CORRELATION OF HEPATOSOMATIC INDEX (I_H) AND FULTON'S CONDITION FACTOR (K) WITH SOME BIOLOGICAL PARAMETERS OF AMBIENT SPECIES FROM MUMBAI INWARD WATERS

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ABSTRACT

Ulhas River Estuary and Thane Creek are two adjacent inward water bodies in the highly polluting environment of urban Thane City. These are impacted due to various anthropogenic activities which almost have subjected them to irreversible status. The hydrological conditions were highly alarming during this study which impacted the biological health of the inhabitant fish species. Nevertheless, *Mystus gulio* (Hamilton, 1822), *Boleophthalmus dussumieri* (Valenciennes, 1837) and *Scylla serrata* (Forskål, 1775) are commonly found species in Ulhas River Estuary and Thane Creek. These were studied for correlating their biological parameters with the deteriorated condition of the study areas. The Principal Coordinate Analysis (PCO) discerned the relationship of environmental pollution with Hepatosomatic index (I_H), Fulton's Condition Factor (K), body glycogen, body fats, and allometric growth coefficient (b-value) of the ambient fish species.

Keywords: *Mystus gulio; Boleophthalmus dussumieri; Scylla serrata;* Ulhas River Estuary; Thane Creek; Pollution status; bioindicators; Principal Coordinate Analysis; hepatosomatic index; condition factor; allometric growth coefficient; hydrological parameters; biological parameters

INTRODUCTION

The inward waters like estuaries and creeks are subjected to high anthropogenic activities causing heavy pollution to them due to industrial effluents; domestic or urban waste water; urban storm water; agricultural sheet flow; solid waste dumping; non-degradable materials such as plastic, synthetic and microplastic; heavy metals; fresh water influx (causing salinity stress); temperature changes etc. Fishes from these inward waters are studied for various bioindicators by experts to correlate them with ambient pollution status. Hepatosomatic index (I_H) and Fulton's condition factor (K) are the most commonly used indices as indicators of fish from inward waters to assessment their health status, since decades (Oguri, 1978; Adams and McLean, 1985; Hick, *et al.*, 2004, Chellappa *et al.*, 2006; Offem, *et al.*, 2007; Lenhardt et *al.* 2009; Ghaffari, et *al.*, 2011; Olapade and Tarawallie, 2014; Hismayasari *et al.*, 2015; Uka and Sikoki, 2016; Rathod, 2016; Morado, et *al.*, 2017; Ryan and Mary, 2017; Araujo, et *al.*, 2018; Hana and

Ramadan, 2019). These biological parameters are often correlated with the stress caused due to salinity, microplastic, chemicals and heavy metals pollutions or biological parameters (Bernardino and Fernandes, 2016; Arias et al. 2019). It was studied that I_H and thereby its CAT (Liver Catalase) activities are correlated to the heavy metal pollution stress (bioaccumulation) in mullets, *Liza saliens* (Fernandez, et *al*., 2008; Tailisi, 2019) and in other fish species (Al-Ghais, 2013; Bervoets, et *al*. 2013;). Other fish species also were studied for impact of heavy metals on fish I_H and K (Olapade and Tarawallie, 2014). The fish reproduction cycle also affect I_H and K (Craig et al., 2000; Blanchard et *al*., 2005; Bekeh, et *al*., 2015). I_H plays important role in the reproduction cycle of decapods (Pollock, 1984; Chu, 1995; Tatiana, et *al*., 2012).

URE (Ulhss River Estuary) and TC (Thane Creek) supported the rural economy of the fishermen localities, thereby, through a significant amount of fish catches in the past (Mutsaddi and Bal, 1973; Qamrul and Sawant, 1980; Jyothi and Nair, 1990). It has been reported that both the waterbodies have declined in perennial fish catches due pollution in the recent studies (Quadros and Athalye, 2007; Lokhande, *et al*., 2oo8; Nikam, Gupta and Lalla, 2008; Ram *et al*., 2009; Quadros and Athalye, 2012).

