2

Distribution, diversity and abundance of scleractinian corals

Rani Mary George, S. Jasmine, K. Vinod, Mary K. Manisseri and H. Jose Kingsly

Abstract

Three extensive surveys were conducted for the assessment of scleractinian coral diversity along Enayam to Kollam waters in southern India during the period 2008-2012 (*i.e.,* in three phases), using the Line Intercept Transect (LIT) method. A total of 15 coral species belonging to 5 families and 6 genera were recorded and the relative abundance values were derived for each species and were assigned the status as dominant/ abundant/ common/ uncommon/rare. The genera *Pocillopora* and *Montipora* were represented by five species each. In Vizhinjam waters, the total coral cover was only 16.2% of the surveyed area in the first phase of the study period. Subsequent studies revealed a decline in coral growth due to construction of a wharf and also by the removal of pocilloporids by divers. But during the third phase of the survey, new colonies were observed in the area resulting in increased coral cover in Vizhinjam Bay. Though during the first phase, 83% of coral cover was observed at Enayam, a decline in the coral cover (75% only) was recorded in the second phase of the study due to replacement of pocilloporids by the luxurious growth of brown mussels and encrusting zooanthids. The incidence of bleached corals was found to have increased considerably after the initial study. An important observation recorded was that though the decline was noticed among the pocilloporids, an increase in coverage was noticed for other groups such as acroporids and poritids. The present paper presents an overview of coral resources along the south-west coast of India, their distribution and diversity and climatic as well as anthropogenic stress on coral growing areas.

Keywords: *Coral diversity, Distribution, Health status, Scleractinian corals*

Introduction

The coral reefs found in different parts of the coasts of the Indian mainland include the sensitive fringing reef ecosystems in the Gulf of Mannar, Palk Bay, the Gulf of Kutch, the atolls of the Lakshadweep Islands and the continental island reefs of Andaman and Nicobar, covering an estimated area of about 2375 km^2. Apart from these main reefs, there are patches of reefs in the intertidal areas of the west coast. There is a lacuna in knowledge regarding the spatio-temporal distribution of coral species and biodiversity parameters in these reef areas of the mainland coast of India. Along the south-west coast of India, Alcock (1893, 1898) recorded deep-water ahermatypes from the Travancore coast and Pillai and Jasmine (1995) listed a total of 29 species belonging to 17 genera of scleractinians, of which 13 were hermatypes collected from the patchy growth along Vizhinjam and Enayam and 16 ahermatypes, all of which were collected during research cruises on board FORV Sagar Sampada. But an extensive study by Jasmine *et al*. (2009) recorded only 13 species from Vizhinjam and Enayam areas.

Materials and methods

Coral diversity and distribution along Thangassery and Thirumullavaram in Kollam and along Vizhinjam and Enayam on the south-west coast of India have been investigated during 2008 to 2012. The Vizhinjam Bay is an enclosed bay (Lat. 08° 22′ 529″ N; Long.76° 59′ 466″ E) with the seaward side having huge granite and concrete boulders as wave breakers with coral colonies attached to them, apart from those found at the bottom of the Bay waters. At Enayam (Lat.08° 12′ 92″ N; Long.77° 10′ 906″ E), there is a patchy reef formed around a rock about 500 m from the shore. The coral growth along Kollam coast extend from Thirumullavaram to Thangassery (08° 54′ 450″ N; 76° 32′ 422″ E to 08° 52′ 263″ N; 76° 35′ 006″ E). Thangassery is also an enclosed bay like Vizhinjam and here also coral colonies were observed on the huge granite and concrete boulders laid as wave breakers. In Thirumullavaram, coral growth was observed on the rocks along the intertidal area. Life-form Line Intercept Transect method (LIT) was adopted for the survey at all these sites. In Enayam, areas around the reefs were chosen at random and 20 m long transects were sampled along the depth contours and the areas covered by live and dead corals and other substrates were recorded. At Vizhinjam, corals were found mostly on the granite and concrete blocks and here 20 m long transects were placed along the shore line at different depths. Transects were sampled in two sites, in the Vizhinjam Bay and in the harbour area. At Thangassery also, 20m long transects were placed along the tetrapods of the breakwaters. At Thirumullavaram, all the rocks having coral growth were estimated using random transects of 20m, parallel to the shore line. All hard corals intercepted by the

