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RESEARCH ARTICLE

Salinity tolerance of laboratory reared fingerlings of common carp, *Cyprinus carpio* (Linn.) during different seasons

H.K. Mangat[1] and S.S. Hundal[2]

1) Ph.D. Research Scholar, Department of Zoology, Punjab Agricultural University, Ludhiana-141004
2) Professor, Department of Zoology, Punjab Agricultural University, Ludhiana-141004.

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Corresponding Author

S.S. Hundal

Abstract

Fish is increasingly being preferred as a part of our everyday diet and *Cyprinus carpio* is one of the favoured freshwater food fish among carps. To bring more area under inland fisheries, the possibility of bringing the brackish water area of the state is being explored. Laboratory studies have been designed to explore tolerance of fingerlings at different salinities during different seasons so as to observe their survival rate. A total of four hundred and fifty fingerlings were subjected to salinity regimes of 0, 1.5, 3, 6, and 12 ppt for 60 days during different seasons (summer, autumn and winter). Temperature variations were indicative of the seasonal changes in ambient environment. Hundred percent survival was detected at 0 ppt to 6 ppt salinity during all seasons. Mortality recorded was 100% at 12 ppt salinity during summer (28.0^0C-37.0^0C) and autumn (22.5^0C-30.5^0C), while 50% survival was observed during winter (14.5^0C-19.0^0C). Fish showed high appetitive behavior to food between 0 to 6 ppt salinities. The present study suggests that common carp fingerlings can be reared in coastal waters with salinity of upto 6 ppt with 100% survival rate indicating that the high salinity areas may be explored for fisheries as well as for stocking enhancement programs.

INTRODUCTION

Cyprinus carpio, commonly known as common carp or golden fish in Indian sub-continent is a highly delicious and valuable fish species among other major carps. Aquaculture production of common carp increases parallel to the increase of global aquaculture production of freshwater fishes. According to FAO (FIGIS, 2013), production of freshwater fishes was 31 839 573 tonnes in 2005 and increased to 45 335 385 tonnes by 2011 (an increase of more than 42 percent). During these years, the contribution of common carp to the global aquaculture production remained at about 8–9 percent. It is well known that salinity is one of the most significant environmental parameters influencing growth and distribution of fish (Holliday, 1969; Beamish, 1970; Boeuf and Payan, 2001), affecting survival by diminishing fish feeding (Dendrinos and Thorpe, 1985; Fielder and Bardsley, 1999), and by modifying the energetic cost for osmotic and ionic regulation (De Boeck et al., 2000; Boeuf and Payan, 2001). The knowledge of salinity tolerance is essential for aquaculture production in different water sources, as well as for stocking enhancement programs with earlier studies on salinity acclimation, tolerance, metabolism and iono-osmoregulation in fishes having been made (Armitage and Olund 1962), Potts and Parry (1964), Potts and Evans (1967), Nelson (1968), Rao (1969, 1971), Parvatheswararao (1970), Prosser et al. (1970), Feldmeth and Waggoner (1972), Mackay (1974). In addition, the knowledge on salinity tolerance at different temperatures and the complex osmoregulatory mechanism it leads to is important because the physiological responses of freshwater stenohaline species to saline environments are attracting increased interest. These aspects need to be explored because of the emphasis being, use saline water for the optimization of aquaculture practices. This study has been carried out in laboratory on tolerance

of varied salinity regimes during different seasons of common carp fingerlings, to provide a baseline data and information on possibility of its culture in brackish water environment.

Material and methods

The experiment was carried out at the fisheries laboratory of Department of Zoology, Punjab Agricultural University, Ludhiana, India.

Fish material and acclimatization: Common carp fingerlings (7-9 cm) were procured from a local fish farm, acclimatized for two weeks in tub having 80 liters of water covered by net, and were fed upon floating type commercial diet (Taiyo Pet Products Pvt. Ltd, Chennai) twice daily.

Experimental design: The brine solution was prepared in the tub by adding the commercial grade of NaCl and CaCl and the salinity level was measured by standard methods provided by APHA (1991). Five graded levels of salinity (0 ppt, 1.5 ppt, 3 ppt, 6 ppt and 12 ppt) were prepared for treatments. The experiment was conducted in three different seasons (summer, autumn and winter) in triplicate for 60 days in aquaria of 38 litres capacity fitted with complete aeration and filteration system, with 10 fishes in each. The replacement of water from each aquarium was done after 30 days by siphoning the bottom of the aquariums and the fish were fed upon standard diet formulated in laboratory, twice daily @ of 5% of fish biomass, during the course of the experiment.

