SOME ECOLOGICAL ASPECTS OF ROCKY SHORE MARINE GASTROPODS IN BO RON GA ISLAND, NORTHERN RAKHINE COASTAL REGION*

Naung Naung Oo[1]

Abstract

Rakhine Coastal Region is known in terms of biodiversity since it is dubbed by the local and international scientists as ecologically and biologically significant marine area. This research is an attempt to investigate the zonal distribution, influencing factors and faunal responses, habitat preference, abundance and determine the species diversity of molluscan species in rocky shore area of Bo Ron Ga Island, Northern Rakhine Coastal Region. This study was carried out from January to December 2020 in five study sites of Bo Ron Ga Island. There were a total of 1548 individuals of macrobenthic fauna collected encompassing 33 known species of molluscs groups. Most of the number of gastropod shells was found in Bo Ron Ga Island which constitutes about 96% of the entire collection and contributed by *Nerita costata* (21.22%), *Nassarius globosus* (17.2%), *Morula nodicostata* (16.11%), *Nerita albicilla* (12.51%) and *Littoraria undulata* (6.88%). In the present study, Hnget Gaung Taung was harboured with the highest species (49 spp.), followed by Pan Nantha Kyun (36 spp.), Lin Noh Kyun (34 spp.), San Taw Shin (33 spp.) and the lowest was observed at Pyin Gyi (25 spp.). In addition, maximum diversity index, equitability and correlation of habitats and species preferences of gastropods were also presented.

Keywords: Rocky shore habitats, species diversity, faunal assessment, molluscs, anthropogenic activity.

Introduction

The rocky shore is an intertidal area of seacoasts where solid rock predominates, still it is considered as a part of marine ecosystem. Rocky shores are biologically rich in terms of the number and variety of species they support, and are a useful 'natural laboratory' for studying intertidal ecology and other biological processes.

The ecological habitat structure may affect the species diversity and abundance in several systems (Connell 1961; Underwood and Chapman 1989). It has been difficult to understand the effects of habitat structure on assemblages because the different elements of habitat structure are often puzzled. The complexity of habitats positively affects the density and richness of molluscs (Beck 2000).

Marine invertebrates and algae living in rocky habitat are alternatively affected by physical forces such as waves and temperature, desiccation and exposure to tidal periods (Denny and Gaines 2007). As a result, the sharp physical gradient and spatially clustered community has made the rocky intertidal zone as an ideal place to study the role of physical and biological factors in determining the abundance and distribution of organisms (Connell 1972 and Paine 1966).

Among different habitats of the islands, the rocky shore ecosystem is physically harsh environment on the earth but supports a wide variety of fauna. This high species diversity is attributable to the existence of a large number of ecological niches. Several studies have accounted the detailed structure of flora and fauna of intertidal zone (Colman 1933; Fletcher and Frid 1996). This zone is one of the hotspots of biodiversity within the marine coastal ecosystem as well as an island ecosystem. In recent times, these rocky shore habitat is under increasing threat as a consequence of anthropogenic activity and climate change. Further, many of these areas are still unexplored and the threat is unexplained to pave the way for its conservation. The objectives of

[1] Dr, Lecturer, Department of Marine Science, Mawlamyine University

[*] Best Paper Award Winning Paper in Marine Science (2022)

current study are 1) to know factors influencing rocky shore habitats and adaptation; and 2) to investigate the habitat preference and species diversity of Bo Ron Ga Island.

Materials and Methods

A study was conducted to assess the present status of rocky shores of Bo Ron Ga Island (Lat. 19˚47′ N and 20˚25′ N, Long. 92˚54′ E and 93˚15′ E), Northern Rakhine Coastal Region as they are known to support more ecological niches. The locations were selected based on the accessibility for sampling, exposure of rocky stretch during low tide, harbouring of different micro-habitats, namely, tide pools, loose boulders, rock on rock, surface of substrata (hard/smooth), vertical surface, flat, phytal cover, etc. Five sampling sites were chosen along the rocky coast of Bo Ron Ga Island (Fig. 1).

