salinity can potentially act as a stressor in aquaculture condition (Varsamos *et al.* 2004). Very few studies have been conducted on the effects of salinity on fish survival and nutritional quality. Understanding the effects of salinity on the growth and survival of pangas fingerlings can help to evaluate the effects of climate change induced salinity intrusion on freshwater aquaculture in Bangladesh. Thus, the present study was conducted to find out the maximum salinity that pangas can tolerate without affecting survival and proximate composition.

MATERIAL AND METHODS

Experimental fish: Pangas, *Pangasius hypophthalmus* (4.68 ± 0.15 g and 3.79 ± 0.25 cm) was used as experimental fish which was obtained from the Nirob Fish Hatchery at Mymensingh and transported to Aquatic Laboratory of the Department of Fisheries, University of Dhaka, Bangladesh. Fingerlings were acclimatized in rectangular tanks at freshwater (salinity; 0‰, temperature; 27.17 ± 1.97 °C, pH; 8.14 ± 0.24 and DO; 8.33 ± 0.33 mg/L) for two weeks prior to conduct the experiment. All the fish fingerlings showed a normal behavioral pattern during this period.

Experimental system: The experiment was conducted in 40L aquaria, each was stocked with 10 fish fingerlings and the initial weight of fingerlings showed no significant difference among treatments. Pond water was used in the present study. The experiment was conducted during the year 2011-2012.

Experimental Design: Nine treatments were conducted with triplicate groups. The range of salinities selected in this experiment was based on the environmental salinities, as Bangladesh has the huge resource of both freshwater and saline water and has a good connected area between freshwater and saline water. The river flow system is very much helpful to regulate the salinity level. The aquaria were covered with wooden shade to prevent fish from jumping out, and continuous aeration was provided to maintain dissolved oxygen near saturation levels. In each aquarium, 50% of water volume was renewed every alternative day with water of the salinity selected for the treatment. For the purpose of conditioning 300L static rectangular plastic tank was used. At first, the fish fingerlings were released into the plastic tank at 0‰

saline water. After 48 hours of acclimatization 10 fish fingerlings were released in the 0‰ saline water and the rest of the fingerlings were kept inside the plastic tank at 2‰ saline water for the next 48 hours. After another 48 hours of acclimatization 10 fish fingerlings were released in the 2‰ saline water and the rest of the fingerlings were again kept inside the plastic tank at 4‰ saline water for the next 48 hours. Accordingly, the salinity was raised up to 14‰. Finally uprising of salinity from 14 to 20‰ was made which was referred as mega dose. During the acclimatization period, salinity was raised up to 2‰ per 48 hours for all treatments by adding required amount of salt (from Coxes Bazar) for each of the following salinity groups: 0, 2, 4, 6, 8, 10, 12, 14 and 20 ‰. Pangas fingerlings were exposed to these salinities for 60 days. Salinity in each tank was measured once daily.

Maintenance of aquaria and sampling: At 20-day interval length and weight of each fish of each treatment were taken and fish were fed with commercially available pangas feed @ 5% of their total weight twice a day. Uneaten feed was removed from the aquarium by siphon from the floor. Fifty percent water was exchanged every alternative day and continuous aeration was provided throughout the experimental period. Fish weight and length were recorded to determine the feed efficiency, feed conversion ratio, condition factor, average daily gain and protein efficiency ratio. Sampling was done at 20th, 40th and 60th day of the experiment.

