Species

Habitat preference and role of Ophiuroidea in the intertidal community of Saurashtra coast, Gujarat, India

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ABSTRACT

The role of brittle stars is explained in this study, concerning the interactive effects with various habitats, for resolving the relationship between community dynamics and ecosystem functions in heterogenous intertidal habitats. The study was conducted at the rocky intertidal area of Veraval (210 35'N, 690 36'E) of the Kathiawar peninsula, Gujarat, India. Habitats containing sponge, coral community, zoanthid community and coralline algae were studied to understand the key preference and role of ophiuroid in these intertidal communities. Ophiuroids act as habitat responder largely due to their being one of the most common and abundant groups. Amongst all studied ophiuroid species, *Ohiactic savignyi* is the only species which interacted with all selected sedentary habitats. *Macrophiothrix variabilis* was occasionally observed within crevices of coral colonies. *A. squamata* was primarily occurred with coralline algae followed by coral community. *Ophiocomella sexradia* was observed within the crevices of coral and zoanthid colonies. From the present study, we concluded that brittle stars mainly rely on other host organisms for their protection, food and shelter. The studied ophiuroids exhibited mutualistic and obligatory commensalism relationship with their host.

Keywords: Ophiuroidea, intertidal, sedentary community, habitat preferences, potential role

1. INTRODUCTION

Echinoderms are highly diverse in many marine habitats. These animals occur from the intertidal belt to the great depths of the oceans. These animals are an important part of the benthic communities such as soft sandy substrata, rocky shoreline, muddy bottom, coral community, zoanthid community and algal tufts. Echinoderms reportedly can alter the composition and structural arrangements of the community as they are sometimes described as habitat engineers which provide space to other creatures for the settlement and growth (Hastings et al., 2006; Wild et al., 2011). They are significantly promoting the growth of biodiversity including populations of benthic assemblages such as molluscs, corals, polychaetas and algae (Birkeland, 1989; Ambrose, 1993; Glynn and Enochs,

2011). Ophiuroids (brittle stars) are one of the ecologically important echinoderm groups.

Few Studies are available on ophiuroid association with other fauna and flora groups (Boffi, 1972; Keegan, 1974; Hendler, 1984; Hendler et al., 1995; Neira and Cantera, 2005; Girard, 2016; Lawley et al., 2018) from diverse habitats such as seaweeds, coralline algae, sponges, cnidarian and bryozoans (Mladenov and Emson, 1998; Hickman, 1998; Tahera, 2001; Mosher and Watling, 2009; Hendler and Brugneaux, 2013; Paim, 2015). Among them, the association of ophiuroid with sponges has been documented widely since the past 70 years from various parts of the world. Brittle stars are recognized as epizoic on Gorgonids (Clark, 1976; Fujita, 2001) on sponges (Caspers, 1985) and echinoids (Kroh and Thuy, 2013) while, as endosymbiotic with jellyfish (Fujita and Namikawa, 2006). The various kinds of associations are characterized by wide-ranging ecological interactions, including obligate/facultative, commensalism, mutualism, competition, predation and parasitism. However, still the particular nature of several associations remains imprecise (Wulff, 2006). In India, very few reports were found on brittle stars associated other fauna. Brittle star associated with sponges (Sivadas et al., 2014; Sadhukhan et al., 2020), with jellyfish (Panikkar and Prasad, 1952), with crinoid (Baroliya et al., 2022) and with various coral species (Sastry, 2002) are the only documentation from India.

The present study describes the habitat preference, association and role of brittle stars with other animals and plants from the intertidal zone at Veraval. Currently nine species of intertidal Ophiuroidea known from Saurashtra (Baroliya et al., 2022). Spatio-temporal variation of some prominent species of brittle star were studied at Veraval (Baroliya and Kundu, 2022) but potential role of the Ophiuroidea in the intertidal community of the south Saurashtra coastline is mostly unknown. Therefore, the present study aims to find out the role of brittle stars in interactive effects of various habitats, for resolving the relationship between community dynamics and ecosystem functions in these heterogenous intertidal habitats.