Sampling site	Position
	Western Bo Ron Ga Island
1. Hnget Gaung Taung (= Mye Ngu Kyun)	(Lat. 19˚55′ N, Long. 92˚58′ E)
2. San Taw Shin	(Lat. 19˚51′ N, Long. 93˚00′ E)
	Middle Bo Ron Ga Island
3. Pan Nantha Kyun	(Lat. 19˚35′ N, Long. 93˚12′ E)
	Eastern Bo Ron Ga Island
4. Pyin Gyi	(Lat. 19˚50′ N, Long. 93˚13′ E)
5. Lin Noh Kyun	(Lat. 19˚45′ N, Long. 93˚16′ E)

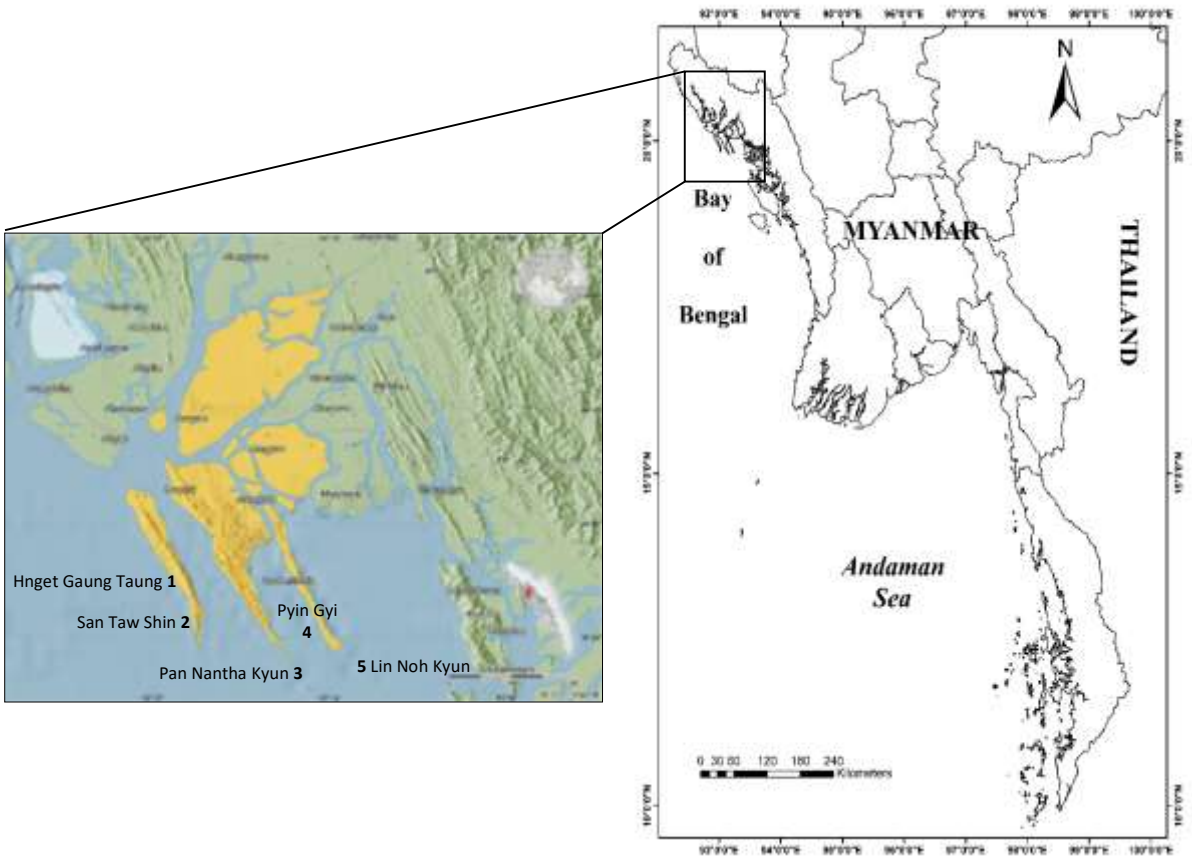

Figure 1 Map showing the sampling sites in Bo Ron Ga Island, Northern Rakhine Coastal Region

Quantitative samples were collected during low tides by adopting quadrat method, with a frame size of 50 × 50 cm. At each station, three replicate samples were collected. Altogether six replicate samplings were made during the study period spread from January to December 2020 during lowest low tides. A total of 90 (18 samples × 5 locations) quantitative samples and several qualitative samples were collected during the study. Samples were first kept in seawater for some time and then transferred to laboratory where they were washed to remove sediments or debris. After narcotising the samples were transferred to 5% buffered formaldehyde. The collected fauna were taxonomically identified up to the lowest possible taxonomic units, for example, species/ or a genus using standard taxonomic literature (Subba Rao 2003; Subba Rao and Dey 2000).

Results and Discussion

Zonal distribution of some rocky shore molluscan faunas in study areas

Based on the amount and type of inundation the rocky shores of Bo Ron Ga Island are generally classified into the following zones: High tide zone, Mid tide zone and Low tide zone. Although some overlap does occur, plants and animals are adapted to live in certain zones on the shore and each zone contains its own unique complement of organisms (Table 1).