transects were recorded and their lengths measured. The colonies were sampled and identified following Scheer and Pillai (1983), Pillai (1986), Veron (2000) and Rani and Sandhya (2007). The relative abundance of each species was calculated according to living coral cover and the methodology adopted was as described in Sandhya *et al*. (2008).

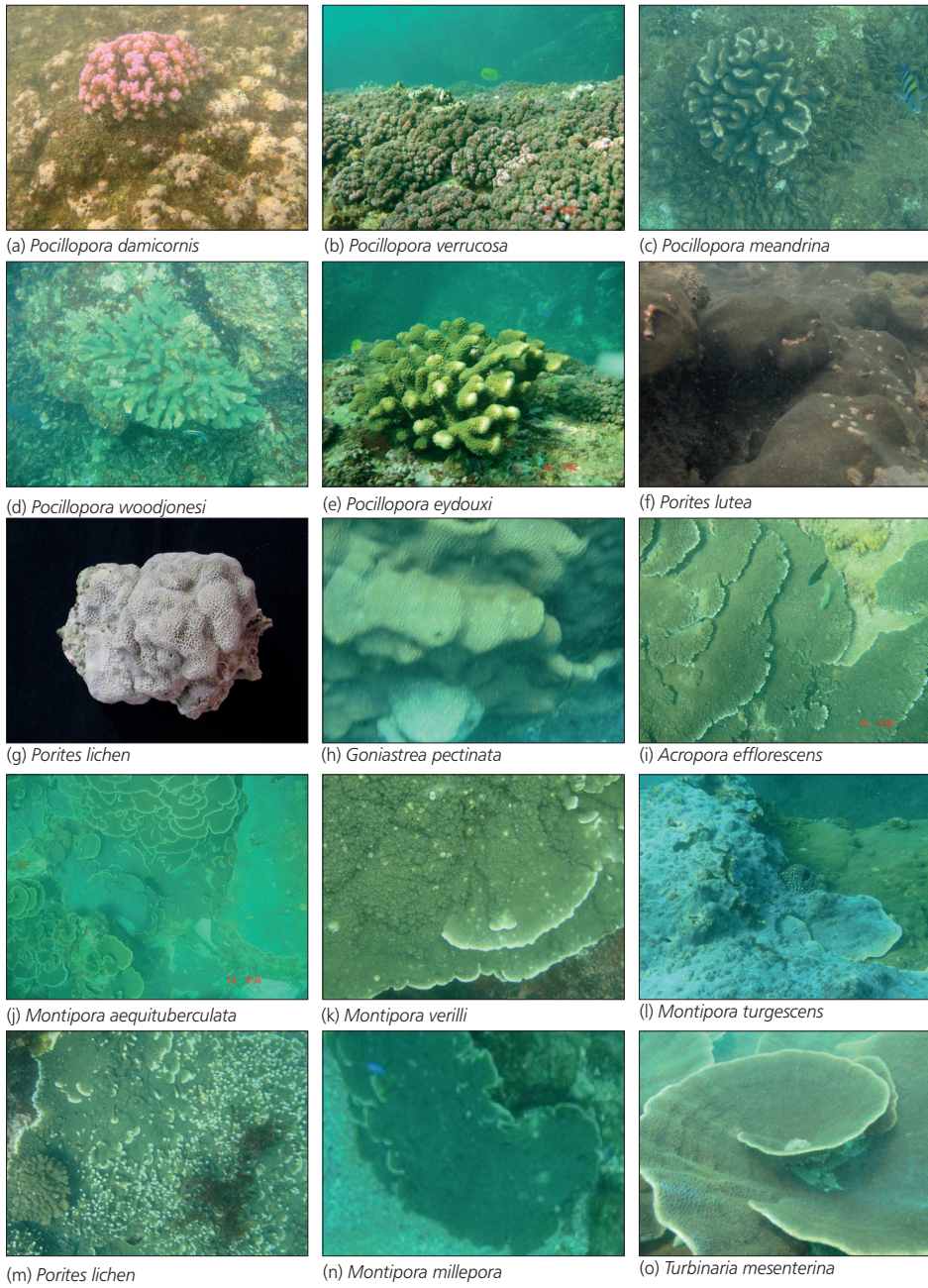
Results and discussion

Hard coral diversity

During the present study, a total of 15 species of hard corals belonging to 5 families and 6 genera were identified from the inshore waters of Enayam to Kollam, on the southern coast of India (Fig.1). The most common genus recorded from the study area was *Pocillopora* and the families Pocilloporidae and Acroporidae were represented by five and six species, respectively; Poritidae with two species and Faviidae and Dendrophyllidae with one species each. However, Pillai and Jasmine have recorded 29 species of scleractinians belonging to 17 genera from this area. Out of these, 13 species falling under six genera were hermatypes and the rest 16 species of 11 genera were ahermatypes. Details on percentage coral cover and relative abundance of hard coral species recorded during the present study are given in Table 1. Distribution of various species so far recorded from the south-west coast of India are summarised in Table 2. It is interesting to note that the most dominant genus in terms of both abundance and species diversity was *Pocillopora* and all the species of *Pocillopora* have been already recorded from Lakshadweep in the past. As evident from Table 2, the coral fauna of the present study was more related to that of the Gulf of Mannar Biosphere Reserve (GOMBR) than any other part of India as confirmed by Pillai and Jasmine (1995).

List of species hitherto reported from south-west coast of India including present collection (Fig. 1 a-o)

Phylum: Cnidaria Hatscheck
Class: Anthozoa Ehrenberg
Subclass: Zoantharia Blainville
Order: Scleractinia Bourne
Sub order: Astrocoenina Vaughan & Wells



(a) *Pocillopora damicornis* (b) *Pocillopora verrucosa* (c) *Pocillopora meandrina*

(d) *Pocillopora woodjonesi* (e) *Pocillopora eydouxi* (f) *Porites lutea*

(g) *Porites lichen* (h) *Goniastrea pectinata* (i) *Acropora efflorescens*

(j) *Montipora aequituberculata* (k) *Montipora verilli* (l) *Montipora turgescens*

