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Diversity and distribution of Cirripedia from Gujarat Coast, India

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Abstract- Compared to other taxons of crustacea, limited literature is available on the diversity of Infraclass Cirripedia (Barnacles), as they are not much studied from the taxonomical point of view. The present study describes a total of 7 species of Intertidal cirripedia from Gujarat coast which includes the actual study and review. The highest species diversity was recorded from the Saurashtra coast bearing rocky intertidal areas, the highly supportive habitat for their attachment. The most common species observed were Tetraclita squamosa rufotincta, Amphibalanus amphitrite, Chthamalus stellatus and Balanus crenatus found flourishing on rocky shore with high density.

***Keywords*:** Cirripedia, Crustaceans, Barnacle, Saurashtra, Intertidal

I. INTRODUCTION

Crustaceans are the most important benthic Arthropods inhabiting aquatic ecosystem, playing an important role in balancing the ecosystem. These are economically important as they are used for human consumption as well. These include, crabs, prawns, shrimps, squilla, crayfishes, lobsters, barnacles *etc*. The estimated crustacean diversity is believed to be approximately 52,000 species which leads them to be on the fourth position next to insects, molluscs and chelicerates, in terms of overall species diversity [1]. The most intensely studied group among different taxons of crustacea are the true crabs (Infra-order Brachyura) consisting of 6793 species and subspecies, 1271 genera and subgenera and 93 families belonging to order Decapoda, worldwide [2]. In India around 2934 species have been described so far, contributing 94.85% of the global biodiversity [3]. Different studies on Gujarat coast contributes a total of 188 species of Crustaceans belonging to 53 families and 8 orders [4],[5],[6],[7],[8],[9],[10],[11],[12],[13].

The crustacean Cyprus larvae normally attach to hard substratum and metamorphose in adult sessile barnacles. They inhabit mostly in marine environment while some species are capable to live in low salinity and found in estuaries [14]. They are very successful group today having 1445 living species as well as good abundance [15]. A total of 280 species of thoracic barnacles have been found [16], [17], [18], but only 48 species have been reported so far from the intertidal zones of India [18]. A few studies have been carried out to know their abundance from the intertidal area due to obstacles in specimen collection. Most of the studies on barnacles conducted so far have highlighted their interesting reproductive relationships. Merely a few species of barnacles are economically important. It may be due to smaller size of individuals, in spite of wide range of varieties on global scale [19], can also be considered as one of the reasons for less exploration.

They have long caused problems as fouling organisms on ships and docks in fishing industry. The barnacle cements are also used in dentistry [20], [21], [22]. In countries like Spain and Portugal, barnacles are also used as food and in Japan certain species are cultivated for fertilizers [15]. Apart from these scientists are also trying to trace migratory pattern of hosts on which they grow [22].

II. MATERIALS AND METHODS

The present study was carried out from 2016 to 2017 in the intertidal areas of Gujarat coast divided into three major parts *viz.*, the Gulf of Kachchh, the Gulf of Khambhat and the Saurashtra region under the Integrated Coastal Zone Management (ICZM) Project. The survey was carried out in two ways: line transects method along with quadrates at regular interval and Opportunistic observation/ whole area search. Each transect was of 100m with quadrates laid at a regular interval of 20m in the intertidal area of different habitats of Gujarat coast during the small temporal window of low tide. Also collection of species was carried out from the non-protected areas of Gujarat coast. The collected specimens were identified by some of the published literatures [23], [24], [25]. The classification was adopted from the World Register of Marine Species website [26]. Biodiversity indices such as species richness, Dominance, Simpson, Shannon and Evenness were calculated with the

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help of PAST software while Density and abundance were performed for quantitative analysis [27].

III. RESULTS AND DISCUSSION

The present study describes a total of 7 species of barnacles from Gujarat coast, most of which are well distributed in the intertidal areas of Saurashtra coast as having rocky shore throughout. There are sporadic reports available for diversity of barnacles, still very few information available and need extensive study. *Tetraclita squamosa rufotincta, Amphibalanus amphitrite, Chthamalus stellatus* and *Balanus crenatus* were found to be the common species of barnacles from the Suarashtra coast and the Gulf of Kachchh areas.