High tide zone: It is also known as the upper zone or the dry upper-beach zone. Organisms are exposed to the drying heat of the sun during daytime and cool and low temperature during night. Because of these severe conditions, only a few resistant organisms live here (Table 1). The most characteristic organisms of this zone are the perwinkles (*Littoraria* sp.) and neritids (*Nerita* sp.). Periwinkles are so common in this zone that it is frequently referred to as the Littorina-zone. At the lower edge of the splash zone, rough snails (periwinkles) graze on various types of algae. These snails are well adapted to life out of the water by trapping water in their mantle cavity or hiding in cracks of rocks. Other common animals are isopods, barnacles and limpets.

Mid tide zone: This zone is known as the middle zone or the middle beach zone. It is the true intertidal zone, subjected to daily ebb and flood of the tides. As such, the animals living in this zone are immersed in water during high tide and exposed to air and drying during low tide. Animals in this zone are more abundant than the above one. Several groups of animals live attached to rocks, hiding in their crevices or in the tide pools. Chitons, limpets, neritids, top shells and turban shells are some of the important molluscs that inhabit this zone (Table 1). Another characteristic feature of this zone is the formation of tidal pools. This is rocky pools in the intertidal zone that are filled with seawater. In low located pools, whelks, mussels, sea urchins and *Littoraria littorea* are common.

Low tide zone: This is the lowest zone and bared only by the ebbing spring tides. This zone is much more stable than above two zones. As such, exposure to air is not as frequent as in the case of mid-littoral. In the study areas, the upper distribution is set by their ability to survive exposure to the air and the lower distribution is controlled by predation and competition with other species for a space on the rock. Tritons (*Cymatium* sp.), distorsios (*Distorsio* sp.), crustaceans and rock boring worms like sipunculids are common in this zone (Table 1). Some of the forms such as limpets, oysters and mussels have developed thick shells and strong power of attachment to withstand the force of battering waves. There are others which have developed soft and flexible bodies, such as seaweeds and hydroids.

Table 1 Zonal distribution of some molluscan faunas on rocky shore in study areas

Dominant species	High Tide	Mid Tide	Low Tide
Polyplacophora			
Chiton shells (*Acanthopleura* sp.)	+		
Chiton shells (*Ischnochiton* sp.)	+		
Gastropoda			
Lottiid limpets (*Patelloida* sp.)	+		
Patellid limpets (*Patella* sp.)	+	+	
Patellid limpets (*Cellana* sp.)	+		
Pyramid tops (*Tectus* sp.)	+	+	
Maculated top (*Trochus* sp.)	+	+	
Turban shells (*Turbo* sp.)	+	+	
Neritids (*Nerita* sp.)	+	+	
Perwinkles (*Littoraria* sp.)	+	+	
Vermetid worms (*Thylacodes* sp.)	+	+	
Clusterwinks (*Planaxis* sp.)	+	+	
Cowries (*Cypraea* sp.)		+	+
Moon snails (*Natica* sp.)		+	
Triton shells (*Cymatium* sp.)			+
Distorsios (*Distorsio* sp.)			+
Firebrand murex (*Chicoreus* sp.)		+	+
Rock shells (*Thais* sp.)		+	
Rock shells (*Drupa* sp.)	+	+	+
Rock shells (*Morula* sp.)	+	+	+
Spider conchs (*Lambis* sp.)			
Nassa mud snails (*Nassarius* sp.)		+	
Miter shells (*Mitra* sp.)		+	+
Whelks (*Cantharus* sp.)		+	
False limpets (*Siphonaria* sp.)	+		
Bivalvia			
Decussate arks (*Barbatia* sp.)		+	+
Horse mussels (*Brachidontes* sp.)	+	+	
Yellowbanded horse mussels (*Modiolus* sp.)		+	
Box mussels (*Septifer* sp.)		+	
Common file shells (*Lima* sp.)			+
Hooded oysters (*Saccostrea* sp.)	+	+	+
Leaf oysters (*Dendostrea* sp.)			+
Jewel box shells (*Chama* sp.)		+	+
Total	17	23	12

Factors influencing on some rocky shore molluscan faunas and their adaptation

The continuously changing environment in the rocky shores demands that the organisms have to be tolerant for these changes and adjust to the factors that influence the survival and distribution of rocky shore species. An adaptation is a characteristic that helps an organism survive.

