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Evaluation of sublethal salinities stress on growth performance, survival and behavioral aspects of *Catla catla* (Hamilton, 1822) under inland saline water

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Abstract

An experiment was carried out to understand the salinity tolerance and growth performance of *Catla catla* (Hamilton, 1822) under inland saline aquaculture at different salinities. In the beginning of the experiment salinity tolerance studies was conducted to understand the behavior of the fish for a period of 96 hr. using LC₅₀ assay at different salinities viz. 0 (control), 5 (T₁), 10 (T₂), 15 (T₃), and 20 (T₄) ppt respectively. The LC₅₀ values was calculated using probit analysis. The calculated value of LC₅₀ assay was 7.25 ppt, based on that a 90 days experiment was designed at different salinities (ppt) viz. control (0), T₁ (2), T₂ (4), T₃ (6) and T₄ (8) respectively in triplicates, following a CRD design, to assess the growth performance and survival of *Catla spp.* under inland saline aquaculture. During the experiment the salinities (0 ppt to 8 ppt) were increased in a phase manner (explained in material & methods). The observed results show that the overall growth performance (SGR, PER, FER, ABWG) was found better in control followed by T₁, T₂, T₃ and T₄ respectively. Similarly, FCR and PER showed an increasing and decreasing trend respectively with the salinity. The survival percent was found in the range from 70-100% and showed a decreasing trend with increasing salinities. The present study suggests that *Catla spp.* can tolerate a salinity up to 8 ppt further, the inference from the present investigation revealed that the better growth and survival of *Catla catla* fingerlings can be obtained up to a salinity levels of 4 ppt without compromising significantly in growth performance and survival respectively. The present studies may be helpful to utilizing the unattended low saline inland areas for the culture of *Catla spp.* in the era of global warming and contribute in climate resilient aquaculture.

Keywords: Climate Resilient, Aquaculture, LC₅₀ Assay, *Catla catla*

1. Introduction

Aquaculture is a sunrise sector of our economy. Aquaculture plays an important role in national economic development, global food supply, achievement of food security and rural development (NACA/FAO., 2000). In recent years, total global fisheries and aquaculture production reached about 223.2 million tonnes, out of which nearly 89% of aquatic animal production was utilized for direct human consumption (FAO, 2024). In India, aquaculture has shown a steady increase and currently contributes about 8% to the global aquatic animal production, placing the country among the leading aquaculture producers worldwide (FAO, 2024). The land is a basic requirement for aquaculture, but due to salinization or modification, the whole world is losing approx. 3 ha. of fertile lands every minute (Abrol *et al.*, 1988). In India approx. 8.62 million ha of salt-affected lands and 1.93 million ha. area have ground saline water (Lakra *et al.*, 2014) [27]. In Gujarat, the Inland saline area is 12 lakh ha and mainly found in Ahmadabad, Amreli, Banaskantha, Bhavnagar, Jamnagar, Kachchh, Rajkot and Surendranagar districts.

India is the second-largest aquaculture producer in the world, dominated by carp production, about 80% of India's aquaculture production is composed of carps (Sivagami and Ronald, 2018). India is known for its rich diversity of carps under freshwater ecosystems in that *Catla spp.* is one of the most important carps among Indian major carps belongs to the family Cyprinidae. The fish is having good local market demand and fetches good price. Salinity is one of the important parameters which imparts great role in osmoregulation and hence in the growth and survival of the fish. Effects of salinity was widely reported on oxygen, pH, temperature and specific gravity by Nikolsky (1963) [32], on gametes and fertilization period of

the fish by Holliday (1965) [15] and Rockwell (1956) [16], on behavioral response by Baggerman (1959) [5]. Due to global warming and incident like decreasing rainfall and increasing salinity levels in soil and water respectively it is important to determine the threshold levels species-wise to establish the optimal requirements for salt contents of the cultured fishes. However, very limited research has been conducted on the effect of salinity on survival and growth performance of *Catla catla*. Therefore, the present experiment was design to investigate how salinity affects the growth and survival of *Catla catla* fingerlings in inland saline waters under laboratory conditions.

