

Distribution of Intertidal Molluscs (Gastropoda, Bivalvia) from selected sites of North Andaman Island, India

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Abstract

Molluscs are benthic macro invertebrates and play an important role in the intertidal ecosystem. The present study aimed to assess the distribution of Molluscan fauna in the intertidal regions of North Andaman Island. The intertidal habitat of the study areas mainly composed of rocky, sandy and muddy regions. In this study, we have collected both live and dead shells from all study sites, and 102 species of gastropods and 17 species of bivalves were recorded. Gastropods are commonly occurring in various substrates such as beneath rocks, muddy, sandy, whereas most of bivalves found at soft substratum and as burrowers on coral and rocks. Among seven study sites, the species richness was highest in Kalipur (82 species), followed by Ram Nagar (20 species). High similarity was observed between Durgapur and Ross Island (74%) and lowest between Ram Nagar and Aerial Bay (28%). A total 89 species were recorded at rocky substratum followed by 58 species in sandy and only 20 species found at muddy substratum. Habitat heterogeneity, geographical distance, physiochemical factors and ecological communities could characterize species composition and distribution among intertidal study areas.

Keywords: Andaman, Benthic invertebrates, habitat, Sea shells, species composition

Introduction

Molluscs are diverse group and second largest phyla after arthropoda in invertebrates including the class Gastropoda, Bivalvia, Aplacophora, Polyplacophora, Scaphopoda and Cephalopoda (Wong and Arshad, 2011; WoRMS, 2020). They are ecologically adapted to any typical environments such as marine (intertidal to deepest ocean), freshwater and land (low to high altitude regions) (Ellen *et al.*, 2008; Rosenberg, 2014). Molluscs constitutes of an important component in marine biodiversity and recorded from various diverse habitats of Andaman and Nicobar Islands (Subba Rao, 2003). They play potential role in ecological sustainability as well as pharmaceutical and economic perceptions. They are extensively important faunal communities in benthic ecosystem through functions related to degradation of organic detritus as they consume living and decaying algae and plant material (Darwin and Padmavati, 2017). These animals acts as pollution level indicators and balancing ecosystem and considered as bioindicator of coastal and marine habitat.

The intertidal zone is one of the most important regions and provides a habitat for benthic micro, macrofauna of

marine biota (Raghunathan *et al.*, 2003). Seashells are much diversified biota from the intertidal zone (rocky, sandy, muddy and mangrove areas) to the sub tidal region of these islands and recorded even from 3000 meters depth in Andaman Sea (Dey, 2016). The highest high tide and lowest low tide plays an important role in community structure and composition of intertidal benthic organisms (Molles, 2013). Rocky shore organisms are facing intense physiochemical conditions during tidal changes from upper to lower intertidal zones (Baharuddin *et al.*, 2018). Among the intertidal marine diversity, molluscs are one of the dominated animal group and successfully adapted to diel changes in dessication, exposure and submergence animal phyla. Studies on molluscs fauna (gastropoda and bivalvia) well known from these Islands (Rajagopal and Daniel, 1973; Daniel and Rajagopal, 1974; Subba Rao and Dey, 1991 and 2000; Ansari *et al.* 2006; Franklin *et al.*, 2013 and 2014; Apte, 2014) among them most of studies were focused on species taxonomic description or functional groups.

The studies on distribution and species composition of intertidal molluscs in the north Andaman Islands were

scarce. Recently Jeeva *et al.* (2018) studied distribution of gastropods in the intertidal environments of South, Middle and North Andaman Islands. However, there is virtually no information available on the status of molluscan fauna along the north Andaman Coast. Therefore, the present study focused on species composition of molluscan fauna in the intertidal habitat especially gastropoda and bivalvia.

Study area

Andaman and Nicobar Islands are a group of 572 islands, islets and rocky outcrops located geographically North to South between 6°45' - 13°40' N latitudes and 92°12' - 93°55' E longitudes extend over 800 km, and coastline covers over 1,962 km. The Andaman Islands

(10°30' - 14°; 92°-93°) are emerged is a part of a mountain chain and lie on a ridge, which extends southward from the Irrawaddy delta area of Burma (Tikader *et al.*, 1986). At many places, rocky, sandy and muddy beaches occur between mangroves and coral reefs in the littoral region. The Andaman Sea surrounded by Burma, Thailand, Malaysia on the East and Andaman and Nicobar Islands on the West. The northern most part of the Andaman Archipelago comprises of pristine mangrove and serene beaches (Venkataraman *et al.*, 2003; <http://www.andamans.gov.in>). In the present study, intensive survey was carried out in the intertidal regions of seven locations along the North Andaman Islands during 2017 to 2019 (Table 1 and Fig. 1).

Table 1: Details of intertidal study areas of North Andaman Island

Study area	GPS coordinates		Habitat description
	Latitude(N)	Longitude (E)	
Aerial Bay	13°16.900'	93°02.583'	Majority muddy habitat and low rocky exposed area. Low and narrow ranges of intertidal exposure. Mangrove patches at upper intertidal region. The water habitat always turbid due to discharge of wastewater runoff.
Durgapur	13°16.350'	93°02.583'	Long intertidal region and wider endowed with rocky area and very less sandy beach. Low tide exposed with dead corals. Rocks and dead corals area covered with algae and rock pools are common.
Kalipur	13°13.516'	93°02.966'	Intertidal exposure is long and constitutes of rocky exposure area one side and sandy substratum on other side. Muddy region (mangroves and their associates) observed at upper intertidal region.
Lamiya Bay	13°12.116'	93°02.383'	Intertidal constitute of rocky area very narrow and long stretch in that region.
Brush Island	13°17.716'	93°02.95'	It is a small Island, one side rocky other side sandy substrates.
Ross Island	13°18.066'	93°04.266'	Island connected with Smith Island by sand bar. Intertidal area exposed small rocks, flat rocks and intertidal pools are present.
Ram Nagar	13°04.345'	93°01.562'	Soft sand and freshwater runoff at right side. Low intertidal exposure.