Rearing period: The period (May-July) was considered to be the high water temperature (28.0^0C- 37.0^0C) for experimental purpose with laboratory air temperature ranging from 31.0^0C-37.5^0C. Similarly, the period (September-November) was considered to be the mild water temperature (22.5^0C-30.5^0C) with air temperature range from 23.0^0C-31.0^0C and the period (December-February) was considered as low water temperature (14.5^0C-19.0^0C) with air temperature range from 13.5^0C -19.0^0C. The experimentation period was referred to as summer, autumn and winter seasons respectively. Water temperature was recorded with the help of an ordinary mercury thermometer having the range of 0-50°C. Live and dead fish were counted every 12 hours. Fish were considered dead when respiratory movement of the opercula stopped and there was no response to touch.

Statistical method: The data were subjected to the Analysis of Variance (ANOVA) with the help of STATGRAPH and Microsoft Excels statistical packages.

Results and Discussion

Effects of salinity on the survival of *C. carpio*

The survival of fingerlings was 100% in 0 ppt to 6 ppt salinities at all temperature variants (Table1-3), during the 60 day rearing period. This is an indication that the fingerlings were able to regulate their body physiology within this salinity-temperature regime and it is supplemented by the findings of Islam et al. (2014), who also recorded 100% survival rate at 0 to 6% salinities in rohu fingerlings. At 12 ppt salinity, mortality was observed from very first day and 100% mortality within 3-4 days was recorded during summer and autumn season temperature indicating stress conditions in fish leading to fatality during these temperature ranges. Salinity stress in freshwater fish primarily affects the gills, as the major organ involved both in osmoregulation and waste nitrogen excretion (Nikolsky, 1963). Upper tolerance limits have been reported as 6 ppt for young and 4.5 ppt for eggs (McCrimmon, 1968). while high salinity has been known to display a highly disrupted epithelium with a diffuse oedema of both the primary and the secondary lamellae (Holliday and Jones, 1967) and this could be the reason why 100% mortality of fish fingerlings in 12 ppt salinity during these seasons was observed. Researchers have recorded 71-90% mortality in 24 hours under 15% salinity in grass carp fingerlings (Kilambi and Zdinak,1980) while Crivelli (1981) has reported that the common carp occurred in brackish-water marshes with salinities up to 14 ppt in southern France. In North America, the common carp inhabits brackish and saline coastal waters of several states bordering the Atlantic and Pacific Oceans and Gulf of Mexico (Schwartz, 1964; Moyle, 2002) as well as the Atlantic and Pacific coasts of Canada (McCrimmon, 1968) while it has been captured in U.S. waters with salinities as high as 17.6 ppt (Schwartz, 1964). It is somewhat puzzling that although the common carp has been reported from estuarine and marine regions in Europe, Asia, and North America, laboratory experiments generally report limited salinity tolerance. Fingerlings have been found to withstand salinities of 10.5 ppt (Wang et al., 1997) indicating that at low temperature osmoregulatory system breaks down at higher salinity over a longer duration of time and vice-versa at high temperature. Survival of fingerlings was reported to be 50% at the end of 60 days rearing period during winter when water temperature ranged from 14.5^0C-19.0^0C. Therefore it may be postulated that low temperature and high salinity could be a positive combination for fingerling survival.

Effect of salinity on feeding response of *C. carpio*

The different levels of response to feeding, high appetite, moderate appetite, low appetite and death have been presented (Table 4-6). A high appetitive behavior of fingerlings was recorded between 0 to 3 ppt salinity in all seasons. The fish displayed high appetitive behavior during first few weeks at 6 ppt and a sequentially moderate, lowered with death occurring at 12 ppt. The high appetitive behavior displayed by the fish towards food is an indication that fish body metabolism could be maintained or regulated in these salinities, while low appetite is an indication of near or total body metabolic break down. Thus the results indicate that high salinity levels lead to physiological breakdown in fish. High appetitive behavior between 0 to 6 ppt salinities has also been observed in Oreochromis niloticus by Ridha (1981) and Sandra et al. (1983) in earlier studies.

Table 1: Survival rate (%) of common carp fingerlings in different salinity (ppt) of 60 day rearing during summer.

