

OPISTHOBRANCH (MOLLUSCA: GASTROPODA) FAUNA OF ROCKY REEF ECOSYSTEMS OF KERALA COAST, INDIA

BAIJU, P. T.^{1,2*}; PRABHAKARAN, M. P.³; AJAS MIRAJ, C. H.⁴; KIRAN, J.⁴ & BENNO PEREIRA, F. G.⁵

1. Center of Excellence in Sustainable Aquaculture and Aquatic Animal Health Management, Kerala University of Fisheries and Ocean Studies (KUFOS), Puthuvype, Kerala, India
2. Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, Kerala, India
3. Department of Aquatic Environment Management, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India
4. Faculty of Ocean Science and Technology, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala, India
5. Department of Zoology, University of Kerala, Thiruvananthapuram, Kerala, India

*Corresponding author: baijuaqua@gmail.com

ABSTRACT

Baiju, P.T., Prabhakaran, M.P., Ajas Miraj, C.H., Kiran, J. & Benno Pereira, F.G. (2023). Opisthobranch (Mollusca: Gastropoda) fauna of rocky reef ecosystems of Kerala Coast, India. *Braz. J. Aquat. Sci. Technol.* 27(1). ISSN 1983-9057. DOI: 10.14210/bjast.v27n1.17676. Opisthobranchs are one of the least studied marine taxonomic groups in Kerala. The present study was carried out to explore the opisthobranch diversity of rocky reefs of Kerala. The study was able to record 13 species of sea slugs belonging to 3 Orders, 8 Families, and 9 Genera. Out of 13 species recorded in the study, 5 species were identified as new to the Kerala coast. Among the 3 Orders recorded in the study, Nudibranchia was noted with the highest species contribution of 10 species and among the 8 families, the Dentrodoridae with a maximum of 3 species.

Key Words: Opisthobranchs. Rocky Reefs. Subtidal Reefs. Kerala Coast.

INTRODUCTION

Opisthobranchs are shell-less molluscan gastropods found in both marine and freshwater ecosystems, and approximately 6000 species were reported throughout the world (Wagele et al. 2008). The distribution range of these fascinating animals stretches from the Indo-Pacific tropical region and the east coast of Africa to the Hawaiian Islands. Nudibranchs belong to Phylum Mollusca, Class Gastropoda, and Subclass Opisthobranchia. Gastropod group receives more importance due to the scarcity of studies in India. Opisthobranchs are one of the least studied groups of mollusks with highly diverse body forms, cryptic coloration, diets and habitats. The works done on Opisthobranchs in India and Kerala are little and patchy, and the earlier works, dating back to the 1880s by Alder & Hancock (1864), Kelaart (1858, 1859, 1883), and Gardiner (1903). From the beginning, opisthobranch diversity studies in India were restricted to the East and Southeast Coasts. The early records of these gastropods from the West Coast of India are limited to the works of Eliot (1905 and 1909), Gideon et al. (1957), Menon et al. (1961) and Narayanan (1968). Recently, the opisthobranchs received good attention from various parts of the country by the promising studies done by renowned researchers.

The opisthobranch diversity of Indian waters has a long history, from the very pioneer study of Alder and Hancock (1864) to the very recent and comprehensive updates from the various eminent researchers in the field of marine biodiversity, including Apte (2009), Bhave & Apte, 2013; Venkataraman et al. (2015), Raghunathan et al. (2016); Apte & Desai (2017); Vadher et al. (2020).

Even though the rocky reefs are important ecosystems of the Kerala coast, biodiversity studies are rare in this regard. The early studies on opisthobranch diversity of the Kerala coast were restricted to a few attempts (Narayanan, 1968b, Valdes et al. 1999). After that, the opisthobranch diversity studies received more attention through remarkable studies done by various researchers Biju Kumar (2012), Ravinesh & Biju Kumar (2013), Chinnadurai et al. (2014), Ravinesh et al. (2014), Sheeja & Padmakumar (2014 a,b), Venkataraman et al. (2015), Apte & Desai, (2017), Baiju et al. (2016), Anu et al. (2017) and Sneha Chandran et al. (2017). The present manuscript may get more attention due to the scarcity of opisthobranch diversity studies from the coast of Kerala.

The present study was carried out in various rocky reef structures of Kerala, the southwest coast of India. The study was able to record 13 species of opisthobranchs belonging to three orders, eight families and nine genera. Out of 13 species recorded

in the study, five species were identified as new to the Kerala coast.

MATERIALS AND METHODS

Study Area

Patchy rocky reefs are present along with the intertidal areas and occasionally at sub-tidal depths of the coast of Kerala. These rocky structures offer substratum for various biotic assemblages of the marine environment. The study mainly focused on coastal and sub-tidal rocky reefs of the coast. The rocky reefs are recognized as one of the most biodiversity-rich ecosystems among the others. These ecosystems are home to various life forms ranging from algae to various groups of invertebrates and fishes. Due to the shallow nature of the coast, extensive macroalgal communities are prominent include *Bryopsis plumose*, *Caulerpa peltata*, *Caulerpa racemosa*, *Caulerpa taxifolia*, *Chaetomorpha antennina*, *Valoniopsis pachynema*, *Ulva prolifera*, *Ulva lactuca*, *Dictyota bartayresiana*, *Lobophora variegata*, *Sargassum wightii*, *Corallina officinalis* and *Kappaphycus alvarezii*. The algal diversity of the rocky reefs will attract and supports various groups of invertebrates and fishes.

Vizhinjam is located at 08°22'36" N and 76°59'32" E. The reef substratum is typically granite boulder rocks that are covered with mussel beds (*Perna perna*). The mussel beds provide secondary hard substratum for many marine animals.