Adaptations are either structural (body form), functional (physiological), and behavioural. The following are the parameters which influence the distribution of rocky shore organisms in Bo Ron Ga Island (Table 2).

Table 2 Influencing factors and faunal responses in study areas

Influencing factors	Responses
Wind	Molluscs fauna developed an adaptation to heating and windy condition by vaporization of internal water reserves
Sunlight	When free radicals are produced from an excess of light, they can be scavenged and deactivated
Temperature	Heat stress can be avoided by evaporative cooling
Salinity stress	Regulate intercellular osmotic pressure by actively excreting salts or water
Desiccation	Avoid the desiccation by migrating to a region that is more moist and cool and attach more firmly to the substrate
Predation	Reacted by visual camouflage and chemical camouflage
Wave action	Move to shelters, permanent attachment use byssal threads or cementation
Platform and composition	One rock platform can support many different kinds of plants and animals, because some sections are almost always under water, while other parts are usually dry
Rock pools	Certain plants and animals can survive in rock pools where sheltered for a big wave washes the boulder out

Habitat preference of some rocky shore molluscan faunas in study areas

To study the habitat preference of macrobenthic rocky shore molluscan faunas, samples were collected from different microhabitats of the five locations in Bo Ron Ga Island. The following characteristics and correlation of rocky shore environment were considered to the study of habitat preference of macrobenthic molluscs fauna (Fig. 2, Table 3 A & B).

Table 3 A Classify rocky shore habitats and faunal preferences in study areas

Habitats	Preferences
Hardness of substratum (smooth and rough)	The most preferred substrata of the rocky shore fauna included rough substrata (accounted more than 30 species during sampling, for example, *Cellana radiata*, *Nerita costata*, *Nassarius globosus*) followed by smooth substrata on 15 species (type species: *Turbo bruneus*).
Vertical surface (sloping and flat)	It was evident that the rocky shore fauna preferred flat surface (type species: *Lambis lambis*) rather than sloping.
Wave action (protected and exposed)	Protected areas from the wave actions have highly diversified macrofaunal population (type species: *Planaxis sulcatus*).
Crevices	Some of the species preferred to live on the rock crevices (type species: *Ischnochiton bouryi*, *Natica severa*).
Rock-on-rock	*Drupa ricinus ricinus*, *Morula nodicostata* and *Littoraria undulata* preferred to live in this rocky micro-habitat.
Loose boulders	Few species were recorded in this region (type species: *Littoraria undulata*).
Tide pools	Organisms living in this habitat have high tolerant capacity to withstand this harsh condition, for example type species such as *Nerita*, *Cypraea* sp., *Trochus* sp., *Lambis* sp. in addition to these benthic invertebrates, fishes namely gobies, damsels, stone fish and blennies were also noted.
Symbiotic association	This category covers close associations of two species. It includes mutualism (both are of beneficiaries), parasitism (harmful to the host) and commensalism (neither obviously harmful nor beneficial to the host). In this habitat, *Desmospongia*, *Holothuria atra*, *Metridium* and *Tridacana* were recorded as symbiotic associations during the period of study.
Phytal association	In the present study, gastropods *Distorsio kurzi* and *Mitra stictica* were observed as phytal (seaweed/seagrass) associated fauna. Among the 12 different habitats, the Flat Vertical Surface (FVS) and Protected from Wave Action (PWA) harboured highest number of species and the epiphytic being the lowest.

Table 3 B Correlation between habitats and species preferences in study areas

	Hardness	Vertical surface	Wave action	Crevices	Rock-on-rock	Loose boulders	Tide pools	Symbiotic	Phytal
Hardness	1.000								
Vertical surface	0.876	1.000							
Wave action	-0.089	0.144	1.000						
Crevices	-0.400	-0.233	-0.042	1.000					
Rock-on-rock	-0.172	0.013	0.043	0.645	1.000				
Loose boulders	-0.049	0.247	0.169	0.073	0.611	1.000			
Tide pools	-0.288	-0.448	0.319	0.233	0.249	-0.268	1.000		
Symbiotic	-0.237	0.138	0.366	0.580	0.762	0.695	0.095	1.000	
Phytal	0.418	0.189	0.357	-0.579	-0.549	-0.295	0.281	-0.520	1.000