(m) *Porites lichen* (n) *Montipora millepora* (o) *Turbinaria mesenterina*

Fig. 1. Scleractinian coral species recorded from Enayam, Vizhinjam and Kollam

Family: POCILLOPORIDAE Lamarck	
1.	*Pocillopora damicornis* (Linnaeus)**
2.	*Pocillopora verrucosa* (Ellis & Solander)**
3.	*Pocillopora meandrina* Dana**
4.	*Pocillopora ligulata* Dana+
5.	*Pocillopora woodjonesi* Vaughan*
6.	*Pocillopora eydouxi* Milne Edwards & Haime**
Family: ACROPORIDAE Verrill	
7.	*Acropora efflorescens* (Dana)**
8.	*Acropora hyacinthus* (Dana) +
9.	*Acropora variabilis* (Klunzinger) +
10.	*Montipora aequituberculata* Bernard *
11.	*Montipora foliosa* (Pallas) +
12.	*Montipora verrilli* Vaughan*
13.	*Montipora turgescens* Bernard**
14.	*Montipora hispida* (Dana)*
15.	*Montipora millepora* Crossland*
Family: PORITIDAE Gray	
16.	*Porites lutea* Milne Edwards & Haime*
17.	*Porites lichen* Dana**
Family: FAVIIDAE Gregory	
18.	*Goniastrea pectinata* (Ehrenberg)*
19.	*Favites abdita* (Ellis & Solander) +
Family: SIDERASTREIDAE Vaughan & Wells	
20.	*Psuedosiderastrea tayami* Yabe & Sugiyama+
Family: DENDROPHYLLIIDAE Gray	
21.	*Turbinaria mesenterina* (Lamarck)**
22.	*Tubastrea aurea* (Quoy & Gaimard) +
23.	*Dendrophyllia indica* Pillai+
24.	*Dendrophyllia cornigera* (Lamarck) +
25.	*Dendrophyllia minuscula* Bourne+
26.	*Endopachys grayi* Milne Edwards & Haime+
27.	*Heteropsammia cochlea* (Spengler) +
Family: FLABELLIDAE Bourne	
28.	*Flabellum stokesi* Milne Edwards & Haime+
Family: CARYOPHYLLIIDAE Gray	
29.	*Solenosmilia variabilis* Duncan+
30.	*Heterocyathus aequicostatus* Milne Edwards and Haime+
31.	*Paracyathus stokesii* Milne Edwards and Haime+
32.	*Paracyathus profundus* Duncan+
33.	*Caryophyllia arcuata* Lamarck+
Family: RHIZANCIDAE	
34.	*Cladangia exiista* Lutken+

* are from the present collection; (+) only from collection of Pillai and Jasmine (1995); (**) common to both collections

Diversity and health of corals

During the present investigation, the patchy reefs of Enayam showed an average live coral cover of 83.08% during the first phase of the study and were in healthy condition (Table 1). A total of 13 species of hard corals were recorded during the transects. Bleached and dead corals were less than 1% of the total coral cover. *Montipora aequituberculata*, which covered nearly 40m (66.98%) was classified as 'dominant'. *Acropora efflorescens* (6.97%), *Pocillopora verrucosa, P. damicornis* and *P. meandrina* belonged to the category 'common'. Other species such as *P. eydouxi*, *Montipora turgescens, Porites lutea, Goniastrea pectinata, Turbinaria mesenterina, Montipora hispida* and *Montipora verrilli* were categorised under 'uncommon'. During the second phase of the study, a decline in the coral cover (75% only) was recorded due to replacement of pocilloporids by encrusting zooanthids and luxurious growth of brown mussels (Fig. 2 and 3). The incidence of bleached corals was found to have increased since the initial study. An important observation was that though a decline was noticed among the pocilloporids, an increase in total coverage was noticed for other groups such as acroporids and poritids. Diseases were prominent among the colonies of *Acropora efflorescens*, *Porites* spp. and *Montipora* spp. Sea urchin infestations were also noticed among the colonies (Fig. 4) during the second and third phases. O'Leary *et al.* (2010) reported that reefs with large numbers of grazing sea urchins reduced the abundance of coralline algae that produce calcium carbonate, an essential building block of the corals themselves, and thereby adversely affect coral growth. Further, this study also showed that sea urchins were the dominant grazers in the fished patch reef areas, where predators of sea urchins namely the triggerfish and wrasses were largely absent. Apart from removal of wrasses and triggerfishes by fishing, removal of bivalves from around these rocks was also observed at Enayam which could be another cause for decrease in the coral cover (Fig. 5).

The coral growth at Vizhinjam was less, rather sparsely distributed, when compared to Enayam. The total coral cover was only 16.2% of the transect area in the first phase of the study period (Table 1). A total of nine species of hard corals were recorded from this area, the genus *Pocillopora* being dominant with five species. Considering the relative abundance, *P. verrucosa* and *P. meandrina* were categorised under 'dominant'; *Pocillopora damicornis* as 'abundant', *P. woodjonesi*, *Montipora aequituberculata*, *M. millepora*, and *M. verrilli* as 'common' and *P. eydouxi* and *Porites* sp. as 'uncommon' (Table 1). Bleached corals were observed where the colonies were exposed to strong sunlight, but their incidence was negligible. Subsequent studies in 2010 revealed a decline in coral growth along the northern side due to construction of a wharf and in the southern side by the removal of beautiful flower-like pocilloporids by people for selling as 'curios'. But the second phase of the