Thirumullavaram is situated along the Kollam coast (08°3'49.2" N and 76°33'05.1" E in the Kollam district of Kerala state. The shore substratum is partially formed by the combination of laterite rocks and sand and subjected to heavy wave action.

Velliyamkallu (Thikkodi, Kozhikode) is considered a subtidal rocky reef, a massive rock that has witnessed many battles in pre-independent India and was once a vantage point for the Marakkar to attack the invading Portuguese. The rocky island is situated between 11°66'32.97" N and 75°54'16.81" E, 10 to 14 km away from the Thikkodi coast. Scientifically it can be defined as "Marine Nearshore Supra tidal Rocky Reef. This zone includes areas above Mean Higher High Water (MHHW) that are affected by wave splash and overwash but does not include areas affected only by wind-driven spray. This zone is subjected to periodic high wave energy, exposure to air and often to variable salinity. The name 'Velliyamkallu' means the white rock because it looks white due to the bird's droppings.

Methodology

Sampling was done from the rocky reef areas of the coast. Live specimens were collected by snorkeling

and with the aid of SCUBA, handpicked specimens from the intertidal areas, inshore rocky reef, reef platforms, mussel beds, and subtidal reef areas of Vizhinjam, Thirumullavaram, and Velliyamkallu (Thikkodi, Kozhikode) of the Kerala coast between the depth range of 2 to 10 m. Sample collection was carried out from November 2018 to March 2019. These rocky reefs are partially formed by rocks and sand substratum and subjected to heavy wave action.

Species description, geographic location, and photographs of the live specimen are given. Collected specimens were photo-documented live whenever possible and preserved in 90% ethyl alcohol for further taxonomical studies. The opisthobranchs were identified with key references such as Alder & Hancock (1864), Apte (2009, 2012), Debelius & Kuitert (2007), Yonow (2008, 2012), Gosliner et al. (2008, 2015), Venkataraman et al. (2015), and Apte & Desai (2017). The material was identified following descriptions provided by Kay & Young (1969), Gosliner et al. (2008) and Yonow (2008).

RESULTS AND DISCUSSION

Present study was able to record 13 species belonging to the 9 Genera, 8 Families, and 3 Orders. Among these, five of them are noticed as a new record from the Kerala coast (Table 1). Of the 3 Orders reported in the study, Nudibranchia with maximum species representation of 10 (77%), followed by Pleurobranchida with 2 (15%) species, and Sacoglossa was the least in this context of 1 (8%) species (Figure 1). While considering the family-wise species distribution (Figures 2 and 3, and Table 3), Dendrodorididae was noticed with the highest species, the contribution of 3 (23%), followed by Facelinidae, Chromodorididae, and Discodorididae with 2 (15%) species in each and Pleurobranchidae, Bornellidae, Phyllidiidae and Plakobrachidae with 1 (8%) species on each.

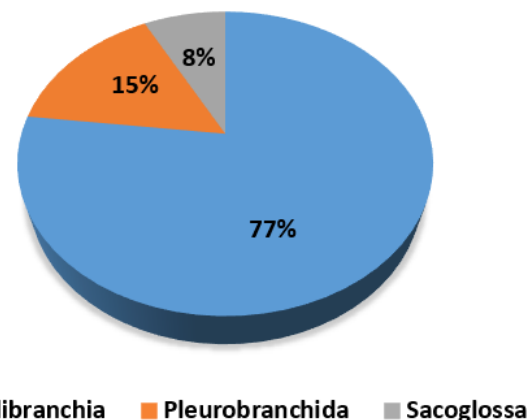


Figure 1 - Order-wise species diversity of Opisthobranchs.

Table 1 - Opisthobranch fauna of rocky reefs of Kerala.

Order	Family	Genus	Species	Present Record	Previous Record from Kerala
Pleurobranchida	Pleurobranchidae	Berthellina	<i>Berthellina citrina</i> (Rüppell & Leuckart, 1828)	Vizhinjam	Sheeja and Padmakumar (2014b), Anu et al (2017), Apte & Desai (2017)
	Bornelliidae	Bornella	<i>Bornella stellifera</i> (Adams & Reeve, 1848)	Vizhinjam	Apte & Desai (2017)
	Facelinidae	Moridilla	<i>Moridilla brockii</i> (Bergh, 1888)	Vizhinjam	Anu et al. (2017)
		Phidiana	<i>Phidiana militaris</i> (Alder & Hancock, 1864)	Vizhinjam	Ravinesh & Kumar (2013), Apte & Desai (2017)
	Chromodorididae	Goniobranchus	<i>Goniobranchus conchylatus</i> (Yonow, 1984)	Vizhinjam	Sneha Chandran et al. (2017)
<i>Goniobranchus cavae</i> (Eliot, 1904)			Velliyamkallu	Sneha Chandran et al. (2017)	
Nudibranchia	Dendrodorididae	Dendrodoris	<i>Dendrodoris fumata</i> (Rüppell & Leuckart, 1830)	Vizhinjam	Baiju et al. (2016), Anu et al. (2017), Apte & Desai (2017)
			<i>Dendrodoris tuberculosa</i> (Quoy & Gaimard, 1832)	Thirumullavaram	New to Kerala coast
			<i>Dendrodoris krusensternii</i> (Gray, 1850)	Velliyamkallu	Sneha Chandran et al. (2017)
	Phyllidiidae	Phyllidia	<i>Phyllidia varicosa</i> (Lamarck, 1801)	Velliyamkallu	New to Kerala coast
	Discodorididae	Sebadoris	<i>Sebadoris fragilis</i> (Alder & Hancock, 1864)	Velliyamkallu	New to Kerala coast
<i>Sebadoris nubilosa</i> (Pease, 1871)			Vizhinjam	New to Kerala coast	
Sacoglossa	Plakobanchidae	Elysia	<i>Elysia grandifolia</i> (Kelaart, 1858)	Velliyamkallu	New to Kerala coast

