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APPLICATION OF CONDITION INDEX TO EVALUATE ENVIRONMENTAL HEALTH OF FISHES: A CASE STUDY WITH *LABEO ROHITA*

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Abstract: We monitored the Condition Index (CI) of *Labeo rohita*, which is an important indicator to evaluate the health and well-being of the cultured fish. In this pilot project, we initiated the culture with *Labeo rohita* as a candidate species in 12 rain water stocked ponds at Diamond Harbour during March, 2022 to October, 2022 and computed monthly condition index considering the mean weight and length of the cultured species (n = 65 for each pond). Simultaneously we measured the relevant hydrological parameters like surface water temperature, Dissolved Oxygen (DO), surface water pH, dissolved NO_3, PO_4 and SiO_3 for all the ponds. We observed significant positive correlations of CI with surface water temperature, DO, and surface water pH, and significant negative correlations with dissolved NO_3 and PO_4. The results reveal the use of CI of *Labeo rohita* as proxy to well-being of the species.

Key words: Diamond Harbour, *Labeo rohita*, Condition Index (CI), hydrological parameters, correlation coefficient

INTRODUCTION

The global population is expected to touch a figure around 9.6 billion by 2050 and there will be a huge challenge to provide food for this rapidly growing population (http://esa.un.org/unpd/wpp/index.htm). Pisciculture is a road map to supply fish protein for human consumption. In addition to food security, pisciculture has also the scope to provide employment in various sectors like feed preparation, culture, water quality management, marketing etc. However, there is a need to look beyond the economic and food security and ensure the environmental security and well- being of the cultured species as well, which can be evaluated using Condition Index (CI) of the cultured species as proxy. India is the second most populated country in the world, with a total population around 1.41 billion in 2022, which is 0.68 % higher from the population of 2021 (Marriner, 2023). The country is facing a great

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challenge to provide food security to the under nourished protein starved population preferably in the rural areas. To meet this challenge, the pisciculture sector needs to be improved and proliferated as the saviour to satisfy the increased food demand. The improvement and growth of the cultured species in the domain of pisciculture can be evaluated through Condition Index, which is a function of the length and weight of the cultured species. Condition Index (CI) for carps has been estimated by several researchers from different types of water bodies in different regions and environments of the country (Choudhari *et al.* 1982,; Johal and Tandon 1983,; Rajbanshi *et al.* 1984,; Zafar and Mustafa 1992). The value of the index decreases with the increase in length and is also influenced by the reproductive cycle in fish (Welcome 1979). The index is also directly regulated by the weight of the fish, which subsequently increases the value of the index indicating the suitability of the ambient aquatic environment.

The Lower Gangetic Delta (LGD) offers a congenial environment for the breeding, growth, and culture of a wide range of fishes (Mitra 2013,; Mitra and Zaman 2016,; Mitra 2020,; Mitra *et al.* 2022). The present study was carried out at Diamond Harbour region adjacent to the Indian Sundarbans in 12 rain water fed stocked ponds using *Labeo rohita* as the culture species. The primary aim of this project is to evaluate the potential of using CI of the culture species as indicator of the ambient aquatic ecosystem.

MATERIAL AND METHODS

Study area: Diamond Harbour (22°11'4.2''N; 88°11'22.2''E) is a region adjacent to the Indian Sundarbans, the designated World Heritage Site (Pramanick *et al.* 2014,; Amin *et al.* 2015,; Roy Chowdhury and Mitra 2017,; Mukherjee *et al.* 2019). The region has large number of freshwater ponds where species like *Labeo rohita*, *Catla catla*, and C*irrhinus cirrhosus* etc. are cultured. In this pilot project, 12 fresh water ponds of approximately 10 ft depth were selected for culturing *L. rohita* for a period of 8 months (March, 2022 to October, 2022). The ponds are basically rain water harvested ponds, but owing to the presence of Hooghly estuary surrounding the region, salinity intrusion results to a very mild salinity around 1.0 to 1.5 psu in the culture ponds.

