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Epibiotic communities (microalgae and meiofauna) on the pneumatophores of *Avicennia officinalis* (L.)

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A B S T R A C T

In a mangrove environment, several groups of organisms are symbiotically associated with pneumatophores (aerial roots). But whether these organisms are exclusively found in this habitat (uniqueness) or accidentally settled here from water or sedimentary habitat, is not clearly understood. This hampers our understanding of their functional ecology. Hence the present study aimed to characterise the epibiotic microalga and meiofauna from the pneumatophores of mangrove *Avicennia officinalis*. To determine the habitat influence, these communities were also compared with those found in water and sedimentary habitat. Four estuarine mangrove sites represented by brackish water (salinity varying from 5 to 12) and located at different spatial scales (5–50 km distance) were chosen to determine whether these communities are consistent or vary with sites. Overall, the microalgal community was found to vary both among the habitats as well as sites. In the pneumatophore habitat, several tychoplanktons such as *Coscinodiscus, Thalassionema*, *Cyclotella, Fragilariopsis,* and *Biddulphia* were observed instead of benthic ones. These diatoms are planktonic genera and might have settled on pneumatophores from the water column. The observed variability in the microalgal composition among the sites is possibly due to predatory interactions or the dominance of particular species of macroalga that govern the diatom community. On the other hand, among the meiofaunal community, diptera, halacarida, tanaidacea, and foraminifera were mainly found in the pneumatophore habitat than in the sediment. Because pneumatophores either provide refugee to meiofauna against predators or are saturated with oxygen that meiofauna can utilize for respiration. Pneumatophores were also found to harbour several rare (abundance <1%) epibionts, the ecological importance of which is discussed in this paper.

1. Introduction

Mangroves are intertidal plants found in tropical and subtropical coastlines. Although this habitat constitutes only 0.5% of the world's coastal area, it provides many ecosystem services including fisheries, nutrient cycling and carbon storage (Donato et al., 2011; Alongi, 2014; Lee et al., 2014). Due to their high primary productivity, sometimes equal to that of tropical humid evergreen forests and coral reefs (Alongi, 2014), they support rich biodiversity. Various organisms living in the mangrove environment, however, prefer their own microhabitats such as sediment (mud), water or root surface, depending upon their ecological interactions. For example, the muddy substratum harbours various infaunal and epifaunal organisms, whereas mangrove roots provide an ideal substratum for the colonisation of varied epibionts starting from microbes to several invertebrates such as hydrozoans, sponges, isopods, crustaceans and cnidarians (Ellison and Farnsworth, 1992; Toledo et al., 1995; Phillips et al., 1996; Cannicci et al., 2008).

The growth of epibionts, when becomes dense, affects the morphology of host and subsequently alters the host's interaction with the environment (Thieltges and Buschbaum, 2007). This interaction could lead to beneficial or harmful effects depending upon the type of epibiotic organisms involved (Perry, 1988; Ellison and Farnsworth, 1990a, b; Ellison et al., 1996). For example, in Belize mangrove forests (Central America), an increased growth rate of mangrove roots was observed, when associated with sponges due to nutrient uptake from them (Ellison et al., 1996); but root growth was negatively affected, when isopods dominated in the epibiotic community (Perry, 1988; Ellison and Farnsworth, 1990a, b). In addition, the root epibionts influence the total energy flow in the mangrove ecosystem (Wada and Wowor, 1990; Rodriguez and Stoner, 1990). Recently, our study from the mangroves of Goa

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(Central west coast of India) revealed that compared to sedimentary habitat, roots are associated with a diverse community of meiofauna (Sahoo et al., 2013); however, no such studies have been carried out on the epibiotic microalgae. These two components play a vital role in the mangrove food web (Schrijvers et al., 1995; Kon et al., 2007). Microalgae as primary producers substantially enhance the productivity of the native system (Kon et al., 2007; Essien et al., 2008) and are consumed by the juvenile fishes (Essien et al., 2008; Nagelkerken et al., 2008), whereas meiofauna are known to be consumed by some benthic fishes and crustaceans (Bell and Coull, 1978; Coull et al., 1995; Dittel et al., 1997).

Avicennia officinalis (L.) is one of the dominant estuarine mangrove species along the Indian coastline and is found in the lower intertidal zone (Duke et al., 2010). The conspicuous feature of this plant is the presence of extensive growth of aerial roots, called pneumatophores which are negatively geotropic (vertically growing in an upward direction). These pneumatophores enable the plant to survive in the hypoxic mud due to the presence of lenticels (minute pores meant for gaseous exchange) on their surface. A single tree of 2–3 m in height produces approx. 10,000 pneumatophores (Hogarth, 1999). It is believed that high density of pneumatophores at a particular site could substantially reduce the speed of water current and enhance the sedimentation rate (Hogarth, 2015), thus forming a sediment layer on the pneumatophore surface. This sediment layer forms a complex habitat for the existence of epibiotic communities such as microalgae and meiofauna.