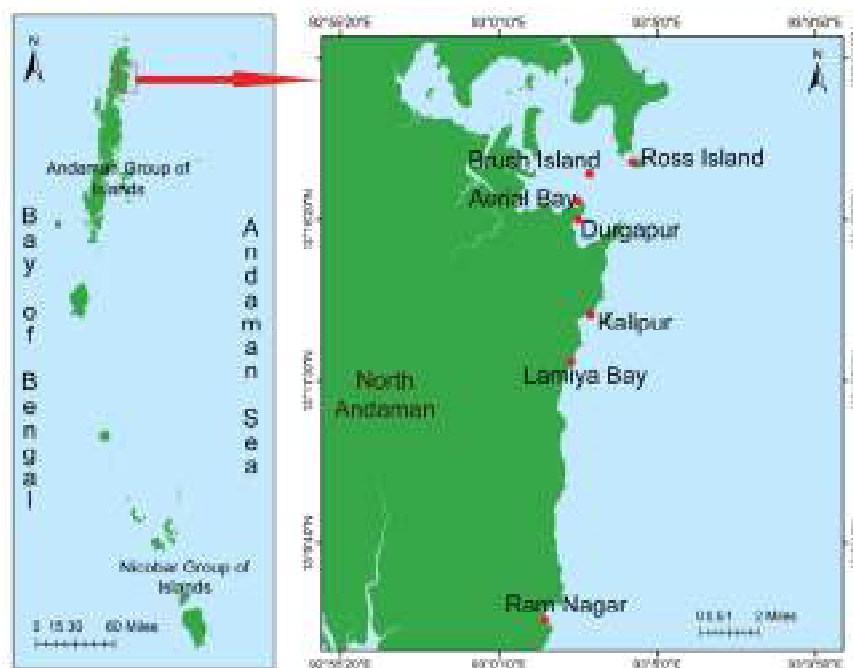


Fig. 1. Map showing study areas of North Andaman group of Islands

Methods

The molluscs were collected from the intertidal areas, besides the rocks and crevices were also searched for molluscs specimens, sometimes rocks were hand lifted or upturned (Underwood and Chapman, 1996). Samplings were carried at lowest low tide covered whole areas wherever possible. Maximum effort taken to identify the species in the field, doubtful samples were collected for identification in the laboratory. Collected materials were brought to the laboratory and rinsed, adhering

debris removed. Later, species were sorted out, and dried shells processed for identification up to lowest possible taxon following standard available literature (Abbott and Dance, 1990; Subba Rao, 2000 and 2003; Ramakrishna and Dey, 2003, 2010; Anbalagan and Samuel, 2012).

Distribution ranges (D) of molluscs were calculated by equation (Ahmadreza *et al.*, 2012) (Table 2). $D = n/N * 100$ (n= Presence of individual in number of stations; N=Total number of stations)

Table 2: Calculation of mollusc species ranges

D (%)	0-19.99%	20-39.99%	40-59.99%	60-79.99%	80-100%
Rarity	Very rare	Rare	Relatively common	Common	Very common

Species similarity among stations were calculated by using PAST software (version 1.83) (Sørensen, 1948).

Results

During the study period, we have recorded 119 species of molluscs (Gastropod and Bivalves). Of which, 102 species of gastropods belonging to 66 genera, 32 families and 7 orders, and 17 species of Bivalves

belonging to 14 genera, 11 families and 6 orders were identified in this study (Table 4; Plate 1-4). The order Neogastropoda showed highest species richness (40 species) followed by Littorinimorpha (32 species), Trochida and Caenogastropoda (11 species each), Cardida (six species), Osteridae, Cycloneritidae and Venerida

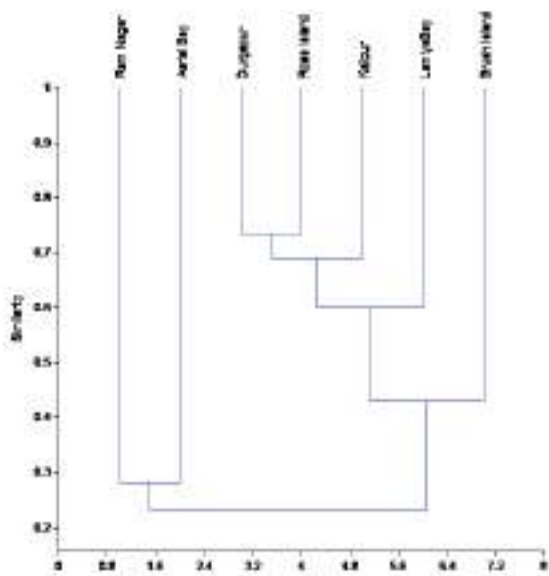


Fig. 6: Bray curtis similarity index among the selected study areas of North Andaman Island

Species Distribution in Habitats

The habitat comprising three types such as Rocky, Sandy, and Muddy substratum. During the surveys, we have encountered 89 species of both Gastropoda and Bivalvia at rocky intertidal region followed by 58 species at sandy shore whereas only 20 species found at muddy substratum. Sorensons similarity among habitats calculated (Table 3). Rocky and Sandy substratum showed more similarity about 0.42 followed by Rocky and Muddy 0.17 while lowest similarity showed between Muddy and sandy substratum 0.08.

Table 3. Sorenson’s similarity among various habitats

	Muddy	Sandy
Rocky	0.17	0.42
Muddy		0.08

Species Abundance

The species were categorized from very rare to very common species based on their distributional range following the methodology of Ahmadrez *et al.* (2012). Relatively Common (39 species), followed by Very rare (38 species), Rare (24 species), Common (12 species) and six species are Very common among the study areas (Fig. 7).