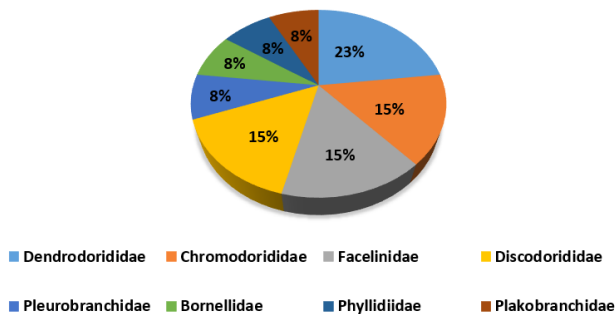


Figure 2 - Family-wise species diversity of opisthobranchs.

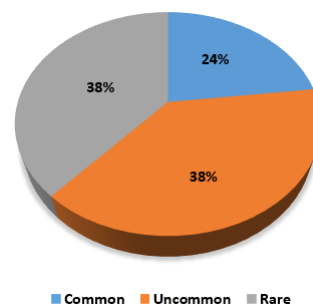


Figure 4 - Species abundance of opisthobranchs observed.

While categorizing the species according to the number of specimens observed in each observation, these thirteen species were grouped into 3 categories as common, rare and uncommon. Out of 13 species observed, uncommon 38% (5 species), rare 38% (5 species), and regular 24% (3 species) (Figure 4).

Comprehensive studies on the biodiversity of marine slugs were restricted to a few eminent researchers in the country. Among these, a few of them need to be discussed. Opisthobranchs are found in both marine and freshwater ecosystems and its approximately 6000 species were reported throughout the world (Wagele et al. 2008). From the beginning, Opisthobranch diversity studies in India were restricted to the East and Southeast coast. Records on these gastropods from the West Coast of India are limited to the works of Eliot (1905 and 1909), Gideon et al. (1957), Menon et al. (1961), and Narayanan (1968). Venkataraman et al. (2015) provided the identification of Opisthobranch species, based on the collective experience of the authors who have been working for several years on marine biodiversity. Apte & Desai (2017) detailed study on about 361 species of sea slug species of Indian waters with their detailed descriptions. Vadher et al. (2020)

validated the total sea slug fauna of the Gujarat coast with a report of 95 species belonging to 62 genera and 29 families.

Studies on opisthobranch diversity the Kerala coast were limited to a few studies. Narayanan (1968 b) reported the three opisthobranchs to belong to Pleurobranchidae (*Pleurobranchus (Susania) ceylonicus*), Doridae (*Platydorid tabulate*) and Hexabanchidae (*Hexabanchus flammulatus*) collected from Thankassery Coast (Kerala State) on the South-west Coast. Valdes et al. (1999), in that study reported one of the species, *Chromodoris mandapamensis* was collected from Muttom, Kerala. Ravinesh & Bijukumar (2013) mentioned six Opisthobranch species in the study of intertidal biodiversity associated with the natural rocky shore and sea wall of the Kerala coast. Chinnadurai et al. (2014) recorded the long-tailed sea slug *Stylocheilus longicauda* for the first time from the Southwest coast of India. This was the first record of the long-tailed pelagic sea slug *Stylocheilus longicauda* (Gastropoda: Opisthobranchia) from the Arabian Sea off Narakkal, Vypeen Island, Kochi, Southwest coast of India. Ravinesh et al. (2014) recorded as first time the sea slug species *Polybranchia orientalis* (Sacoglossa: Caliphyllidae) from the Southwest