Nevertheless, both, URE and TC have presently been identified as most polluted waterbodies. However, there is little knowledge about the impact of pollution on inhabitant fish biology triggered due to various anthropogenic activities existent in the ambient waterbodies. There are few attempts made for the studies on proximate composition of fish from URE and TC are cited (Tandel, 1986; Pejaver, 1987), which do not include both I_H and K. Therefore, the present study envisages to reveal the relation of I_H and K with certain fish biological parameters viz. glycogen, fats and b-vale (allometric growth coefficient) in three ambient species viz. *Mystus gulio* (Hamilton, 1822), *Boleophthalmus dussumieri* (Valenciennes, 1837) and *Scylla serrata* (Forskål, 1775).

Study areas, Ulhas River Estuary (URE) and Thane Creek (TC):

URE and TC are two adjacent inward water bodies located in the vicinity of Thane City of Maharashtra State, India (Fig.1). URE commences from S-E near Dombivli regions upstream between latitude 19°14'43"N and longitude 16°06'59"E; meanders for about 40 km before it joins the Arabian Sea towards N- W at Vasai (Bassein) creek situated between the latitude 18°

45'toI9° 19', N and longitude 73°21 'to72° 45', E. URE is highly impacted by agricultural fields, domestic sewage, sand excavation, bridges and pipelines, solid waste dumping, boat building stone quarry, and mangrove annihilation. TC runs downstream from Balkum to the Mankhurd-Vashi Bridge towards the east side of the Thane City. The mouth of the creek opens towards its S- W approach to Mumbai harbor bay in the Arabian Sea between Latitude 19° 01'N and Longitude72° 58'E and heads northwards for about 26 km to join the URE at Balkum towards N-W between latitude 19° 13’N and longitude 73° 00'E on world map. TC is subjected to huge industrial pressure due to Thane-Belapur (formerly known as Central Business District) industrial belt in addition to the urban activities such as domestic sewage, shoreline docking activities, ritual activities and idol immersion practices, solid waste dumping, reclamation and civil constructions, bridges and pipelines, mangrove annihilation, plastic pollution and salt pans.