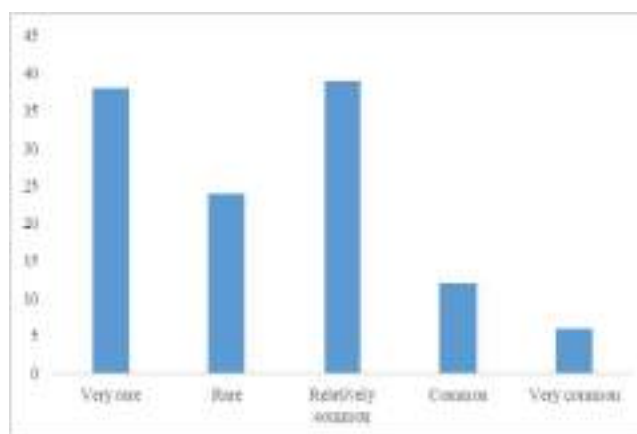


Fig. 7: The histogram shows abundance of very rare to very common molluscs species in intertidal areas of North Andaman Island

Table 4: Systematics and distribution of molluscs recorded during the study from intertidal region of North Andaman Island

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Phylum Mollusca									
Class Gastropoda									
Family Lottidae Gray, 1840									
<i>Patelloida saccharina</i> (Linnaeus, 1758)		+	+		+		+	R	RC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Order Lepetellida									
Family Haliotidae Rafinesque, 1815									
<i>Haliotis jacnensis</i> Reeve, 1846		+	+		+		+	R	RC
Order Trochida									
Family Tegulidae Kuroda, Habe & Oyama, 1971									
<i>Rochia nilotica</i> (Linnaeus, 1767)		+	+		+		+	R	RC
<i>Tectus fenestratus</i> (Gmelin, 1791)		+	+		+		+	R	RC
Family Trochidae Rafinesque, 1815									
<i>Monodonta labio</i> (Linnaeus, 1758)						+		S	VR
Family Angaridae Gray, 1857									
<i>Angaria delphinus</i> (Linnaeus, 1758)	+	+	+		+	+	+	R, S	VC
Family Turbinidae Rafinesque, 1815									
<i>Astrarium rhodostomum</i> (Lamarck, 1822)		+						R	VR
<i>Turbo argyrostomus</i> Linnaeus, 1758			+					R, S	VR
<i>Turbo bruneus</i> (Röding, 1798)		+	+		+	+	+	R	C
<i>Turbo crassus</i> W. Wood, 1828		+	+		+		+	R	RC
<i>Turbo sparverius</i> Gmelin, 1791		+	+		+	+	+	R	C
<i>Turbo petholatus</i> Linnaeus, 1758						+		S	VR
<i>Lunella cinerea</i> (Born, 1778)		+	+			+		R, S, M	RC
Order Cycloneritida									
Family Neritidae Rafinesque, 1815									
<i>Nerita albicilla</i> Linnaeus, 1758	+	+	+	+	+	+	+	R, S	VC
<i>Nerita chamaeleon</i> Linnaeus, 1758			+					R	VR
<i>Nerita costata</i> Gmelin, 1791		+	+				+	R	RC
<i>Nerita polita</i> Linnaeus, 1758		+	+		+	+	+	R, S	C
Order Caenogastropoda									
Family Planaxidae Gray, 1850									
<i>Planaxis sulcatus</i> (Born, 1778)	+	+	+		+		+	R, S	C
Family Potamididae H. Adams & A. Adams, 1854									
<i>Telescopium telescopium</i> (Linnaeus, 1758)	+	+			+		+	M	RC
<i>Terebralia palustris</i> (Linnaeus, 1767)	+			+				M, R, S	R
Family Cerithiidae J. Fleming, 1822									
<i>Cerithium nodulosum</i> Bruguière, 1792	+	+	+				+	M	RC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
<i>Cerithidea obtusa</i> (Lamarck, 1822)	+			+				M, S	R
Family Pachichilidae P. Fischer & Crosse, 1892									
<i>Clypeomorus batillariaeformis</i> Habe & Kosuge, 1966		+	+				+	R, M	RC
<i>Faunus ater</i> (Linnaeus, 1758)	+							R, M	VR
<i>Rhinoclavis aspera</i> (Linnaeus, 1758)	+	+	+				+	R, M	RC
<i>Rhinoclavis vertagus</i> (Linnaeus, 1767)			+					S, M	VR
<i>Rhinoclavis articulata</i> (A. Adams & Reeve, 1850)			+					R	VR
<i>Rhinoclavis sinensis</i> (Gmelin, 1791)		+	+				+	R	RC
Order Littorinimorpha									
Family Strombidae Rafinesque, 1815									
<i>Lambis lambis</i> (Linnaeus, 1758)		+	+		+	+	+	R, S	C
<i>Lambis scorpius indomaris</i> Abbott, 1961		+	+		+	+	+	S	C
<i>Harpago chiragra</i> (Linnaeus, 1758)		+	+				+	R	RC
<i>Canarium labiatum</i> (Röding, 1798)		+						R, S	VR
<i>Canarium mutabile</i> (Swainson, 1821)		+						S	VR
<i>Laevistrombus canarium</i> (Linnaeus, 1758)	+	+	+		+	+	+	R, S	VC
<i>Dolomena variabilis</i> (Swainson, 1820)		+			+			R	R
<i>Gibberulus gibberulus</i> (Linnaeus, 1758)					+		+	S	R
Family Seraphsidae Gray, 1853									
<i>Terebellum terebellum</i> (Linnaeus, 1758)			+					S	VR
Family Cypraeidae Rafinesque, 1015									
<i>Arestorides argus</i> (Linnaeus, 1758)		+	+	+	+		+	R, S	C
<i>Bistolida kieneri</i> (Hidalgo, 1906)		+	+					R	R
<i>Erronea caurica</i> (Linnaeus, 1758)		+	+		+		+	R, S	RC
<i>Erronea erronea</i> (Linnaeus, 1758)			+					R	VR
<i>Luria isabella</i> (Linnaeus, 1758)		+	+		+			R	RC
<i>Lyncina carneola</i> (Linnaeus, 1758)		+	+		+		+	R, S	RC
<i>Lyncina lynx</i> (Linnaeus, 1758)		+	+	+		+	+	R	C
<i>Lyncina vitellus</i> (Linnaeus, 1758)		+	+					R	R
<i>Mauritia arabica</i> (Linnaeus, 1758)		+	+	+	+	+	+	R	VC
<i>Monetaria annulus</i> (Linnaeus, 1758)		+	+		+	+	+	R, S	C
<i>Monetaria caputserpentis</i> (Linnaeus, 1758)		+	+	+	+	+	+	R, S	VC
<i>Monetaria moneta</i> (Linnaeus, 1758)		+	+		+	+	+	R	C
<i>Naria erosa</i> (Linnaeus, 1758)		+	+		+	+	+	R	C
<i>Palmadusta asellus</i> (Linnaeus, 1758)			+					R	VR