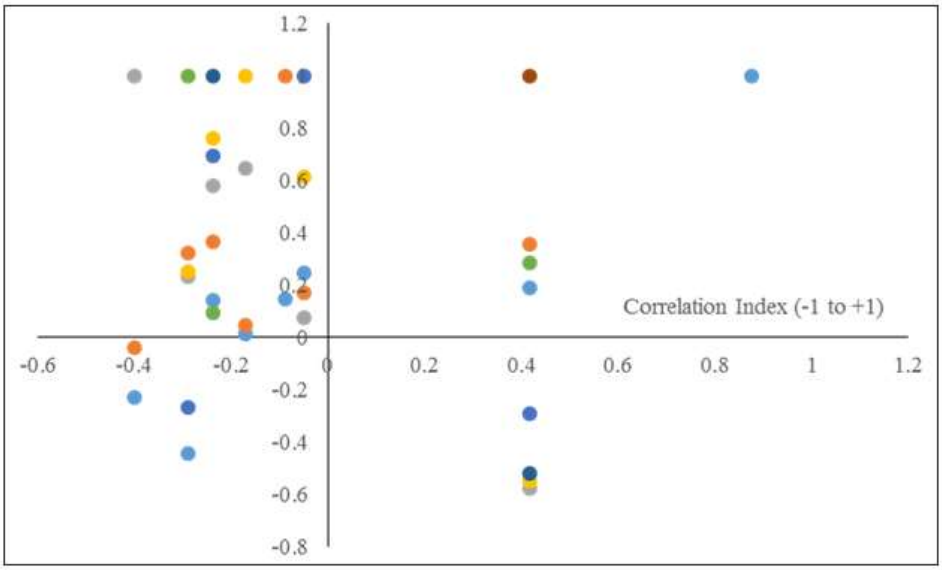

Figure 2 Correlation between habitats and species preferences in study areas

Abundance of some rocky shore molluscan faunas in study areas

From the Bo Ron Ga Island in Northern Rakhine Coastal Region, 1548 individuals of macrobenthic fauna represented by diverse phyla, namely, Porifera, Cnidaria, Annelida, Arthropoda, Mollusca, Echinodermata and Chordata, were collected.

Table 4 Numerical abundance (Mean no/m^2) of molluscan fauna in study areas

Species	HGT	STS	PNTK	PG	LNK	Total	%
Acanthopleura sp.	2	1			1	4	2.26
Ischnochiton sp.	1		1			2	1.13
Patelloida sp.	2	2		1		5	2.82
Patella sp.	1	1	1		1	4	2.26
Cellana sp.	4	2	2	1	2	11	6.21
Tectus sp.	2				1	3	1.69
Trochu sp.	2	1	2	1	1	7	3.95
Turbo sp.	1	2	2	1	1	7	3.95
Nerita sp.	1	1	1		1	4	2.26
Littoraria sp.	5	4	3	4	4	20	11.30
Thylacode sp.	2					2	1.13
Planaxis sp.	1		1			2	1.13
Cypraea sp.	1		1	1	1	4	2.26
Natica sp.	5	3	2	2	4	16	9.04
Cymatium sp.	2	1	1			4	2.26
Distorsio sp.	1		1	1		3	1.69
Chicoreus sp.		1	1		1	3	1.69
Thais sp.	4	1	3	4	4	16	9.04
Drupa sp.		1	1		1	3	1.69
Morula sp.					2	2	1.13
Lambis sp.			1	1		2	1.13
Nassarius sp.	1	1	2	2	2	8	4.52
Mitra sp.	2			1		3	1.69
Cantharus sp.	1	1	2	1	1	6	3.39
Siphonaria sp.	1	1	1		1	4	2.26
Barbatia sp.	1	1	1	1		4	2.26
Brachidontes sp.	1	1	1		1	4	2.26
Modiolus sp.	1	2	2			5	2.82
Septifer sp.	2	2				4	2.26
Lima sp.	1	1			1	3	1.69
Saccostrea sp.	1	1	1	1	3	7	3.95
Dendostrea sp.		1	1	1		3	1.69
Chama sp.			1	1		2	1.13
Total	49	33	36	25	34	177	
% contribution	27.68	18.64	20.34	14.12	19.21		
Mean	1.81	1.43	1.44	1.47	1.70		

Symbols: HGT = Hnget Gaung Taung, STS = San Taw Shin, PNTK = Pan Nantha Kyun, PG = Pyin Gyi, LNK = Lin Noh Kyun.