2. Material and Methods

2.1 Experimental Site

The experiment was performed at the wet lab of Postgraduate Institute of Fisheries Education and Research (PGIFER) Rajpur (Nava), Himmatnagar, Gujarat (23°39'56.7"N 72°59'52.6"E).

2.2 Fingerling collection

The fingerlings (3.0±0.2 gm) of *Catla catla* were procured from state fisheries department, fish farm, Ukai, Gujarat. The fishes were transported in a polythene bag at low stocking densities with well aerated water to the experimental site. After receiving the fishes at wet lab of PGIFER, the fishes were acclimatized for a period of two weeks in the freshwater having 0 ppt salinity under well aerated water in the inflated pools of 500 litres.

2.3 Determination of lethal concentration value

To determine the 0-, 6-, 12-, 24-, 48-, 72- and 96-h median lethal concentration (MLS-50) of salinity for fingerling of catla. Four different salinity concentrations (0, 5, 10, 15 and 20 ppt), each having three replications, were applied to find mortality percentage (0-100%). All the salinity concentrations were prepared by mixing of inland saline water (36ppt) with freshwater (0 ppt) and Salinity was measured by twice per day using digital refractometer (HANNA HI-96822 Seawater Refractometer) to maintain the salinity and provision of aeration were made two weeks prior before starting the experiment.

2.4 Experimental Design

Based on the median lethal salinity, completely randomized design was followed where four different sublethal concentrations of salinities (2 ppt, 4 ppt, 6 ppt and 8 ppt) and a control (0 ppt), each having three replications, were implemented to assess the effect of salinity on the fish. The experiment was conducted for a period of 90 days in clean rectangular tank of 150-litre capacity of water with a stocking density of 20 fish per tank. The fishes were fed twice/day with the commercial feed (GROWFIN) having proximate composition *viz.* crude protein 40%, crude fat 6.0%, fibre 3%, and moisture 11.5%. The feeding ration was divided into two halves and broadcast at 10.00 am and 5.00 pm, @ 5% body weight after switching off the aeration system. The regular health monitoring and provision of removing the dead specimens and the record maintenance were strictly monitored.

2.5 Assessment of physico-chemical parameters

The physico-chemical properties of the collected water were estimated in terms of temperature, pH, Dissolved oxygen, Total Hardness, Total Alkalinity, Total ammonium nitrogen (TAN), Nitrite and Nitrate by Hanna multiparameter instrument.

2.6 Growth analysis

Growth sampling was done at an interval of 15 days by collecting the fishes using hand net. Randomly 10 fishes were caught to estimate the weight (gm). Total weight of fish was measured using a weighing balance. The utmost care was taken while sampling to minimize stress on the animal. The growth parameters like weight gain (%), feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER), specific growth rate (%) (SGR) and survival (%) were determined as follows:

Weight gain (%) = $(FW - IW) \times 100 / IW$, FCR = Dry weight of feed given (DW)/body weight gain (WW), FER = 1/FCR, PER = Body weight gain (g)/Protein fed (g), SGR (%) = $[\ln(FW) - \ln(IW)] / N \times 100$, Survival rate (%) = $100 \times (\text{final fish count} / \text{initial fish count})$.

Where FW = Final body weight, IW = Initial body weight, DW = Dry weight of feed, WW = Wet weight of fish, ln = Natural log and N = Number of days of the experiment.

2.7 Data analysis

The data analysis of median lethal concentration value (LC50) by using the Probit Analysis Statistical Method under SPSS statistical analysis software (Version 25) and physiological parameters were analyzed by one-way analysis of variance (ANOVA) using SPSS VERSION 26.0. Duncan's multiple range tests were used for post-hoc comparison of the mean ($P < 0.05$) between different groups. All the data presented in the text, figures and tables expressed are mean ± standard error and statistical significance for the test was set at $P < 0.05$.

3. Results

3.1 Physico-chemical water quality parameters during LC₅₀ assay

The observed physio-chemical water quality parameter *viz.* temperature (°C) and pH were recorded twice per day using a digital thermometer and pH meter (PCTestr35) respectively. The range of pH and temperature recorded during the experiment was 7.8±0.01^a to 8.1±0.01^b and 18.7±1.44^a to 18.9±1.64^a respectively are depicted in (Table 1). The pH values show significant difference ($p < 0.05$) in T₄ compare to control.

