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A review analysis on environmental factors influencing morphology and behaviour of estuarine Mollusc

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ABSTRACT

The phylum mollusca, the second largest non chordate group of organisms inhabits all types of terrestrial and aquatic habitats. Benthic invertebrates represent an important group in the mangrove food web; influence various functional aspects in the ecosystem like energy flows, nutrient re-mineralization in the sediment etc. In this article, strong relationship between various environmental factors on molluscs in estuarine habitats is discussed. Analysis have been made on the influential environmental variance such as temperature, light, pH, tidal cycle, salinity, soil substratum, humidity and other environmental attributes on the behavioural response and external structure of molluscs.

Key words: *Environmental factors, Benthic mollusc, Morphology, Behaviour, Adaptation.*

Introduction

Estuarine environment being one of the most productive natural habitats supports a unique assemblage of flora and fauna especially adapted to live at the margin of the sea. To survive within the intertidal zone of coastal environments, plants and animals may have to withstand exposure to desiccation, osmotic stress, temperature stress, UV radiation, as well as problems associated with gas exchange and accumulation of metabolic wastes during their periodic exposure to air. Henceforth, intertidal organisms exhibit adaptive structural, behavioural and physiological modifications or adaptation in response to such environmental stresses (Vermeij, 1973). Molluscs being the predominant fauna in the mangrove play a significant ecological role in the structure and functioning of this ecosystem, show a great complexity in their trophic status due to their presence at different levels in the food web as detrivore, filter feeders, herbivores and predator (Kottè-Mapoko *et al.*, 2017). The nature of the molluscan community is strongly influenced by physical conditions of the environment (Kabir *et al.*, 2014). Availability of food and shelter with spatio-temporal variation and hydrodynamic forces in the estuarine region create microhabitats for macrofauna and directly or indirectly affect the quality of living of immigrating larvae and juveniles of benthic organisms (Ronnback, 1999). Pulmonate snail and several other groups have conquered mangrove lands with the elimination of the gills and conversion of the mantle cavity into lungs (Shanmugam and Vairamani, 1999). The malacofauna species restricted to the tree zones of mangroves and salt grasses have adapted for re-absorption of calcium carbonate from internal shell structures to survive in difficult situation (Sanpanich *et al*., 2004). Byssus threads formation in *Mytilus edulis* are very much influenced by environmental conditions like agitation, excision, temperature, salinity, tidal regime and seasonality. (Young, 1985). Organic sheet formation on inner shell wall in *Geloina erosa* and *G. expansa* was observed as an adaptive response in the individuals who had suffered from extreme shell dissolution. (Isaji, 1993).

Effect of temperature and light: Water temperature played a crucial role on movements of L*ittorina littorea* for high recovery of snail distribution on upper intertidal and mid-intertidal bed during winter months. (Carlson *et al.,* 2006). *In vitro condition Littorina littorea*, maintained at low temperature (16° C and 20° C) showed induced defences by growing larger and thicker shells which decreased or inhibited at higher temperature (24° C) (Bibby *et al*., 2007) and similar result was also observed in scallop *Argopecten purpuratus* (Lagos *et al.,* 2016). The movement of male *Littorina ardouiniana* and *Littorina melanostoma* in mating season to track females by following their mucus trails might be influenced by temperature (Erlandsson and Kostylev, 1995). *Littorina* spp were so sensitive to sunlight that they were translocated to lower side of the leaves of mangrove plants and shaded part of mangrove stilt root which show control over diurnal movements with changing illumination (Kamardin *et al.,* 2006).

Effect of pH: Gastropods, *Bembicium auratum* from acidified sites showed significantly higher activity in vertical migration using mangrove trunk and pneumatophores and more rapid migration out of acidified waters than highly alkaline estuarine waters (Amaral *et al*., 2014). At extremely low pH ($pH<5.0$), retraction into the shells of *Bembicium auratum* which might be learned or inherited over multiple exposures serves as a cue to reduce the acidity stress in the population (Amaral *et al*., 2014). The formation of thicker shells in gastropod, *Littorina littorea* in presence of predator (crab) was disrupted at low pH (Eschweiler *et al.,* 2009, Bibby *et al.,* 2007). Similar response was also observed in scallop, *Argopecten purpuratus* where large and thick shell production was negatively influenced by acidic condition of the environment (Lagos *et al.*, 2016).