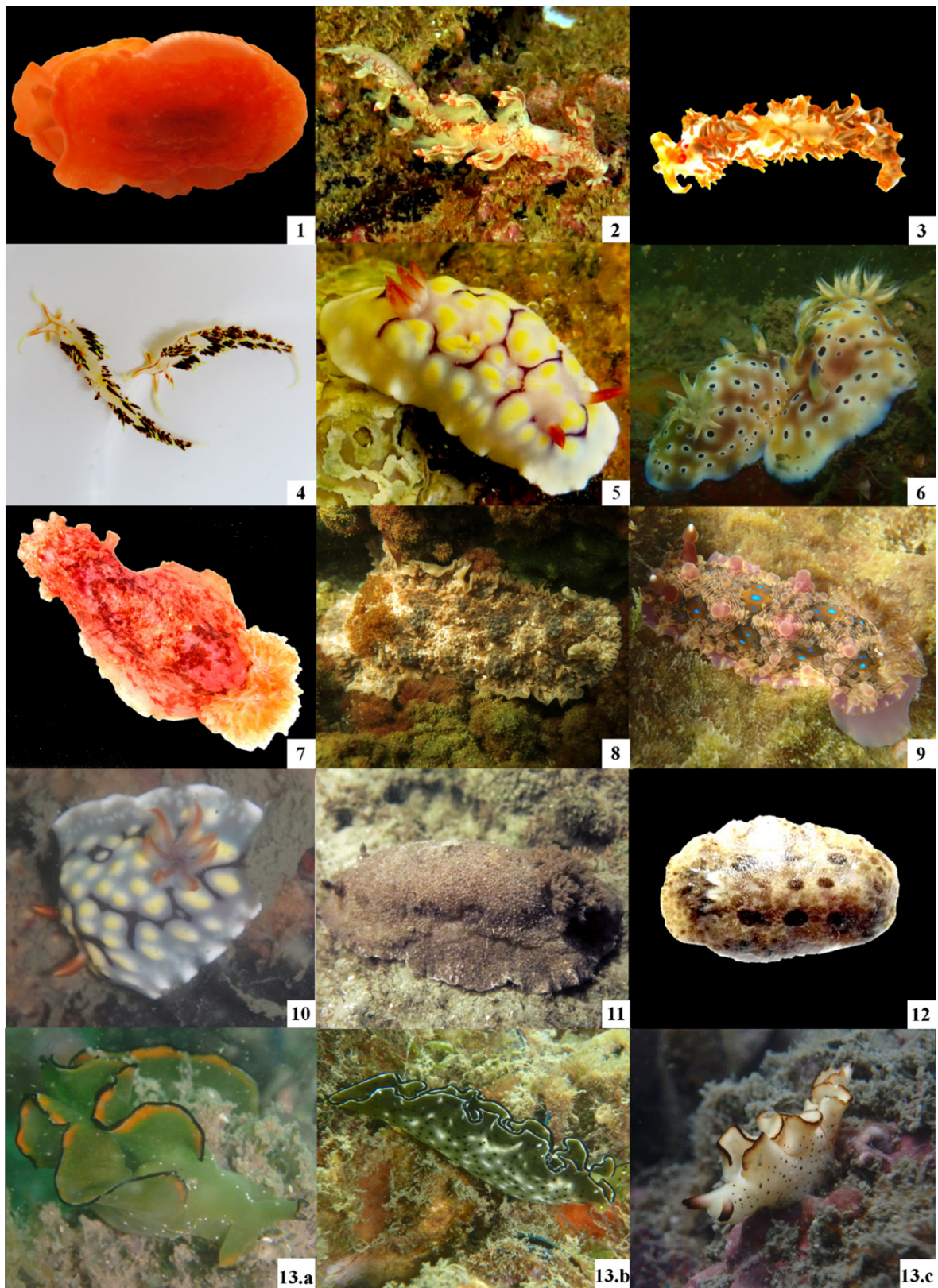


Figure 3. 1. *Berthellina citrina*; 2. *Bornella stellifera*; 3. *Moridilla brockii*; 4. *Phidiana militaris*; 5. *Goniobranchus conchylitatus*; 6. *Goniobranchus cavae*; 7. *Dendrodoris fumata*; 8. *Dendrodoris tuberculosa*; 9. *Dendrodoris krusensternii*; 10. *Phyllidia varicosa*; 11. *Sebadoris fragilis*; 12. *Sebadoris nubilosa*; 13.a,b,c. *Elysia grandifolia*.

Figure 3 - Species recorded in rocky reefs of Kerala.

Table 2 - Taxonomic description of species recorded in rocky reefs of Kerala.

