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Some intertidal gastropods and bivalves of Thae Chaung Coastal area in Northern Rakhine state of Myanmar

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Abstract
Rakhine Coastal Region has a rich diversity of marine life with fisheries. However, there is no publication of basic information of marine bivalves and gastropods such as identification and ecological habitats in Thae Chaung intertidal water, northen Rakhine Coastal Region. The current research on marine mollusks was conducted and emphasize on small geographical area of Thae Chaung intertidal area in December 2019. A total of 11 species belonging to 5 orders, 8 families and 11 genera of gastropods and 6 species belonging to 4 orders, 4 families and 5 genera of bivalves reported from study area were reported. This research paper describes the identification of some economic importance of marine mollusks from Thae Chaung intertidal water in northern Rakhine Coastal Region.

Keywords: mollusks, bivalve, gastropod, intertidal, Thae Chaung Coastal area, northen Rakhine, Rakhine Costal region

Introduction
Myanmar has a long coastline of around 2400 km^2 with many marine resources, and is thought to be one of the most undeveloped coastlines in mainland Southeast Asia [1]. The coast is divided into three coastal regions; the Rakhine Coastal Region (from the mouth of Naaf River to Mawdin Point, about 740 km in length), the Ayeyarwady Delta and the Gulf of Martaban Coastal Region (about 460 km in length) and the Tanintharyi Coastal Region (from the Gulf of Martaban to the mouth of the Pakchan River, about 1200 km in length) [2].

Northern Rakhine coastal area is the portion of Rakhine Coastal Region of Western Myanmar, and is popular for both local and foreign tourists for its beautiful islands, beaches, and submarine fauna and flora. This includes Nantha Island and near Mayyu estuary designated as Ramsar wetland site in Myanmar, Sittway Point and Hnget Gaung Taung (Myengu Kyun = Western Bo Ron Ga Island), a large island in northern Rakhine State. Land development can be found in many areas around the island.

As Rakhine state is closely related to the coast, the costal and marine ecosystem of this state provides food sources, 20 percents of regional people are working in fishery industry, 90 percents of fishery products are mainly transported to mainland and China and the left 10 percents are consumed by local people.

Furthermore, shellfishes; bivalves and gastropods, which play a vital role, are economic importance. Some are utilized to make handicraft and the other are heavily harvested as food for regional populace. The mollusks are among the most diverse marine invertebrates on the coastal tropical environments and the vast majority is found in intertidal, estuarine and coastal lagoons, and in the shallow areas of continental shelf [3, 4].

The phylum mollusca is one of the most distinct animal groups which comprising 100,000 to 200,000 species with above 52,000 species have been identified and characterized [5, 6]. In Myanmar, there were about 160 species of gastropods and 120 species of bivalves had been reported [7, 8]. Mollusca is further divided into Scaphopoda, Gastropoda, Cephalopoda, Bivalvia, Polyplacophora, Caudofoveata, Solenogastres, and Monoplacophora [9]. People are capturing the molluscs because of their taste and attractiveness characteristics. Molluscs have been utilized for several years for the various purposes.

Shellfishes are used to create the jewelry decoration. Some molluscs are very harmful to humans. For example, some cone shells can inject the people who get a deadly toxic effect [10]. Many molluscs species are apply in traditional medication in various countries of the world [11]. Molluscs are play an important role in marine ecosystem, they perform as refining water quality through filtration, balancing algal bloom and improving habitat and substratum complexity through ecosystem engineering [12].

The research area of Thae Chaung is located in the most south-western part of the Sittway. This place is not connected with Sittway Point is not far away from mouth of Kaladan River. Many people from this village relay on livelihood fisheries. Thae Chaug intertidal water owns different habitats; sandy beach, mudflat, estuarine creek and rocky shore. It provides not only shelter and nurseries for marine species but also rich food sources for villagers. This paper aims to evaluate the preliminary checklist of marine shellfishes; bivalves and gastropods of Thae Chaung intertidal coastal water.

Materials and Methods

This study was conducted in Thae Chaung intertidal water of different habitats such as sandy beach, rocky shore, and mudflat of northen Rakhine Coastal Region in December 2019 (Fig 1). During the survey, samplings of mollscus (gastropods and bivalves) were taken with random hand picking. Both dead and alive specimens were collected in the field. Samples were carefully brought to department laboratory (Marine Science Department, Sittway University) and all collecting samples were soaked in the solution of caustic soda and then was cleaned and dried. In which some alive specimens, fresh meat tissue and some epifaunas were removal with forceps. We brushed the shells to use for further taxonomic works. All shells were preserved in 70% alcohol for two days, after those specimens were washed for a few hours and dry again in the sun for one day. We took the digital images for each species by using olive oil and pure cotton for a little bit shell lighting. Some of which collecting samples are stored in the laboratory and other are displayed at the Museum of Marine Science Department, Sittway University (MMSD, SU). The classification of bivalves and gastropods was based on shell morphological characteristics such as shape; color and texture according to the literatures of Soe Thu [7], Dance [13], Feinberg [14], Maung win *et al* [15], Taat Tun Thu [16], Aye Thant Zin *et al* [17], Thaw Zin Naing Tun *et.al* [18], Naung Naung Oo [19] and Hossain *et al* [20].