2. MATERIALS AND METHODS

The study was conducted at the rocky coastal areas of Veraval (210 35'N, 690 36'E) of the Kathiawar peninsula, Gujarat. The sampling site was selected based on their community structures and the habitats within the communities and peripheral area (Figure 1). For studying the habitat heterogeneity and to understand the possible ecological role and association of ophiuroids in the existing intertidal communities, the Veraval intertidal was sampled for Sponge, coralline algae, coral and zoanthid intertidal communities. Animals were categorized into three distinct categories, viz., habitat former, habitat responder and habitat determiner (Jones and Andrew, 1992). The reason behind the selection of this coastline was due to its dominant sedentary intertidal community, substratum types and availability of extensive habitats. For this study, visual survey and field observational methods were followed. Whole coastal stretch was surveyed at monthly intervals from January-2019 to March-2020 to determine the species interaction. Selected sedentary communities were extensively observed for the brittle star avability, their movements, habitat types, color pattern resemblance, hiding behavior and other activity during low tide. During field observation all these activities were recorded as photographs for evidence. Brittle stars were counted to check the frequency of occurrence with specific community.

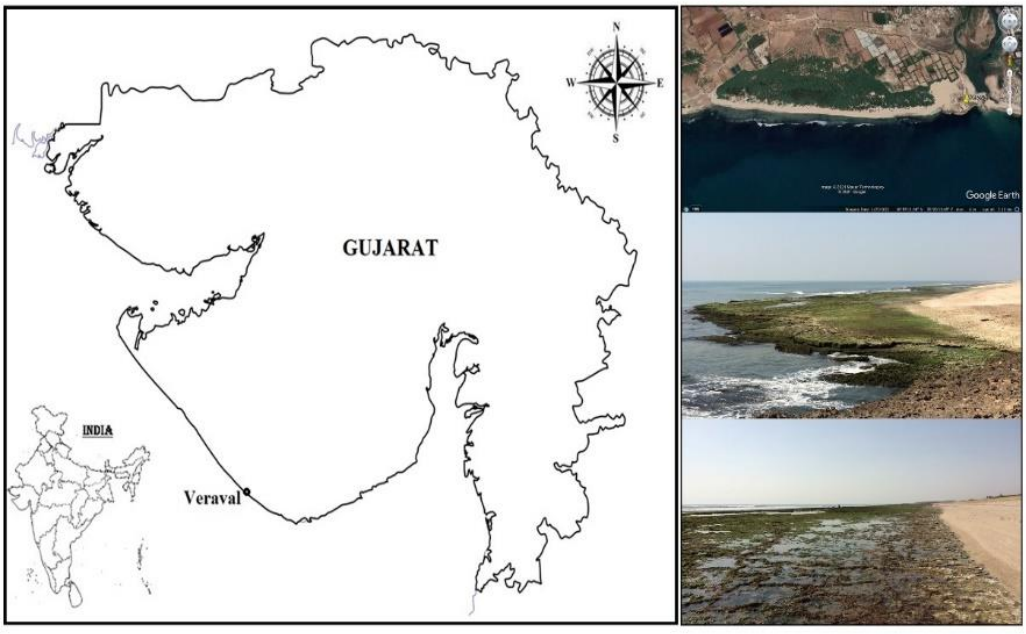

Figure 1 Map of the study area and photographs showing the intertidal belt of the study area.

3. RESULT & DISCUSSION

During this study, the most common and widely distributed ophiuroids species *Amphipholis squamata* and *Ophiactics savignyi* appeared to be playing major roles in the ecological system of Saurashtra coast. Along with the two main species mentioned above, *Ophiocomella sexradia* and *Macrophiothrix variabilis* were also the next prominent echinoderms in the studied ecosystem. Habitats such as sponge, coral community, zoanthid community and coralline algae were studied to understand the key preference and role of Ophiuroidea in this intertidal community.

Habitat heterogeneity structure of Veraval

The Veraval intertidal zone was observed for sponges, coralline algae, coral community and zoanthid community, including their habitat and peripheral area. Distributions and abundances of the ophiuroid species were linked to these certain habitats. Availability of these habitats determine the abundance of brittle star species. From this observation, ophiuroids come under the habitat responder category. We describe the habitat heterogeneity structure as follows:

Habitat formers

At the Veraval intertidal zone, the sedentary community coral (*Porites* sp.) and zoanthid (*Zoanthid sansibaricus*) strongly characterize habitats which are considered as highly distinct community due to their role as substratum forming animals. So, these two are main habitat former species of this coast.