Table 1: Diversity Indices for barnacle diversity

Diversity Indices	1	2	3	4	5	6	7	8
Richness	3	2	1	2	2	1	1	1
Dominance	0.50	0.51	1	1	1	1	1	1
Simpson	0.49	0.48	0	0	0	0	0	0
Shannon	0.69	0.68	0	0	0	0	0	0
Evenness_	0.99	0.98	1	1	1	1	1	1

(1-Sutrapada, 2 – Harsiddh, 3 – Jhanjmer, 4 – Gosa, 5 – Poshitra, 6 – Dwarka, 7 – Okha, 8 – Sikka)

The highest species richness was observed in Sutrapada which represents three species of barnacles. The highest Shannon diversity index was found in Sutrapada (0.6892) followed by Harsidh (0.6775), indicating high species as each site shows 2 species. The evenness value for Sutrapada and Harsidh was found nearer to 1 so it can be concluded that species found in those areas are evenly distributed.

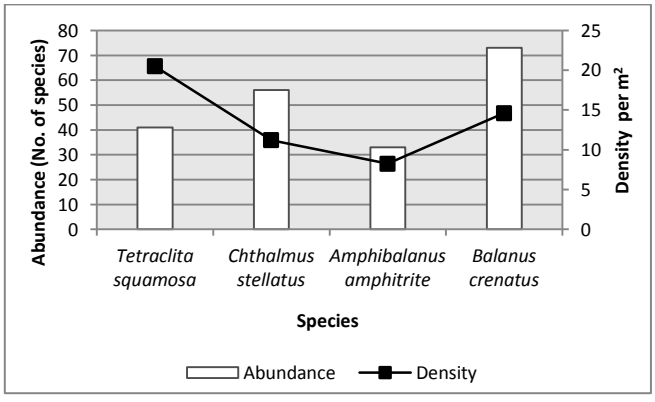

Figure1: *Abundance and density of most common species of Gujarat coast*

The graph (fig.1) clearly reveals that *Balanus crenatus* has the highest abundance among all species but its density was found lower. It means the species are sparsely distributed in the study area. On the other hand, *Tetraclita squamosa rufotincta* have comparatively low abundance but have highest density among the other common species of the study area. The barnacle *Tetraclita squamosa rufotincta* was recorded only from Sutrapada and is found in very big colony covering a huge area and favoured this highest density as compared to other species. In the case of *Amphibalanus amphitrite*, some similarities were observed in abundance and density which ultimately conclude that the species is equally distributed among all the zones of intertidal areas.

Table 2: Species checklist of Barnacles

SN	Family	Species	References
1	Balanidae	*Amphibalanus Amphitrite* (Darwin, 1854)	Singh *et.al.*,2004; Trivedi *et al.* 2015; present study
2	Balanidae	*Megabalanus tintinnabulum* (Linnaeus, 1758)	Singh *et.al.*,2004; Trivedi *et al.* 2015
3	Chthamalidae	*Chthamalus stellatus* (Poli, 1791)	Present study
4	Balanidae	*Balanus crenatus* Bruguière, 1789	Present study
5	Tetraclitidae	*Tetraclita squamosa rufotincta* (Bruguière, 1789)	Daniel, 1972; Fernando, 2006; Present study
6	Tetraclitidae	*Tetraclitella purpurascens* (Wood), 1815	Fernando, 2006; Present study
7	Lepadidae	*Lepas (Anatifa) anserifera* Linnaeus, 1767	Present study

***1) Balanus crenatus*:** The individuals were found having acute carinal end and blunted rostral end creating a pentagonal shape. Valves have distinctive form**.** Scutum was found with strong growth ridges. There were total 6 wall-plates having ridged surface. Both the sides of carinal plate were covered by lateral plates, the two lateral plates found to have one alae (side covered by adjacent plate) and one radii (side covering the adjacent plate) while the rostral plate was found to cover the lateral plates on both sides. The open valve barnacles were found to have crenate rim of the aperture.