Among all the major taxonomic groups considered, Polyplacophora, Gastropoda and Bivalvia of phylum Mollusca significantly contributed the highest (33 species) number of species, followed by Echinodermata (4 species), Crustacea (3 species), Annelida (2 species) and the least represented phyla were Porifera, Cnideria and Chordata (each 1 species). Overall, molluscs were the dominant taxa accounted about 96% of total population and contributed by *Nerita costata*

(21.22%), *Nassarius globosus* (17.2%), *Morula nodicostata* (16.11%), *Nerita albicilla* (12.51%) and *Littoraria undulata* (6.88%). Spatially, there were considerable differences in number of species among locations (Fig. 3). In present study, Hnget Gaung Taung was harboured with highest species (49 spp.), followed by Pan Nantha Kyun (36 spp.), Lin Noh Kyun (34 spp.), San Taw Shin (33 spp.) and lowest was observed at Pyin Gyi (25 spp.) (Table 4).

Overall, Hnget Gaung Taung showed highest percentage contribution (27.68 no/m^2) followed by Pan Nantha Kyun (20.34 no/m^2) whereas the lowest contribution was observed at Pyin Gyi (14.12 no/m^2) (Table 4). Among the five locations, Hnget Gaung Taung recorded highest mean abundance (1.81 no/m^2) followed by Lin Noh Kyun (1.70 no/m^2), Pyin Gyi (1.47 no/m^2), Pan Nantha Kyun (1.44 no/m^2) and San Taw Shin (1.43 no/m^2) (Table 4).

Hnget Gaung Taung: *N. costata* registered the highest abundance (84 no/m^2) followed by *N. albicilla* (45 no/m^2) and *M. nodicostata* (22 no/m^2).

San Taw Shin: In this location, the species were more or less evenly distributed. *N. albicilla* was the dominant species (32 no/m^2) followed by *M. nodicostata* (23 no/m^2) and *N. costata* (22 no/m^2).

Pan Nantha Kyun: *N. globosus* observed as the dominant fauna (7 no/m^2) followed by *M. nodicostata* (5 no/m^2) and *N. albicilla* (4 no/m^2).

Pyin Gyi: The highest contribution at this location was by *N. costata* (28 no/m^2) followed by *N. globosus* (24 no/m^2) and *N. albicilla* (14 no/m^2).

Lin Noh Kyun: In this location, the highest contribution was recorded by *M. nodicostata* (28 no/m^2) followed by *N. albicilla* (24 no/m^2) and *N. globosus* (14 no/m^2).