Habitat determiners

An animal's grazing or predation activity determines the presence or absence of habitat formers. For the coral community, different varieties of fishes (Zebra sp., Balck spot surgent), crab, Moray eel, sea star (*Aquilonastra* sp.), hermit crab and gastropods (*Turbo* sp., *Nerita* sp.) are mainly determining the presence and absences of these community. For the zoanthid community, no such major predator or grazer was observed except for nudibranchs.

Habitat responders

These include organisms whose distribution and abundance are intricately linked to the biological or physical structure of habitat. In the coral community, marine worms like Sabelladae, Serpulidae and Nereidae family and brittle star species like *Ophiactics savignyi* and *Amphipholis squamata* come under this habitat responder category. Barnacles and a few groups of gastropods are also linked to the structure of habitat as habitat responder. For the zoanthid community, mainly nudibranchs are linked to the structure of habitat as habitat responder, which may feed on the zoanthid polyps.

Habitat preferences of Ophiuroidea

Sponges

Amongst Echinodermata, the common brittle star *Ophiactic savignyi* is mostly observed in associated with massive, tubular and elegantly branching small to large sponge species *Haliclona (Reniera) tubifera* and associated with *Spheciospongia* sp. (chocolate-yellow sponge) at the intertidal zone of Saurashtra coast (Figure 3). The frequency of occurrence of *O. savignyi* with sponge was relatively high in winter followed by summer, post monsoon and monsoon (Figure 2). *O. savignyi* was densely observed in the canal of fully developed single *H. (Reniera) tubifera* branches at a nearby location, while, as at the Veraval coast, they were observed moderately on the outer periphery of sponge and rock crevices of the growing *H. (Reniera) tubifera* sponge species. Two types of relationship may be possible between sponges and brittle star (Hendler, 1984). These can be either commensal to sponges as they are found on other habitats also, or as mutualism because brittle stars clean the inhalant surfaces by its feeding mechanism as a suspension feeder who feed on large particles which are difficult to enter in the sponge.

In return, sponges gave shelter from predation to the brittle stars. Brittle star suspension feeding activity and sponge internal current system was likely the reason of their association (Sivadas et al., 2014). The spinous structure and chemical defense of sponges decreases the chance of predation (Pawlik et al., 1995). So brittle stars living on sponges may face a lesser chance of predation compared to other habitats (Wahl and Hay, 1995). Small brittle stars are not as capable of capturing food efficiently, thus, they depend on sponges for their water current for higher food capture efficiency (Xavier turon, 2000). Ribeiro et al., (2003) and Abdo, (2007) suggested that there is an opportunistic relationship between brittle stars and sponges as they found brittle stars rely on sponges as temporary shelter during vulnerable phases of their life cycle such as reproductive or juvenile stages. *O. savignyi* were mostly found with *H. (Reniera) tubifera* throughout the study period while the association with *Spheciospongia* sp. (chocolate-

yellow) is seasonal specific. Results indicate that the association with sponges may be beneficial to brittle stars by providing a structural habitat, easy availability of a rich source of food and low risk of predation, while sponges may get benefited by brittle stars which work as surface cleaners of sponges and generate water current activity, as many reports suggest. These outcomes propose that *O. savignyi* may be in a mutualism relationship with sponges.