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
<i>Talparia talpa</i> (Linnaeus, 1758)		+	+	+	+		+	R, S	C
Family Naticidae Forbes, 1838									
<i>Naticarius onca</i> (Röding, 1798)			+		+			R, S	R
<i>Mammilla sebae</i> (Récluz, 1844)	+			+				R, S, M	R
<i>Notocochlis gualtieriana</i> (Récluz, 1844)	+		+					R, M	R
<i>Polinices flemingianus</i> (Récluz, 1844)		+						R	VR
<i>Polinices mammilla</i> (Linnaeus, 1758)			+					R	VR
Family Cassididae Latriella, 1825									
<i>Casmaria ponderosa</i> (Gmelin, 1791)			+			+		R	R
Family Tonnidae Suter, 1913 (1825)									
<i>Tonna tessellata</i> (Lamarck, 1816)					+			S	VR
Family Bursidae Thiele, 1925									
<i>Bursa granularis</i> (Röding, 1798)		+	+			+	+	R, S	RC
Order Neogastropoda									
Family Muricidae Rafinesque, 1815									
<i>Coralliophila violacea</i> (Kiener, 1836)		+						S	VR
<i>Chicoreus brunneus</i> (Link, 1807)		+	+				+	R	RC
<i>Drupa morum</i> Röding, 1798			+					R	VR
<i>Volema myristica</i> Röding, 1798		+	+	+			+	R	RC
<i>Menathais tuberosa</i> (Röding, 1798)		+	+		+		+	R	RC
<i>Nassa sarta</i> (Bruguière, 1789)			+					R	VR
Family Turbinellidae Swainson, 1835									
<i>Vasum turbinellus</i> (Linnaeus, 1758)		+				+		R, S	R
Family Pisaniidae Gray, 1857									
<i>Engina lineata</i> (Reeve, 1846)			+		+			R	R
<i>Engina mendicaria</i> (Linnaeus, 1758)		+	+		+		+	R, S	RC
Family Nassariidae Iredale, 1916									
<i>Nassarius coronatus</i> (Bruguière, 1789)	+	+	+					S, M	RC
<i>Nassarius distortus</i> (A. Adams, 1852)			+					S, M	VR
<i>Nassarius livescens</i> (Philippi, 1849)	+							S, M	VR
<i>Nassarius olivaceus</i> (Bruguière, 1789)			+					S, M	VR
Family Fascioliariidae Gray, 1853									
<i>Filifusus filamentosus</i> (Röding, 1798)		+						R	VR
<i>Latirus gibbulus</i> (Gmelin, 1791)		+			+			R	R
<i>Turritatirus craticulatus</i> (Linnaeus, 1758)			+					R	VR

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
<i>Latirolagena smaragdulus</i> (Linnaeus, 1758)						+		R, S	VR
Family Mitridae Swainson, 1831									
<i>Pterygia dactylus</i> (Linnaeus, 1767)		+			+			R	R
<i>Strigatella aurantia</i> (Gmelin, 1791)		+	+		+	+		R	RC
<i>Strigatella paupercula</i> (Linnaeus, 1758)		+	+					R	R
Family Harpidae Bronn, 1849									
<i>Harpa major</i> Röding, 1798			+					S	VR
Family Olividae Latreille, 1825									
<i>Oliva annulata</i> (Gmelin, 1791)			+					S	VR
<i>Oliva miniacea</i> (Röding, 1798)		+	+					S	R
<i>Oliva oliva</i> (Linnaeus, 1798)			+					S	VR
<i>Oliva sericea</i> (Röding, 1798)		+	+	+				R, S	RC
Family Conidae Rafinesque, 1815									
<i>Conus araneosus nicobaricus</i> Hwass in Bruguière, 1792		+	+				+	R	RC
<i>Conus capitaneus</i> Linnaeus, 1758	+				+			R	R
<i>Conus chaldaeus</i> (Röding, 1798)	+			+				R, S	R
<i>Conus coronatus</i> Gmelin, 1791			+					R	VR
<i>Conus ebraeus</i> Linnaeus, 1758		+		+		+		R, S	RC
<i>Conus eburneus</i> Hwass in Bruguière, 1792		+	+				+	R	RC
<i>Conus litteratus</i> Linnaeus, 1758	+							R, M	VR
<i>Conus lividus</i> Hwass in Bruguière, 1792	+							R, M	VR
<i>Conus rattus</i> Hwass in Bruguière, 1792		+	+				+	R, S	RC
<i>Conus striatus</i> Linnaeus, 1758		+		+				R, S	R
Family Turridae H. Adams & A. Adams, 1853 (1838)									
<i>Lophiotoma abbreviata</i> (Reeve, 1843)		+						R, S	VR
<i>Lophiotoma acuta</i> (Perry, 1811)			+					R, S	VR
Family Clavatulidae Gray, 1853									
<i>Turricula javana</i> (Linnaeus, 1767)		+	+					R	R
Family Terebridae Morch, 1852									
<i>Hastula cinerea</i> (Born, 1778)	+							M	VR
<i>Terebra subulata</i> (Linnaeus, 1767)		+			+	+		R, S	RC
Order Cephalaspidea P. Fischer, 1883									
Family Bullidae Gray, 1827									
<i>Bulla ampulla</i> Linnaeus, 1758		+	+	+	+	+	+	S	VC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Family Haminoeidae Pilsbry, 1895									
<i>Atys naucum</i> (Linnaeus, 1758)		+	+	+				S	RC
Class Bivalvia									
Order Arcida Stoliczka, 1871									
Family Arcidae Lamarck, 1809									
<i>Barbatia lacerata</i> (Bruguère, 1789)			+					S	VR
Order Pectinida Gray, 1854									
Family Pectinidae Rafinesque, 1815									
<i>Gloripallium pallium</i> (Linnaeus, 1758)		+	+	+			+	S, R	RC
Order Ostreida Ferussac, 1822									
Family Gryphaeidae Vialov, 1936									
<i>Hyotissa hyotis</i> (Linnaeus, 1758)		+	+		+		+	R	RC
Family Pinnidae Leach, 1819									
<i>Atrina vexillum</i> (Born, 1778)		+						R	VR
Family Ostreidae Rafinesque, 1815									
<i>Saccostrea cucullata</i> (Born, 1778)		+	+				+	R	RC
Family Margaritidae Blainville, 1824									
<i>Pinctada margaritifera</i> (Linnaeus, 1758)		+			+			R	R
Order Venerida Gray, 1854									
Family Veneridae Rafinesque, 1815									
<i>Periglypta reticulata</i> (Linnaeus, 1758)		+	+			+		R	RC
<i>Periglypta puerpera</i> (Linnaeus, 1771)		+						R	R
<i>Gafrarium pectinatum</i> (Linnaeus, 1758)	+	+			+			R, M	RC
<i>Lioconcha ornata</i> (Dilwyn, 1817)			+					S	VR
Order Cardiida Ferussac, 1822									
Family Cardiidae Lamarck, 1809									
<i>Tridacna crocea</i> Lamarck, 1819			+		+			R	R
<i>Tridacna maxima</i> (Röding, 1798)		+	+	+			+	R	RC
<i>Vasticardium elongatum</i> (Bruguère, 1789)	+		+					S	R
<i>Vasticardium flavum</i> (Linnaeus, 1758)	+	+				+		S	RC
Family Psammobiidae J. Fleming, 1828									
<i>Asaphis violascens</i> (Forsskål in Niebuhr, 1775)	+	+		+				S	RC
Family Tellinidae Blainville, 1814									
<i>Tellinella cruciata</i> (Spengler, 1798)			+					S	VR
Order Adapedonta Cossmann & Peyrot, 1909									

