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Vicissitudes of oxidative stress biomarkers in the estuarine crab *Scylla serrata* with reference to dry and wet weather conditions in Ennore estuary, Tamil Nadu, India

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ABSTRACT

The primary objective of this study was to understand the impact of monsoon and summer seasons on the Polychlorinated Biphenyls (PCB's) and petroleum hydrocarbon compounds (PHC's) load in Ennore estuary and how the physiological response of estuarine *Scylla serrata* inhabiting in this estuary changed with reference to antioxidant defense. Seasonal levels of PCB's and PHC's were assessed in the water along with their bioaccumulation in gills, hemolymph, hepatopancreas and ovary of *S. serrata*. Concentration of PCB's and PHC's in water and their bioaccumulation was found to be higher in summer season when compared to monsoon season. Enzymic antioxidant assays [superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione reductase (GR), glutathione-*S*-transferase (GST)]; non-enzymic antioxidant assays [glutathione (GSH), vitamin C, vitamin E] and macromolecular alterations [membrane lipid peroxidation (LPO), and DNA Damage (strand breaks)] were assessed in the gills, hemolymph and hepatopancreas of *S. serrata*. There was a significant ($p < 0.05$) upregulation in lipid peroxidation activity and DNA damage activity collected during the summer season when compared to the pre- and post-monsoon seasons. On the contrary, the enzymic and non-enzymic antioxidants exhibited significant ($p < 0.05$) down regulation in the gills, hemolymph, hepatopancreas and ovary of *S. serrata*. Oxidative stress biomarkers represented a significant ($p < 0.05$) maximum in gills when compared to hemolymph and hepatopancreas of *S. serrata*. Present study provided scientific evidences of how the antioxidant defense status of *S. serrata* responded to PCB's and PAH's stress with reference to seasonal vicissitudes, which indirectly represented the environmental health conditions of the estuary.

1. Introduction

Estuarine environment exhibits a combination of freshwater from riverine discharges and salt waters influxes from oceans due to tidal activity. Anthropogenic pollutants eventually find their way to oceans as the final repository through estuaries (Ridgwaya and Shimmield, 2002). Water chemistry of estuarine environment undergoes constant changes due to land-based discharges and are further influenced by environmental stressors especially temperature, sun light, humidity, rainfall, and oxygen content (Vijayavel, 2010).

Climate change may drastically change the physicochemical processes and alter the characteristics of estuarine waters (Sheahan et al., 2013). Wet weather conditions such as rain events can bring in large volumes of freshwaters resulting in dilution of pollutants level. On the contrary, drought conditions are associated with the reduced surface runoff, and increased water evaporation which results in increasing the pollutants level. For instance, field investigations by Zwolsman et al. (1997) have shown strong seasonal variations in terms of riverine discharges, dissolved oxygen, pH, temperature, salinity and suspended particulate matter. Biomonitoring programs are designed by keeping weather conditions as a critical factor (Savóia et al., 2009).

Aquatic species harboring the estuarine ecosystem are under constant stress due to anthropogenic and environmental stressors, which has a negative impact on their physiology and biochemistry (Walker et al., 2000). Crustaceans and several other aquatic species use estuarine ecosystem as their breeding ground where they undergo a series of morphological, behavioral and physiological changes to sustain life (Maes et al., 1998; Vijayavel et al., 2006).

Measuring the bioaccumulation of contaminants and the response of biochemical biomarkers in estuarine sentinels can offer potential clues regarding the toxic manifestations (Van der Oost et al., 1996). Decades of environmental research have documented that aquatic organism's exhibit antioxidant defense mechanism to mitigate the oxidative stress elicited by a wide variety of environmental and anthropogenic stressors (Van der Oost et al., 2003; Vijayavel et al., 2012; Pavlović et al., 2013; Chainy et al., 2016). In brief cellular antioxidant resistance system is one of the natures biochemical stratagems that protects reactive oxygen species (ROS) mediated cellular damages. The antioxidant resistance system comprised of a battery of enzymic antioxidants viz. as

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superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione reductase (GR), glutathione-*S*-transferase (GST), and non-enzymic antioxidants viz. reduced glutathione (GHS), ascorbic acid, α-tocopherol act up on the cellular damage caused by ROS by a cascade of biochemical reactions.

While, researches have documented the association between oxidative stress biomarkers and seasonal changes in various aquatic species *Perna viridis* (Lau et al., 2004; Verlecar et al., 2008); *Ruditapes decussatus* (Banni et al., 2009); *Mullus barbatus* (Pavlović et al., 2010); *Viviparus acerosus* (Despotović et al., 2012); *Chelidonychthys obscurus* (Pavlović et al., 2013); the combined influence of anthropogenic and environmental stressors in the estuarine crabs are meager. Hence, the present investigation was carried out to understand the impact of wet and dry weather conditions on pollutants load in an estuarine environment (site details described in below section) followed by how the physiology and biochemistry of crab *Scylla serrata* inhabiting the estuary changed with reference to oxidative stress biomarkers.