Table 1: Water quality parameter pH and temperature (°C) during the experiment (for LC₅₀) (Mean±SEM).

Treatment (ppt)	pH	Temperature °C
Control	7.8±0.01 ^a	18.8±1.34 ^a
T ₁	8.0±0.02 ^b	18.7±1.44 ^a
T ₂	8.1±0.01 ^b	18.8±1.52 ^a
T ₃	8.1±0.03 ^b	18.9±1.52 ^a
T ₄	8.0±0.02 ^b	18.9±1.64 ^a

3.2 Salinity tolerance and behavioral studies of Catla during LC₅₀ assay

The observation of fish behavior during the experiment are described *viz.* swimming pattern, reflux action, response to external stimuli and feed intake) and percentage of dead specimens at different salinities *viz.* 0 (control), 5 (T₁), 10 (T₂), 15(T₃) and 20 (T₄) respectively of *Catla catla* are described in (Table 2 and 3) respectively. Whereas, the observed LC₅₀ values by using probit analysis of *Catla catla* under various salinities at different duration are portrayed in (Table 4) and illustrated in (Fig.1).

Table 2: Observed behavioural response of *Catla catla* under various salinities at different duration (hrs.).

Treatments (ppt)	Durations (hr)						
	1	6	12	24	48	72	96
Control	N	N	N	N	N	N	N
T ₁ (5ppt)	N	N	N	N	N	N	N
T ₂ (10ppt)	N	N	M	H	D	D	D
T ₃ (15ppt)	N	D	D	D	D	D	D
T ₄ (20ppt)	D	D	D	D	D	D	D

(N= Normal, M=Moderate, H=Hyperactive, D=Death)

Table 3: Percentage death of fish exposed to different salinities at different times

Treatment (ppt)	Mortality (%)						
	1	6	12	24	48	72	96
C	0	0	0	0	0	0	0
T ₁	0	0	0	0	0	0	0
T ₂	0	0	0	0	50	50	100
T ₃	0	100	ND	ND	ND	ND	ND
T ₄	100	ND	ND	ND	ND	ND	ND

Percentage death of fish exposed to different salinities at different times. (*ND= Data not found due to 100% mortality)

Table 4: Observed LC₅₀ values of advance fry of *Catla* under various salinities (ppt) at different duration (hrs.) under inland saline water and 95% confidence limit.

Duration (hr.)	Observed LC ₅₀ values using probit analysis of catla	95% confidence limit (CL*)
1	17.191	-
6	12.412	11.29 - 13.628
12	12.412	11.219 - 13.628
24	9.931	7.783 - 11.027
48	7.256	5.831 - 8.630
72	7.255	5.829 - 8.629
96	7.254	5.826-8.625

**Fig 1:** Observed LC₅₀ values of *Catla catla* at different duration and salinities.

3.3 Physico-chemical water quality parameters of *Catla catla* at different salinities.

The range of water quality parameters presented in (Table 5) and graphically presented in (Fig. 2-9). The average minimum and maximum values of temperature are recorded during the experiment in the range from 18.40±0.03^a to 24.75±0.01^a in the month of February and April respectively. It was observed that temperature showed no significant difference ($p>0.05$) throughout the experimental period among treatment and control respectively. The difference in the values of temperature may be attributed due to seasonal variation as the experiment period was selected in the month of February to April. The range of pH recorded during the experiment was 7.52±0.03^a to 8.39±0.04^b. The recorded range of DO and hardness during the experiment was from 5.51±0.12^c to 7.57±0.01^a mg/l and

277.86±2.07^c to 1105.24±9.19^a mg/l respectively. The range of alkalinity of present study was 191.63±0.66^d to 243.35±1.46^a mg/l and at 15th day of experiment T₃ and T₄ shows a significant difference ($p<0.05$) with control and T₁ and C, T₁ and T₂ respectively whereas, 30th, 60th, 75th and 90th days a significant difference ($p<0.05$) was observed among all the treatments and control further at 45th day of experiment T₄ showed a significant difference ($p<0.05$) with rest of the treatments and control respectively. In the present experiment the observed maximum and minimum range of ammonia was 0.05±0.00^c to 0.60±0.01^a mg/l respectively. The minimum and maximum range of nitrite during the experiment was 0.00±0.00^c to 0.42±0.02^a mg/l. The average min and max values of nitrate observed during the study was 0.00±0.00^c to 5.51±0.12^amg/l during the experiment.

