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The Pangas Catfish *Pangasius pangasius*; Growth Efficiency and Nutritional Composition Under Variety of Saltwater Challenges

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ABSTRACT

This study investigated the effects of varying salinity levels on the growth and nutritional composition of the pangas catfish (*Pangasius pangasius*) over 60-day intervals. Fish seeds (25.3g) from Tawakal Fish Hatchery were acclimated and then exposed to four salinity treatment groups: T0 (0 ppt), T1 (2 ppt), T2 (4 ppt), and T3 (6 ppt). Parameters including salinity, temperature (26.2°C), pH (8.13), and dissolved oxygen (7.32mg/ L) were monitored daily. Fish were fed a commercial diet twice daily at 5% of their body weight. Significant differences in growth parameters were observed. Initial body weight remained consistent across treatments ($P > 0.05$), but final body weight decreased upon increasing salinity, with significant reductions in T2 and T3 compared to T0 ($P < 0.01$ and $P < 0.001$, respectively). Weight gain also significantly declined with higher salinity levels ($P < 0.01$), and feed conversion ratio increased with salinity ($P < 0.01$). Nutritional analysis revealed that crude protein decreased significantly with increasing salinity, while crude fat and ash content increased ($P < 0.05$ to $P < 0.001$). The study confirms that elevated salinity adversely affects growth and nutritional composition, with significant impacts indicated at higher salinity levels.

INTRODUCTION

After decades of rapid growth, aquaculture has become the fastest-growing global animal food production sector. In 2022, global aquaculture production reached 87.5 million tons, surpassing marine capture production of 78.8 million tons, and has established itself as the primary source of aquatic animals for human consumption **(Al Sulivany *et al.*, 2024A)**.

The pangas catfish (*Pangasius pangasius*) (Hamilton, 1822) is a catfish species of the family Pangasiidae under the order Siluriformes. It is fast-growing, disease-resistant, and tolerates various environmental conditions. In the aquaculture sectors of Asian countries, *P. pangasius* has experienced significant growth and emerged as a major aquaculture commodity, contributing to the country's economic development and export income **(Ali *et al.*, 2013; Ho *et al.*, 2016; Jeyakumari *et al.*, 2016; Nguyen *et al.*, 2018)**. It is characterized by white flesh, a firm cooked texture, high nutritive values, and a highly delicious taste. It is now traded worldwide as skinless, boneless steaks and fillets and is beneficial for human health **(Islami *et al.*, 2015)**. The growth performance of fish mainly depends upon feed intake, feed consumption, assimilation, and conversion into body tissues. Moreover, it is a popular freshwater aquaculture species that can survive in a wide range of environmental conditions and has been found to have better growth performance in brackish water. It should, therefore, be considered essentially stenohaline in its environmental preferences **(Al Habbib & Al Sulivany, 2013; Fiúza *et al.*, 2015; Jahan *et al.*, 2019)**. Additionally, some internal factors, including endocrine and ecological factors such as salinity, influence their survival and growth rate **(Rubio *et al.*, 2005; Thammapat *et al.*, 2010)**. Salinity is a main abiotic factor in aquaculture and acts as an essential stressor that directly influences the standard inner stability, metabolism, and physiological and osmoregulatory activities of fish **(Islam *et al.*, 2014; Mubarik *et al.*, 2015)**.

Salt-affected soils (SASs) are an important ecological entity, occupying 6% of global land areas, and their utilization for productive purposes is one of the significant challenges in this regard. Saline aquaculture practices are adaptive measures that provide approaches and opportunities for diversifying and expanding aquatic agriculture through potentially productive use of land with economic, social, and environmental benefits **(Mandal & Sharma, 2006; Thomas *et al.*, 2019)**.

Aquaculture production has been experienced throughout Southeast and Central Asia (India, Bangladesh, and Thailand) to bring exotic fish species like pangas to Pakistan to promote aquaculture technology **(Chowdhury *et al.*, 2020)**. A few studies have been conducted to evaluate the effects of salinity on the growth, survival, and nutritional qualities of fish.

