Ecosystem based Adaptation Options against Salinity Intrusion in Freshwater Aquaculture System in Sundarban Delta of India

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Abstract

Fish loss in freshwater ponds in Sundarban delta due to saline water intrusion during cyclones and storm surges is a serious climate induced risk for the farmers. This study tested whether problem can be solved through ecosystem based adaptation options. The study involved the assessment of eleven numbers of commonly cultured freshwater fish species for their sensitivities to salinity. In Salinity tolerance (MLS_{96h}) test, *Macrobrachium rosenbergii* exhibited maximum salinity tolerance (24‰), followed by *Channa punctatus (*18‰*), Puntius javanicus* (17‰), *Puntius sarana, Cyprinus carpio (*both 13‰*), Labeo rohita (*11‰), *Ctenopharyngodon idella, Hypophthalmichthys molitrix, Catla catla (*all 9‰) and *Labeo bata (*8‰*).* Growth performance study for different species at various sub-lethal salinities indicated that the freshwater fish tend to naturally adapt till a certain salinity level, but showed significant retardation in growth beyond that. The natural adaptability level was 5‰ for the species like *Labeo rohita, Puntius sarana,* Cyprinus carpio, *Cirrhinus mrigala, Labeo bata, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Catla catla;* 10‰ for *Puntius javanicus, Channa punctatus;* and 15‰ for *Macrobrachium rosenbergii.* Post-flooding mortality recorded for freshwater species at different salinities (5, 10, 15 & 20 ‰) revealed that *Macrobrachium rosenbergii* was the most tolerant species and could withstand sudden saline water flooding followed by *Channa punctatus, Puntius javanicus, Cyprinus carpio, Puntius sarana, Labeo rohita, Cirrhinus mrigala, Ctenopharyngodon idella, Catla catla, Hypophthalmichthys molitrix,* and *Labeo bata.* Therefore, culture of salt tolerant freshwater species can be an ecosystem based adaptation option in freshwater aquaculture for the areas vulnerable to saline water flooding.

Key words: Adaptation, Ecosystem, Salinity Tolerance, Survival

Introduction

Climate change is one of the greatest threats of the new millennium as it alters the function, diversity and productivity of the ecosystem. Sundarban, the delta of Ganges and Brahmaputra river systems, is the largest river-mouth system in the globe and is a UNESCO World Heritage site. The biodiversity-rich ecosystem of Sundarban in India is highly vulnerable to climate-induced risks like sea level rise, salinity intrusion, land erosion, cyclone, storm surge etc. Here the people depend heavily on functioning ecosystem which provides their livelihoods. Climate change is one of the major causes of changes and deterioration in ecosystem services and its impact will most likely increase in the future. At the same time, functioning ecosystems help people to mitigate and more importantly to adapt to climate change which is referred to as "Ecosystem-based Adaptation" (EbA). In Sundarban, inhabited islands are protected by man-made embankments against ingression of saline water and inside these islands freshwater aquaculture is very much prevalent. The embankments are very much vulnerable to breach and overtopping during high intensity weather events like cyclones and storm

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surges. The areas inside the islands often suffer huge crop (agriculture and fish) loss due to saline water ingression. In this study Ecosystem based Adaptation (EbA) option was considered as a solution to above climate change impact. This involved the testing of salinity tolerance of various freshwater culture fish and prawn species and ranking them based on the tolerance level. This information can be used in selecting the suitable salt-tolerant fish species for the freshwater areas vulnerable to saline water flooding.

Materials and Methods

The study involved 11 numbers of commonly cultured freshwater fish species, e.g. *Labeo rohita, Puntius sarana, Cyprinus carpio, Macrobrachium rosenbergii, Cirrhinus mrigala, Labeo bata, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Catla catla, Puntius javanicus* and *Channa punctatus* to assess the sensitivity of these species to salinity through (i) salinity tolerance trial, (ii) assessment of natural adaptive capacity to salinity and (iii) field trials on effect of saline water flooding. The basic salinity tolerance of the species was carried out in the laboratory (in aquaria of size 30 cm X 20 cm X 20 cm) Median Lethal Salinity (MLS_{96h}) test to determine the salinity at which 50 % of test species survived for 96h. Observations of the fish species under salinity stress conditions in relation to mortality, swimming behaviour and feeding were recorded. Natural adaptive capacity of the species was tried out through growth performance study at various sub-lethal salinities (0, 5, 10, 15 and 20 ‰ depending upon the species) in FRP tanks (180 cm X 60 cm X 60 cm) for 30 days duration in wet laboratory. Response of the species to sudden saline water flooding was assess in the field (in earthen ponds of size 0.02ha and putting different species in different hapa) by flooding the freshwater ponds artificially with saline water to obtain the resultant salinities of 5, 10, 15 and 20 ‰ (after 4 weeks of culture). Forty numbers of fishes were kept in each hapa. Post-flooding mortality was recorded. Based on above findings, the trial species were ranked for their composite tolerance.