Table1. Percentage coral cover and relative abundance of hard coral species

Species	% cover			Relative abundance			Species status
	2008	2010	2012	2008	2010	2012	
Enayam							
Pocillopora damicornis	1.04	0.45	0.42	1.25	1.02	1.04	Common
Pocillopora verrucosa	2.75	2.30	2.22	3.31	2.87	2.90	Common
Pocillopora meandrina	0.68	0.63	0.57	0.82	0.78	0.74	Uncommon
Pocillopora woodjonesi	1.71	0.97	0.88	2.05	1.08	0.98	Uncommon
Pocillopora eydouxi	0.56	0.44	0.40	0.67	0.55	0.52	Uncommon
Montipora aequituberculata	66.98	63.46	62.82	80.76	81.12	81.2	Dominant
Montipora verrilli	0.46	0.45	0.42	0.56	0.58	0.55	Uncommon
Montipora turgescens	0.23	0.24	0.24	0.28	0.28	0.30	Uncommon
Montipora hispida	0.23	0.22	0.25	0.28	0.26	0.27	Uncommon
Acropora efflorescens	6.97	8.20	7.80	8.40	8.20	8.20	Common
Porites lutea	0.74	1.93	1.88	0.89	2.40	2.82	Uncommon
Goniastrea pectinata	0.56	0.58	0.43	0.67	0.72	0.55	Uncommon
Turbinaria mesenterina	0.16	0.14	0.18	0.19	0.17	0.22	Uncommon
Vizhinjam							
Pocillopora damicornis	1.75	1.78	1.98	10.79	12.48	12.54	Abundant
Pocillopora verrucosa	9.15	7.80	9.02	56.46	55.68	57.02	Dominant
Pocillopora meandrina	3.58	2.85	3.05	22.08	20.40	19.28	Dominant
Pocillopora woodjonesi	0.61	0.56	0.70	3.77	4.02	4.48	Common
Pocillopora eydouxi	0.12	0.10	0.12	0.73	0.68	0.70	Uncommon
Montipora millepora	0.44	0.42	0.53	1.05	3.02	3.33	Common
Montipora verrilli	0.17	0.07	0.13	0.26	0.48	0.82	Common
Montipora aequituberculata	0.26	0.35	0.53	1.61	2.48	1.20	Common
Porites sp.	0.12	0.13	0.10	0.76	0.92	0.64	Uncommon
Thangassery							
Pocillopora damicornis	-	4.84	3.75	-	22.00	20.8	Abundant
Pocillopora verrucosa	-	11.4	9.68	-	51.80	53.78	Dominant
Pocillopora meandrina	-	5.19	4.09	-	23.60	22.74	Abundant
Porites sp.	-	0.57	0.60	-	2.60	2.68	Common
Thirumullavaram							
Porites lutea	-	72.32	69.45	-	90.48	90.20	Dominant
Porites lichen	-	7.68	7.54	-	9.52	9.80	Common

survey revealed new colonies in the area resulting in increased coral cover in the Bay. Due to the intervention and awareness given to the fisherfolk by scientists of ICAR-CMFRI, about the consequences of removal of these corals on the ornamental fish fauna of the region, there was a decrease in their destruction resulting in healthy and luxurious coral growth on the rocks outside the Bay resulting in the revival of coral growth, which was evident during the third phase of the study (Fig. 6 & 7).