Growth study: Condition factor (K) was calculated by the following formula as suggested by Hile (1936); $K = (w/L^3) \times 100$; Where, K- condition factor; W- body weight in grams and L- body length in centimeters. Average daily gain was determined by the following formula: $ADG = (W_2\text{-}W_1)/t_2\text{-}t_1$ where, W_2, final weight, W_1, initial weight, $t_2\text{-}t_1$ duration of experiment. Specific growth rate (SGR %) was calculated as the percentage increase in weight per animal per day as suggested by Hopkins (1992), i.e. $SGR (\%) = LnW_t - LnW_I / (T - t) \times 100$. Where, LnW_t= Natural log of weight at time T; LnW_I Natural log of initial weight; T: Time t; Initial time. Food conversion ratio (FCR) was calculated from the weight (Kg) of feed that are used to produce one Kg of whole fish. Food conversion ratio (FCR) was determined by the following formula: FCR = Feed consumed by the fish (Kg) (dry weight basis)/ Live weight of the fish (Kg). Survival rate of fish fingerlings was also determined.

Water quality monitoring: Salinity levels were monitored by using the salinometer (YSI, Japan), pH and DO with pH and DO meter (ITOSENCE, Japan) twice a week.

Proximate analysis: Proximate composition was analyzed according to AOAC (1990) with some modifications as described below. Briefly, for the determination of moisture content 5g of sample was dried in an oven at 105 °C for complete evaporation of moisture. After complete dryness of the sample the loss of moisture was calculated as percent moisture content. For the determination of lipid content, the dried sample left after moisture determination was finely ground and about 0.5g were taken in a mortar and macerated with fine sand. Lipid content was then determined using chloroform-methanol method. Ash content was determined from 2g of sample which burnt over a flame until it charred and then placed in a muffle furnace at 550 °C temperature for complete combustion. White residue was weighed, and ash content was determined. Crude protein content was determined using the standard micro-Kjeldahl method.

Statistical analysis: Data were analysed by using SPSS (version 11) with a level of significance at p<0.05. One-way ANOVA was done, and significant results were further analyzed using Tukey Test in order to determine ranking and significant differences between treatment means.

RESULTS AND DISCUSSION

Salinity induced survival and growth of pangas: During the experimental period the survival rate of pangas fingerling was determined from the starting time of the experiment to at the end of 60 days. In case of 0, 2, 4, 6, 8, 10 and 12‰ salinity, no mortality was found during the cultural period while Kumar *et al.* (2017) recorded 86-97% mortality at the salinity range between 15 and 5‰. All fish died within 6 hours of stocking at 20‰ salinity while about 50% died at 14‰ salinity in the same duration (Table 1). Thus, findings of the present study suggest that pangas can be cultured at a salinity of 12‰ without any effect on survival.

Table 1. Survival rate (%) (Mean± SEM) of pangas fingerlings in different salinity (‰) at 60 day rearing period. Means in the same column with different superscripts are significantly different at P<0.05

Salinity (‰)	Survival rate (%) in different duration			
	0 day	20 day	40 day	60 day
0	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
2	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
4	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
6	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
8	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
10	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
12	100 ± 0.0	100 ± 0.0^a	100 ± 0.0^a	100 ± 0.0^a
14	100 ± 0.0	43.75 ± 6.25^b	43.75 ± 6.25^b	43.75 ± 6.25^b
20	100 ± 0.0	0.0 ±0.0^c	0.0 ±0.0^c	0.0 ±0.0^c

Specific growth rate (SGR), is one of the indicators to investigate the growth of fishes. The SGR rate was found at 0 and 2‰ salinity at 20, 40 and 60 day. Moreover, at 8‰ salinity maximum SGR was also found at day 60. On the other hand, lowest SGR was observed at 14‰ on 20 day. Salinity of 6, 8, 10 and 12‰ showed moderate SGR (Table 2). Medawars (1945) has demonstrated that "the specific growth rate declines more and more slowly as the organism increases in age" which has been observed in the present study.