Table 5: The range of physico-chemical parameters of water in different salinity levels during the experimental period.

Parameters	Treatments				
	C1	T ₁	T ₂	T ₃	T ₄
Temperature (°C)	18.4 to 24.4	18.4 to 24.4	18.5 to 24.5	18.7 to 24.5	18.8 to 24.8
pH	7.4 to 7.7	7.6 to 7.8	7.8 to 8.1	7.8 to 8.2	7.9 to 8.4
DO (ppm)	6.2 to 7.5	5.9 to 7.5	5.7 to 7.5	6.5 to 7.4	5.35 to 7.3
Hardness (ppm)	280.1 to 320.4	474.9 to 503.0	587.9 to 606.0	867.7 to 899.6	1061.2 to 1105.2
Alkalinity (ppm)	191.6 to 207.7	200.1 to 221.41	207.9 to 226.5	211.6 to 234.1	214.1 to 243.3
Ammonia (ppm)	0.05 to 0.36	0.07 to 0.47	0.07 to 0.54	0.13 to 0.57	0.19 to 0.60
Nitrite (ppm)	0 to 0.23	0.01 to 0.28	0.03 to 0.27	0.03 to 0.32	0.05 to 0.42
Nitrate (ppm)	0 to 3.3	0 to 4.2	0.2 to 4.8	0.02 to 5.2	0.4 to 5.5



Fig 2: Fortnight variation of temperature during the experiment. Values are mean $\pm$ SE.



Fig 3: Fortnight variation of pH during the experiment. Values are mean $\pm$ SE.



Fig 4: Fortnight variation of DO level at different salinities during the experimental period. Values are mean $\pm$ SE.



Fig 5: Fortnight variation of hardness during the experimental period. Values are mean $\pm$ SE.



Fig 6: Fortnight variation of alkalinity during the experiment. Values are mean $\pm$ SE.



Fig 7: Fortnight variation of ammonia during the experiment. Values are mean $\pm$ SE.



Fig 8: Fortnight variation of nitrite during the experiment. Values are mean $\pm$ SE.

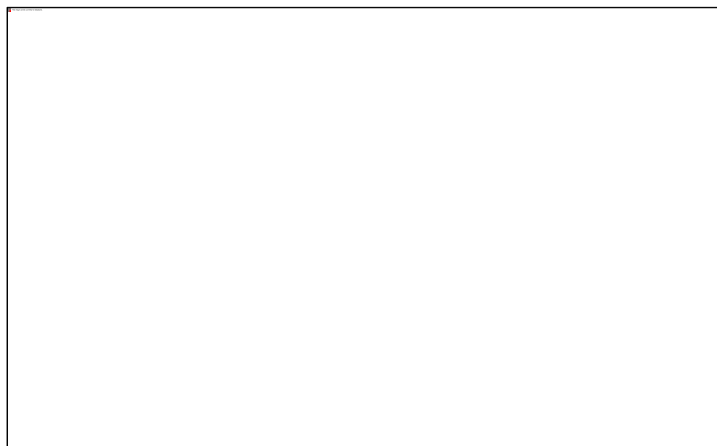


Fig 9: Fortnight variation of nitrate during the experiment. Values are mean $\pm$ SE

3.4 Growth Performance of *Catla catla* reared under different salinities

A three months study was conducted to investigate the feasibility of growth performance and survival of *Catla catla* under inland saline water at different salinities viz. 0, 2, 4, 6 and 8 ppt respectively. The detail results of growth performances are depicted in (Table 6) and graphically illustrated in (Fig.10-15). The weight gain and body weight gain were decline with increase in salinity during the experiment. The mean values of WG was recorded highest in control and lowest in T₄ throughout the experimental period similarly, the mean values of BWG% was observed highest in control and shows decreasing trends with the treatments T₁, T₂, T₃ and T₄ respectively with the range from 29.89±0.56^a (max) at 30th day to 2.69±0.63^b (min) in the end of the experiment. The maximum WG was recorded at 0 ppt and 2 ppt salinity at 30, 45 and 60 days whereas, lower WG was found in 8ppt at 75 and 90 day respectively. The mean values of SGR were recorded highest in control