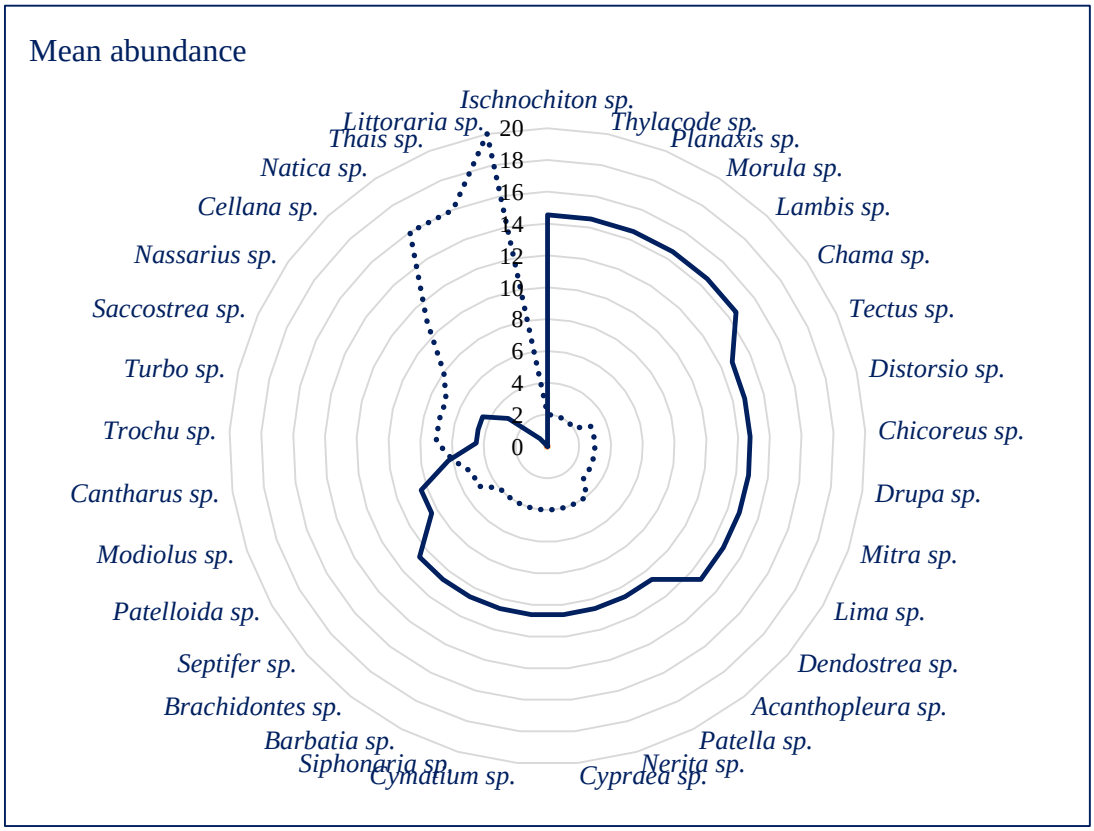

Figure 3 Mean abundance of some rocky shore molluscan faunas in study areas

Species diversity of some rocky shore molluscan faunas in study areas

Tropical shoreline is interspersed with the variety of habitats and thus the susbstrate heterogeneity is an inherent feature of the tropic (Hillebrand 2004). Rocky shores are known for their great diversity of animals and plants. The benthic communities of the intertidal habitats are largely shaped by the prevailing physical forces such as wave action, tidal range and tidal inundation, submergence, exposure to the light, temperature and the monsoon mediated variability in physico-chemical parameters. In this study, the intertidal zone tends to be colonized by algae in wave-sheltered conditions, and by limpets, barnacles and mussels as wave-exposure increases. Comparison of station-wise species diversity of molluscan faunas in study areas were shown in figure 4.

Table 5 Species diversity measures of some molluscan faunas in study areas

Sampling sites	Diversity (*H'*)	Evenness (*J'*)	Richness (*R'*)	H_{max}	Equitability
Hnget Gaung Taung	3.111	0.944	6.681	3.296	0.944
San Taw Shin	3.019	0.963	6.292	3.135	0.963
Pan Nantha Kyun	3.131	0.973	6.697	3.219	0.973
Pyin Gyi	2.664	0.940	4.971	2.833	0.940
Lin Noh Kyun	2.818	0.941	5.388	2.996	0.941

Diversity (*H'*): The highest value of *H'* was recorded at Pan Nantha Kyun (3.131), followed by Hnget Gaung Taung (3.111). The lowest value of *H'* was recorded at Pyin Gyi (2.664) (Table 5).

Evenness (*J'*): Pan Nantha Kyun showed the highest value of Pielou's Evenness (*J'*: 0.973), whereas the lowest value was recorded at Pyin Gyi (*J'*: 0.940) (Table 5).

Richness (*R'*): Over all, the third sampling at Pan Nantha Kyun showed the highest Margalef's diversity value (*R'*: 6.697), followed by first sampling of Hnget Gaung Taung (*R'*: 6.681). On the other hand the lowest value (*R'*: 4.971) was recorded at Pyin Gyi (Table 5).