Habitat: Rocky shore

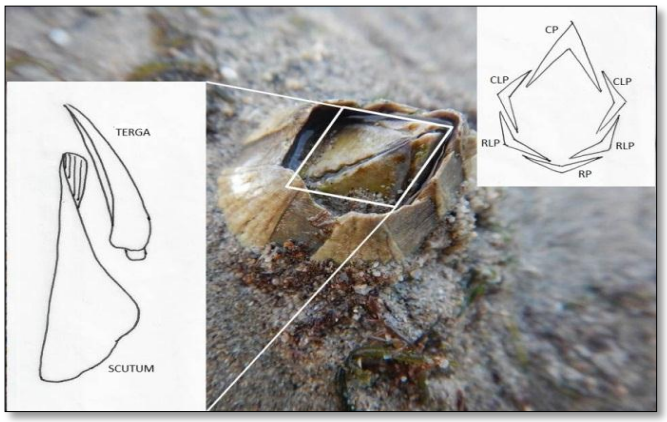

Figure 2: *Balanus Crenatus*
(CP- Carinal Plate; CLP – Carino-lateral Plate, RLP – Rosstrolateral Plale; RP- Rostral Plate)

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2) Chthamalus stellatus: Some of the individuals were found having oval while some having kite shaped aperture. A very few growth-lines were found on the edge of the scuta towards rostral plate. The barnacles generally possess 6 lateral plates but were found distinct only in few juvenile forms while in older individuals they were found to be fused.
Habitat: Rocky shore

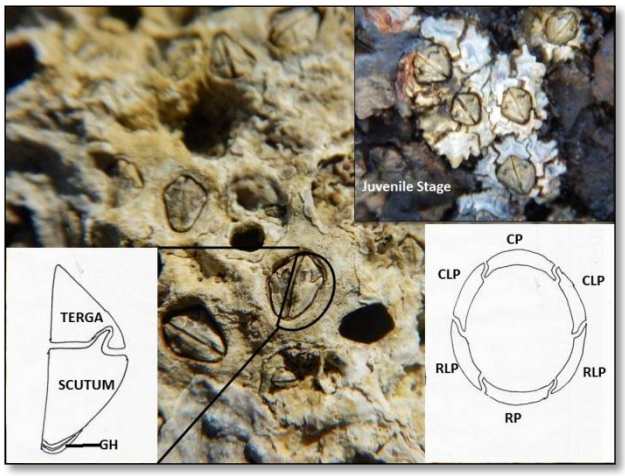

Figure 3: *Balanus stellatus*
(CP- Carinal Plate; CLP – Carino-lateral Plate, RLP – Rosstrolateral Plale; RP- Rostral Plate, GL- Growth Lines)

***3) Tetraclitella purpurescens*.:** The individuals were found having diamond shaped operculum having distinct pairs of terga and scutum valves. Scutum valves found to have strong growth ridges. The operculum was guarded by four wall plates a paired lateral, one carinal and one rostral. Both the sides of carinal plate were covered by lateral plates. The lateral plates have one alae and one radii while both sides of rostral plates cover the lateral plates.
Habitat: Rocky shore

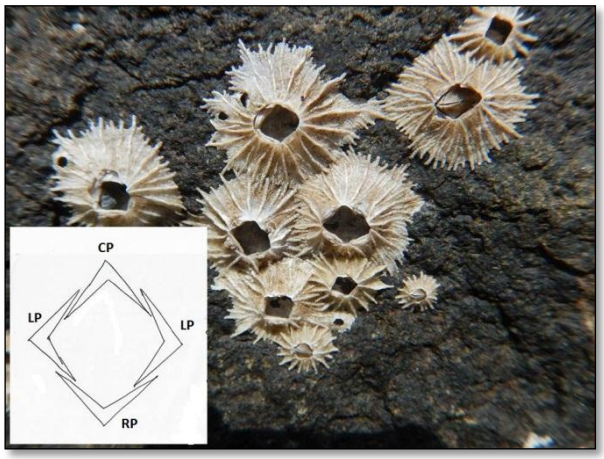

Figure 4: *Tetraclitella purpurescens*
(CP- Carinal Plate; LP –Lateral Plate, RP- Rostral Plate)