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Family Pharidae H. Adams & A. Adams, 1856									
<i>Siliqua radiata</i> (Linnaeus, 1758)			+	+	+			S	RC

(+, presence; nil, absence; R, Rocky substratum; S, Sandy substratum; M, Muddy substratum; VR, Very Rare; R, Rare; RC, Relatively Common; C, Common; VC, Very Common)

Discussion

This study was carried out to assess the distribution and species composition of molluscan fauna especially on Gastropoda and Bivalvia in the intertidal regions of North Andaman Island. The surveys were conducted at selected seven sampling sites of rocky, sandy and muddy intertidal region revealed 119 species (89 gastropods and 17 bivalvia) that are commonly inhabit in North Andaman Coasts. Although, the Andaman and Nicobar archipelago are estimated to harbor 983 species molluscs (except opisthobranchs) belonging to 67 families (Mondal *et al.*, 2018). There is always fluctuation of species number because of more attention on addition or describing new records or new species from these Islands. Moreover, only few researches have been focused on diversity and distribution, quantitative analysis and species assemblages around North Andaman Coasts (Jeeva *et al.*, 2018). Their studies limited to Kalipur intertidal region and recorded only 20 species. In the present study 119 species were identified among them most of Mollusca taxa have been reported by Subba Rao (2003), Subba Rao and Dey (2010) of Indian Seashells (Part I) and Catalogue of Marine Molluscs of Andaman and Nicobar Islands. Recently, Dey (2016) has published Catalogue of Marine Molluscs of India.

Rocky shores provides heterogeneous environments due to their various substrate composition and structure and they support numerous habitats for flora and fauna (Araujo *et al.*, 2005; Cruz *et al.*, 2014). Gastropods are largest class of Mollusca comprises 80% of phylum Mollusca (Strong *et al.*, 2008). Recently, Pandey *et al.* (2016) substantiated habitat heterogeneity is important variable for the growth and survival of gastropod species. The distribution of intertidal organisms influenced by

physical factors and ecological communities vary widely through time and space (Susintowati *et al.*, 2019). Species similarity and distribution of species attributed by habitat heterogeneity such as coralline rocks, flat rocks, rocky patches, mangrove substratum and geographical distance. Bray-Curtis similarity showed Durgapur and Ross Island showed highest species similarity (0.74) because of both locations share habitat structural complexity and near geographical distance. The study area Ram Nagar and Aerial Bay recorded lowest species similarity (0.28) and lack of substratum complexity due to contain sand and muddy area, and nearby fresh water runoff.

The highest abundance of relatively common species (32.77%) in comparison with other division while only 5.04% of very common species were noted during the study. This could be substrate quality, physio-chemical factors, environmental factors and other biological characteristics of intertidal zones influencing the distribution and species composition of intertidal regions of North Andaman Island.

The distribution of limped (*Patelloida saccharina*) and abalone shells (*Haliotis jacnensis*) prefers only rocky substratum. These shells are found in upper, middle and lower rocky intertidal regions. The shells of family Tegulidae, Trochidae, Angaridae and turbinidae are common in Andaman Islands could frequently encounter in almost all intertidal regions, most of shells were found below the rocks, and crevices. Hermit crabs were occupied most of the dead shells in the upper intertidal regions. The shells of family Neritidae are very common, *Nerita costata*, *N. polita* were prefers upper and middle rocky intertidal region. Live *N. albicilla* were observed at rocky upper to lower intertidal regions whereas most of dead *N. albicilla* were found in sandy shore. *Nerita chamaeleon*



Plate 1: a - *Patelloida saccharina* (Linnaeus, 1758); b - *Haliotis jaccensis* Reeve, 1846; c - *Rochia nilotica* (Linnaeus, 1767); d - *Tectus fenestratus* (Gmelin, 1791); e - *Monodonta labio* (Linnaeus, 1758); f - *Angaria delphinus* (Linnaeus, 1758); g - *Astraliium rhodostomum* (Lamarck, 1822); h - *Turbo argyrostomus* Linnaeus, 1758; i - *Turbo sparverius* Gmelin, 1791; j - *Turbo petholatus* Linnaeus, 1758; k - *Lunella cinerea* (Born, 1778); l - *Nerita albicilla* Linnaeus, 1758; m - *Nerita chamaeleon* Linnaeus, 1758; n - *Nerita costata* Gmelin, 1791; o - *Nerita polita* Linnaeus, 1758; p - *Planaxis sulcatus* (Born, 1778); q - *Telescopium telescopium* (Linnaeus, 1758); r - *Terebalia palustris* (Linnaeus); s - *Clypeomorus batillariaeformis* Habe & Kosuge, 1966; t - *Rhinoclavis sinensis* (Gmelin, 1791)