(0.92±0.01^a) and lowest in T₄ (0.46±0.00^e) and there was a significant difference ($p < 0.05$) found among all the treatments with control throughout the experiment. The specific growth rate (SGR) decreased as the salinity increased. The lowest FCR observed in control (2.58±0.03^d) and T₁ (2.91±0.06^d) and highest FCR found in T₄ (5.88±0.11^a). The highest and lowest mean values of FER was observed in T₁ (0.34±0.00^a) and T₄ (0.17±0.00^e) there was significantly different ($P < 0.05$) observed among all the treatment compare to control. The mean values of PER showed a significant difference ($P < 0.05$) in different treatments with a control. The highest mean value of PER was observed in control (0.96±0.01^a) whereas, lowest in T₄ (0.42±0.00^e). 100% survival of fish was observed up to 2.0 ppt salinity, and 70% survival calculated in 8.0 ppt salinities at the end of experiment. The survival percentage showed a significant difference ($P < 0.05$) in control and T₁ compared to other treatment.

Table 6: Growth parameters of *Catla catla* at different salinity levels during the experimental period.

Growth Parameters	Treatments				
	C1	T ₁	T ₂	T ₃	T ₄
WG (%)	0.03-1.12	0.29-0.83	0.20-0.66	0.17-0.58	0.12-0.42
BWG	5.42-29.89	4.60-22.22	3.83-16.59	3.48-15.25	2.69-11.54
SUR (%)	30	30	29.33-29.66	23.66-26.33	21-23.66
SGR	0.92	0.82	0.65	0.56	0.46
FCR	2.58	2.91	3.80	4.61	5.88
FER	0.38	0.34	0.26	0.21	0.17
PER	0.96	0.85	0.65	0.54	0.42

Data are the range of observed values of different water quality parameters during the experiment.



Fig 10: Weight gain (g) of *Catla catla* reared in different salinities at 15 days interval



Fig 11: Bodyweight gain (%) of *Catla catla* reared in different salinities at 15 days interval



Fig 12: SGR of *Catla catla* at different salinities during the experiment.

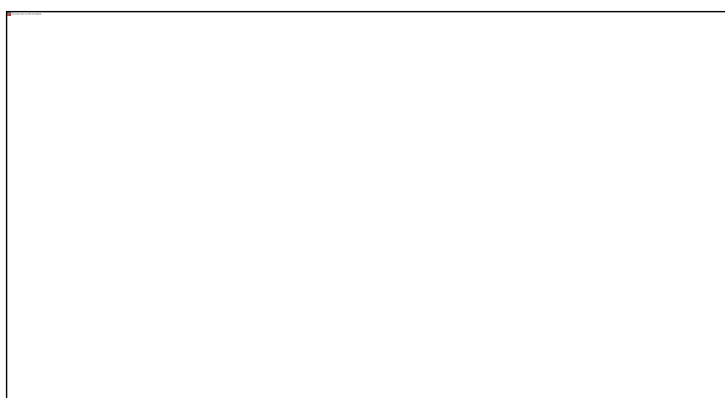


Fig 13: FCR of *Catla catla* at different salinities during the experiment.

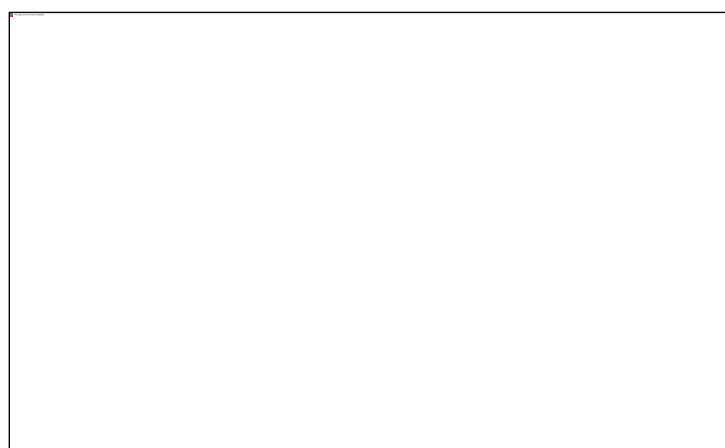


Fig 14: FER of *Catla catla* at different salinities during the experiment.