The present study was implemented to investigate the stressful effects of various salinity levels and determine the maximum salinity for pangas that can be tolerated without affecting growth, survival, or proximate composition under laboratory conditions.

MATERIALS AND METHODS

Fish collection and experimental designs

Fish seeds of *Pangasius pangasius*, averaging 25.3 grams and of both sexes, were acquired from Tawakal Fish Hatchery in Punjab, Pakistan. These fish were transported to the aquaculture laboratory at the Saline Water Aquaculture Research Center (SWARC), Department of Fisheries, Muzaffargarh. The fish were placed in a glass aquarium measuring 140×35×52cm³ upon arrival.

The data measured in the pond included salinity (0- parts per thousand [ppt]), temperature (26.2°C), pH (8.13), and dissolved oxygen (7.32mg/ L). These parameters were daily monitored using an Apera 8500 EC meter for electrical conductivity, an Apera 8500 pH meter for acidity, and a P-512 dissolved oxygen meter. Aeration was continuously provided throughout the experimental period to maintain optimal conditions **(Ahmed, 2023)**.

The fish were allowed seven days to acclimate to the new conditions in the laboratory. The aquaria used for experiments were then caterorized into four groups: T0 (control), T1, T2, and T3, corresponding to salinity levels of 0, 2, 4, and 6 parts per thousand (ppt) of sodium chloride powder (NaCl) was purchased from Sigma-Aldrich, respectively. Each treatment group included one replicate with a stocking density.

The fish were provided with a standard pellet of 30% crude protein, which included 13.8% fish meal, 6.75% rice protein, 6% mustard oil cake, 2.4% rice bran, and 2% wheat bran, along with a vitamin premix. They were fed twice daily at a rate of 5% of their body weight **(Mandal *et al.*, 2020)**. Water was daily exchanged, and detritus and uneaten feed were daily removed by siphoning **(Xia *et al.*, 2013)**. The fish were exposed to varying salinity levels for 60 days.

Growth efficiency measurements

After sixteen days of exposing the fish to different levels of salinities, fish were deprived of food for one night and got free access to water. On the following day, the fish were measured by using Digital Balance Adventure (Model; A&D HT-120), and the growth performance parameters were measured, including feed intake (the amount of food consumed by fish over a specific period), weight gain (the increase in body weight over time), growth rate percentage (evaluate the increase in their weight over a period), and feed conversion ratio (FCR) (the efficiency of converting feed into body mass). All prameters were measured as per the methodologies described by **Hosseini and Al Sulivany (2024)** and **Jewel *et al.* (2024)** .

The growth parameters were determined according to the formulas below:

$$WG = FW - IW$$
$$FCR = FG / WG$$
$$GR = (WG / IW) \times 100$$
$$FI = FCR \times WG$$

Where, WG stands for weight gain (g/day); FW: final weight (g); IW: initial weight (g); FCR: feed conversion ratio (%); GR: growth rate (%), and FI is feed intake (FI; g/day).

Nutritional composition measurements

After assessing growth efficiency parameters, fish were removed from each aquarium and euthanized with a swift blow to the head. The flesh was then excised and rinsed with distilled water **(Secci *et al.*, 2018)**. The nutritional composition of the muscle was analyzed according to **AOAC (1990)** standards. A 5g portion of the fish flesh was dried in an oven at 105ºC to measure moisture content **(Owais *et al.*, 2023; Francis *et al.*, 2024)**. The dried samples were pulverized using a mortar and pestle, and lipid content was quantified with chloroform-methanol **(Truzzi *et al.*, 2017)**. Crude protein content was measured using the micro-Kjeldahl method **(Malva *et al.*, 2018)**. Ash content was determined by combusting a 2g dried sample in a muffle furnace at 550ºC until all material was reduced to ash, which was then weighed **(Yi *et al.*, 2014)**.

