**Synopsis of the Thesis Entitled**

# DIVERSITY AND ECO-PHYSIOLOGY OF ACTINIARIANS ALONG THE COAST OF SAURASHTRA, GUJARAT

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# INTRODUCTION

The intertidal zone or "littoral zone" referred to the area covered during high tide and exposed during low tide, revealing a unique biome which survives under such fluctuating conditions The members of these communities are subject to the many and frequent changes imposed by wave action and the ebb and flow of the tide. Consequently, animals living permanently in the intertidal zone have evolved a variety of anatomical, physiological and behavioural adaptations that enable them to survive in this challenging habitat. The intertidal zone has the greatest biodiversity of coastal habitat as they provide shelter from various biotic and abiotic stresses and protection from larger predator.

Cnidarians inhabit such intertidal regime subject to the varieties of environmental stresses as they are benthic sedentary organism. Cnidarians have high ecological importance because they associate with a vast variety of faunal species and often represented by high species diversity in reefs. Phylum Cnidaria includes animals that exhibit radial or bi-radial symmetry and are diploblastic, meaning that they develop two embryonic layers, ectoderm and endoderm. Anthozoans, representative of Phylum Cnidaria, are the most important group of organisms playing a significant role in the formation of coastal forms. The Anthozoans skeleton is made from detritus and sand particles which are not hard enough to sustain the currents, but it definitely helps in forming huge colonies in areas with high sediment rates (Pandya et al., 2013).

The class Anthozoa has two subclasses classified on basis of body fold symmetry, the Hexacorallia and the Octacorallia. Atiniarians (Sea anemones) are among the most diverse and successful members of the Phylum: Cnidaria, Class: Anthozoa, Subclass: Hexacorallia, Order: Actinaria occupying benthic marine habitats across all depths and latitudes. Many species of sea anemones inhabit rocky shores, especially where there are tide-pools in which remain submerged during low tide. Their greatest diversity is in the tropics although their many species are adapted to relatively cold waters. The majority of species cling on to rocks, shells or submerged timber, often hiding in cracks or under seaweed, but some burrow into sand and mud, and few are pelagic. Sea anemones are soft bodied Actiniarians, having exoskeleton divided into upper oral disc, with tentacles, the body column and the basal disc below for attachment to substratum. They are benthic, sessile as single polyps. Actiniarians are easily recognized by the presence of small intracellular stinging capsules called nematocysts. This structure, which consists of a tubule attached at one end that typically bears spines, are a synapomorphy for the group as all members of the phylum produce them (Reft, 2012). These structures are used in many aspects of everyday biology including defence against predators, attachment to substrate, capture of prey and aggression against other cnidarians. It is known that sea anemones (Anthozoa: Actinaria) are capable of reproducing both ways sexually and asexually (Stephenson, 1928 and Hyman, 1940). Even in the same species the mode of reproduction may differ from population to population (Chia, 1976).

Actiniarians have ecological and pharmaceutical importance. They have been playing an important role in ecosystem that act as habitats for diverse invertebrate and fish communities. It has also become an interest of pharmaceutical research as Actiniarians are novel sources for biologically active compounds which are potentially valuable materials in biomedical research. They also played a role in the marine aquarium trade. Considering their roles as an integral part of marine biodiversity and ecosystem services, Studies on sea anemones gained attention across the world.

Diversity studies and documentation at species level provide the base line data for further ecological and pharmaceutical research. Some factors could be important in the sea anemone’s external morphology and identification: Habitat preferences and colour pattern (Daly and Fautin, 2004), the size of specimen and diameter of the oral disc, the type and size of tentacles and their arrangement on oral disc, and the pattern of verrucae on the column (Fautin et.al, 2008). The nematocyst types and size from different parts of the anemone body is also an important criterion for identification (Ostman et al., 2013). Many of the characteristics used in sea anemone taxonomy can only be examined through histological sections. Basilar musculature, for instance, has been traditionally employed on taxonomic keys (Stephenson, 1935; Carlgren, 1949) to distinguish large groups within Actiniaria. Certain muscles such as the sphincter not only vary in shape and degree of development, but also in the tissue derivation (endodermal or mesogleal), which, until today, has been particularly useful to define families. Even at genus level, there are specific biological characteristics (e.g., type of reproduction) that can only be verified through histology.

Studies on sea anemones gained attention across the world following Verrill's (1928) monograph 'Hawaiian shallow water Anthozoa' in which there are 21 sea anemone species described. Dunn (1974a) redescribed the species Macranthea cookie described by Verrill (1928) in Hawaii and Radianthus papillosa, described by Kwietniewski (1898) as Stichodactis papillosa from Ambon. Dunn (1978) described new species Anthopleura handi, an internally brooding intertidal actiniarian from Malacca Strait, Malaysia. Fifteen species of sea anemones including 3 new species from two orders, Actiniaria and Ptychodactiaria (1 species) were reported by Dunn (1983) from sub-Antarctic and Antartic areas. Fautin (1988) identified 22 species of Actiniarian and Corallimorpharian sea anemones from Madang Province. Further, Fautin et al. (1989) studied the systematic of genus Metridium and described the new species Metridium giganteum from west coast of North America. Fautin et al. (2009) documented 16 species of sea anemones belong to the families Actiniidae, Actinodendridae, Aiptasiidae, Boloceroididae, Diadumenidae, Stichodactylidae and Thalassianthidae including Diadumene lineata (invasive species) in Singapore.