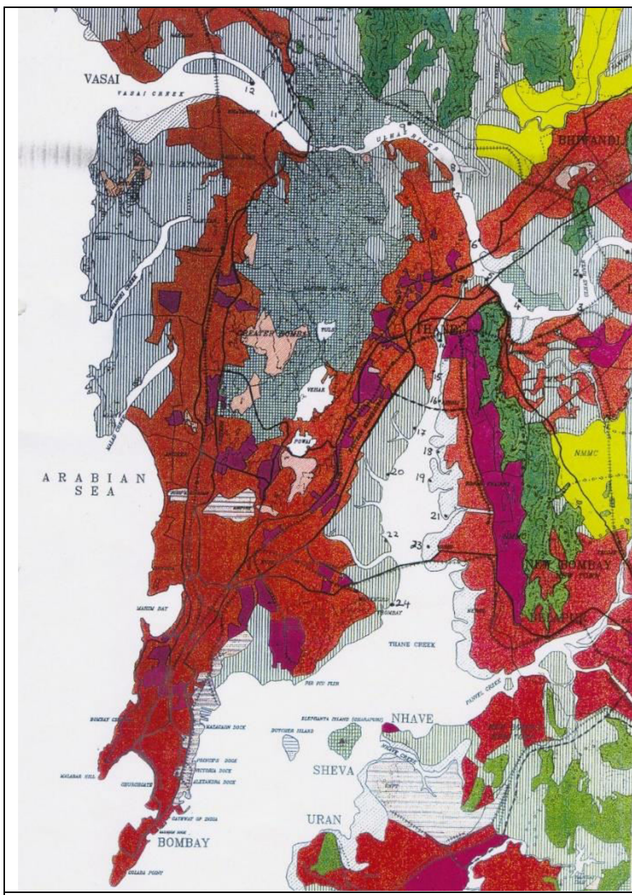


Fig. 1: Study area: URE and TC

MATERIALS AND METHODS

Sample Collection: Fish samples were collected directly from fish landing centers viz. Mankoli naka, Kasheli, Kalher, Kevani-Diva jetties along URE and Vitawa, Ghansoli, and Vashi bridge jetties along TC. *Mystus gulio* (Hamilton, 1822), *Boleophthalmus dussumieri* (Valenciennes, 1837) and *Scylla serrata* (Forskål, 1775) are common fish species found in URE and TC. *M. gulio* is hardy and voracious fish (Begum, *et al*., 2008), *B. dussumieri* sensitive and benthic strainer while (Clayton, 1993) *S. serrata* from crustacean representative were sought for the present study to justify the findings. However, *B. dussumieri* and *S. serrata* occur sporadically in TC, probably due to elevated level of pollution status of TC, corroborated to earlier findings (Quadros and Athalye, 2012; Rathod, 2016). Four seasons namely MON (monsoon), EPM (early post monsoon), LPM (late post monsoon) and PRM (pre-monsoon) were classified dividing 12 months into four as April-June; July-September; October-December and January-March, respectively. Present study was carried from April 2008 to March 2009. These four seasons were determined based on earlier hydrological studies of URE and TC together (Rathod, 2016).

Analyses of Water Parameters: Water and sediment samples were collected seasonally from URE and TC. The important physicochemical parameters using universally accepted standard methods as indicated in the table (MM.1) below:

Table MM.1: The methods used for the water parameters analyses-

Sr. No.	Water Parameter	Method
1	Water color (FU unit)	Forel-Ule scale
2	Light penetration (cm)	Secchi disc
3	Suspended solids (gm/L)	Evaporation method
4	Salinity (psu)	Argentometric method
5	Dissolved oxygen (DO) (mg/L)	Winkler's method
6	Biochemical oxygen demand (BOD) (mg/L)	Winkler's method
7	NO3-N (mg/L)	Phenol-disulphonic acid method
8	PO4-P (mg/L)	Ammonium molybdate method
9	Sediment Organic Carbon (Org-C)	Walkley and Black method (1934)

Water samples were collected during spring tide. At least 6 samples were collected for each season, two sample each month. Data was pooled season wise for the analyses. Principal Coordinate Analysis (PCO) was performed using Primer software (v. 6, with PERMANOVA)

Analysis of Body Glycogen and Fats: The fish specimens were carried in an ice-box to laboratory and were analyzed for glycogen and fat content from body muscles using anthrone reagent method and Folch method (Folch, Lees and Stanley, 1957; Murat, 1974) respectively. Some individuals were utilized for estimating I_H and K.

Analysis of hepatosomatic index (I_H): Animal was dissected carefully to retrieve intact liver and sex was determined examining the gonads in species which lack the external sexual dimorphism. The I_H was determined using Adams and Mc Lean's equation (*Htun-hun, 1978; Overstreet, 1983; Saborowski and Buchholz, 1996; Smith, *et al.* 2014) as:

$$I_H = \frac{Liver\ wieght\ x\ 100}{Body\ weight}$$

Mean monthly values were computed and plotted to ascertain seasonal variations. Means were also computed for size classes and test of significant differences between males and females was performed. Allometric growth coefficient (b-value) was obtained through length-weight relationship using following equation in MS excel:

$$W = aL^b \qquad \text{OR} \qquad Log\ (W) = Log\ (a) + b\ Log\ (L)$$

where, 'a' is the intercept parameter or shape coefficient and 'b' is the allometric growth coefficient.