The nutritional composition was calculated using the following formulas:

$$\text{Moisture Content (MC)} = (\text{IW - DW / IW}) \times 100$$

$$\text{Lipid Content (LC)} = (\text{Weight of extracted lipid / SW}) \times 100$$

$$\text{Crude Protein (CP)} = \text{NC} \times 6.25$$

$$\text{Ash Content (AC)} = (\text{WA / SW}) \times 100$$

Where, MC denotes moisture content (%); DW is dry weight; LC represents lipid content (%); SW is sample weight; CP stands for crude protein (%); NC indicates nitrogen content, and AC signifies ash content (%).

Statistical analysis

The data obtained from the experimental outcomes were analyzed using GraphPad Prism viewer mode 9 for Windows. One-way analysis of variance (ANOVA) was conducted to compare the control group with the experimental groups. Subsequently, the Kurskal-Wallis test for multiple comparisons was applied after ANOVA to determine the significance between different groups. Statistical significance was considered at $P< 0.05$ **(Al Sulivany *et al*., 2024B)**.

RESULTS

The experiment was specially designed for sixty days to assess the growth efficiency (initial body weight, final body weight, feed intake, growth rate, weight gain, and feed conversion ratio) and proximate composition (crude protein, crude fat, moisture, and ash) of *P. pangasius* at different salinity levels (2, 4, and 6-ppt) along with their replicates and the control group (0-ppt).

Growth efficiency

The initial body weight (IBW) over all treatments remained relatively non-significant ($P> 0.05$), with T0 showing an IBW of 25.32± 0.2g, T1 at 25.92 ± 0.13g, T2 at 25.84 ±0.74g, and T3 at 25.52 ±0.22g (Table 1 & Fig. 1A). On the other hand, the final body weight (FBW) decreased with increasing salinity: T0 (44.86 ±0.34g), T1 (43.4 ±0.16g), T2 (41.4 ±0.24g), and T3 (40.24 ±0.1g). The *P*-values reveal significant differences between T0 and T2 ($P< 0.01$) and T0 and T3 ($P< 0.001$) (Table 1 & Fig. 1B). Furthermore, weight gain (WG) was increased in the control group (T0) at 19.54 ±0.42g, decreasing progressively in T1 (17.48 ±0.17g), T2 (15.56 ±0.3g), and T3 (14.72 ±0.22g). These data reveal significant reductions in WG for T2 and T3 compared to T0 ($P< 0.01$) (Fig. 1C). Feed intake (FI) remained somewhat stable across groups. The differences were not statistically significant ($P> 0.05$) (Fig. 1D). The growth rate (GR) also showed significant differences ($P< 0.01$) between T0 and T3; it exhibited a decline with increasing salinity: T0 (77.22 ±2.11g), T1 (67.44 ±0.44g), T2 (60.22 ±1.33g), and T3 (57.72 ±1.31g), as shown in Table (1) and Fig. (1E). Furthermore, the feed conversion ratio (FCR) increased with salinity: T0 (1.2), T1 (1.3), T2 (1.5), and T3 (1.6), with significant differences noted between T0 and T3 ($P< 0.01$) (Fig. 1F).

Table 1. The growth efficiency of *P. pangasius* in both the control (T0; 0-ppt) and experimental group (T1; 2-ppt, T2; 4-ppt, and T3; 6-ppt)

Group	IBW (g)	FBW (g)	WG (g)	FI (g)	GR (g)	FCR (%)
T0	25.32±0.2	44.86±0.34	19.54±0.42	23.54±0.38	77.22±2.11	1.2±0.04
T1	25.92±0.13	43.4*±0.16	17.48±0.12	24.2±0.20	67.44±0.64	1.3±0.12
T2	25.84±0.74	41.4**±0.24	15.56**±0.3	24.1±0.31	60.22**±1.33	1.5*±0.24
T3	25.52±0.22	40.24***±0.1	14.72**±0.22	23.79±0.23	57.72**±1.31	1.6**±0.31

$P>0.05$= Non-significant.
$P< 0.05$= Significant.
$P<0.01$= Highly significant.
$P<0.001$= Extremely significant.