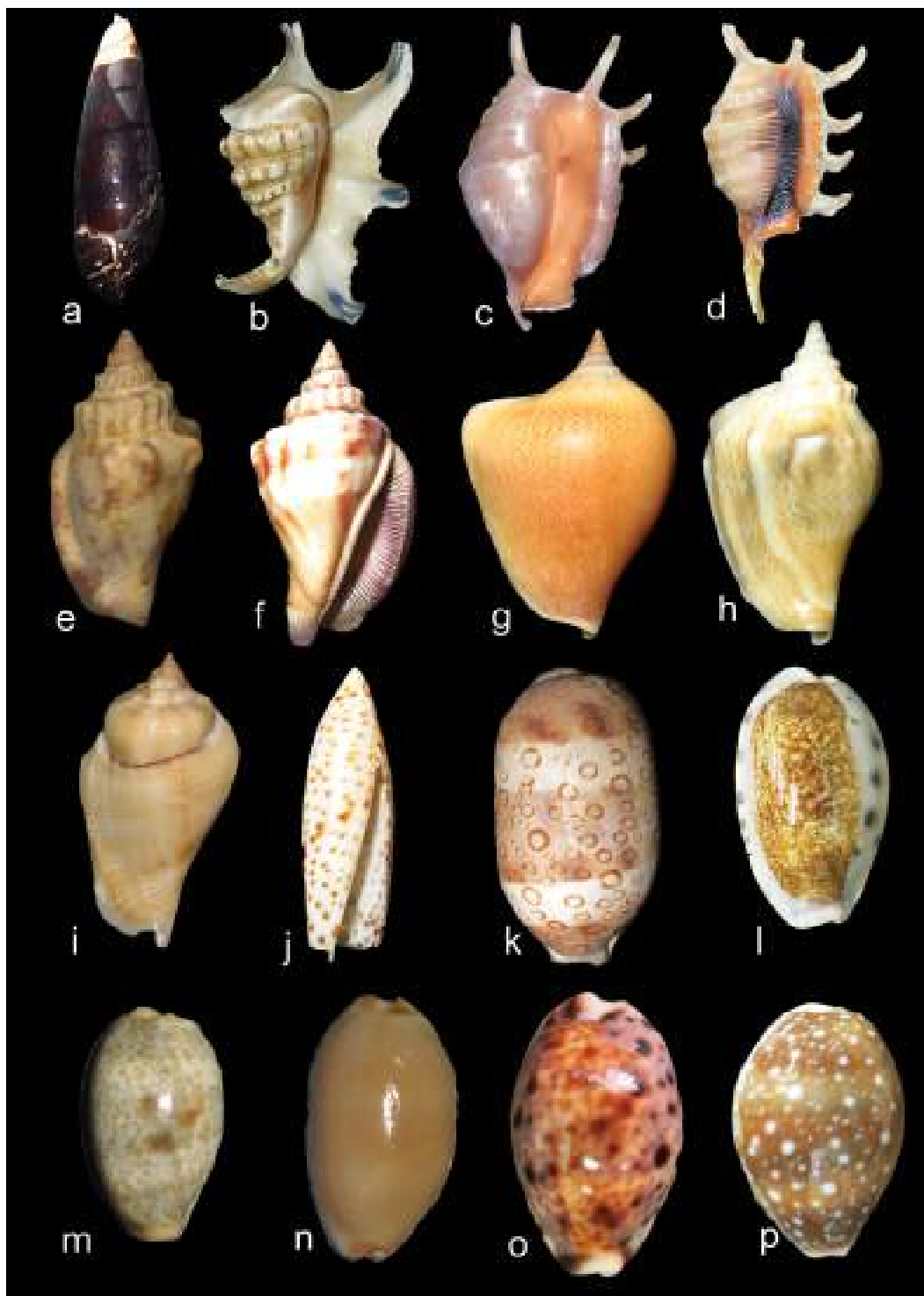


Plate 2: a - *Faunus ater* (Linnaeus, 1758); b - *Harpago chiragra* (Linnaeus, 1758); c - *Lambis lambis* (Linnaeus, 1758); d - *Lambis scorpius indomaris* Abbott, 1961; e - *Canarium labiatum* (Röding, 1798); f - *Canarium mutabile* (Swainson, 1821); g - *Laevistrombus canarium* (Linnaeus, 1758); h - *Dolomena variabilis* (Swainson, 1820); i - *Gibberulus gibberulus* (Linnaeus, 1758); j - *Terebellum terebellum* (Linnaeus, 1758); k - *Arestorides argus* (Linnaeus, 1758); l - *Erronea caurica* (Linnaeus, 1758); m - *Erronea erronea* (Linnaeus, 1758); n - *Luria isabella* (Linnaeus, 1758); o - *Lyncina lynx* (Linnaeus, 1758); p - *Lyncina vitellus* (Linnaeus, 1758)