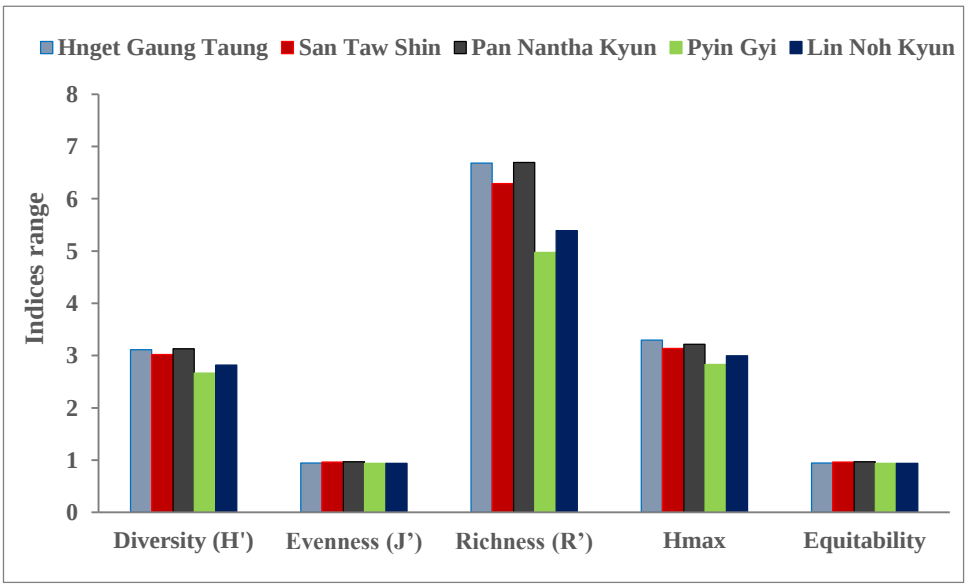

Figure 4 Diversity of some rocky shore molluscan faunas in study areas

Conclusion

A rocky shore is an intertidal area that consists of mostly solid rocks but the rocky shores are not all the same. It is often a biologically rich environment and can include many different habitat types such as steep rocky cliffs, platforms, rock pools and boulder fields. Together with the wind, sunlight and other physical factors it creates a complex environment in different places. Organisms that live in this area experience temporal fluctuations in their environment; consequently they have developed adaptation characters during the evolutionary development to survive. A study of Bo Ron Ga Island in Northern Rakhine Coastal Region revealed a total number of 47 species/taxa belonging to 30 families under 7 diverse phyla namely Porifera, Cnidaria, Annelida, Arthropoda, Mollusca, Echinodermata and Chordata. Among the seven phyla the Mollusca was the more diverse and constituting 33 species. Overall, molluscs were the dominant taxa accounted about 96% of total population and contributed by *Nerita costata*, *Nassarius globosus*, *Morula nodicostata*, *Nerita albicilla* and *Littoraria undulata*. Spatially, there were considerable differences of species composition between locations. At all locations, diversity of gastropods was recorded highest, followed by echinoderms. Based on the correlation matrix analysis different habitats can be studied to understand the habitat preference of rocky shore macrofauna. Some of the rocky shore communities are naturally unstable. This may be due to frequent physical disturbance caused either by anthropogenic activities or as a result of climate change and natural calamities as well. In general severe disturbance to the rocky shore habitat can shift community composition to an alternate state dominated by low profile algae, and fewer mussels. Eventually this could result in the local extinction of the displaced species.

Acknowledgements

I would like to express my gratitude to Dr. Aung Myat Kyaw Sein, Rector of Mawlamyine University; Dr Khine Khine San, Dr Myint Thida and Dr Mar Lar Aung, Pro-rectors of Mawlamyine University for their permission to undertake this research work. I would like to express my sincere thanks to Dr Nyo Nyo Tun, Professor and Head of Department of Marine Science in Mawlamyine University and Dr Soe Pa Pa Kyaw, Professor and Head of Department of Marine Science in Pathein University, for their advices and needful assistance. My final thank goes to local people from my study areas, for their assistance in the sample collections and Daw Lwin Lwin who has put in back breaking hours studying seashells but more importantly has kept me focused.

References

Beck, M. W. (2000). Separating the elements of habitat structure: independent effects of habitat complexity and structural components on rocky intertidal gastropods. J. Exp. Marine Biol. Ecol. vol. 249, pp. 29-49.

Colman, J. (1933). The nature of the intertidal zonation of plants and animals. *J. Marine Biol. Assoc*. vol. 18, pp. 435-476.

Connell, J. H. (1961). Effects of competition, predation by *Thais lapillus*, and other factors on the distribution of the barnacle *Balanus balanoides*. *Ecol. Monogr*. vol. 31, pp. 61-104.

Connell, J. H. (1972). Community interactions on marine rocky intertidal shores. *Annu. Rev. Ecol. Evol. Syst*. vol. 3, pp. 169-192.

Denny, M. W. and Gaines, S. D. (2007). *Encyclopedia of Tide pools and Rocky Shores*. University of California Press, Berkeley.

Fletcher, H. and Frid, C. L. J. (1996). Impact and management of visitor pressure on rocky intertidal algal communities. *Aquatic Conserv: Mar. Freshw. Ecosyst*. vol. 6, pp. 287-297.

Hillebrand, H. (2004). Strength, slope and variability of marine latitudinal gradients. *Marine Ecol. Prog. Ser*. vol. 273, pp. 251-267.

Paine, R. T. (1966). Food web complexity and species diversity. *Am. Nat*. vol. 100, pp. 65-75.

Subba Rao, N. V. (2003). Indian Seashells (Part 1): Polyplacophora and Gastropoda. *Zoological Survey of India*. Kolkata. no. 192, pp. 1- 416.

Subba Rao, N. V. and Dey, A. (2000). Catalogue of Marine Molluscs of Andaman and Nicobar Islands. *Zoological Survey of India*, Kolkata. pp. 1-323.

Underwood, A. J. and Chapman, M. G. (1989). Experimental analyses of the influences of topography of the substratum on movements and density of an intertidal snail, *Littorina unifasciata*. *J. Exp. Marine Biol. Ecol*. vol. 134, pp. 175-196.