Table 2. Distribution of species so far recorded from the south-west coast of India

Species	Vizhinajm	Enayam	Kollam	KadiyaPatnam
Pocillopora damicornis (Linnaeus)	x	x	x	
Pocillopora verrucosa (Ellis & Solander)	x	x	x	
Pocillopora meandrina Dana	x	x	x	
Pocillopora woodjonesi	x	x		
Pocillopora ligulata Dana		x		
Pocillopora eydouxi Milne Edwards & Haime	x	x	x	
Acropora efflorescens (Dana)		x		
Acropora hyacinthus (Dana)		x		
Acropora valida (Dana)		x		
Montipora aequituberculata Bernard, 1897	x	x		
Montipora turgescens Bernard	x	x		
Montipora verrilli	x	x		
Montipora foliosa (Pallas)	x	x		
Montipora hispida (Dana)	x	x		
Montipora millepora Crossland	x			
Psuedosiderastrea tayami Yabe & Sugiyama			x	
Porites lichen Dana		x	x	
Porites lutea Milne Edwards & Haime	x	x	x	
Favites abdita (Ellis & Solander)	x			
Turbinaria mesenterina (Lamarck)				
Cladangia exiista Lutken				
Paracyathus stokesii Milne Edwards & Haime			x	x
Paracyathus profundus Duncan				x
Caryophyllia arcuata Milne Edwards & Haime			x	
Heterocyathus aequicostatus Milne Edwards & Haime			x	
Solenosmilia variabilis (Duncan)			x	
Flabellum stokesi Milne Edwards & Haime			x	
Balanophyllia gumingii Milne Edwards & Haime			x	
Endopachys grayi Milne Edwards & Haime			x	
Heteropsammia cochlea (Spengler)			x	
Tubastrea aurea (Quoy & Gaimard)				x
Dendrophyllia indica Pillai			x	x
Dendrophyllia cornigera (Lamarck)			x	
Dendrophyllia minuscula Bourne			x	

Courtesy: Pillai and Jasmine (1995); present study

The coral growth spread around the Thangassery Harbour area in Kollam, was found to be dominated by *Pocillopora verrucosa* followed by *P. meandrina* and *P. damicornis* (Fig. 8) and *Porites lutea* attached to the granite stones. In Thirumullavaram, coral growth was dominated by *P. lutea* followed by *P. lichen* among the algal settlement in the inshore areas extending from Thirumullavaram to Marathodi, covering a stretch of two kilometers (Fig. 9). Bleached and diseased corals were more prominent in this area. The rocky patch was mostly dominated by algae and corals, both live and dead. In Thangassery, heavy siltation during monsoon often caused a decline in the live coral cover. But gradual decrease of siltation in the pre-monsoon and post-monsoon months helped in the revival and growth of the existing coral colonies and formation of new colonies, especially of *P. damicornis, P. verrucosa* and *P. meandrina* (Fig. 8). During monsoon months, in Thirumullavaram also, the small rocks with poritids were covered by sand and again the colonies were found to revive during fair weather conditions. The estimated total coral cover in this area was 82% of the total transect area and the rest was dominated by thick algal growth.

Coral bleaching due to the increased sea surface temperature is reported to have impacted many of the reefs of India. Further, it has been reported to be one of the major threats, which is most pronounced in shallow waters of less than 15 m depth. In addition, several diseases are also found to affect the corals, causing large-scale mortality of some species of corals.

The coral fauna of Enayam to Kollam waters (with the exception of ahermatypic species off the south-west coast) reported here is almost in conformity with those reported by Pillai and Jasmine (1995), in structure and composition. However, these species are more related to that of the GOMBR, than to those of Lakshadweep Islands. The health and productivity of coral reefs are declining due to both environmental and man-made reasons. Hard corals are the principal builders of coral reef ecosystems; however, they are struggling to survive due to pollution, catchment clearing and climate change. The health of coral reefs is reported in terms of the level of coral cover. It is assumed that a reef with high cover is healthier than one with low cover. A high level of coral cover does not always mean a high level of species diversity, though diversity is important. Coral communities can be dominated by a single or small number of species as in Enayam and Thirumullavaram. The loss of biodiversity is irreversible and the coral destruction due to anthropogenic reasons has to be curtailed through awareness programmes. Increased fishing activities and removal of predatory fishes caused increase in the number of sea urchins, as seen in Enayam, which need to be restricted in order to encourage coral growth.