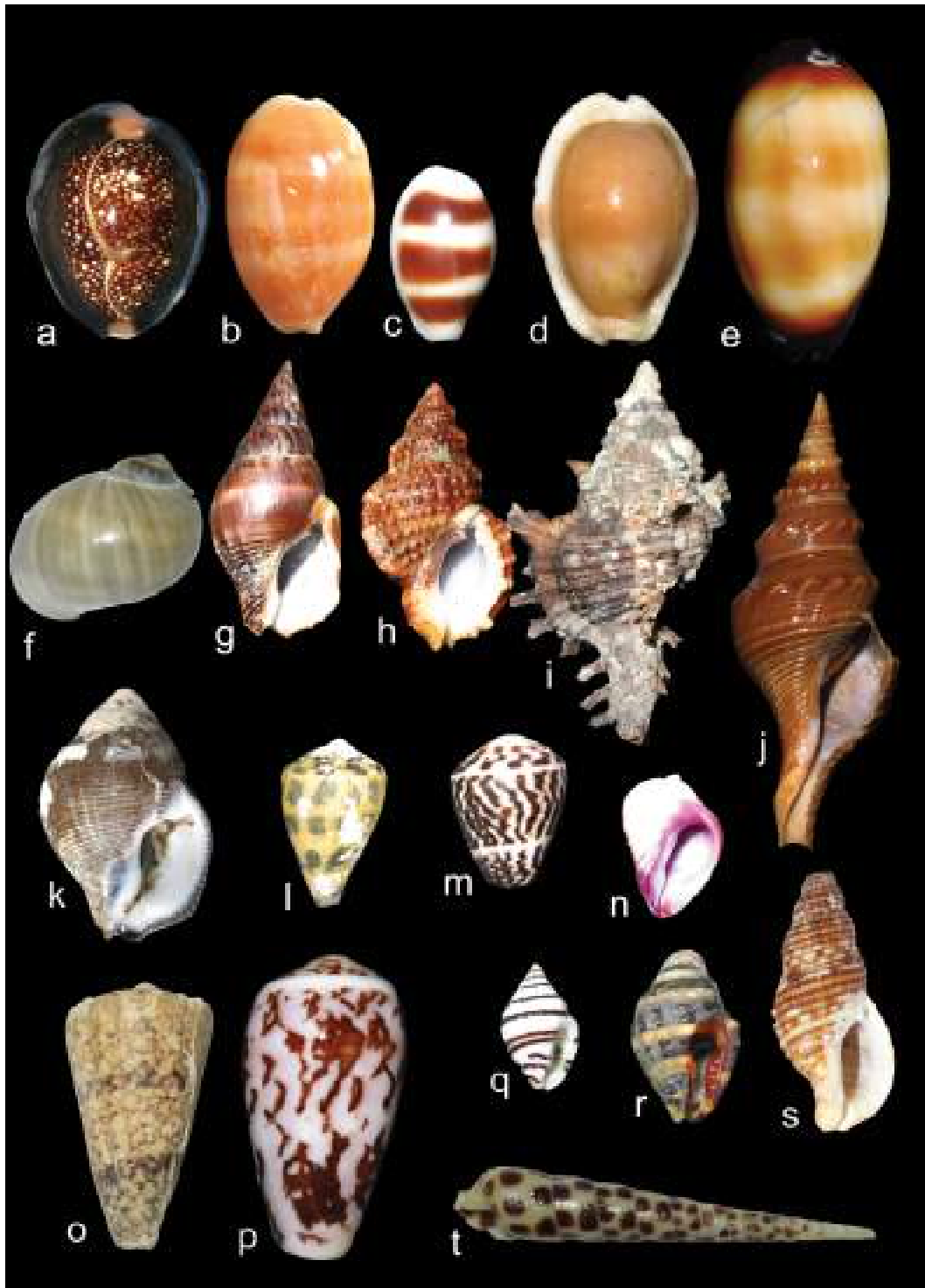


Plate 3: a - *Monetaria caputserpentis* (Linnaeus, 1758); b - *Lyncina carneola* (Linnaeus, 1758); c - *Palmadusta asellus* (Linnaeus, 1758); d - *Naria erosa* (Linnaeus, 1758); e - *Talparia talpa* (Linnaeus, 1758); f - *Notocochlis gualtieriana* (Récluz, 1844); g - *Nassarius olivaceus* (Bruguière, 1789); h - *Bursa granularis* (Röding, 1798); i - *Chicoreus brunneus* (Link, 1807); j - *Turricula javana* (Linnaeus, 1767); k - *Latirolagena smaragdulus* (Linnaeus, 1758); l - *Conus ebraeus* Linnaeus, 1758; m - *Conus chaldaeus* (Röding, 1798); n - *Coralliophila violacea* (Kiener, 1836); o - *Conus araneosus nicobaricus* Hwass in Bruguière, 1792; p - *Conus striatus* Linnaeus, 1758; q - *Engina lineata* (Reeve, 1846); r - *Engina mendicaria* (Linnaeus, 1758); s - *Turritatirus craticulatus* (Linnaeus, 1758); t - *Terebra subulata* (Linnaeus, 1767)