Pond preparation: The selected ponds were dewatered with pump and the bottom was sun- dried for one month to allow excavation of the bottom mud and to complete digging of the experimental ponds; thus, aquatic weeds and unwanted fauna were removed. The embankments of the ponds were repaired and constructed. After testing the soil pH, liming was done at a dose 250kg/ha that helps to maintain good water quality.

Monitoring of hydrological parameters: Analysis of physico-chemical variables like surface water temperature, surface water pH, dissolved oxygen (DO), and dissolved nutrients (nitrate, phosphate and silicate) were carried out in every month for all the 12 selected ponds as per the method outlined by Strickland and Parsons (1972).

Monitoring of Condition Index (CI): Monthly CI of the cultured species was carried out using the expression (Fulton 1904):

$$K = 100 \times \frac{W}{L^3}$$

Where *K* is the Condition Index, *W* is the average weight (g) and *L* is the average length (cm).

RESULTS AND DISCUSSION

On the basis of average length and weight of the cultured species, Condition Index was estimated for 240 days (8 months) at an interval of 30 days for all the 12 selected ponds. From each pond length and weight of 65 fishes were considered to evaluate the mean CI along with standard deviation (Table 1).

Hydrological parameters: The relevant hydrological parameters like surface water temperature, DO, surface water pH, dissolved nitrate, dissolved phosphate and dissolved silicate were monitored simultaneously during length-weight observation periods to find the impacts of these variables on the CI of the cultured species. The mean values of these relevant hydrological parameters are presented in Fig. 1 – 6.

Condition Index is a function of length and weight of fish species and is useful to evaluate the health of the ambient aquatic phase (Koutrakis and Tsikliras 2003,; Froese 2006,; Mitra 2013). Condition Index and length-weight relationship studies adds beneficial knowledge towards farmed fish producers as these indices are helpful to measure fish growth, population densities, onset of fish maturity, metamorphosis, life history of fishes and over all fish biomass production (Hossain *et al.* 2006,; Araneda *et al.* 2008,; Ferdaushy and Alam 2015). In the present study, the mean CI (mean of 8 months of the culture period) of *L. rohita* varies as per the order Pond 7 (CI = 0.9402) > Pond 3 (CI = 0.9400) > Pond 10 (CI = 0.9333) >Pond 12 (CI = 0.9300) > Pond 11 (CI = 0.9233) > Pond 9 (CI = 0.9222) > Pond 6 (CI = 0.8988) > Pond 2 (CI = 0.8911) > Pond 8 (CI = 0.8900) > Pond 5 (CI = 0.8822) > Pond 4 (CI = 0.8766) > Pond 1 (CI = 0.8644). It can be interpreted that Pond 7 is the best amongst all the 12 selected ponds in terms of hydrological parameters and natural feed like phytoplankton and zooplankton. Fagade (1979) used CI as an indicator of growth and feeding intensity of cultured fish species. According to LeCren (1951) CI can be used as proxy to suitability of aquatic ecosystem for growth of the fish.

We also monitored hydrological parameters relevant to the growth of the fish species in all the 12 ponds during the entire culture period. The mean surface

Table 1. Condition Index (CI) of *L. rohita* in 12 selected ponds at Diamond Harbour, WB, India