The nutritional composition

The statistical analysis of the data presented in Table (2) and Fig. (2A, B, C, and D) reveals significant differences in the biochemical composition of fish, crude protein (CP), crude fat (CF), moisture (M), and ash (AS), under varying salinity levels (T0: 0ppt, T1: 2ppt, T2: 4ppt, and T3: 6ppt) over a 60-day interval. As shown in Table (2), CP content exhibited a significant decline with increasing salinity, starting from 16.28 ±0.24% in the control group (T0) and decreasing to 15.3 ±0.07% in T1, 14.24 ±0.04% in T2, and further dropping to 13.34 ±0.09% in T3. The differences between T2 and T0 ($P< 0.05$) and between T3 and T0 ($P < 0.001$) were statistically significant. In contrast, CF content increased significantly with rising salinity, with T0 showing 8.62 ±0.07%, T1 at 9.52 ±0.1%, T2 at 10.5 ±0.07%, and T3 reaching 12.06 ±0.23%. The increase in CF content was significant between T2 and T0 ($P< 0.05$) and even more pronounced between

T3 and T0 (P< 0.001). Moisture content displayed a decreasing trend as salinity increased, with T0 recording 76.54 ±0.11%, T1 at 75.34 ±0.11%, T2 at 74.24 ±0.05%, and T3 at 72.98 ±0.20%. Significant differences in moisture content were observed between T2 and T0 (P< 0.05) and between T3 and T0 (P< 0.001). Similarly, the ash content also showed a significant increase with salinity, with T0 at 1.28 ±0.02%, T1 at 1.52 ±0.03%, T2 at 1.74 ±0.02%, and T3 at 2.02 ±0.04%. The differences in AS content were statistically significant between T2 and T0 (P< 0.05) and between T3 and T0 (P< 0.001).