Analysis of Fulton's condition factor (K_{TL} or K): Condition factors was calculated taking length (cm) and weight (g) of the samples. The total body length of fish was deliberated for estimating K, in cm. While crabs were measured for their carapace width in cm. Body weight was taken using digital balance with 1 mg accuracy. Utmost care was taken to select the appropriate sizes of individuals, proportionate to catch.

$$K_{TL} = \frac{10^N \bullet W}{L^3}$$

where, K_{TL} or K is Fulton's condition factor for total length (TL), W is weight of fish (g) and L is total length in (cm). N is figure set to bring the value of K close to unity. It could be 2, 3, 5 etc.

RESULT AND DISCUSSION

Hydrological Parameters: The following hydrological parameters were used for further statistical analysis to discern the stress. The pooled seasonal hydrological parameters data depicted stressful conditions in URE and TC, variously. Water color (WC) was of least concern whilst the light penetration (LP), salinity (Sal), suspended solids (SS), phosphates (PO4-P), nitrates (NO3-N), dissolved oxygen (DO), biochemical oxygen demand (BOD), and organic carbon from sediment (Org-C) caused overall stress in URE and TC. Seasonally, URE remained highly disturbed in LPM and PRM whereas TC was impacted during EMP and LPM. The LPM and EPM in URE and MON and PRM seasons in TC were comparatively good in condition (Fig. 2).

URE had very extreme and different hydrological regimes during MON and LPM. In MON, URE was highly impacted due to (LP) and salinity (Sal) while in LPM and PRM, due to Dissolved oxygen (DO) and Nitrates (NO_3-N). Water color though not significantly but disturbed in URE to a considerable extent due to existent sand dredging activities. Salinity and LP dropped during rainy season due to land run off water and riverine influx during MON. But the salinity kept fluctuating due to domestic sewage and dam water influx occasionally in URE causing a considerable impact in PRM. Nitrates levels were also shot beyond standard limits frequently due to nearby agricultural lands sheet flow and industrial effluents during LPM and PRM.

TC on the other hand was impacted differently since it is not connected to any river the only source of water and effluents were oceanic tidal water current, domestic sewage and industrial effluents. TC was highly impacted by LP and Salinity during MON mostly due to urban storm water. Also phosphates and Org-C were very high in the creek probably due to domestic sewage during MON and PRM. TC showed suspended solids high during LPM, since the tidal water was much turbulent due to winds. The turbulence in water might cause mixing of sediment in water. PRM was most affected season in TC principally due to BOD in addition to SS and Org-