Phylum	Class	Order	Family	Genus	Species	Observed Locality	Distribution in World	Distribution in India	Size (mm)	Taxonomic Description	Status		
Mollusca	Gastropoda	Nudibranchia	Plakobranchoidea	Family Plakobranchoidea	<i>Berthellina</i>	<i>Berthellina citrina</i> (Rüppell & Leuckart, 1828) (Figure 3.1)	Mussel beds of Vizhinjam (South Kerala coast)	Philippines, French Polynesia	Lakshadweep Islands and Kerala	35 - 40	It is a small slug. The species with dark orange color body and light orange foot with a gelatinous texture. The species are mostly found in rocky reef habitats of protected to exposed sites, including rock pools and under rocks on lagoon reefs and pinnacles.	Common	
						<i>Bornella</i>	<i>Bornella stelfifera</i> (A. Adams & Reeve, 1848) (Figure 3.2)	Mussel beds of Vizhinjam (South Kerala coast)	Indo-West Pacific: South China Sea, Australia, Korea, Indian Ocean, South Africa, East Africa, Philippines, Arafura Sea, China Sea, Japan, Hong Kong, Tahiti, New Caledonia, Taiwan, Thailand, Marshall Islands, and Papua New Guinea (Poia et al. 2009).	Ratnagiri and Revdianda (Maharashtra), Gulf of Kutch (Gujarat), Andaman and Nicobar Islands, and Kerala.	22	The slug with translucent cream-white in color with a network of orange markings on all the body and scattered sub-epidermal opaque white granules. The color pattern extends to the rhinophore sheaths. The lobe-like oral tentacles, rhinophoral papillae, and dorsolateral processes are translucent white and have a subapical orange ring. Posterior to the rhinophores, there are six pairs of dorsolateral processes. The rhinophore sheath has tall and stalked with branches distally into elongate papillae.	Rare
							<i>Moridilla brocki</i> (Bergh, 1888) (Figure 3.3)	Mussel beds of Vizhinjam (South Kerala coast)	Tropical Indo-West Pacific	Gulf of Mannar, Ritchies Archipelago South Andaman and West coast of India (Kerala)	45	The slug can be identified by the bright red tips of the cerata. The slug species are mostly able to see under an overhanging rock in less than 1 m of water. <i>Moridilla brocki</i> is characterized by a translucent orange foot and clusters of orange cerata. There is a central row of large rolled cerata, which are in some specimens, translucent at the base, then white, and then orange. The rhinophores are orange, and translucent at the base. The oral tentacles are translucent orange, then translucent white in the last third, then orange again. In some specimens, there is a broad white band at the dorsal midline between the cerata clusters, going from the orange tip of the tail to the rhinophores, then to the upper half of the oral tentacles. When disturbed <i>M. brocki</i> unrolls the large rolled cerata and points them at the source of the disturbance.	Uncommon
						<i>Phidiana</i>	<i>Phidiana militaris</i> (Alder & Hancock, 1864) (Figure 3.4)	Mussel beds of Vizhinjam (South Kerala coast)	Malaysia, Papua New Guinea, Indo-West Pacific	Widespread on the East and West coast of India, Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Andaman	15 - 17	Characterised by the bright orange median line on the head which forks anteriorly, with a branch running up the anterior edge of each oral tentacle. Another orange line runs along the posterior edge of each oral tentacle and then runs along each side of the body below the cerata. The oral tentacles, rhinophores, tentacular foot corners, and cerata are all tipped with yellow, and there is a broad orange band on the rhinophores. Originally described in India, it has been reported two or three times. The only other record is from a photo that seems to be of this species from Hong Kong.	Common
							<i>Goniobranchus conchyliatus</i> (Yonow, 1984) (Figure 3.5)	Mussel beds of Vizhinjam (South Kerala coast)	Indo-Pacific: Sri Lanka (Yonow, 1984), Burma, Reunion Island (Yonow, 2008), Thailand, Maldives, Myanmar (Rudman, 2000), Andaman and Nicobar Islands (Sreeraj et al. 2012 a, 2013, Shaktivel et al. 2014, Apte and Desai, 2017), and Indian Ocean (Gosliner et al. 2015), Goa (Apte and Desai, 2017).	Gulf of Mannar coast, Goa, Andaman and Nicobar Islands	8 - 9	The gills of this Chromodoris are lined with red or reddish-orange. The rhinophores are uniformly red or reddish-orange with a white stalk. The body is pale violet with rounded areas of creamy yellow pustules and deeper violet and red markings. These marks follow the contours of bilaterally symmetrical yellow pustules. The gills, usually 8 simple pinnate structures, are tricolored: the upper half is red or orange (both rachs and pinnae), and the lower half has a pale violet internal rachs and anus area with white pinnae.	Rare
						<i>Dendrodoris</i>	<i>Goniobranchus cavae</i> (Eliot, 1904) (Figure 3.6)	Vellymkallu, Subtidal rocky reef of Kozhikode Coast, Kerala.	Tropical Indian Ocean (Indonesia, Thailand, Red Sea, Maldives, South Africa), India: Ritchies Archipelago.	South Andaman.	45	They all have large purple or purple-brown spots or marks, ringed with white, often reticulate brownish background, and a purple border. The mantle base is lined with a blue tint, and the rhinophore (are the horn-like structures that project from the front of the sea slug. "Rhino" means nose and "phore" means carrier. They are functioning as the organ for the sense of smell), gills are also lined with blue color.	Uncommon
							<i>Dendrodoris fumata</i> (Rüppell & Leuckart, 1830) (Figure 3.7)	Mussel beds of Vizhinjam (South Kerala coast).	Gujarat, Tamil Nadu, Andhra Pradesh, Andaman Islands, Nicobar Islands.	Tropical to warm temperate Indo-West Pacific.	65	The species is characterized by having an irregular color pattern of dark blotches over a reddish ground body color. Body dorso-ventrally flattened, soft and slimy, with a broad and smooth mantle, and thin and wavy mantle edge. Head extremely small, bearing a pore-like mouth. Rhinophores are bulbous, lamellated, with thick stalks. Rhinophora pockets with simple, thin, slightly elevated rims. Branchial plumes extended over the posterior part of the dorsum, their circle interrupted by the anal papilla. Each gill is finely subdivided.	Rare
							<i>Dendrodoris tuberculosa</i> (Quoy & Gaimard, 1832) (Figure 3.8)	Thirumullavaram coast, Kollam (South Kerala coast).	The Red Sea to Australia, Hawaii, Japan, South Pacific.	Lakshadweep, Andhra Pradesh.	180	The largest sea slug species recorded in the study. The species was observed while grazing over the <i>Gayralia fibrata</i> algal mat. It is also seen in shallow pools and undersides of the rocks. They prefer muddy reefs with turbid water. These slugs produce a powerful toxin when they are disturbed and can make a severe burning sensation on the skin. The surface is extremely warty and dark brown with white patches. The lower part of the body has white spots, which is diagnostic for the species. Rhinophores are stalked. The stalk is dark brown, and the rhinophores are light brown in color. Gills are light brown, leafy, and highly branched.	Rare
							<i>Dendrodoris krusensternii</i> (Gray, 1850) (Figure 3.9)	Vellymkallu, Subtidal rocky reef of Kozhikode Coast, Kerala.	Throughout the Indo-West Pacific. Tropical and warm temperate Indo-West Pacific.	Ritchies Archipelago, South Andaman.	45	The species are mostly seen on seaweeds on rocky reef substratum. Broad, soft body with lots of bumps and pimples and distinctive electric blue spots. The tubercles are large and pink-tipped. The blue spots are more easily noticeable than the black spots, which are more numerous. The mantle is pink-coloured with thick club-like rhinophores, and large feathery gills. The animal is generally beige with a purplish or pinkish tinge.	Common
						<i>Phyllidia</i>	<i>Phyllidia varicosa</i> (Lamarck, 1801) (Figure 3.10)	Vellymkallu, Subtidal rocky reef of Kozhikode Coast, Kerala.	Mauritius, Seychelles, Red Sea, Sri Lanka to Hawaii, Japan, Africa, Papua New Guinea, Thailand, Malaysia, Australia.	Lakshadweep, Andaman.	60	It is a large slug species like all other members of the family. The body surface presents highly yellow warts. The species shows remarkable variation in color and body pattern according to the substratum provided. The rhinophores and dorsal gills are light orange in color. The foot sole has a broken black median line.	Uncommon
<i>Sebadoris fragilis</i> (Alder & Hancock, 1864) (Figure 3.11)	Vellymkallu, Subtidal rocky reef of Kozhikode Coast, Kerala.	Indian Ocean, Australia, Philippines, Red Sea, Japan, South Africa, Thailand, Hawaii, New Caledonia.	Ratnagiri (Maharashtra), Gulf of Mannar (Tamil Nadu), Waltair (Andhra Pradesh).	77	The second largest sea slug species recorded in the study is usually seen in shallow pools and under rocks. It prefers rocky substrate. Brown mottling is distinct on the foot. The species can autotomize large parts of the mantle or sometimes the entire mantle skirt if disturbed. Gills are highly frilled. The species was re-designated as <i>S. fragilis</i> by Dayrat (2010) in his comprehensive review of basal discodorids.		Uncommon						
<i>Sebadoris</i>	<i>Sebadoris nubilosa</i> (Pease, 1871) (Figure 3.12)	Mussel beds of Vizhinjam (South Kerala coast).	Tropical Indo-West Pacific.	Andaman and Nicobar Islands, Gulf of Mannar.	45	This species can be characterized externally by its relatively softy mantle, covered with softly pointed tubercles, mottled with light brown colors, and a few small dark brown patches. The underside of the mantle is translucent white with scattered large brown spots. The specimen was recorded from the mussel beds of the Vizhinjam coast while snorkeling. As per the ecology, the species may be observed in intertidal to the shallow subtidal, rocky reef, sandy sediment, and under rocks.	Rare						
	<i>Elysia grandifolia</i> (Kelaart, 1858) (Figures 3.13a, 3.13b and 3.13c)	Vellymkallu, Subtidal rocky reef of Kozhikode Coast, Kerala.	South Africa to the Maldives; Australia to Hawaii, the Red Sea to Polynesia, Norfolk Is. (South Pacific), Indonesia, Taiwan, French Polynesia, Circumtropical.	Gulf of Mannar, Gulf of Kutch, Andaman, and Nicobar.	20 - 25	Body long with a pair of very large 'wings' (called parapodia). The overall body color of the slug may be shades of green, yellow, or even white. The species shows remarkable color variation. It is believed that the color depends on how much and what seaweed is in the animal's digestive system. But all have a black margin on the edge of the parapodia, with an orange or yellow margin next to the black. There is a pair of long thick tentacles with tips in the same color banding as the body edge. The body has either black or white spots. The parapodia are often held in ruffles so that the animal resembles seaweed. Found feeding on <i>Bryopsis plumosa</i> (Jensen, 1981) and <i>Caulerpa racemosa</i> .	Common						