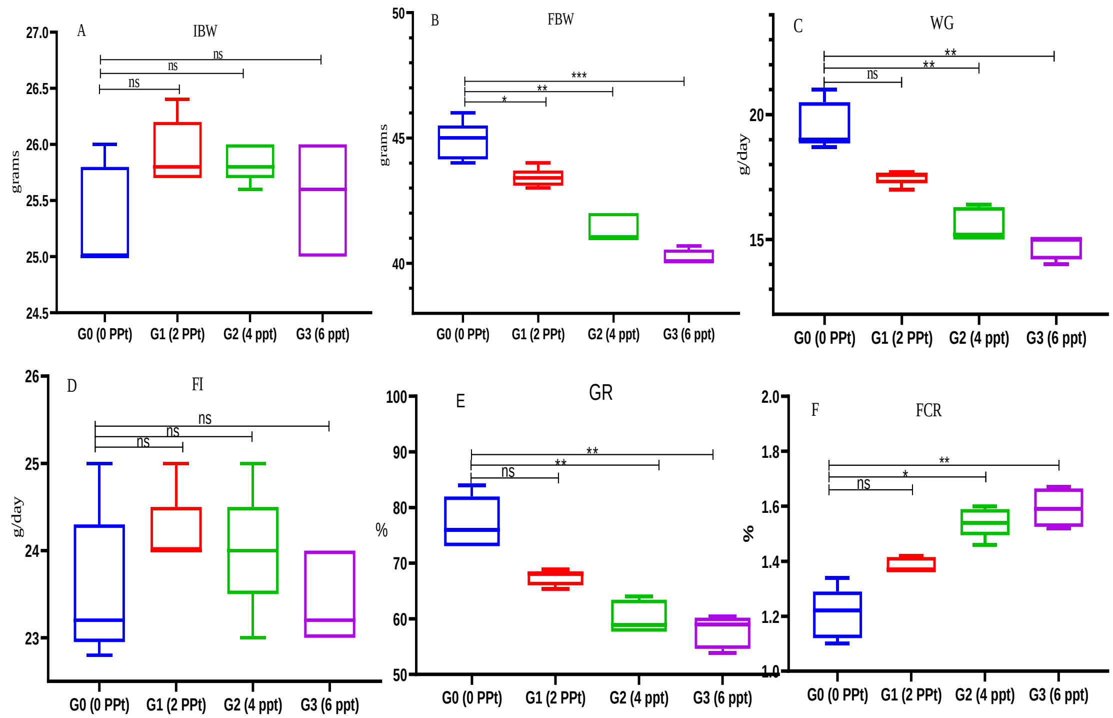

Fig. 1. The growth efficiency of *P. pangasius* in both the control (T0; 0-ppt) and experimental group (T1; 2-ppt, T2; 4-ppt, and T3; 6-ppt). (A) IBW, (B) FBW, (C) WG, (D) FI, (E) GR, and (F) FCR

Table 2. The nutritional composition of *P. pangasius* in both the control (T0; 0-ppt) and experimental group (T1; 2-ppt, T2; 4-ppt, and T3; 6-ppt)

Parameter	Treatment			
	T0(0-ppt)	T1(2-ppt)	T2(4-ppt)	T3(6-ppt)
Crude protein (%)	16.28±0.24	15.3±0.07	14.24*±0.04	13.34***±0.09
Crude fat (%)	8.62±0.07	9.52±0.1	10.5*±0.07	12.06***±0.23
Moisture (%)	76.54±0.11	75.34±0.11	74.24*±0.05	72.98***±0.20
Ash (%)	1.28±0.02	1.52±0.03	1.74*±0.02	2.02***±0.04

P>0.05= Non-significant.
P< 0.05= Significant.
P<0.01= Highly significant.
P<0.001= Extremely significant.

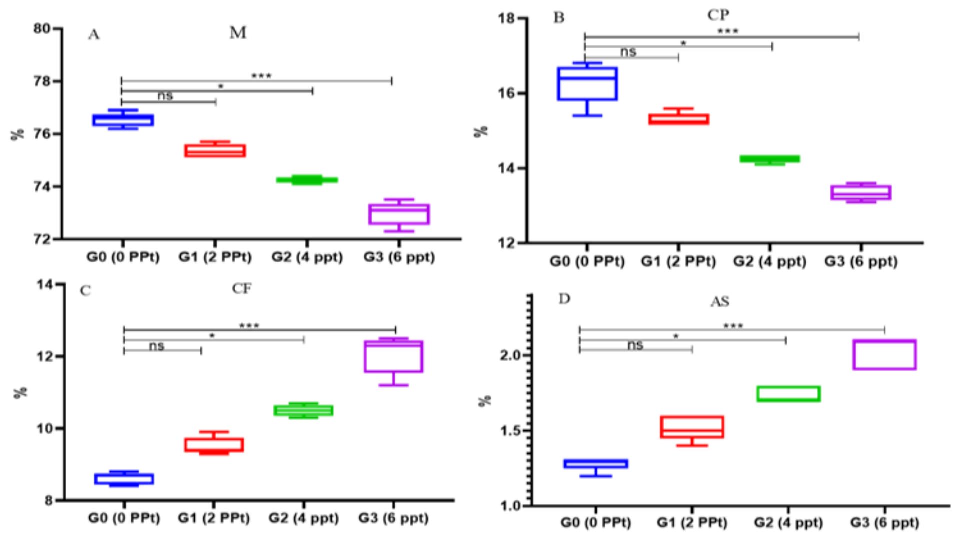

Fig. 2. The nutritional composition of *P. pangasius* in control (T0; 0-ppt) and experimental group (T1; 2-ppt, T2; 4-ppt, and T3; 6-ppt). (A) M, (B) CP, (C) CF, and (D) AS, (E) GR, and (F) FCR

DISCUSSION

The influence of salinity on *P. pangasius's* growth performance and survival is a critical area of research, particularly in aquaculture, where water quality parameters can fluctuate significantly. Salinity is a key conditional factor that can directly affect fish growth by altering feeding behavior and elevating the energy expenditure required for osmoregulation **(Washim *et al.,* 2022)**. As fish are ectothermic, their physiological processes are susceptible to changes in their aquatic habitats including salinity.