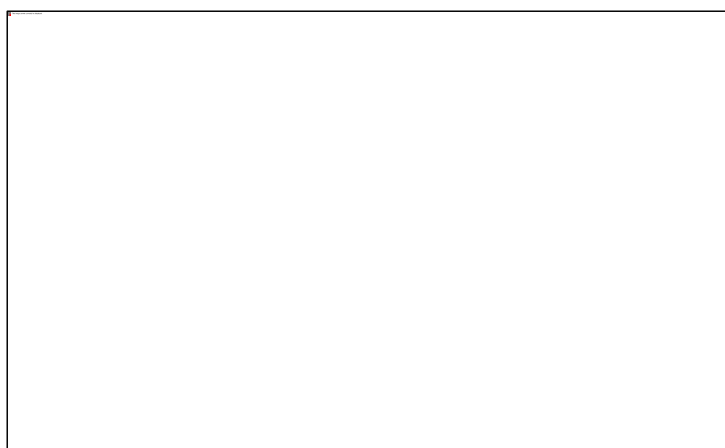


Fig 15: FER of *Catla catla* at different salinities during the experiment.

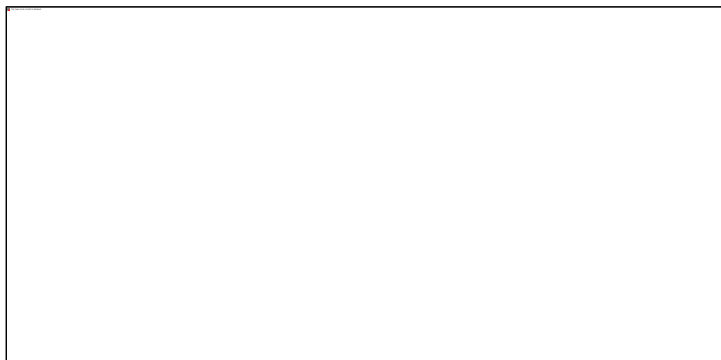


Fig 16: Survival percentage of *Catla catla* during the experiment

Discussion

The calculated LC_{50} values at different point of intervals (hr.) viz. 1, 6, 12, 24, 48, 72, and 96 were 17.191, 12.41, 12.41, 9.93, 7.25, 7.25 and 7.254 ppt respectively. Our results agree with the findings of Akther *et al.* (2017) they conducted experiment on salinity tolerance to *Barbodesgoniotus* at different interval and salinities using common salt and seawater respectively they revealed that after 18 ppt all the fishes died within 96 hrs. In the present study the calculated LC_{50} values of *Catla catla* at 96 hrs was 7.254 which shows in the agreement with the finding of Kilambi *et al.* (1980) [23] they revealed that, *L. fimbriatus* can tolerate salinity (prepared by commercial mother salt solution) levels up to 7.07ppt. The behavior like erratic swimming pattern and fast movement in operculum was noticed within 1-12 hr. after stocking of fishes particular in T_2 , T_3 and T_4 tanks respectively. It was observed that difficulty in breathing (gulping at the surface) and lethargy (still condition in the water column) were seen after 45 minutes just before the death of fishes within 1hr of exposure, particularly in T_4 respectively. A similar observation was seen under treatment T_3 after 12 hr. of exposure which was supported by Kilambi *et al.* (1980) [23] they observed that at a specific salinity, an erratic behavioral trend was noticed in different carps, in which common carp displayed higher salinity tolerance compare to rohu and mrigal. It was noticed that the mortality (M) was observed within all the treatments except control and T_1 .