DOC	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	Pond 8	Pond 9	Pond 10	Pond 11	Pond 12
1st day	0.63±0.03	0.61±0.03	0.73±0.03	0.60±0.03	0.68±0.03	0.67±0.03	0.76±0.03	0.64±0.03	0.73±0.03	0.74±0.03	0.72±0.03	0.73±0.03
30th day	0.71±0.03	0.73±0.03	0.75±0.03	0.71±0.03	0.72±0.03	0.72±0.03	0.75±0.03	0.70±0.03	0.74±0.03	0.74±0.03	0.74±0.03	0.73±0.03
60th day	0.73±0.03	0.75±0.03	0.81±0.04	0.72±0.03	0.76±0.03	0.78±0.03	0.83±0.04	0.77±0.03	0.80±0.03	0.82±0.04	0.81±0.04	0.82±0.04
90th day	0.78±0.04	0.81±0.04	0.84±0.04	0.71±0.03	0.80±0.04	0.79±0.03	0.83±0.04	0.78±0.03	0.81±0.04	0.82±0.04	0.81±0.04	0.82±0.04
120th day	0.85±0.04	0.83±0.04	0.90±0.05	0.80±0.04	0.87±0.04	0.86±0.04	0.91±0.05	0.86±0.04	0.88±0.04	0.90±0.04	0.89±0.04	0.90±0.04
150th day	0.96±0.05	1.05±0.06	1.01±0.06	0.91±0.04	0.97±0.05	0.99±0.05	1.02±0.06	0.98±0.05	1.00±0.05	1.02±0.05	1.00±0.05	1.01±0.05
180th day	1.09±0.07	1.11±0.07	1.21±0.08	1.09±0.07	1.10±0.07	1.14±0.08	1.16±0.08	1.15±0.08	1.16±0.08	1.16±0.08	1.16±0.08	1.16±0.08
210th day	0.99±0.05	1.05±0.06	1.11±0.07	1.20±0.08	1.00±0.06	1.10±0.07	1.12±0.08	1.10±0.07	1.11±0.07	1.12±0.08	1.11±0.07	1.12±0.07
240th day	1.04±0.06	1.08±0.07	1.10±0.07	1.15±0.08	1.04±0.06	1.04±0.06	1.08±0.07	1.03±0.06	1.07±0.07	1.08±0.07	1.07±0.07	1.08±0.07

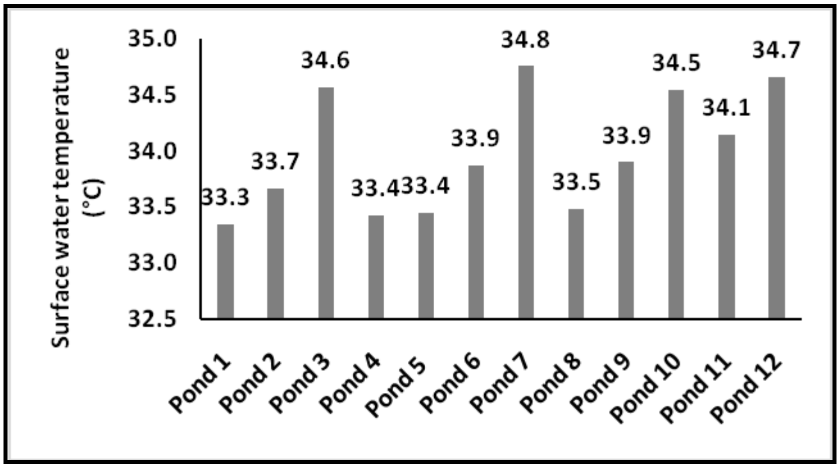

Fig. 1. Variation of mean surface water temperature of the cultured ponds.

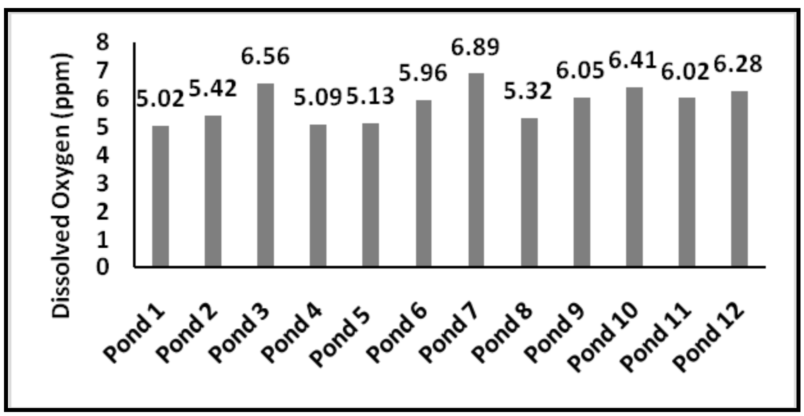

Fig. 2. Variation of mean Dissolved Oxygen (DO) of the culture ponds.