It has been reported that fish often experience stress as salinity increases, which can suppress feed intake and overall growth rates **(Sarma *et al.,* 2013)**. The physiological stress induced by elevated salinity levels diverts energy toward maintaining osmotic balance rather than promoting growth, leading to decreased growth performance **(Dawood *et al.,* 2021)**. This is supported by findings indicating that *P. pangasius* tolerates salinity levels up to approximately 5.5ppt, beyond which growth parameters decline significantly **(Mohamed *et al.,* 2021)**.

The mechanisms underlying these alternations in growth efficiency are multifaceted. High salinity levels in aquatic habitats can lead to elevated metabolic demands as fish work to maintain homeostasis. This is particularly evident in the FCR, a critical measure of feed efficiency. Elevated salinity levels have been associated with poorer FCR values, indicating that fish require more feed to achieve growth under stressful conditions **(Sinha *et al.,* 2015)**. The highest FCR values observed in higher salinity treatments suggest that fish are not converting feed into body mass efficiently, likely due to stress and decreased feed intake.

Moreover, the negative correlation between salinity and growth efficiency has been reported in different species. **Küçük *et al.* (2013)** found that increased salinity adversely affected the growth rate and gain in *Carassius auratus*. Similarly, studies on *Clarias batrachus* and *Tilapia rendalli* reported similar detrimental impacts of elevated salinity on growth metrics **(Kangombe & Brown, 2008; Sarma *et al.*, 2013)**.

The findings in this study are consistent with recent research, such as that conducted by **Abduh *et al.* (2024)**, which indicated the growth of *P. hypophthalmus* across different concentrations of salts. Their results revealed optimal growth conditions in freshwater up to 9ppt, consistent with the idea that specific salinity thresholds exist for optimal growth in different species. **Hossain *et al.* (2022)** also showed that *Channa striata* exhibited no significant growth differences from freshwater to 6ppt, suggesting species-specific tolerance levels that merit further investigation.

The research study also reveals that the protein content in *P. pangasius* diminishes by elevating the salt concentration in the water. This is consistent with a previous study, where the protein content displayed an inverse correlation with salinity. For instance, **Mandal *et al.* (2020)** observed a decrease in CP from 17.59 to 15.56% as salinity increased. The protein is an essential component that plays a vital role in the development and metabolic processes of the fish. A reduction in protein with elevated salinity may be attributed to energy diversion toward osmoregulation, which diminishes the energy available for protein synthesis.

Additionally, **Thomas *et al.* (2021)** reported a significant reduction in protein levels in the milkfish at higher salinity, supporting the current study's findings. This decrease in protein content may also be linked to stress responses in aquatic organisms, where increased salinity can lead to physiological stress, affecting growth and metabolic efficiency **(Fiúza *et al.*, 2015)**.

The increases in CF content were recorded in this research. This finding supports that fish may accumulate fat reserves in response to environmental stressors including salinity alternations. Previous studies, such as that of **Jahan *et al.* (2019)**, showed that high salinity can enhance fat deposition as a physiological adaptation to osmotic stress. The significant decrease in moisture content and the elevating in ash content with higher salinity levels further corroborate the complex interactions between salinity and fish physiology. **Blum *et al.* (2013)** examined the reduced moisture retention at elevated salinity, which coincides with findings elucidating that fish adapt to saline environments by modifying their osmotic balance, thereby affecting overall body composition.

CONCLUSION

P. pangasius exhibits remarkable adaptability to a diverse range of environmental conditions. This study's findings have shed light on the salinity tolerance of *P. pangasius*, which has been determined to be 6ppt in controlled laboratory settings. Based on these results, it is highly recommended that local farmers consider large-scale cultivation of *P. pangasius* in natural saline water earthen ponds.

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