Salinity (%)	Survival rate (%) during different duration of 60 days									
	0 day	**7 day**	**14 day**	**21 day**	**28 day**	**35 day**	**42 day**	**49 day**	**56 day**	**60 day**
0 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
1.5 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
3 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
6 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
12 ppt	83.3±3.33[a]	-	-	-	-	-	-	-	-	-

Values are Mean± S.E. Different superscripts in columns represent significant difference at 95% confidential level

Table 2: Survival rate (%) of common carp fingerlings in different salinity (ppt) of 60 day rearing during autumn.

Salinity (%)	Survival rate (%) during different duration of 60 days									
	0 day	**7 day**	**14 day**	**21 day**	**28 day**	**35 day**	**42 day**	**49 day**	**56 day**	**60 day**
0 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
1.5 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
3 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
6 ppt	100±0.0[b]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]	100±0.0[a]
12 ppt	90±5.77[a]	-	-	-	-	-	-	-	-	-

Values are Mean± S.E. Different superscripts in columns represent significant difference at 95% confidential level

Table 3: Survival rate (%) of common carp fingerlings in different salinity (ppt) of 60 day rearing during winter

Salinity (%)	Survival rate (%) during different duration of 60 days									
	0 day	**7 day**	**14 day**	**21 day**	**28 day**	**35 day**	**42 day**	**49 day**	**56 day**	**60 day**
0 ppt	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]
1.5 ppt	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]
3 ppt	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]
6 ppt	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]	100±0.0[b]
12 ppt	90±5.77[a]	80.0±5.7 [a]	80.0±5.7 [a]	80.0±5.7 [a]	63.3±12.0 [a]	56.6±8.82 [a]	56.6±8.82 [a]	56.6±8.82 [a]	50.0±5.77 [a]	50.0±5.77 [a]

Values are Mean± S.E. Different superscripts in columns represent significant difference at 95% confidential level

Table 4: Summary of daily feeding response of *C. carpio* in different salinity regimes during summer.

Days	Salinity concentrations				
	0 ppt	1.5 ppt	3 ppt	6 ppt	12 ppt
0	HA	HA	HA	HA	LA
7	HA	HA	HA	HA	D
14	HA	HA	HA	HA	D
21	HA	HA	HA	MA	D
28	HA	HA	HA	MA	D
35	HA	HA	HA	MA	D
42	HA	HA	HA	MA	D
49	HA	HA	HA	MA	D
56	HA	HA	HA	MA	D
60	HA	HA	HA	MA	D

HA= High Appetite, MA= Moderate Appetite, LA= Low Appetite, D= Death

Table 5: Summary of daily feeding response of *C. carpio* in different salinity regimes during autumn.

Days	Salinity concentrations				
	0 ppt	1.5 ppt	3 ppt	6 ppt	12 ppt
0	HA	HA	HA	HA	LA
7	HA	HA	HA	HA	D
14	HA	HA	HA	HA	D
21	HA	HA	HA	HA	D
28	HA	HA	HA	HA	D
35	HA	HA	HA	MA	D
42	HA	HA	HA	MA	D
49	HA	HA	HA	MA	D
56	HA	HA	HA	MA	D
60	HA	HA	HA	MA	D

HA= High Appetite, MA= Moderate Appetite, LA= Low Appetite, D= Death

Table 6: Summary of daily feeding response of *C. carpio* in different salinity regimes during winter.

Days	Salinity concentrations				
	0 ppt	1.5 ppt	3 ppt	6 ppt	12 ppt
0	HA	HA	HA	HA	LA
7	HA	HA	HA	HA	LA
14	HA	HA	HA	HA	LA
21	HA	HA	HA	HA	LA
28	HA	HA	HA	HA	LA
35	HA	HA	HA	HA	LA
42	HA	HA	HA	HA	LA
49	HA	HA	HA	MA	LA
56	HA	HA	HA	MA	LA
60	HA	HA	HA	MA	LA

HA= High Appetite, MA= Moderate Appetite, LA= Low Appetite

Conclusion

Common carp fingerlings can adapt to gradual increase of salinity. The baseline data from this study indicate that fingerlings of common carp, *C. carpio* (Linn.) will easily adapt and tolerate culture systems of fresh and low brackish water environments of 0 ppt to 6 ppt salinity. As adaptation with the changed climatic condition is the best policy to combat the global climate change. In that aspect the finding of this study could be applicable in carp polyculture in waterlogged areas and saline water contaminated coastal ponds as these can be easily grown up to 6% ppt salinity.

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