Table 2. Specific growth rate (%) (Mean ± SEM) of pangas fingerlings in different salinity (‰) at 60 day rearing period. Means in the same column with different superscripts are significantly different at P<0.05

Salinity (‰)	SGR %		
	20 day	40 day	60day
0	10.95 ± 0.25[a]	7.10 ± 0.16[a]	5.64 ± 0.06[a]
2	10.30 ± 0.41[a]	6.88 ± 0.18[a]	5.65 ± 0.06[a]
4	10.25 ± 0.27[ab]	6.73 ± 0.17[ab]	5.39 ± 0.07[ab]
6	8.72 ± 0.27[bc]	6.16 ± 0.13[bc]	5.28 ± 0.07[bc]
8	8.55 ± 0.29[cd]	6.13 ± 0.11[bc]	5.35 ± 0.07[abc]
10	7.70 ± 0.41[cde]	5.78 ± 0.21[cd]	5.24 ± 0.08[bc]
12	7.27 ± 0.27[de]	5.57 ± 0.09[cd]	5.03 ± 0.05[cd]
14	6.58 ± 0.22[e]	5.20 ± 0.07[d]	4.94 ± 0.05[d]

More than a century ago, Minot (1908) has postulated that most animals have the specific growth rate at pick at early stage of their life cycle which typically decreases with increasing age, even becomes zero in some animals.For optimum growth and survival each fish has a specific range of temperature, DO or salinity which are also important for a successful spawn, where a change in one variable can negatively impact on successful reproduction (Barnard and McBain 1994). Findings of the current study demonstrate that pangasgrowth and survival is not affected by salinities up to 4‰, while growth was significantly decreased at 8‰ salinity and above. This is in agreement with the findings of other study where blacknose silverside and pike silverside fishes have been shown to tolerate salinity up to 5‰ and reduced growth and survival at salinities of 10‰ and above (Martinez-Palacios *et al.* 2004).

In the current study, similar FCR was observed in all the treatments during 60-day rearing period (Table 3). Altinok and Grizzle (2001) showed better SGR, and FCR in three freshwater euryhaline species at 3 or 9‰ salinity compared to 0 or 1‰ salinity, which are opposite to the findings of the present study. No significant effect of salinity was found on the FCR in pangas of the present study. However, FCR in pangas in this study was similar to other findings in different fishes (Doolgindachabaporn 1994).

Table 3. Feed conversion ratio FCR (mean ± SEM) of pangas fingerlings in different salinity (‰) at 60 day rearing period

Salinity (‰)	FCR		
	20th day	40th day	60th day
0	2.75 ± 0.10	2.82 ± 0.04	2.54 ± 0.01
2	2.67 ± 0.20	2.75 ± 0.05	2.50 ± 0.11
4	2.43 ± 0.17	2.70 ± 0.03	2.49 ± 0.01
6	2.89 ± 0.10	2.61 ± 0.02	2.47 ± 0.01
8	2.69 ± 0.08	2.59 ± 0.03	2.48 ± 0.01
10	2.48 ± 0.12	2.57 ± 0.03	2.48 ± 0.13
12	2.33 ± 0.09	2.54 ± 0.19	2.44 ± 0.01
14	2.36 ± 0.05	2.45 ± 0.01	2.4 1± 0.01

The significant difference of average daily gain was observed at the end of 60 days rearing period. The maximum average daily gain was found at 0 and 2‰ salinity and the lowest average daily gain was observed at 14‰ salinity (Table 4). Average daily gain (ADG) was found to be affected by salinity, which was negatively related with increasing salinity. Significantly reduced condition factor was observed at salinity of 6‰ and onwards at duration of 20 day while at day 40, condition factor significantly reduced at sanity 12 and 14‰ ($p<0.05$; Table 5). However, the fish were found to be able to maintain condition factor at day 60 in all the salinity conditions.