2. Materials and methods

2.1. Seasonal selection

The Indian Meteorological Department divides the year into four seasons such as, summer (April, May, June); pre-monsoon (July, August, September); monsoon (October, November, December), and post-monsoon (January, February, March).

2.2. Study site

The Ennore estuary (Lat 13°14′10″N & Long 80°19′00″E) located to the north of Chennai, Tamil Nadu, India extends over 3 km long and 1 km wide, with a surface area of about 4 km^2, and the depth ranging from 0.5 m to 3 m (Fig. 1). The Ennore estuary is fed by Kosasthalaiyar River, which eventually drains into the Bay of Bengal Sea. Due to the rapid industrialization (thermal power station, shipping port, fertilizer plants, oil refineries, thermal power station, chemical factories, smelters, and electroplating units) Ennore estuary has become a sink loaded with a cocktail of xenobiotics (PAH's PCB's, heavy metals, nutrients etc.) and the recent water quality studies have confirmed this (Jayaprakash et al., 2005; Kuppusamy and Giridhar, 2006; Seshan et al., 2010; Natesan, 2013; Kalaivani and Krishnaveni, 2015). Hence, Ennore estuary was chosen as the polluted site for the present investigation.

2.3. Test species

The estuarine crab *Scylla serrata* (Crustacea: Decapoda: Portunidae) is of particular interest because of its bottom dwelling and euryhaline in nature. Scylla species migrate into brackish water bodies, such as estuaries, backwaters and coastal lagoons during their post-larval and juvenile stages, where they grow to attain adult hood and therefore used as sentinels for assessing the health conditions of estuarine environment (Vijayavel et al., 2006; Vijayavel and Balasubramanian, 2008a).

2.4. Sampling and grouping

Sampling season was from January to December 2014 which covered post-monsoon, summer, premonsoon and monsoon seasons. With the help of local fishermen, intermoult female crabs ($n = 10$) weighing 100 ± 10 g were fished each month along the Ennore estuary and transported to alive to the laboratory. At the same time, separate surface water samples ($n = 10$) were collected each month using sterile High Density Polyethylene bottles and transported to laboratory in coolers. Crabs and water samples collected each month were designated and grouped together based on the four seasons for further analysis.

2.5. Water analysis

Upon the arrival of water samples in the lab, physicochemical parameters (Table 1) were analyzed immediately by following the protocols described in Standard Methods for the Examination of Water and Wastewater, 22nd Edition by Rice et al. (2012). Water samples were analyzed for PHC and PCB as mentioned below. Each month ten water samples were analyzed and the data for each season was averaged together to represent each season.

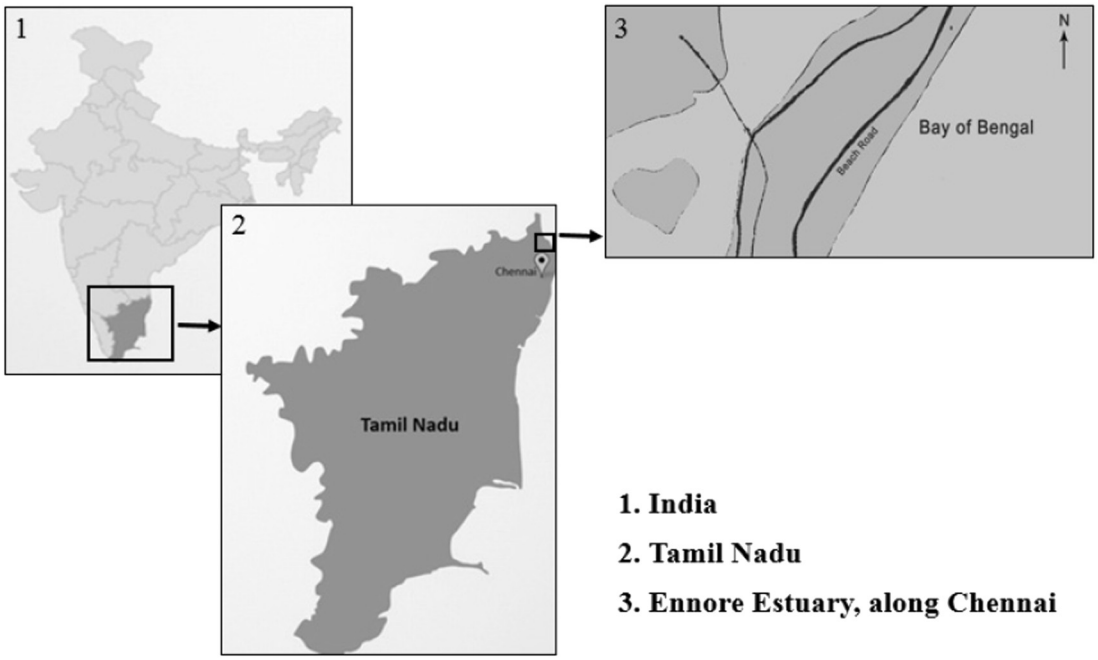

Fig. 1. Map showing the Ennore Estuary near Chennai, Tamil Nadu, India.

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