Each biological community is represented by some taxa that are either restricted to a particular habitat/site or present in low abundance. These taxa are termed as rare if their percentage of abundance is <1% (Bianchelli et al., 2010; Semprucci et al., 2013; Ignatiades and Gotsis-Skretas, 2014) and unique if they are found exclusively in a particular habitat (Ellingsen et al., 2007). Generally, they are neglected in ecological studies because of their low abundance or restricted distribution. However, recent studies have revealed their crucial role in ecosystem functioning (Ellingsen et al., 2007; Ignatiades and Gotsis-Skretas, 2014). Rare species, particularly phytoplankton, play a significant role in the trophodynamics of the system (Lyons et al., 2005) and can enhance the functional resilience in response to any kind of perturbations (Weithoff, 2003). Unfortunately, they are highly vulnerable to anthropogenic activities because of their restricted distribution and/or low abundance. Hence, it is imperative to document these taxa in the pneumatophore-associated epibiotic communities. As such, this study addresses the following questions:

(1) Does the epibiotic microalgae and meiofauna on the surface of pneumatophores vary with sites?
(2) Are epibiotic communities different from that of water and/or sedimentary habitat?
(3) What are the extent of rarity (abundance <1%) and uniqueness (exclusive presence in a particular habitat) in these epibiotic communities?

2. Materials and method

2.1. Experimental design and field sampling

This study was carried out in Goa, Central west coast of India. To address the question whether the epibiotic communities found on the pneumatophore surface are consistent or vary with sites, four mangrove sites represented by brackish water (salinity varying from 5 to 12) were selected, namely Chorao, Divar, Vanxim and Galgibaga (Fig. 1). Among them, Chorao, Divar, and Vanxim are spatially close to each other (average distance 5–6 km), whereas Galgibaga is located far away at a distance of ~50 km.

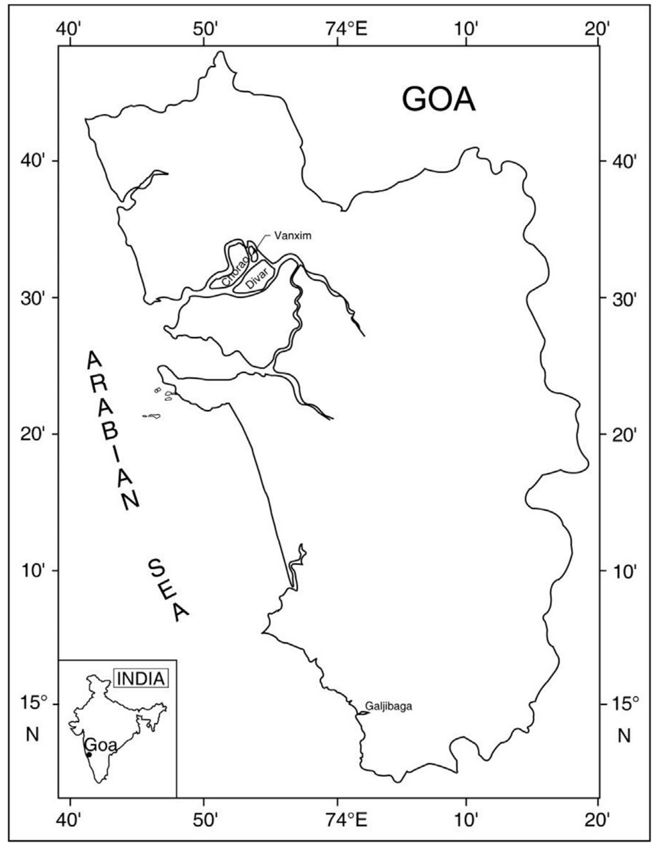

Fig. 1. Sampling sites in Goa, Central west coast of India.

This study focused on two major epibiotic components, microalgae and meiofauna associated with mangrove pneumatophores. To know whether these communities differ from adjacent sedimentary and water habitats or not, microalgal samples were also collected from the water and sediment, whereas meiofaunal samples were collected only from the sediment (Fig. 2a–b).

During field sampling in each site, three quadrats (15 × 15 cm) were fixed at an interval of 5 m (Fig. 2a–b), and all the pneumatophores in each quadrat were counted to estimate pneumatophore density. For microalgal analysis, one pneumatophore (>5 cm in length) was clipped from each quadrat by a knife and kept in a polythene bag (Fig. 2a–b), whereas the remaining pneumatophores were collected and preserved in 5% formalin-rose bengal solution for meiofaunal analysis. In addition, the sediment (top one cm) from where pneumatophores emerge, was also collected separately for microalgae and meiofauna analysis by the help of a syringe (surface area: 7.065 cm^2). Five hundred ml of nearby sea water was also collected to assess the composition of microalgae (phytoplankton) in the water habitat.

During the sampling, temperature of air (close to pneumatophore) and water were measured *in situ* by a hand-held thermometer, water salinity by a refractometer (Atago, Japan) and water pH by a pH meter. Nutrient samples (nitrate, nitrite, and phosphate) were also collected from nearby water because of its influence on the epibiotic communities associated with pneumatophores.