Table 4. Average daily gain (ADG) (mean ± SEM) of pangas fingerlings in different salinity (‰) at 60 day rearing period. Means in the same column with different superscripts are significantly different at P<0.05

Salinity (‰)	ADG
	60 day
0	$1.73±0.04^{a}$
2	$1.73±0.04^{a}$
4	$1.56±0.04^{b}$
6	$1.47±0.03^{b}$
8	$1.45±0.04^{b}$
10	$1.43±0.04^{bc}$
12	$1.29±0.02^{cd}$
14	$1.20±0.02^{d}$

Condition factor (K) is one of the important growth parameters in fish (Ighwela*et al.* 2011). In the current study, salinity was found to decrease the value of condition factor at early stage of culture until day 40 while no effect of salinity was found at late stage of culture (day 60) which might be because of less feeding at higher salinity (Ighwela*et al.* 2011). Similar finding has been reported by Saha*et al.* (1998)in *Clariasbatrachus* (Linn.) fed on formulated diets. Rahman *et al.* (1997) foundthe values of condition factor between 0.81 and 0.87 on the survival and growth of catfish after giving selected supplemental feeds.

Table 5. Condition factor (Mean ± SEM) of pangas fingerlings in different salinity (‰) at 60 day rearing period. Means in the same column with different superscripts are significantly different at P<0.05

Salinity (‰)	Condition factor (K)		
	20 day	40 day	60day
0	$1.44 ± 0.08^{a}$	$1.04 ± 0.07^{a}$	1.23 ± 0.06
2	$1.32 ± 0.07^{a}$	$1.30 ± 0.05^{a}$	1.30 ± 0.08
4	$1.30 ± 0.05^{a}$	$1.29 ± 0.04^{a}$	1.22 ± 0.07
6	$0.97 ± 0.03^{b}$	$1.27 ± 0.05^{a}$	1.18 ± 0.02
8	$0.91 ± 0.03^{b}$	$1.15 ± 0.05^{a}$	1.29 ± 0.02
10	$0.86 ± 0.03^{bc}$	$1.14 ± 0.04^{a}$	1.30 ± 0.02
12	$0.81 ± 0.02^{bc}$	$1.14 ± 0.04^{b}$	1.31 ± 0.02
14	$0.68 ± 0.02^{c}$	$1.06 ± 0.04^{b}$	1.27 ± 0.01

Proximate composition of fish and fish feed: Proximate composition is one of the factors that determines the flesh quality of fishes which might be changed due to salinity exposure. The proximate composition was thus determined at different salinity and duration of exposure where lipid, protein and ash content did not show significant variation between treatments and duration except moisture which was found to be increased with increasing salinity with a little fluctuation. The initial proximate composition (mean ± SEM) of pangas fingerling was determined just after released in different salinity (day zero, Table 6). The lowest amount of moisture (76.27±0.04) % was found at 4‰ and the height amount (78.69±0.54) % was at 14‰ salinity. Maximum crude protein 17.59 ± 0.23% was found in 0‰ salinity while minimum 15.56 ± 0.22% was found in 14‰ salinity. The highest crude lipid 3.56±0.24 % was detected at 6‰ and lowest 3.21±0.18% was at 14‰ and maximum ash content 2.79±0.08% was observed at 6‰ and minimum 2.45±0.14% was at 4‰ salinity. No significant difference was found in proximate composition of pangas fingerlings at the initial time (0 day).On the other hand, after 60 days studied period only moisture showed significant differences among the treatments ($p<0.05$, Table 7).

Table 6. Initial Proximate composition (%) (Mean ± SEM)of pangas fingerlings at day zero (0) of rearing

Salinity (‰)	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)
0	77.18 ± 0.19	17.59 ± 0.23	3.51 ± 0.36	2.66 ± 0.12
2	77.69 ± 0.04	16.8 ± 014.	3.22 ± 0.09	2.60 ± 0.04
4	76.38 ± 0.07	17.67 ± 0.57	3.31 ± 0.03	2.27 ± 0.04
6	77.02 ± 0.66	17.02 ± 0.01	3.56 ± 0.24	2.79 ± 0.08
8	76.39 ± 0.41	16.66 ± 0.25	3.32 ± 0.20	2.54 ± 0.05
10	78.01 ± 1.32	16.72 ± 0.54	3.32 ± 0.32	2.64 ± 0.14
12	77.11 ± 1.31	16.04 ± 0.52	3.27 ± 0.07	2.61 ± 0.38
14	77.50 ± 0.70	15.56 ± 0.22	3.21 ± 0.18	2.45 ± 0.14