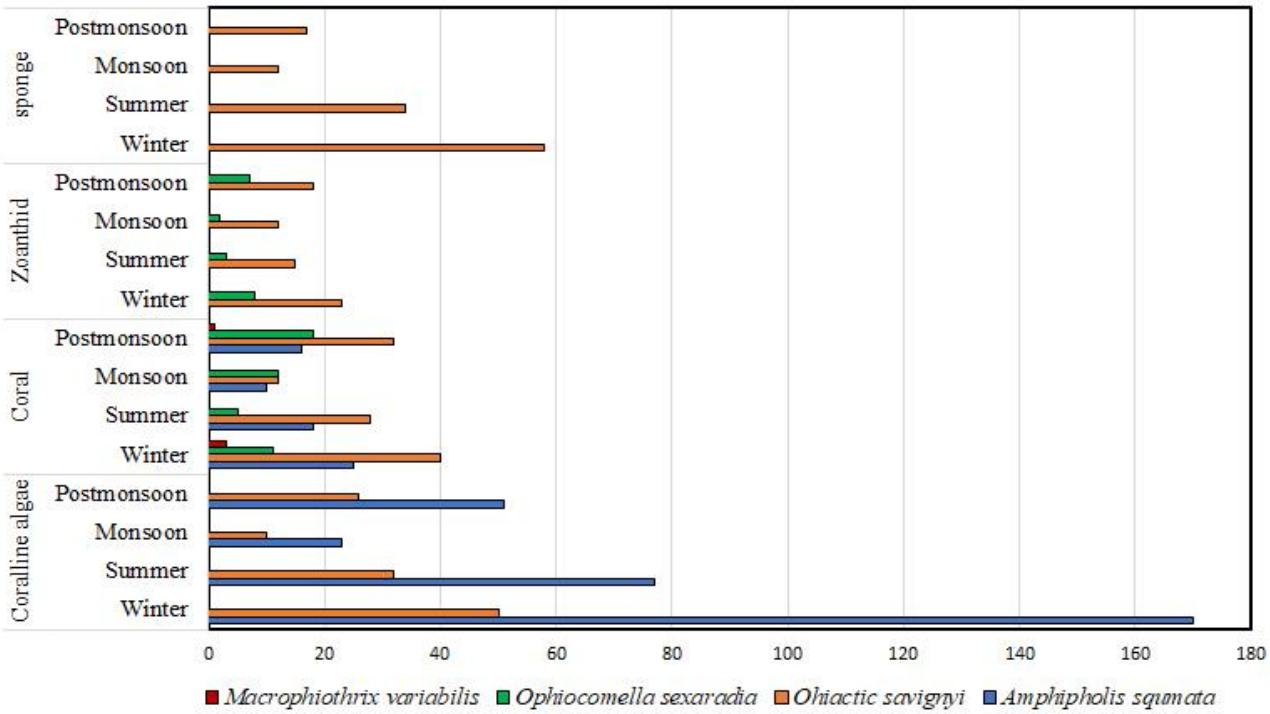

Figure 2 Graphs representing the seasonal variation in frequency of occurrence of Ophiuroidea species with studied habitats.

Coral community

Echinoderms are a significant coral inhabiting group due to their living habitats, size and their influence on coral cover. They prefer corals and other heterogenous ecosystems for their shelter, reproductive activities and food (Sastry, 2002). Various small to large colonies of *Porites* sp. thrive in the middle littoral zone of Veraval (Poriya et al., 2014). In Echinodermata, all the ophiuroid species which are present at this coastline were observed with corals during the study period but in terms of their frequency of occurrence, they have seasonal specificity for the coral (Figure 2). Among all the ophiuroids, the frequency of occurrence of *O. savignyi* was relatively high and the frequency of occurrence of *Macrophiothrix variabilis* was relatively low during the study period. *M. variabilis* was only observed during winter and post monsoon (Figure 2). *O. savignyi* and *A. squamata* has the highest frequency of occurrence observed in summer while the lowest occurrence followed in monsoon and post monsoon, respectively. For *Ophiocomella sexradia*, the highest frequency of occurrence was observed in Monsoon followed by post monsoon, winter and summer. The relationship with coral likes mucus secreting organisms may provide diverse food options and their crevices provides shelter for protection (Dittrich, 1992). Grange, (1991) studied mutualistic associations between *A. Constrictum* and *Antipathes fiordensis* and suggested that this brittle star feeds on detritus and mucus of coral colonies, like the cleaning symbiosis with sponges suggested by Thiel, (1976).

The presence of varied habitats may be a reason for the heterogeneous and fascinating complex structure of coral reefs (Hendler et al., 1995). The reason for selection of this habitat may be because of enriched food options, as this brittle star is a filter feeder and physical structure of the dense colonial form of coral may protect it from predators. Sedentary worms and coral tentacles circulate the water which passes through water currents. A key role of this brittle star is feeding on mucus and floating microorganisms which help to clean the water and reducing silt load settling on corals. The small brittle star species *O. savignyi*, *A. squamata* and *O. sexradia* were observed in the crevices at the peripheral area of the coral pool with numerous sedentary and mobile worms. *M. variabilis* also was observed within the coral colony crevices in coral patches (Figure 4). However, it was observed that the color combination of *Porites* sp. and *M. variabilis* resembles each other. Therefore, to live with *Porites* sp. may be beneficial for brittle stars by means of camouflage that inhibits the chance of predation and *M. variabilis* larger arms clean the slits from *Porites* sp. These findings support the conclusion that all studied ophiuroids may have a mutualistic association with coral.