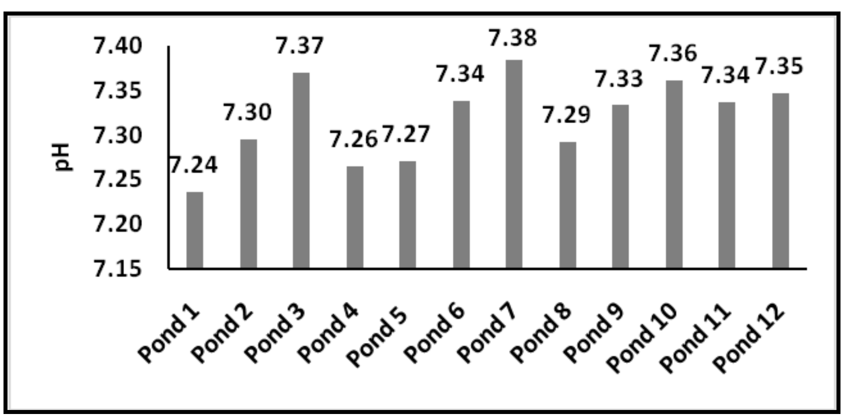

Fig. 3. Variation of mean pH during in the culture ponds.

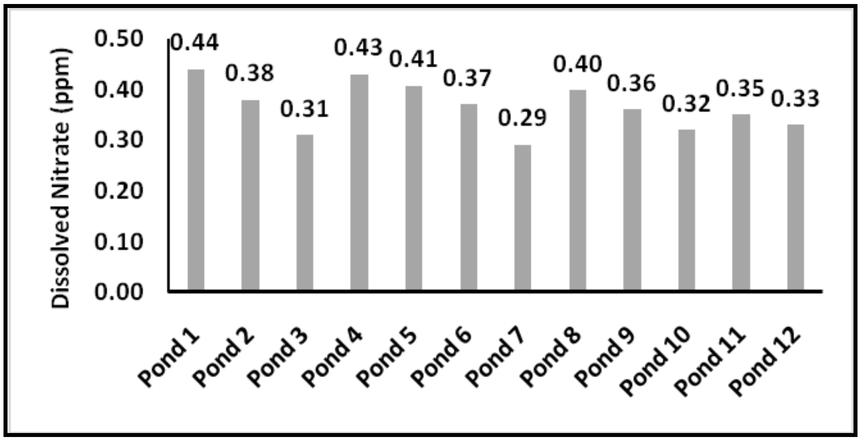

Fig. 4. Variation of mean Dissolved Nitrate (ppm) in the culture ponds

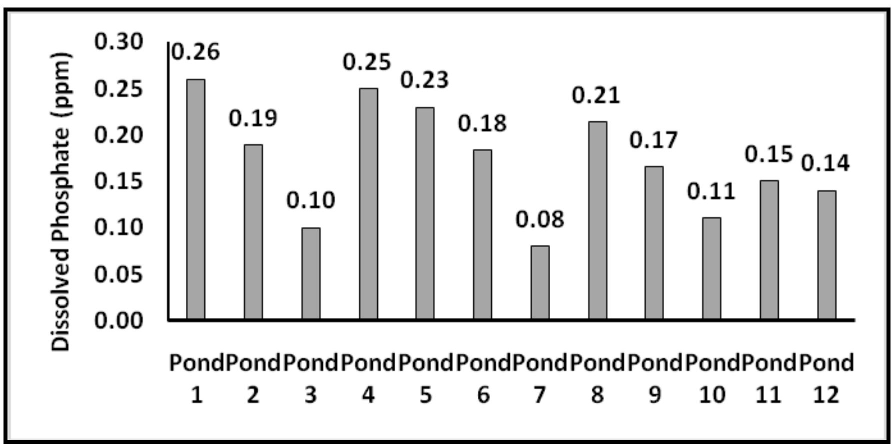

Fig. 5. Variation of mean Dissolved Phosphate (ppm) in the culture ponds.