coast of India. Sheeja & Padmakumar (2014 a,b) recorded the *Plakobranchnus ocellatus* VanHasselt, 1824 and *Berthellina citrina* (Rüppell & Leuckart, 1828) (Mollusca: Gastropoda) from the Kerala coast, India. In this, *Berthellina citrina* (Rüppell & Leuckart, 1828) was reported for the first time from the Southwest coast of India. Sneha Chandran et al. (2017) reported 15 species belonging to 4 families through the countries' first citizen science initiative, which includes two new records to India and five new records to the West coast of India. An extensive study was done by Yogesh et al. (2019) to explore the opisthobranchs diversity and associated faunal community in and around the Gulf of Mannar Marine Biosphere Reserve (GoMBR), South-east coast of India, resulting in eight species of Opisthobranch which includes few new records in the South-east coast of India. Vadher et al. (2020) validated the total sea slug fauna of the Gujarat coast with a report of 95 species belonging to 62 genera and 29 families.

By perusing the available literature on previous records about Opisthobranch diversity from Kerala's coastal water. The studies on opisthobranch diversity on the Kerala coast were limited to a few studies during the two different periods. The most pioneer study on Opisthobranch diversity from the Kerala coast done by Narayanan (1968 b), reported the three opisthobranchs belong to Pleurobranchidae (*Pleurobranchus (Susania) ceylonicus*), Doridae (*Platydorid tabulate*) and Hexabranchnidae (*Hexabranchnus flammulatus*) collected from Thankassery Coast (Kerala State) on the Southwest Coast. After a long period, Valdes et al. (1999), reported three species of opisthobranchs along with the redescription of *Chromodoris trimarginata* (Winckworth, 1946) in that study, one of the species, *Chromodoris mandapamensis* was collected from Muttom, Kerala. Ravinesh & Bijukumar (2013), mentioned six opisthobranch species in the study of intertidal biodiversity associated with the natural rocky shore and sea wall of the Kerala coast. Ravinesh et al. (2014), recorded the sea slug *Polybranchia orientalis* (Sacoglossa: Caliphyllidae) from the coasts of Vizhinjam, Kovalam, and Thirumullavaram for the first time. Sheeja and Padmakumar (2014 a, b) recorded two species belonging to Pleurobranchomorpha (*Berthellina citrina* (Rüppell & Leuckart, 1828) (Mollusca, Gastropoda)) and Plancobranchna (*Plakobranchnus ocellatus Hasselt, 1824* (Sacoglossa, Opisthobranchia)). Chinnadurai et al. (2014) recorded the long-tailed sea slug *Stylocheilus longicauda* for the first time from the Southwest coast of India. This was the first record of long-tailed pelagic sea slug *Stylocheilus longicauda* (Gastropoda: Opisthobranchia) from the Arabian Sea off Narakkal, Vypeen Island, Kochi, Southwest coast of India. Baiju et al. (2016) reported

six species of opisthobranchs from the coast of Vizhinjam while studying the biodiversity associated with mussel fishery. Anu et al. (2017) recorded four opisthobranch species as an associated fauna of mussel beds (*Perna perna*) of Vizhinjam, South coast of Kerala, India, including two new records to Kerala coast. Sneha Chandran et al. (2017) reported 15 species of opisthobranchs to belong to 4 families through the countries' first citizen science initiative, which includes two new records to India and five new records to the West coast of India. Present study recorded thirteen species of opisthobranchs and taxonomically identified under 3 Orders, 8 Families, and 9 Genera. The study specifically recognized the presence of eight new records on the Kerala coast.