Figure 3 Photographs showing brittle stars associated with sponges. A-D shows *O. savingyi* with *Haliclonia tubifera* (Photos taken by Dr. Bhavik Vakani). A- *H. tubifera* sponge, B- *O. savingyi* on the surface, C- aggregating *O. savingyi* on the sponge canal, D- *O. savingyi* ventral view. E &F shows *O. savingyi* with *Spheciospongia* sp. with coralline algal bed (arrows show sponge and circles show *O. savingyi*)

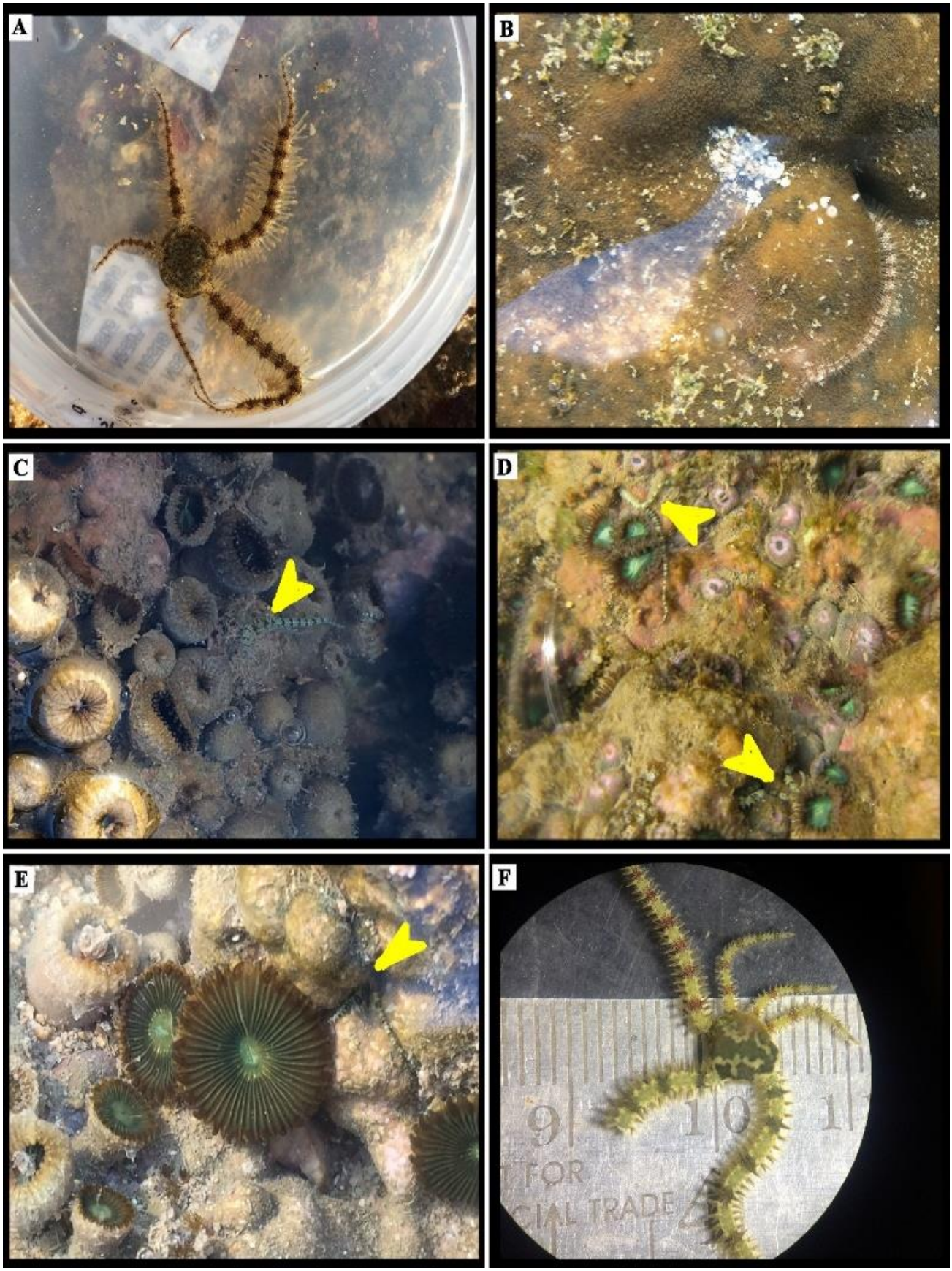

Figure 4 Photographs showing the brittle stars associated with corals and zoanthids. A- *Macrophiothrix variabilis*, B- *Macrophiothrix variabilis* with coral (*Porites* sp.), C, D & E- zoanthid with *Ophiocomella sexradia* and *O. savingyi*, F- *Ophiocomella sexradia*

Zoanthid community

Various small to big, growing and well established zoantharian colonies were observed in the intertidal zones of Veraval and these appear to provide vast habitats to fauna such as annelids like spaghetti worms, scale worms, sponges and anemones along with brittle stars (Poriya and Kundu, 2016). Some of the brittle star species such as *Ophiocomella sexradia* and *O. savignyi* were observed with zoanthids (Figure 4). *O. savignyi* has a relatively higher frequency of occurrence compared to *Ophiocomella sexradia* with zoanthids. *O. savignyi* exhibited the highest relative abundance in monsoon followed by summer, winter and post monsoon, while *O. sexradia* showed highest relative abundance observed in post-monsoon followed by summer, winter and monsoon (Figure 2). The zoanthids provide sheltering many animals which in-turn also increases the chances of food availability for brittle stars. In zoanthid colonies, brittle stars observed within crevices and they often have similar color patterns