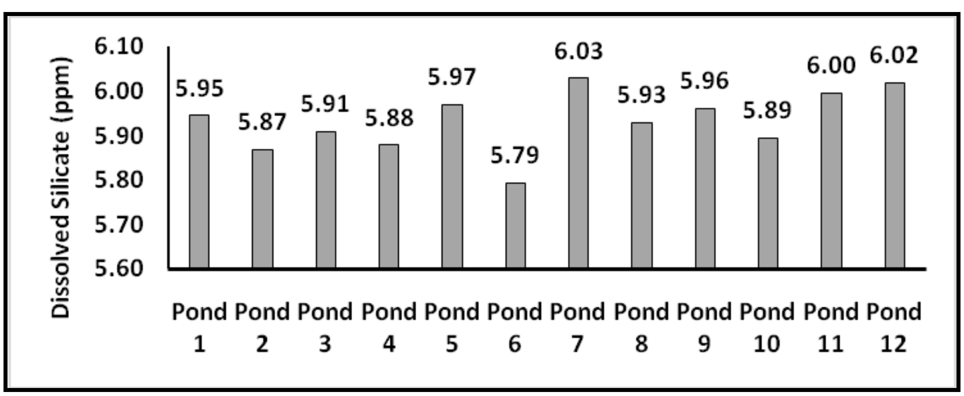

Fig. 6. Variation of mean Dissolved Silicate (ppm) during the culture pond.

Table 2. Correlation coefficient (r) computed between Condition Index (CI) and selected environmental variables

Combination	r values												Average
	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	Pond 8	Pond 9	Pond 10	Pond 11	Pond 12	
CI × SWT	0.6405	0.9365	0.9615	0.6100	0.8116	0.9701	0.9742	0.9033	0.9826	0.9408	0.9617	0.9781	0.8892
CI × DO	0.9200	0.9655	0.9816	0.9474	0.9864	0.9764	0.9732	0.9885	0.9655	0.9884	0.9889	0.9551	0.9697
CI × SWpH	0.8839	0.8552	0.7639	0.9452	0.9070	0.9192	0.9712	0.9745	0.8715	0.9195	0.9347	0.9284	0.9062
CI × D.	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate	0.9740	0.9505	0.9826	0.9537	0.9888	0.9905	0.9839	0.9927	0.9903	0.9879	0.9872	0.9896	0.9810
CI × D.	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphate	0.9955	0.9868	0.9894	0.9844	0.9765	0.9886	0.9968	0.9942	0.9786	0.9961	0.9884	0.9849	0.9884
CI × D.	-	-	-	-	-	-	-	-	-	-	-	-	-
Silicate	0.1386	0.1420	0.0533	0.4424	0.0819	0.5228	0.5786	0.2444	0.1441	0.5650	0.1607	0.3228	0.1418

water temperature varies as per the order Pond 7 (34.8°C) > Pond 12 (34.7°C) > Pond 3 (34.6°C) > Pond 10 (34.5°C) > Pond 11 (34.1°C) > Pond 9 (33.9°C) = Pond 6 (33.9°C) > Pond 2 (33.7°C > Pond 8 (33.5°C) > Pond 5 (33.4°C) =Pond 4 (33.4°C) > Pond 1 (33.3°C) (Fig. 1).

It is observed that the DO of the ponds varies as per the order Pond 7 (6.89 ppm) > Pond 3 (6.56 ppm) > Pond 10 (6.41 ppm) > Pond 12 (6.28 ppm) > Pond 11 (6.02 ppm) > Pond 9 (6.05 ppm) > Pond 6 (5.96 ppm) > Pond 2 (5.43 ppm) > Pond 8 (5.32 ppm) > Pond 5 (5.13 ppm) > Pond 4 (5.09 ppm) > Pond 1 (5.02 ppm) (Fig. 2).

The pH of the pond water varies as per the order Pond 7 (7.38) > Pond 3 (7.37) > Pond 10 (7.36) > Pond 12 (7.35) > Pond 11 (7.34) = Pond 6 (7.34) > Pond 9 (7.33) > Pond 2 (7.30) > Pond 8 (7.29) > Pond 5 (7.27) > Pond 4 (7.26) > Pond 1 (7.24) (Fig. 3). Three major dissolved nutrients (nitrate, phosphate, and silicate) were also monitored during the entire culture period in all the 12 ponds. The nitrate varies as per the order Pond 1 (0.44 ppm) > Pond 4 (0.43 ppm) > Pond 5 (0.41 ppm) > Pond 8 (0.40 ppm) > Pond 2 (0.38 ppm) > Pond 6 (0.37 ppm) > Pond 9 (0.36 ppm) > Pond 11 (0.35 ppm) > Pond 12 (0.33 ppm) > Pond 10 (0.32 ppm) > Pond 3 (0.31 ppm) > Pond 7 (0.29 ppm) (Fig. 4).