C. BOD remained continuously higher in TC also hypoxic conditions were overwhelming throughout the study period.

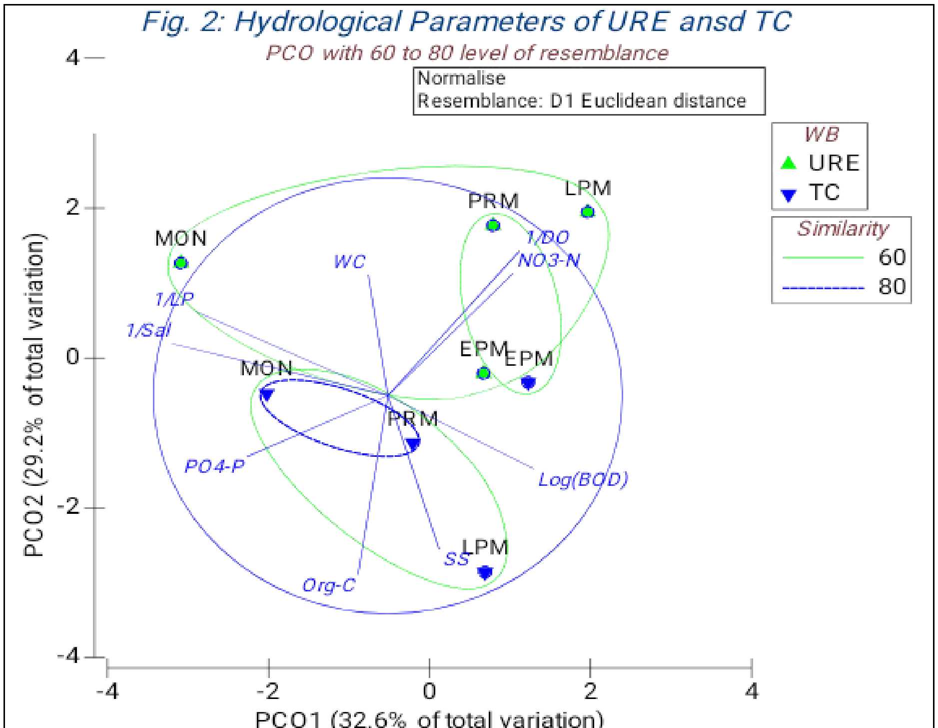


Fig.2: PCO of hydrological pooled data (season wise) was obtained with 61.8% ordination of the variables with Euclidean distance resemblance. A 'Bray-Curtis Similarity' resemblance hierarchical cluster analysis using Pearson's correlation coefficient at 60-80 level was overlayed to discern the closeness of seasonal environmental conditions.

URE and TC I_H profiles of ambient fish species: Seasonal and gender wise analyses of hepatosomatic index (I_H) revealed highly distressed conditions in URE and TC. The number of outliers in box-whisker plot for I_H profile in *M. gulio* discerned high seasonal stress particularly during MON, EPM and PRM. However, LPM was comparatively stable. *M. gulio* from TC showed poor I_H profile (Fig. 3 & 4). *S. serrata* was found for better I_H profile in TC, probably due to low salinity stress in URE owing to the fresh water influx. Nevertheless, both the sexes of *S. serrata* from URE showed better I_H profile in the EPM and LPM (Fig. 5 & 6). *B. dussumieri* showed excellent I_H profile in URE as compared to [1]TC, especially, during EPM and LPM. Female *B. dussumieri* were having better I_H profile in URE during MON and EPM (Fig. 7 & 8).

[1] Pooled data has been produced due to unavailability of *B. dussumieri* from TC during most of the months very few specimens were collected as and when they were caught in 'Dol net' towards the lower stretch of the creek.

There was no significant differences on gender basis for I_H profile per season, except *M. gulio* from URE and *S. serrata* from TC. But overall the outliers showed disturbed conditions in both URE and TC.

The I_H profile result has thus support the hypothesis of the present study. I_H profile remains highly disturbed due to pollution stress in the ambient environmental.