The present study results prove that rocky reef ecosystems are under-exploited in the sense of Opisthobranch diversity. In-depth studies are required to assess the diversity of one of the least studied animals from the coast. Even in the short span of the study period, we were able to record thirteen species of sea slugs belonging to 8 Families and 9 Genera.

CONCLUSION

Compared with other areas of marine biodiversity documentation, the knowledge about the opisthobranchiate faunal diversity of the Indian subcontinent is too little to interpret. The research gap will become more prominent in the Kerala scenario. A little research was carried out on this group of animals. The recent and sudden changes in the coastal ecology are due to the pressure from both natural and anthropogenic sources. The biodiversity of coastal ecosystems rocky reefs is subjected to silent loss of biodiversity. The concern is that we may lose many species without being aware of their existence in our coastal rocky reef ecosystems. The present attempt was able to record 13 species of opisthobranchs belonging to 3 orders, 8 families and 9 genera. This manuscript deals with the strictly rocky reef ecosystem-based biodiversity study. Present study results prove that rocky reef ecosystems are under-exploited in the sense of opisthobranch diversity.

ACKNOWLEDGEMENTS

We take this opportunity to express our sincere thanks to Dr. Ravinesh, R. who helped us identify a few species. We also express our sincere thanks to SCUBA Kerala, Calicut to provide diving equipment for sample collection. Special thanks to Rahul and Ranjith for their valuable support in the field work and found some species.

REFERENCES

- Alder, J.; & Hancock, A. 1864. Notice of a collection of nudibranchiate Mollusca made in India by Walter Elliot Esq., with descriptions of several new genera and species. *Trans. Zool. Soc, London*, 5: 113-147.
- Angel Valdes.; Ernesto Mollo & Jesus Ortea, 1999. Two New Species of Chromodoris (Mollusca, Nudibranchia, Chromodorididae) from Southern India, with a Re description of Chromodoris trimarginata (Winckworth, 1946). *51(13)*: 461-472.
- Anu, S.; Ravinesh, R.; Binil Shijith, V. & Biju Kumar, A. 2017. Biodiversity Associated with the Mussel Beds of Vizhinjam Coast, Kerala, India. *Journal of Aquatic Biology & Fisheries*. 5: 36-53.
- Apte, D.; 2009. Opisthobranch Fauna of Lakshadweep Islands, India, with 52 New Records *Journal of the Bombay Natural History Society*. 106(2): 162-175.
- Apte, D.; 2012. Field guide to the marine life of India. 1st edition. Mumbai: Stusa Mudra Private Limited.
- Apte, D.; & Desai, D. 2017. Field Guide to sea slugs of India. Bombay Natural History Society, Mumbai, 459p.
- Baiju, P.T.; Benno Pereira, F.G.; Jayaprakas, V. & Prabhakaran, M.P. 2016. Biodiversity associated with mussel fishery at Vizhinjam Arabian Sea, South Kerala. *J. Bio. & Env. Sci*. 9(3): 73-89.
- Bhave, V.; & Apte, D. 2013. Current status of Indian opisthobranch fauna. In: K. Venkataraman, C. Sivaperuman & C. Raghunathan (Eds.). *Ecology & Conservation of Tropical Marine Faunal Communities*. Springer, London: 63-79p.
- Biju Kumar, A.; 2012. Marine animals of Kerala coast (Malayalam). Kerala State Biodiversity Board, Thiruvananthapuram, India, 304p.
- Chinnadurai, S.; Bhave, V.; Apte, D. & Mohamed, K.S. 2014. First record of long-tailed pelagic sea slug *Stylocheilus longicauda* (Gastropoda: Opisthobranchia) from southwest coast of India *J. Mar. Biol. Ass. India*. 56(2): 81-84.
- Dayrat, B.; 2010. A monographic revision of basal discodorid sea slugs (Gastropoda, Opisthobranchia, Nudibranchia, *Doridina*). *Proceedings of the California Academy of Sciences*. 4(61): 1-403, 382.
- Debelius, H.; & Kuitert, H.R. 2007. Nudibranchs of the World. IKAN-Unterwasser archiv, Frankfurt, 360p.
- Eliot, C.; (1905). Nudibranchs of the Indo-Pacific Islands. Notes on a collection dredged near Karachi and Maskat. *Journal of Conchology*. 11(8): 237-256.
- Eliot, C.; 1909. Report on nudibranchs collected by Mr. James Hornell at Okhamandal in Kattiawar in 1905-1906. In: Report to government of Baroda on the marine zoology of Okhamandal. 1: 137-145p.
- Gardiner, J.S.; 1903. The fauna and geography of the Maldives and Laccadive Archipelagoes. 2: 1080p. Cambridge University Press.
- Gideon, P.W.; Menon, P.K.B.; Rao, S.R.V. & Jose, K.V. 1957. On the marine fauna of the Gulf of Kutch: A preliminary survey. *J. Bombay Nat. Hist. Soc.*, 54: 690-706.
- Gosliner T.M.; Behrens D.W.; & Valde's, A. 2008. Indo-Pacific nudibranchs and sea slugs. A field guide to the world's most diverse fauna. Washington: Sea Challengers Natural History Books.
- Gosliner, T.M.; Valdés, A. & Behrens. D.W. 2015. Nudibranch and Sea Slug Identification-Indo-Pacific. New World Publications, Jacksonville, Florida, 408p.
- Kay, E.A.; & D.K. Young 1969. The Doridacea (Opisthobranchia; Mollusca) of the Hawaiian Islands. *Pac. Sci*. 23: 172-231p.
- Kelaart, E.F.; 1858. Description of new and little known species of Ceylon nudibranchiate molluscs and zoophytes. *Journal of the Ceylon Branch of the Royal Asiatic Society, Colombo*. 3: 84-139p.
- Kelaart, E.F.; 1859. Descriptions of new and little-known species of Ceylon nudibranchiate molluscs. *Annals and Magazine of Natural History Series*. 3(3): 291-304.
- Kelaart, E.F.; 1883. New and little known species of Ceylon nudibranchiate molluscs, and zoophytes. *Journal of the Ceylon Branch of the Royal Asiatic Society*. 1856-613(9): 76-125.
- Menon, P.K.B.; Gupta, A.K.D. & Gupta, D. D. 1961. On the marine fauna of the Gulf of Kutch. *J. Bombay Nat. Hist. Soc.*, 58: 475-494.
- Narayana, K.R.; 1968. On three opisthobranchs from south west coast of India. *J. Mar. Biol. Ass. India*. 10(2): 337-380.
- Narayanan, K.R.; 1968b. On three opisthobranchs from the south-west coast of India. *J. Mar. Biol. Ass. India*. 10: 377-380.
- Raghunathan, C.; Sudhanshu, D. & Kailash, C. 2016. Diversity of opisthobranchs in coastal waters of India. In: Kailash Chandra, Raghunathan, C; Tamal Mondal & Dash, S. (eds.) *Current status of marine faunal diversity of India edited*. Zoological Survey of India, Kolkata, 525p.
- Ravinesh, R.; & Bijukumar, A. 2013. Comparison of inter tidal biodiversity associated with natural rocky shore and sea wall: A case study of Kerala coast India. *Indian J. Mar. Sci*. 42(2): 223-235.
- Ravinesh, R.; Jabir, T.; Biju Kumar, A. & Hatha, A.A.M. 2014. First record of sea slug *Polybranchia orientalis* (Sacoglossa: Caliphyllidae) from the south-west coast of India. *Mar. Biodivers. Rec.*, 7: 1-2.