The phosphate varies as per the order Pond 1 (0.26 ppm) > Pond 4 (0.25 ppm) > Pond 5 (0.23 ppm) > Pond 8 (0.21 ppm) > Pond 2 (0.19 ppm) > Pond 6 (0.18 ppm) > Pond 9 (0.17 ppm) > Pond 11 (0.15 ppm) > Pond 12 (0.14 ppm) > Pond 10 (0.11 ppm) > Pond 3 (0.10 ppm) > Pond 7 (0.08 ppm) (Fig. 5).

The silicate varies as per the order Pond 7 (6.03 ppm) > Pond 12 (6.02 ppm) > Pond 11 (6.00 ppm) > Pond 5 (5.97 ppm) > Pond 9 (5.96 ppm) > Pond 1 (5.95 ppm) > Pond 8 (5.93 ppm) > Pond 3 (5.91 ppm) > Pond 10 (5.89 ppm) > Pond 4 (5.88 ppm) > Pond 2 (5.87 ppm) > Pond 6 (5.79 ppm) (Fig. 6). Our first order analysis on the inter-relationships of CI with hydrological parameters exhibit significant positive correlations with surface water temperature, DO and surface water pH. In contrast, dissolved NO_3 and PO_4 levels are negatively related to CI of the cultured fishes. Dissolved SiO_3 exhibits a mosaic pattern with both negative, positive, and insignificant relationships with the cultured species (Table 2).

Correlation coefficients were also performed between mean CI and mean values of all the hydrological parameters (Table 3) where it is clearly observed that significant positive correlations exist between CI and surface water temperature ($r = 0.9486$; $p \leq 0.01$), CI and pH ($r = 0.9829$; $p \leq 0.01$) and CI and DO ($r = 0.9916$; $p \leq 0.01$). However, with dissolved nitrate, phosphate and silicate significant negative relationships are observed ($r_{CI×nitrate} = -0.9931$; $p \leq$

0.01; $r_{CI \times phosphate}$ = -0.9946; $p \leq 0.01$; $r_{CI \times silicate}$ = - 0.5447; $p \leq 0.01$). The significant positive correlation of CI with surface water temperature was pointed out by Kausar and Salim (2006). According to them growth of the fish is accelerated in warmer water and the food intake rate also increases. In case of surface water pH, it has been observed that highly acidic and alkaline environment suppress the growth of fish, but within the range pH 6.0 and pH 7.0, best growth is observed (Ndubuisi *et al.* 2015). In the present study, the pH values oscillate around 7.31 (range = 7.24 in Pond 1 – 7.38 in Pond 7). Due to this congenial pH range, the inter-relationship between pH and CI is significantly positive. The significant positive correlations between CI and DO may be attributed to increase of the activities of the antioxidant and digestive enzymes due to which the growth of the fish exhibits an increasing trend. Interestingly, it is observed that with the dissolved nutrients like nitrate, phosphate and silicate, significant negative relationships exist.

Table 3. Interrelationships between mean condition index and mean hydrological values

Combination	r- value	p- value
CI × surface water temperature	0.9486	≤ 0.01
CI × DO	0.9916	≤ 0.01
CI × surface water pH	0.9829	≤ 0.01
CI × D. Nitrate	-0.9931	≤ 0.01
CI × D. Phosphate	-0.9946	≤ 0.01
CI × D. Silicate	-0.5447	≤ 0.01

The main reason behind such relationship is the triggering of algal growth due to high nutrient level, which causes the lowering of DO, thereby retarding the growth of the species. To sum up, it can be stated that CI of fish acts as a potential indicator of ambient aquatic ecosystem and the value of the index is regulated by the relevant hydrological parameters for which a Total Quality Management (TQM) in the culture sector is required. Use of aerators to enhance DO level and lime to control pH and algal growth are part and parcel of TQM, provided a dose optimisation of the external inputs is scientifically maintained.

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