Table 7. Proximate composition (%) (Mean ± SEM) of pangas fingerlings at 60thday of rearing. Means in the same column with different superscripts are significantly different at P<0.05

Salinity (‰)	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)
0	76.27 ± 0.04^{c}	16.24 ± 0.06	4.01 ± 0.10	2.54 ± 0.21
2	77.74 ± 0.16^{abc}	16.24 ± 0.01	3.62 ± 0.11	2.50 ± 0.01
4	76.72 ± 0.21^{bc}	17.25 ± 0.09	3.82 ± 0.14	2.54 ± 0.11
6	76.67 ± 0.34^{bc}	16.64 ± 0.35	3.84 ± 0.17	2.50 ± 0.11
8	77.48 ± 0.50^{abc}	17.37 ± 0.21	3.80 ± 0.03	2.43 ± 0.24
10	77.31 ± 0.08^{abc}	15.90 ± 1.17	3.68 ± 0.24	2.44 ± 0.10
12	78.06 ± 0.08^{ab}	16.94 ± 0.90	3.59 ± 0.08	2.34 ± 0.34
14	78.69 ± 0.54^{a}	16.73 ± 0.42	3.64 ± 0.15	2.12 ± 0.13

The maximum amount of moisture 78.01±1.32% was found at 14‰ and minimum 76.38±0.07% was in 0‰ salinity. The proximate composition of pangas did not show any significant different except moisture. The ranges of moisture, crude protein, crude lipid and ash were (15.90±1.17)% to (17.37±0.21)%,(3.59±0.08)% to (4.01±0.10)% and (2.12±0.13)% to (2.54±0.11)%, respectively (Table 7). The proximate composition of fish feed was also determined where starter feed contain more crude protein and less moisture than that of grower feed. Both fish feeds were found to contain similar percentage of crude lipid and ash (data not shown).

Water quality parameters: The observed water temperature, DO, and pH were 27.23 ± 0.02 °C, 8.33 ± 0.05 mg/L and 8.05 ± 0.03, respectively. No significant variation was found for the observed water quality parameters throughout the experimental period. Water temperature has profound effect on growth, reproduction and other biological activities of fishes. The metabolic rate of fish is closely related to the water temperature. Boyd (1982) reported that the range of water temperature from 26.06 to 31.97 ºC is suitable for warm water fish culture. In the present experiment, the temperature was found (27.23 ± 0.02) °C which was in suitable range during the entire experiment. Dissolved oxygen (DO) is another important factor that plays a significant role in the productivity of a reservoir. The overall DO was (8.33 ± 0.05) mg/L at present experiment. Oxygen levels of 3 mg/L and above have been recommended by Ross (2002) for satisfactory level of fish culture. The present result showed appropriate for pangas culture. Hydrogen ion concentration (pH) is very important factor in fish life. Normally pH ranges from 6.4 to 8.3 is favorable for fish growth (Devi *et al*. 2017). The optimum range of pH is 6.5 to 8.5 whereas 7.5 to 8.0 are considered suitable for aquatic organisms. The overall pH value in the present investigation was (8.05 ± 0.03) which was suitable for pangas culture.

CONCLUSION

Pangas is one of the economically important fish species in Bangladesh. The salinity intrusion can result in the reduction of production of this species. However, the results of this study have shown that pangas fingerlings can easily survive at salinity upto 12‰. The growth and feed conversion efficiency was found to remain same at salinity of 4‰. However, the growth of pangas has been found to be negatively correlated with increasing salinity above 4‰. The study suggests the necessity of large-scale trial on survival and growth of pangas in saline water.

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