- Shaktivel, G.; Mohan, H. & Ganesh, T. (2014). Additions to the Knowledge of Shallow Water Opisthobranch Molluscs. *International Journal of Science and Nature* 5(2): 249–253.
- Sheeja, M.S.; & Padma Kumar, K. 2014a. New Record of *Plachobranchnus ocellatus* Van Hasselt, 1824 from Kerala coast, India. *Indian J. L. Sci.* 4(1): 1-5.
- Sheeja, M.S.; & Padmakumar, K. 2014b. First report of the Pleurobranchomorpha, *Berthellina citrina* (Rüppell & Leuckart, 1828) (Mollusca: Gastropoda) from Southwest coast of India. *Journal of Biodiversity and Environmental Sciences.* 5: 229-233.
- Sneha Chandran, B.K.; Shrinivaasu, S.; Ravinesh, R.; Robert, P.; Aneesha, A.B. & Biju Kumar, A. 2017. Opisthobranch (Mollusca: Gastropoda) fauna of Kerala, India: A citizen science initiative. *J. Mar. Biol. Ass. India.* 59(1): 49-58.
- Sreeraj, C.R.; Sivaperuman, C. & Raghunathan, C. 2012a. Report on twelve newly reported Opisthobranchs (Opisthobranchia, Gastropoda) from Andaman and Nicobar Islands, India. *Int. J. Ocean Mar Ecol Syst.* 1(2): 50-59.
- Sreeraj, C.R.; Sivaperuman, C. & Raghunathan, C. 2013. Species diversity and abundance of opisthobranch Molluscs (Gastropoda: Opisthobranchia) in the coral reef environments of Andaman and Nicobar Islands, India. K. Venkataraman et al. (eds.), *Ecology and Conservation of Tropical Marine Communities.* Ch- 6, 81-106p.
- Vadher, P.; Kardani, H. & Beleem, I. 2020. An annotated checklist of sea slug fauna of Gujarat coast, India. *Journal of Threatened Taxa.* 12(8): 15835–15851.
- Valdes, A.; Mollo, E. & Ortea, J.A. 1999. Two new species of *Chromodoris* (Mollusca: Nudibranchia: Chromodorididae) from southern India with a re description of *Chromodoris trimarginata* (Winckworth 1946). *Proc Calif Acad. Sci.* 51: 461-472.
- Venkataraman, K.; C. Raghunathan, R. Raghuraman & S. Dixit. 2015. Fascinating Sea slugs and Flatworms of Indian seas. *Zoological Survey of India, Kolkata,* 149p.
- Wagele, H.; Klussmann-Kolb, A.; Vonnemann, V. & Medina, M. 2008. Heterobranchia I. The Opisthobranchia. In: Ponder, WF. & Lindberg, DR. (eds.) *Phylogeny and evolution of the Mollusca,* University of California Press, Berkeley, 385-408p.
- Yogesh Kumar, J.S.; Venkataraman, C.; Shrinivaasu, S. & Raghunathan, C. 2019. New records of Opisthobranchs (Mollusca: Gastropoda) from Gulf of Mannar, India. *Indian Journal of Geo Marine Sciences.* 48(10): 1508-15.
- Yonow, N.; 1984. Doridacean nudibranchs from Sri Lanka, with descriptions of four new species. *Veliger.* 26: 214-228.
- Yonow, N.; 2008. *Sea slugs of the Red Sea.* Sofia: Pen soft Publishers.
- Yonow, N.; 2012. Opisthobranchs from the western Indian Ocean, with descriptions of two new species and ten new records Mollusca, Gastropoda. *ZooKeys,* 197: 1-129