with zoanthids which seems to be camouflage which may help to prevent predation. However, we observed that a reason behind the association between brittle star and zoanthid colonies is mainly for shelter and protection from the predators such as crabs, shrimps, hermit crabs and fishes due to the palytoxin poison of zoanthids which effect nerve stimuli of animals (Moore and Scheuer, 1971). These outcomes support the conclusion that brittle stars may have an obligate commensal relationship with zoanthid colonies.

Coralline algae

In the present study, the most abundant species *Amphipholis squamata* was frequently observed under the holdfast of articulated coralline algae (*Amphiroa* sp.) and other types of algal holdfast within the corals and zoanthid communities at the upper and middle littoral zone of Veraval (Figure 5). *A. squamata* has relatively higher frequency of occurrence compared to *O. savignyi*. Both these species are totally opposite to each other in seasonal occurrence pattern. *A. squamata* highly occurred in winter and had least occurrence in post monsoon while *O. savignyi* highly occurred in post monsoon and had least occurrence in winter (Figure 2). Brittle stars were mainly observed within dense branched algae but sparsely occurred within the branched or soft algae (Zavodnik, 1967). This trend may provide essential habitat and allow interactions with other species such as worms, sponges and gastropods. Color patterns of *A. squamata* appeared to mimic *Amphiroa* sp. which suggests that camouflage aspects may reduce the rate of predation. These coralline algae are found on rocky and rocky sandy substratum. Therefore, brittle stars may help in resuspension of sediment as they are suspension feeders (Labarbera, 1978)