Results and Discussion

In Salinity tolerance (MLS_{96h}) test *Macrobrachium rosenbergii* exhibited maximum salinity tolerance (24‰), followed by *Channa punctatus* (18‰), *Puntius javanicus* (17‰), *Puntius sarana, Cyprinus carpio* (both 13‰), *Labeo rohita* (11‰), *Ctenopharyngodon idella, Hypophthalmichthys molitrix, Catla catla* (all 9‰) and *Labeo bata* (8‰). Irrespective of species, at high salinity, fish started surfacing and with gradual increase the swimming became erratic, then lethargic and motionless at lethal levels. Feeding rate reduced at high salinities and fish stopped feeding at lethal levels. The similar results have been reported by Pillai *et al.* (2003) for *Labeo rohita.*

Study for different species at various sub-lethal salinities indicated that the natural adaptability level was 5‰ for the species like *Labeo rohita, Puntius sarana, Cyprinus carpio, Cirrhinus mrigala, Labeo bata, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Catla catla;* 10‰ for *Puntius javanicus, Channa punctatus;* and 15‰ for *Macrobrachium rosenbergii.* This can be corroborated with the findings reported by Garcia *et al.* (1999), Sahoo *et al.* (2003), Mateen *et al.* (2004) and Schofield *et al.* (2011).

Post-flooding mortality recorded for freshwater species at different salinities (5, 10, 15 & 20 ‰) revealed that *Macrobrachium rosenbergii* was the most tolerant species and could withstand sudden saline water flooding followed by *Channa punctatus, Puntius javanicus, Cyprinus carpio, Puntius sarana, Labeo rohita, Cirrhinus mrigala, Ctenopharyngodon idella, Catla catla, Hypophthalmichthys molitrix,* and *Labeo bata. M. rosenbergii* remained unaffected at all salinity

levels, whereas *L. rohita, C. carpio & P. sarana* remained unaffected upto 10 ‰. Therefore, culture of salt tolerant freshwater species can be an ecosystem based adaptation option in freshwater aquaculture for the areas vulnerable to saline water flooding.

Table 1. Lethal salinity, Salinity Adaptability Level and Composite Tolerance Rank of few freshwater species

Freshwater Species	Median Lethal Salinity (MLS_{96h} in ‰)	Natural Adaptability Level (‰ Salinity)	Field Adaptability Trial through saline water flooding		Composite Salt Tolerance Rank
			100 % mortality (h after flooding)	Salinity level (‰)	
L. rohita	11	5	98	15	6
P. sarana	13	5	168	15	5
C. carpio	13	5	6	20	4
M. rosenbergii	24	15	Indefinite	20	1
C. mrigala	10	5	14	15	7
L. bata	8	5	20	10	11
C. idella	9	5	46	10	8
H. molitrix	9	5	28	10	10
C. catla	9	5	40	10	9
P. javanicus	17	10	6	20	3
C. punctatus	18	10	48	20	2

Table 2. Post-flooding mortality recorded for freshwater species at different salinities

	Mortality Starting (h)			Highest Mortality (h)			Complete Mortality (h)		
Species	10 ‰	15 ‰	20 ‰	10 ‰	15‰	20‰	10 ‰	15 ‰	20 ‰
C. mrigala	28	4	0	34	10	0	36 (50%)	14	0
L. bata	14	6	0	16	8	0	20	10	0
C. idella	24	6	0	30	12	0	36	12	0
C. catla	20	8	0	28	12	0	30	14	0
P. javanicus	-	34	0	-	34	0	-	42 (40%)	0
H. molitrix	18	8	0	26	12	0	28	12	0
C. punctatus	-	34	0	-	42	0	-	42 (20%)	0
L. rohita	-	16	1		22	2	-	98	4
P. sarana	-	16	1		22	3	-	168	3
C. Carpio	-	16	1		28	12	-	168 (50%)	12
M. rosenbergii	-	-	-	-	-	-	-	-	-

Note: 1. The values are in hours (duration).
2. - Indicates no mortality.
3. Figure in the parenthesis indicates the % of mortality
4. The numbers of fishes used in the experiment are 40 in each hapa

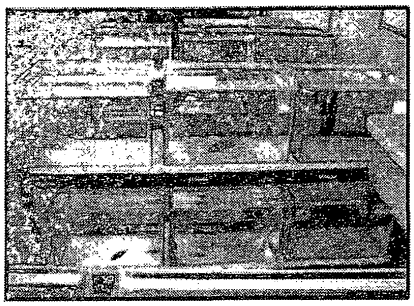

Fig 1. MLS_{96h} test

Fig 2. Natural Adaptability Trial

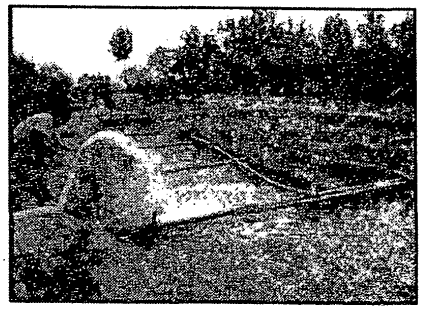

Fig 3. Saline water flooding

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