Effect of tidal cycle

Telescopium telescopium inhabiting on upper intertidal zone found inactive and clustered together in refuge microhabitats and succumbed to heat stress on exposure at mudflat and their migratory behaviour started with the onset of tidal inundation (Lasiak and Dye, 1986). *Littorina. littorea* preferred to remain stationary during high tide period. As their mobility was mostly negatively influenced by tidal amplitude, they showed a high affinity to low water line (Stanhope *et al*., 1982). The adult individuals of gastropod, *Melampus coffeus* (Pulmonata, Ellobiidae), a common snail in mangrove forests and salt marshes along the Atlantic Ocean coast showed a particular behaviour related to tidal cycles by climbing trunks, seedlings, prop roots and pneumatophores of mangrove plants during spring tide to avoid submergence, while juveniles remain on substrate surface under leaves and inside trunks (Proffitt and Delvin, 2005). The magnitude of hydrodynamic forces directly influences a snail to hide from free-stream flows in sheltered cracks or crevices as a resistance of dislodgement from the substratum (Trussell, 1997). *Littorina obtusata* exhibits clear morphological variation in respect to shell height, shell length, and aperture area along shores exposed to differential wave energies. Decreased shell length of *L. obtusata* was observed after storm in wave exposed area (Trussell, 1997). Copulation in *Littorina scabra* was correlated with lunar cycle and very much influenced by moist environment both in vivo and in vitro condition (Maruthamuthu and Kasinathan, 1986). Tidal inundation also influenced the age specific association of mollusc species with others. Such as, high association of *Littorina littorea* was observed with mussel bed, *Mytilus edulis* in low intertidal zone whereas the juveniles of *L. littorea* were greatly associated with barnacles in deep tidal bed (Saier, 2000). The ratio beween shell length and aperture height was observed to be increased in individuals of *Littorina plena* exposed to high wave action (Rugh, 1997).

Effect of Salinity: *Telescopium telescopium* being an euryhaline species can tolerate a wide range of salinity from 15 to 34 ppt (Alexander and Rae, 1979) with decreasing survival rate at fresh water level. *T. telescopium*, which distributed widely in marine, estuarine and brackish water system has potential resistance to withstand desiccation for a long period of time up to 6 months (Vermeij, 1973).

Effect of soil substratum: In *Nodilittorina australis*, developmental plasticity in shell morphology indicates partial dissociation of colour and sculpture (Yeap *et al.*, 2001). Soil parameters such as nitrate, phosphate, ammonia, pH, temperature and salinity affect the density of *T. telescopium* in either submerged area or dry area in an estuarine landscape (Graffer, 2014). Better activities like rasping, copulating and movements on semi-fluid soil substratum were observed in *Telescopium telescopium* which was also oriented by ebb tide, light and wave motion (Petraitis, 1982). The foraging behaviour of molluscs was also influenced by the richness of mangrove leaf litter and microbial growth on substratum and the slime trace and odour of other animals on mangrove trunks (Kamardin *et al.*, 2006).

Effect of humidity: Deposition of organometallic complex (Fe, Mn) in sediment is very important as a humidity preserving factor for maintaining smoothness of shell (Plaziat, 1984). Smooth coated shells are found solitary and sparsely distributed at shaded areas, whereas the typical type was found in abundant and aggregated at open and bare areas. (Budiman, 2009). The density of *Telescopium telescopium* in dry area was higher than the submerged area (Lasiak and Dye, 1986; Rangan *et al.*, 2015). Habitat segregation or degree of shadiness might be an influential factor on shell form in *Telescopium* sp (Budiman, 2009). Besides the reduction of colonization density in dry season, shipworm *Neoteredo reynei* (Bivalvia, Teredinidae) showed a peculiar behaviour by closing off their burrow on wooden log during low tide for better protection from desiccation and overheating (Rimmer *et al.*, 1983). The unique tree-climbing bivalve, *Enigmonia aenigmatica*, which occurs mostly on *Avicennia* sp and *Sonneratia* sp shows shell colour variation from red/ deep purple to golden brown when attached directly to the mangrove leaves (Sigurdsson and Sundari, 1990).

Effect of other environmental attributes: The structure of the mangrove forest may represent a fundamental factor for the survival of estuarine molluscs (Maia and Coutinho, 2013). The habitat preference of *Telescopium telescopium* is made by the quiet nature of the environment (Haque and Choudhury, 2015). Increased predation pressure might forced medium size group of *Littorina irrorata* to stay out of water, whereas large sized snails being not susceptible to predator's attack did not show any kind of response (Stanhope, 1982). In vitro condition on predation-related mortality of *L. irrorata* was observed in restricted vertical migration (Vaughn and Fisher, 1988). Changing in foot colour was suggested to be an indicator of trematode (*C. lingua)* infection in *Littorina* sp (Willey and Gross, 1957). Microhabitats like cracks and crevices on tidal flat were preferred for shelter during storm surge or tidal wave shock (Saier, 2000; Carlson *et al.*, 2006). Trail following behaviour in gastropods help them to locate prey and attached food particles on previously laid mucus trail (Ng *et al.*, 2013).

Conclusion

All the studies discussed here indicate that environmental factors like temperature, pH, salinity, light intensity, humidity, tidal inundation and habitat specialization impose largely on the morphology and behavioural pattern of molluscan community inhabiting in mangrove as well as estuarine habitats. Among these factors pH, light luminescence and tidal amplitude create greater impact on morphological characteristics in respect to size, thickness, smoothness and colour pigmentation of molluscan shell. On the other hand, water temperature, tidal flow and uniqueness of habitats are analyzed as the major influential factors regulating various behavioural pattern of mangrove based mollusc species. A very minimal number of studies have been done till date on morphological and behavioural changes of malacofauna in dynamic estuarine environment. This review analysis will foster interest for detailed research on the dynamicity of mollusc community in estuarine environment especially in India.

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