***4) Tetraclita squamosa rufotincta*:** The individuals were found having pink coloured conical shell made up of four thick plates, i.e., carinal plate, rostral plate and two lateral plates. The plates were almost fused together and were not distinguishable. The plates were found having number of ridges along with the rows of pores. The operculum was found almost irregular in many individuals while some was found with diamond or oval in shape.
Habitat: Shaded rocky substratum

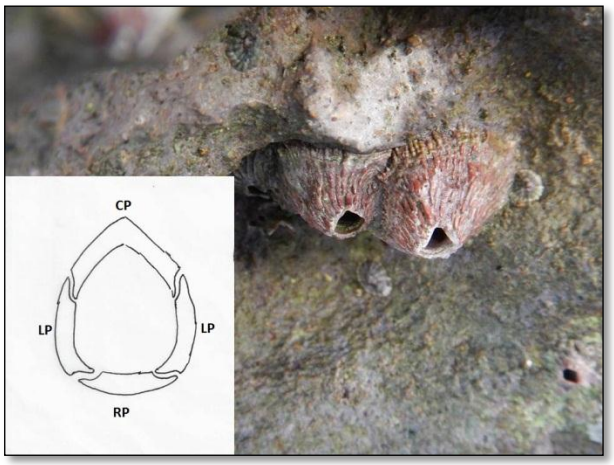

Figure 5: *Tetraclita squamosa rufotincta*
(CP- Carinal Plate; LP –Lateral Plate, RP- Rostral Plate)

5) Amphibalanus amphitrite: Same as *Balanus crenatus*, the 6 wall plates consists of carinal plate having both the sides covered by lateral plates, the two lateral plates having one alae one radii while the rostral plate was found to cover the lateral plates on both sides. Pale and white coloured wall plates with purplish brown stripes. Shape was depressed conical. Operculum having rhomboid shape. Scutum with prominent growth ridges. The colour of scutum having tinge of mauve.
Habitat: Coral reef and Rocky shore

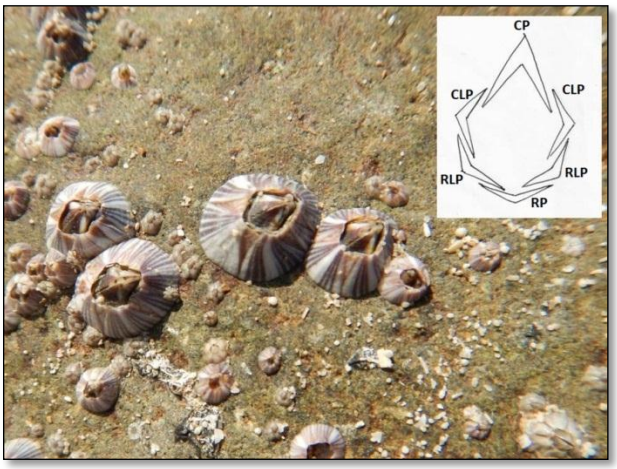

Figure 6: *Amphibalanus amphitrite*
(CP- Carinal Plate; CLP – Carino-lateral Plate, RLP – Rostrolateral Plale; RP- Rostral Plate)

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***6) Lepas (Anatifa) anserifera*:** Individual was found having flexible peduncle. Uppermost part of the peduncle was orange. Capitulum was found more elongated compared to its breadth. It was found having five valves, paired Scuta, paired Terga and one Carina. Occludent margin of scutum was more arched**.**

Habitat: Hard substratum such as shells, artificial substratum such as plastics, wood etc.

Figure 6: *Lepas (Anatifa) anserifera*

IV. CONCLUSION

A total of 7 species of barnacles have been identified from the intertidal region of Gujarat coast. Most of the species diversity was recorded from the rocky coast of Saurashtra region followed by the Gulf of Kachchh and the least species diversity was from the Gulf of Khambhat and the south Gujarat coast. *Amphibalanus amphitrite* was found equally distributed species among different zonation of intertidal areas

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AUTHOR CONTRIBUTION

The Manuscript was prepared by Heena Parmar, Devanshi Joshi and R. D. Kamboj. Species identification was carried out by Heena Parmar and Devanshi Joshi. Analysis of the study was carried out by Heena Parmar and Devanshi Joshi. Methodology development and overall conduction of field works were managed by Devanshi Joshi and Harshad Salvi.

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