Temperature observed in treatment tanks during the experiment varied within a range of 18 to 24°C. The difference in the values of temperature may be attributed due to seasonal variation as the experiment period was selected in the month of February to April. Indian major carps can tolerate temperature ranging from 18.3 to 37.8 °C (Jhingran, 1982) [19] and Kasim. (2002) [20]. The range of pH recorded during the experiment was 7.52 ± 0.03^a to 8.39 ± 0.04^b , agreed with the findings of Ahmed *et al.* (2013). The optimum range of pH for carp culture is 7.5-8.5. The recorded range of DO during the experiment was from 5.51 ± 0.12^c to 7.57 ± 0.01^a mg/l a similar observation was noticed by Kumar *et al.* (2018) [25]. In the present study solubility and the trends of dissolve oxygen shows an inverse relation with salinity and temperature agreed with (Boyd and Tucker. 1998) [9] they revealed that the solubility of oxygen in water decreases as water temperature and salinity increase. The range of hardness recorded during the experiment was 277.86 ± 2.07^e to 1105.24 ± 9.19^a mg/l. In the present study total hardness showed an increasing trend with the salinity, this may be attributed due to increasing the Ca^{2+} and Mg^{2+} ion in saline water compare to freshwater. Our

results are in agreements with the outcomes of Pathak *et al.* (2019) [31] and Kumar *et al.* (2018) [25]. Total alkalinity of water was recorded within the range of 191.63 ± 0.66^d to 243.35 ± 1.46^a mg/l. The result is similar to Santhosh and Singh (2007). The observed maximum and minimum range of ammonia was 0.05 ± 0.00^c to 0.60 ± 0.01^a mg/l respectively. In the present study the increasing concentration of ammonia with temperature and pH showed a decreasing trend in the growth performance, this may be attributed due to increase in unionized fraction of ammonia with increase with temperature, pH and salinity respectively, which ultimately decreased the daily food consumption, suggested by El-Sherif *et al.*, (2008) [12]. The minimum and maximum range of nitrite during the experiment was 0.00 ± 0.00 to 0.42 ± 0.02^a mg/l. Agreement with Sharma *et al.* (2017). In the present experiment decreasing trends of oxygen with increasing salinity also coupled the nitrite toxicity which may reduce the oxygen-carrying capacity of blood and hampered the growth performances of organisms supported by Bowser *et al.* (1983) [8]. The average min and max values of nitrate observed during the study was 0.00 ± 0.00 to 5.51 ± 0.12^a mg/l during the experiment. There is an increasing trend showed in nitrate values with increase in salinity. Garg *et al.* (1996) [13] who observed the nitrate range between 2.8 to 5.8 mg/l at different salinity.

Catla catla reared in 0 ppt showed better growth performance in terms of average body weight and specific growth rate than the saline water exposed fishes. The SGR result obtained from the experiment was within the range reported in tilapia (Likongwe 2002) [29]. The lowest weight gain and SGR were observed at 8 ppt which clearly indicates that increase in water salinity has negative effect on growth performance of *Catla spp.* The weight gain and body weight gain% was decline with increase in salinity during the experiment. The weight loss might be due to depressed appetite and increased osmotic stress at higher salinity. The increased WG of the fish in the low saline treatment and control is may be attributed that the fish were able to regulate easily osmotic balance through body fluids, the more the osmo-regulatory adaptation, lesser the difference between the compositions and pressures of the internal fluid of the organism and its external environment. Our results, matches with the finding of Islam *et al.* (2014) [17]. The SGR value markedly decreased above 6‰ salinity and the lowest SGR was observed at 8 ppt salinity. The decreasing trends of SGR may be attributed due to increased salinity coupled with other physicochemical parameter viz. ammonia and nitrite respectively. Our results agreement with the finding of Kalidas *et al.* and supported by Islam *et al.* (2014) [17] they recorded highest SGR of *Labeo rohita* at

0‰ salinity and lowest SGR at 8‰ cultured at different salinities.