Most of the species under these families are widespread in Indo-Pacific tropics as common intertidal and shallow subtidal sea anemones in Singapore.. Panama coast resulted with 26 species, of which 14 species belonging to the order Actiniaria found in Pacifi c coast of Panama, while 11 species recorded from Caribbean coast of Panama and one species Calliactis polypus found to be new record to Panama (Garese et al., 2009). Acuna et al., (2013) has updated the inventory of sea anemones of Costa Rica to 16 species with the addition of 8 new records from Caribbean and Pacific coasts. Gul and Häussermann, 2017 reported five species of sea anemones: Hormathianthus tuberculatus, Neoaiptasia commensali, Anthopleura waridi, Paracondylactis sinensis and Entacmaea quadricolor are reported for the first time from Pakistani waters.

Inspite of India having 7600 km long coastline, studies on Indian waters sea anemones are very limited, except the studies made by Annandale (1907 & 1915), Panikkar (1936, 1937a-c, & 1939) and Parulekar (1966, 1967, 1968, 1969a, b & 1971). However, these studies have discontinuously been investigated and are better known through new species and new genera, rather than the magnitude and diversity of the fauna itself (Parulekar, 1990). Parulekar (1990) enumerated 40 species of sea anemones belonging to 33 genera under 17 families, of which 13 species were reported for the first time from India. Madhu and Madhu (2007) reported the occurrence of 10 species of sea anemones at 14 sites from Andamans. More than15 species of Actiniarian belonging to 11 Genere and 8 Families from the Andaman and Nicobar islands (Raghunathan *et al*., 2015).

The sea anemone of Gujarat is still insufficiently studied. There is some handful of papers available from Gujarat: Parulekar (1990) documented Boloceroides mcmurrichi, Anemonia indicus, Paracondylac indicus, Stoichactis giganteum, Phymanthus loligo, Paraphellia sanzoi and Metridium senile from the Gulf of Kachchh. However, Hartog and Vennam (1993) had described the Actiniarians like Bundosoma goanensis, Synantheopsis parulekari and Stichodactyla haddoni from the Okha Coast of Saurashtra.

Hence the study was carried out as a part of survey for sea anemone diversity along the intertidal zone of Saurashtra coast of Gujarat. Shah *et al*, (2017) reported 15 species along the Saurashtra coast, out of which 13 species are new to Gujarat.

The identification of Anthozoans species based only on morphological characters has led to dilemma owing to the phenotypic plasticity of these organisms and has often called for additional support of genetic studies (Reimer et al., 2006a, b, 2010). In the case of the hexacorallian order Actiniaria, the lack of consensus about phylogeny based on morphological features makes the DNA data especially important. This in turn makes the choice of markers and the potential of those markers to reconstruct phylogeny more critically. The animal mitochondrial genome exhibits several characteristics that make this molecule suitable for population genetic and phylogenetic analysis.

Identification of species via DNA sequences is the basis for DNA taxonomy and DNA barcoding. Currently there is a strong focus on using a mitochondrial marker for this purpose, in particular a fragment from the cytochrome oxidase I gene (COI). While there is ample evidence that this marker is indeed suitable across a broad taxonomic range to delineate species, it has also become clear that a complementation by a nuclear marker system could be advantageous (Sonnenberg *et al*, 2007).

In members of the Actiniaria, Three genetic markers namely the cytochrome oxidase subunit I (COI), a COI Intron with a Homing Endonuclease Gene (HEG), and the Internal Transcribed Spacer II (ITS II) were tested to assess their utility for molecular species identification . Both the power of COI and the COI Intron to distinguish species is limited by events of very low inter-specific sequence differences and not by high intraspecific diversity (Dohna & Kochzius, 2016). This finding implies that more comprehensive taxon sampling will not resolve this problem and other markers need to be investigated in several families.

Evaluation of the phylogenetic signal for a suite of markers is commonly used for phylogenetic inference in a sample of hexacorallians, members of the order Actiniaria. These markers have been evaluated with respect to a broad sample of the major lineages (approximately familial-level) of Actiniaria. Among the markers studied, (a more-focused sampling of members of the family Hormathiidae and its allies) the fragments of 12S rDNA and 18S rDNA most effectively recover well-supported nodes; those of 16S rDNA and 28S rDNA are less effective (Daly, 2010).

The sequence verification has been performed on this Indian sea anemone species for cytolysins and compared with a Singaporean species of which the sequence has been already known. The sequence comparison among cytolysins of other cnidarians – such as *Stichodactyla helianthus, Heteractis crispa, Actinia equina* and *Oulactis orientalis* – has also been performed by a phylogenetic analysis for establishing a genetic relationship (Karthikayalu et al., 2010). Biju Kumar *et al.,*2015 reported the presence of an intertidal sea anemone *Anthopleura buddemeieri* in Indian coast, indicating the extended distribution of this species to Western Indian Ocean and provide the sequence data of the mitochondrial gene cytochrome c oxidase 1 (CO1) of the species.

Rising sea temperatures are causing significant destruction to coral reef ecosystems due to coral mortality from thermally-induced bleaching (loss of symbiotic algae and/or their photosynthetic pigments). Although bleaching has been intensively studied in corals, little is known about the causes and consequences of bleaching in other tropical symbiotic organisms. Anemone bleaching also has negative effects to other species, particularly those that have an obligate relationship with anemones which include reductions in abundance and reproductive outputs of anemone fishes (Hobbs et al., 2013). Some of the belching effect on sea anemone also has been recorded from Saurashtra coast.

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