Fig. 3: Seasonal I_H in *M. gulio* from URE

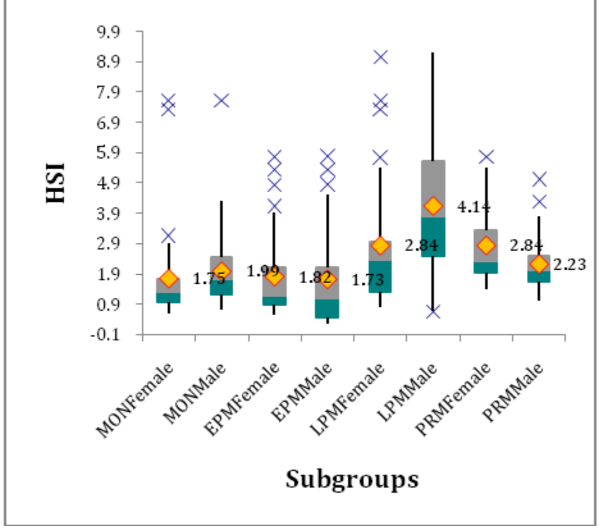


Fig. 4: Seasonal I_H in *M. gulio* from TC

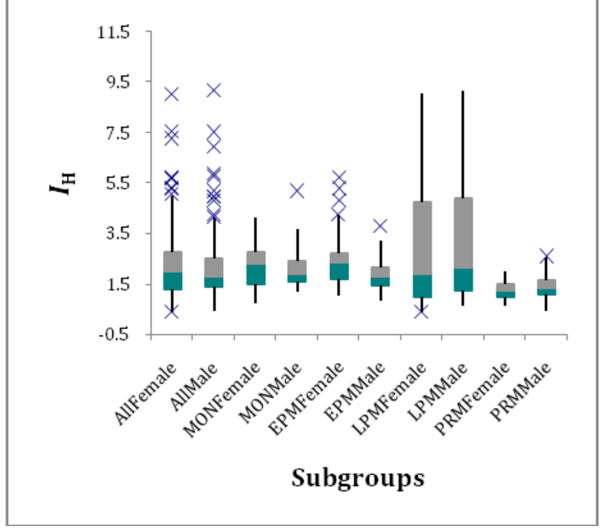


Fig. 5: Seasonal I_H in *S. serrata* from URE

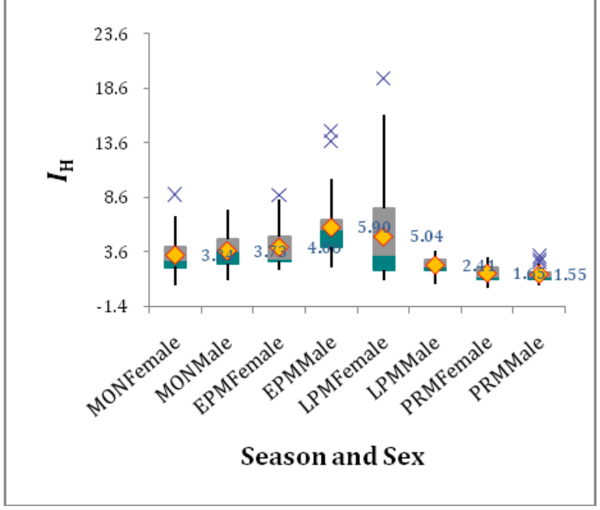
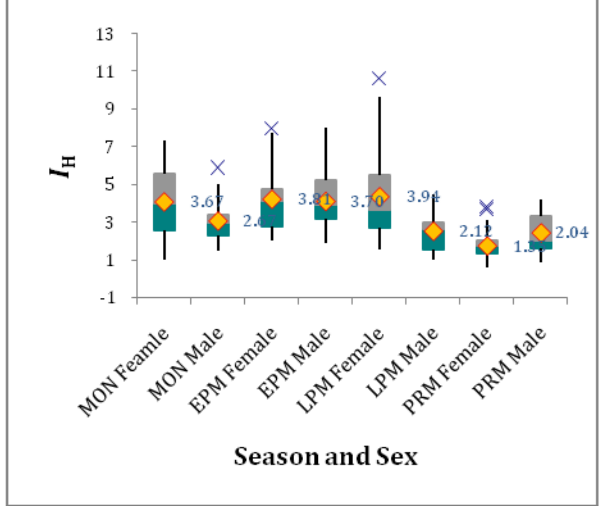
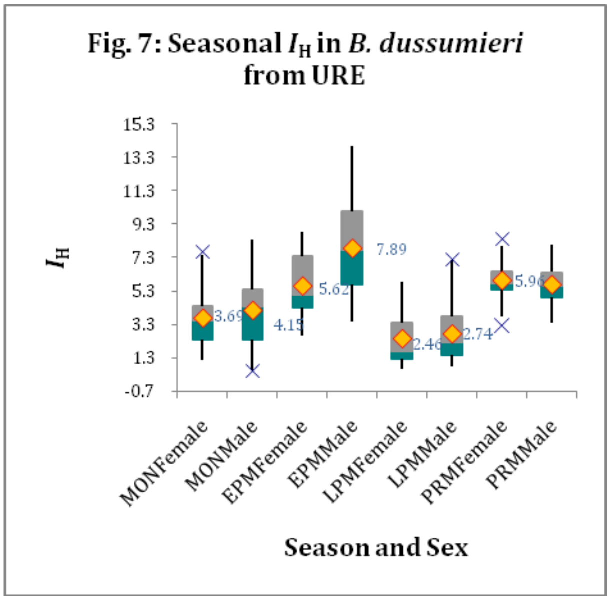
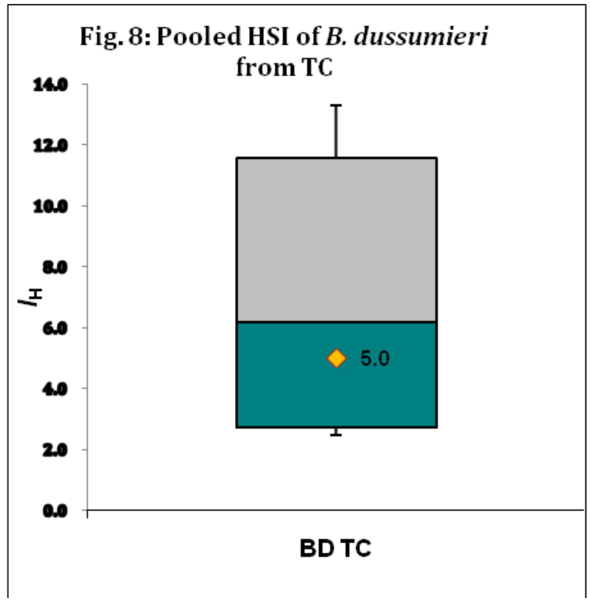