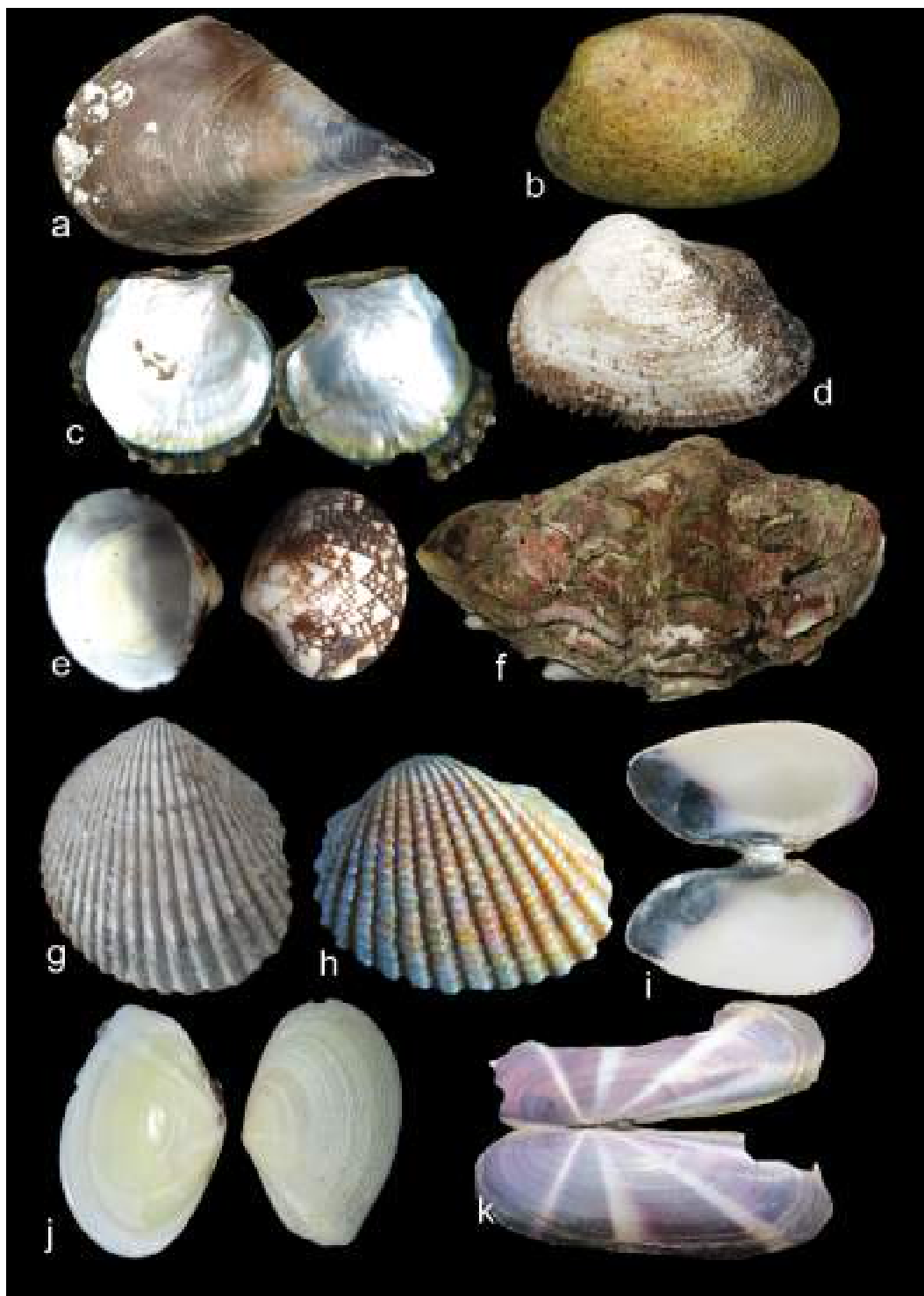


Plate 4: a - *Atrina vexillum* (Born, 1778); b - *Periglypta puerpera* (Linnaeus, 1771); c - *Pinctada margaritifera* (Linnaeus, 1758); d - *Barbatia obliquata* (Wood, 1828); e - *Lioconcha ornata* (Dilwyn, 1817); f - *Tridacna maxima* (Röding, 1798); g - *Vasticardium elongatum* (Bruguière, 1789); h - *Vasticardium flavum* (Linnaeus, 1758); i - *Asaphis violascens* (Forsskål in Niebuhr, 1775); j - *Tellinella cruciata* (Spengler, 1798); kv - *Siliqua radiata* (Linnaeus, 1758)

Linnaeus, 1758 could be found to be very rare only recorded from Kalipur intertidal region. The shells of Neritidae are generally euryhaline, herbivores, inhabit brackish and fresh water habitats (Tan and Climents, 2008).

The species of family Planaxidae found in rocky and muddy substratum, Potamididae (*Telescopium* and *Terebralia*) species found on muddy substrate > muddy and few shells were encountered at sandy region. Cerithidae shells were found at muddy and sandy substratum. The species of Pachichilidae were mostly found in Rocky and Muddy substratum. The high number of *Clypeomorus batillariaeformis* shells were encountered beneath rocks at upper intertidal region and small hermit crabs occupied most of dead shells. The common strombidae shells are noted in almost all intertidal regions of north Andaman Islands. Live *Lambis* species were observed at sandy substratum of Durgapur, Kalipur and Ross Island where dead shells were found at Brush Island and Ram Nagar Beach and considered as sea washed shells.

The snorkeling at Durgapur subtidal region resulted vast area covered with seagrass, seaweed and reef constitute live corals and their associated fauna. Moreover, most of shore seine carried out by fishermen (local fishing) at Durgapur area. The interesting fact we have noted during the surveys at Durgapur intertidal region i.e. encountered large number of sea washed dead shells of *Laevistrombus canarium*, could be attributed reason behind most of shells affected by local fishing and washed towards the shore. During the study we have recorded only single specimen of empty *Terebellum terebellum* (Linnaeus, 1758) belonging to Seraphsidae at sandy bottom of Kalipur intertidal region. Fifteen species of family cypraeidae were noted; they are common and found everywhere at intertidal regions (beneath the rocks, crevices and rocky pools) from upper sandy shore (seawashed shells) increasing live specimens towards the sea. The species of family Naticidae (*Natica*, *Naticarius*, *Notocochlis*, *Mammilla* and *Polinices*) found live and mostly prefers sandy > rocky > muddy intertidal region.

A single dead shell of *Tonna tessellata* (Tonnidae) found at upper sandy intertidal of Lamiya Bay. The species of Bursidae, Muricidae, Turbinellidae, Pisannidae and

Nassaridae, Fasciolaridae, Mitridae, Harpidae found at almost all intertidal regions specimen number increasing upper > mid > lower intertidal regions of study areas. Species of family Olividae are only found at Durgapur and Kalipur intertidal areas, among four species *Oliva oliva* and *Oliva annulata* found live mostly preferred at sand pools (beneath huge rocks) and Conidae species are common, found small specimen (*Conus chaldeus*, *C. ebraeus*) to large specimen (*Conus litteratus*) at North Andaman intertidal areas.

The species of Turridae, Clavatulidae, Terebridae were found very rarely from only few locations. *Bulla ampulla* was common in all intertidal regions, and large number of dead specimens were recorded at Durgapur, same wise *Atys naucum* also found at Durgapur and Kalipur that could be probably because of local fishing activities. The species family Cardidae are common inhabitants of Indo-Pacific coral reef benthic communities in shallower waters (Jantzen *et al.*, 2008). *Tridacna* species are common reef dwellers mostly founds in lower intertidal regions of North Andaman Island. Most common specimens of dead shell of marine bivalves belonging to the family Pectinidae, Gryphaeidae, Pinnidae, Ostreidae, Margaritidae, Veneridae were found in the intertidal regions of almost all regions of North Andaman Island. Most oysters are very important to consume as food (Boominathan *et al.*, 2008). Bivalves could possibly attach to calcareous substratum, gaps of the cracks and rocky because of their borrowing nature. *Siliqua radiata* commonly called sunset shells, sandy bottom of shores in small burrows (Sujit *et al.*, 2010). Sometimes they found in various calcareous hard materials lying in the muddy substratum (Joseph and Ramesh Babu, 2014).

Present study reveals that habitat (rock, muddy and sand) complexity is one of the major attributes to assemblage of Mollusca fauna. Most of mollusca species were observed in rocky intertidal regions. This is baseline data for record of species composition and taxa distribution of molluscs intertidal region. Furthermore, sampling at other localities and in other habitats, is required for prepare the comprehensive list of molluscan fauna of this region.

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