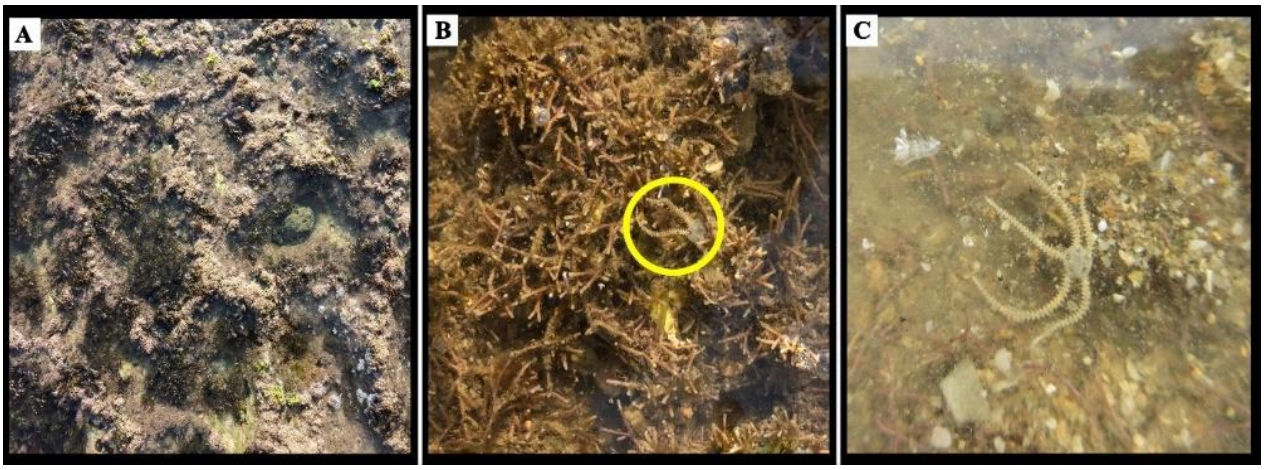

Figure 5 Photographs showing *Amphipholis squamata* associated with coralline algae (*Amphiroa* sp.), A- patches of *Amphiroa* sp., B- *A. squamata* with *Amphiroa* sp., C- *A. squamata*

The rate of being subject to predation is low in coralline habitat then other habitats. Complex morphology of coralline algae provides dense habitat to brittle stars as well as other marine fauna. According to Boffi, (1972) *A. squamata* mainly preferred calcareous algae in the middle littoral zone because the compact structure of these algae keeps high humidity during low tide which prevents desiccation. In the present study, *A. squamata* was observed within holdfasts of coralline algae (*Amphiroa* sp.). This trend was for the first time noted from this coastline. We observed that *A. squamata* in association with *Amphiroa* sp. appears mainly to be used for protection, possibly to allow an easy access to a source of calcium from coralline algae, enriched resources of food and to keep itself hydrated during low tide.

4. CONCLUSION

The present study is to our knowledge the first comprehensive report about the habitat preferences, association and role of brittle stars with other fauna and flora from the intertidal flat of the Veraval coast off the Arabian Sea. The results of the present study expressed a few striking revelations regarding the habitat preference and association of these animals with their environment. The results also revealed which community they are most strongly associated with. Ophiuroidea comes under habitat responder category because of its being the most common and abundant group in these sedentary community. *A. squamata* has its distribution and abundance intricately linked to the coralline algae patches at the Veraval coast. It was evident from the present study that brittle stars used diverse living habitats in rocky intertidal areas of the Saurashtra coastline. These animals are mostly found in coralline beds, sponges, crevices/holes within coral and zoanthid colonies. Opportunistic observation on the association of brittle stars with sponges, corals, zoanthids and coralline algae is a primary valuation between the existing marine fauna of Saurashtra coastline.

Amongst all studied ophiuroids species, *O. savignyi* is the only species which interacts with all selected sedentary habitats. This species occurred regularly with zoanthid colonies and occurred least with coralline algae compared to other habitats. Surprisingly *O. savignyi* is the only species which occurred with sponges and *Macrophiothrix variabilis* was occasionally observed with crevices of coral colonies only. *Ophiocomella sexradia* was observed within the crevices of coral and zoanthid colonies. As the present study was based on visual observations, more detailed and experimental work are required to recognize the ecological significance of these potentially important associations. From the present study, we conclude that brittle stars mainly rely on other host organisms for their protection, food and shelter. The studied ophiuroids here mainly have mutualistic and some obligatory commensalism relationship with their hosts. We did not find any evidence of harm being caused by these brittle star species to the host organisms.

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Author's contribution

HB and RK conceived the study; HB and ZG did the field work, collected data and identification; PP survey literature; HB and ZG analyzed the data; HB preceded the manuscripts writing with inputs from PP; PP and RK review the manuscript. All authors contributed significantly to draft the manuscript.

Ethical approval

Ophiuroidea from Saurashtra coast, Gujarat, India was observed in the study. The ethical guidelines are followed in the study for species observation & identification.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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