Fig. 6: Seasonal I_H in *S. serrata* from TC







Correlation of I_H and K with the biological parameters:

It is evident that I_H tend to drop when muscle moisture fell below 74% in both URE and TC (Rathod, 2016). Normally, the health status of fish exhibits direct relationship with biological parameters (Lenhardt, *et al.* 2009). Variations in K and I_H have been reported for fish subjected to food constrains, both under laboratory and field conditions (Blanchard *et al.*, 2005; van Dijk *et al.*, 2005).

In present findings, it was endeavored to depict the relations of I_H and K with the biological parameters like b-values, fats, and glycogen. There was a parallel relationship of I_H and K with glycogen and b-value, whereas, fats depicted inverse relation with b-value, except PRM season in both URE and TC for all three ambient species (Fig. 9 & 10). It was reported by Tandel (1986) that *M. gulio* contained high body fats in polluted condition in TC. This corroborates with the present outcomes. However, seasonal K remained highly fluctuating in SS both from URE and TC.

In *M. gulio,* b-value discerned direct relation with I_H and glycogen in URE and TC. However, fats reciprocated in URE with b-value, but in TC no such relationship was revealed. 'K' was directly proportional to b-values in URE which was not true in TC. Therefore both Fats and 'K' did not follow the expected rule in TC which is ordained the wellbeing of *M. gulio* in URE as compared to TC. In both the waterbodies the conditions improved gradually from MON to LPM bringing ultimately poor in PRM (Fig. 9).

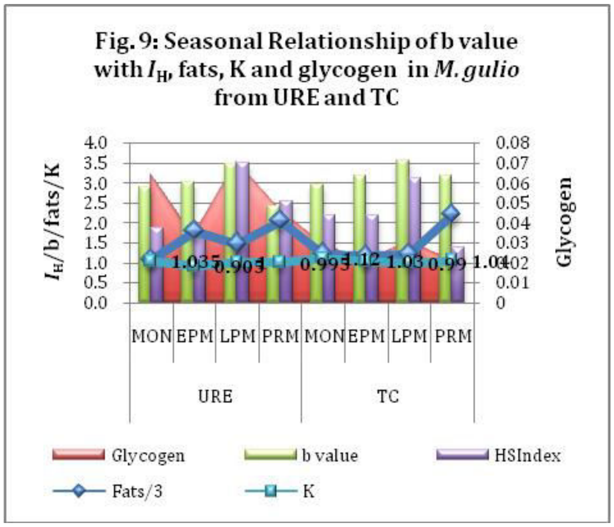


Fig. 9: Seasonal Relationship of b value with I_H, fats, K and glycogen in *M. gulio* from URE and TC