Fig.2. Encrusting zooanthids

Fig.3. Brown mussel colonies over corals at Enayam

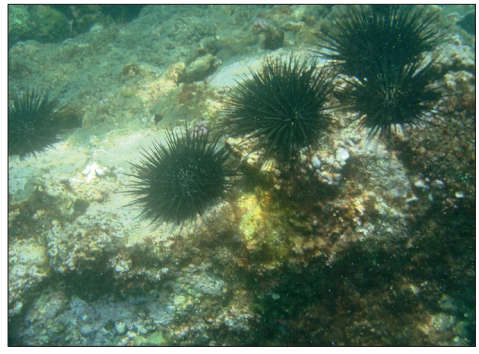


Fig.4. Sea urchins among the corals

Fig.5. Mussel removal by local fishermen

Fig.6. Coral growth in Vizhinjam

Fig.7. Mussel growth among corals at Vizhinjam

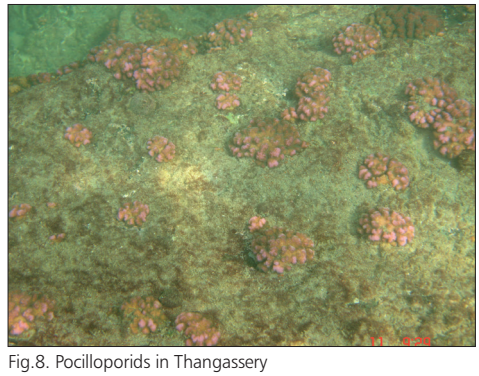


Fig.8. Pocilloporids in Thangassery

Fig.9. *Porites* sp. in Thirumullavaram

References

Alcock, A. 1893. Newly recorded corals from the Indian seas. *J. Asiat. Soc. Beng.*, 62(2): 130-149.

Alcock, A. 1898. An account of the deep sea madreporaria collected by the Royal marine survey ship "Investigator*". Investigator Reports of Indian Museum,* Calcutta, p.1-29.

Jasmine, S., Rani Mary George, Mary K. Manisseri and H. Jose Kingsly. 2009. Hard coral diversity along south-west coast of India. *J. Mar. Biol. Ass. India,* 51 (2): 189-193.

O'Leary Jennifer, K. and Timothy R. McClanahan. 2010. Trophic cascades result in large-scale coralline algae loss through differential grazer effects. *Ecology*, 91 (12): 3584.

Pillai, C. S. G. 1986. Recent corals of the south-east coast of India. *In*: P. S. B. R. James (Ed.), *Recent advances in marine biology*. Today and Tomorrow Printers and Publishers, New Delhi, p.107-201.

Pillai, C. S. G. and Jasmine, S. 1995. Scleractinian corals of erstwhile Travancore coast. *J. Mar. Biol. Ass. India,* 37 (1 & 2): 109-125.

Qasim, S. Z. and Wafar, M. V. M. 1979. Occurrence of living coral at several places along the west coast of India. *Mahasagar*, 2 (1): 53-58.

Rani, M. G. and Sandhya, S. 2007. A systematic appraisal of hard corals (family Acroporidae) from the Gulf of Mannar Biosphere Reserve South-east India. *Bull. Cent. Mar. Fish. Res. Inst.,* 50: 118 pp.

Sandhya, S., Rani, M. G. and Kasinathan, C. 2008. Biodiversity and community structure evaluation of coral reefs around Krusadai Island, Gulf of Mannar, India. *Indian J. Fish.*, 54(3): 275-282.

Scheer, G. and Pillai, C. S. G. 1983. Report on the stony corals from the Nicobar Islands. *Zoologica Stutt.*, 122: 1-75.

Veron, J. E. N. 2000. *Corals of the world*. Australian Institute of Marine Science, Australia.1: 463 pp., 2: 429 pp., 3: 490 pp.