FCR and FER values are used as an important growth determining factor as feed constitute the largest operational cost in aquaculture system (Amin *et al.*, 2005) [4]. The FCR value observed in the present experiment was within the range as reported in black bream (Partridge and Jenkins, 2002) [35], mullets (Barman *et al.*, 2005) [7] and *Pangasius* (Amin *et al.*, 2005; Khan *et al.*, 2009) [4, 22]. The change in FCR noticed with the species, age, size, and metabolic activity of fish, environmental parameters and the culture system respectively (Criag, 2009). The present study also revealed that increase in salinity caused an increase in FCR and reduction in FER. As fish cannot exhibit similar kind of growth (in weight) for the same amount of feed (in weight) given because it spends the energy in feed for metabolic heat, digestion, respiration, nerve impulses, salt balance, swimming and other life activities (Ndome *et al.*, 2011) [34]. The possible reason for lowest FCR and highest FER in 0 ppt reared fishes may be due to the less energy expenditure for the osmotic and ionic regulation. The fishes reared in 8 ppt showed high FCR and lowest FER may be due to the salinity stress which hampered the feed intake and resulted in poor growth. In the present study, a decreasing trend of PER was observed with increasing in salinity, similar observation was found by De Silva *et al.*. The present study indicated PER value within the range of those reported in rohu (Jayaprakas and Euphrasia, 1997; Tewary and Patra, 2008; Kumar *et al.*, 2014) [18, 37, 26]. These results clearly indicated that increase in salinity decrease the PER.

The survival rate of *Catla catla* has indirect relationship with salinity. At higher salinity (8ppt) significantly lower survival rate was observed. The possible reason of less survival at higher salinities may be attributed to difficult in osmoregulation, as gills are vital structures for the fish health, being involved mainly in gaseous exchanges the other important role are taking part in osmoregulation and composites nitrogen excretion as well. Our results are in agreements with the findings of our study are Bhavesh *et al.*, they reported that 100, 80.32 and 66.25% survival of *Catla catla* at 6.0, 8 and 10 ppt respectively, which was supported by Islam *et al.* (2014) [17]. The results of the experiment suggest that better growth and survival of *Catla catla* can be obtained up to salinity levels upto 6.0 ppt. Ghosh *et al.* (1973) [14] reported that fry and fingerlings of *Labeo rohita* and *Catla catla* can tolerate salinities up to 8 ppt salinity without any mortality. The survival of fish depends on overall adapting ability to ever-changing environment conditions (Koedjick *et al.*, 2012) [24]. Kumar (2000) reported that *Cirrihinus mrigala* can be culture in saline water of 8-10 ppt.

Overall the fishes reared in 8 ppt showed lower growth rate and survival compare to other treatment groups which indicates that *catla spp.* getting salinity stress at higher salinity (8 ppt) and unable to cope at higher salinities. It has been claimed that higher salinity (8 ppt) act as stressor for *catla spp.* since it is a freshwater fish. It clearly indicates that fishes reared in 8 ppt spend more energy for osmoregulation which lowered the available energy for body growth and leads to poor growth performance. So, it can be concluded that prolonged exposure of *catla spp.* to higher salinity (8 ppt) interrupt the body growth and survival.

Conclusion

Growth parameters obtained from the study clearly indicates that fishes reared in 0 ppt exhibited higher growth rate compared to fishes raised in other treatment groups. The lowest specific growth rate was recorded in 8 ppt found significant difference in SGR compare to other treatments. The highest body weight gain was recorded in 0 ppt and least in 8 ppt reared fishes. The highest FCR & the lowest FER, PER and survival% were observed in 8 ppt reared fishes. In the present study, it was observed that the higher salinity may affect the growth parameters (AWG, TWG, Survival, FCR, SGR, FER, PER, etc.). The experiment revealed that though *Catla catla* can tolerable a salinity up to 6 ppt, further, increase in salinity has a negatively affected on the growth of this species. Even though, *Catla catla*, can tolerate a salinity up to 8 ppt under inland saline water, but it is expected to perform well in salinities ≤6 ppt. The results of the experiment suggest that better growth and survival of *Catla catla* fingerlings can be obtained up to salinity levels of 4 ppt. In conclusion, *Catla catla* can be considered as an ideal species to promote in view of current and future climate variables as more and more coastal areas and inland saline areas of india which are vulnerable to increase salinity in the future.

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