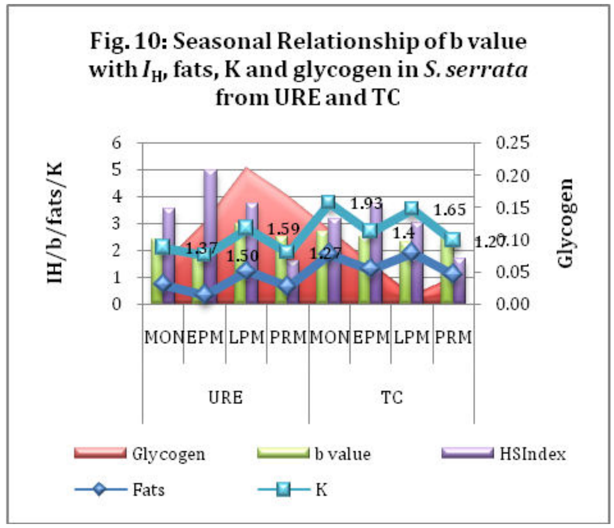


Fig. 10: Seasonal Relationship of b value with I_H, fats, K and glycogen in *S. serrata* from URE and TC

The conditions of *S. serrata* also depicted improvement from MON season towards LPM and declined in PRM in URE and TC. Glycogen and I_H established direct relationship with b-values and 'K' and Fats of *S. serrata* remained independent. 'K' and fats were concomitant with each other in both URE and TC (Fig. 10). Sarower *et al.* (2013) also reported the high protein and fats in fattened crabs (with better 'K'). The conditions of *B. dussumieri* in URE were similar to that of *S. serrata* (Fig. 9 &11). The high I_H, K, b-value and glycogen content during LPM, in all the study species, is pertinent to the overall healthy seasonal condition, particularly in URE. Therefore, in LPM season the fish catches are highest in biomass and diversity (Rathod, 2016) from the ambient waterbodies.

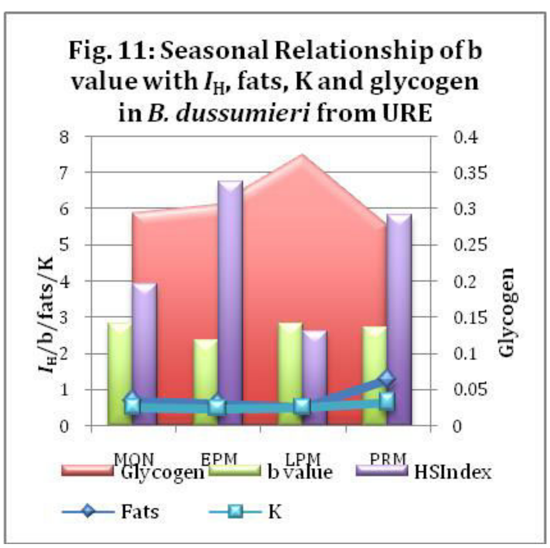


Fig. 11: Seasonal Relationship of b value with I_H, fats, K and glycogen in *B. dussumieri* from URE

CONCLUSION

Hydrological conditions are poor in TC. The poorest season being PRM in both URE and TC. The water conditions put impact on the health status of the ambient species discussed above. I_H profile found to be most concurrent to the environmental pollution conditions of the URE and TC. I_H found to be most sensitive biological parameter was concomitant to the level of glycogen and K. However, K did not show strong correlation with I_H profile of the study species although it related feebly. I_H profile found to be more sensitive in fish species than a crab. Body fats showed inverse relationship to the health of ambient environment in *M. gulio*. Thus, it is true that biological indices could be used as the indicators of the pollution status of the ambient waterbodies.

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