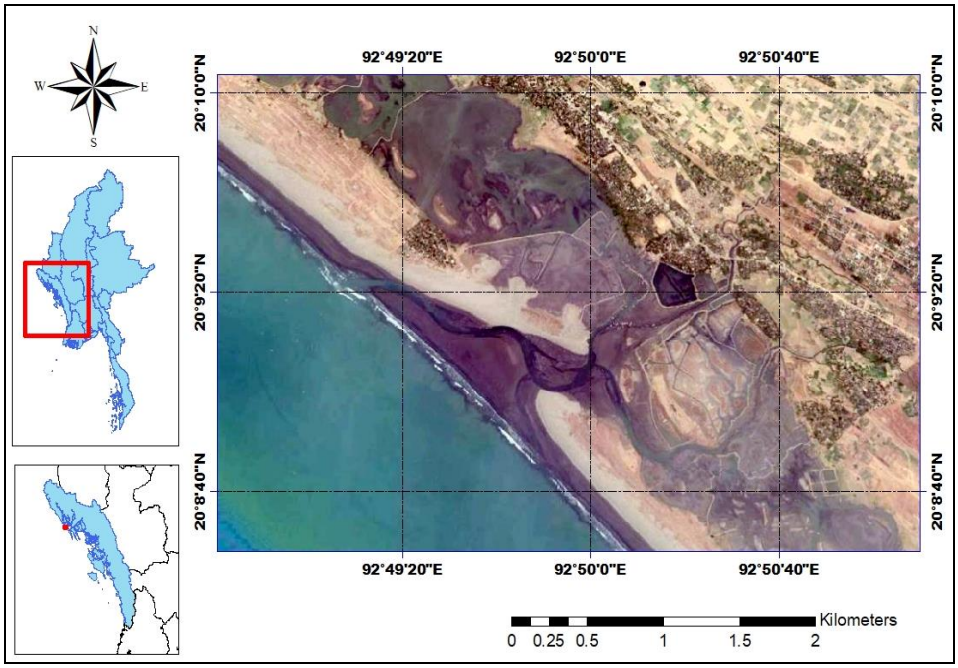

Fig 1: Map showing the collection site of gastropods and bivalves in Thae Chaung intertidal water

Results and Discussion

The preliminary checklist of marine bivalves and gastropods survey was conducted in Thae Chaung intertidal water in December 2019. This survey was carried out for the intertidal mollusks species in different types of substratum; sandy beach, muddy sand and rocky fringe (Table 1). A total of 17 species of mollusks were recorded on which 11 species of gastropods and 6 species of bivalves were shown in table (1) and figure (2).

Table 1: Record of some intertidal gastropods and bivalves in study area

Sr. No.	Species	Common Name	Local Name
Gastropods			
1	*Nerita lineata* Gmelin, 1791	Linear nerite	Jake/ Kha-yu-ma
2	*Turritella duplicata* (Linnaeus, 1758)	Duplicate turret shell	Kha-yu-sae-di
3	*Natica tigrina* (Röding, 1798)	Spot necklace shell	Kha-yu-lone
4	*Polinices didyma* (Röding, 1798)	Common moon snail	Phoe-la-minn
5	*Bursa elegans* (G. B. Sowerby I, 1835)	Elegant frog shell	Sue-kha-yu
6	*Thais mutabilis* (Link, 1807)	Common rock shell	Kyauk-lone
7	*Murex pecten* Lightfoot, 1786	Venus comb murex	Kha-yu-nga-zin-yine

8	*Babylonia formosae* (G. B. Sowerby II, 1866)	Mud whelk	Nan-dar-hlaing
9	*Nassarius olivaceus* (Bruguière, 1789)	Dog whelk	Kha-yu
10	*Pugilina ternatana* (Gmelin, 1791)	Ternate melongena	Kha-yu
11	*Turris unedo* Kiener, 1839	Common turrid	Kha-yu-pyat-thet
Bivalves			
12	*Anadara granosa* (Linnaeus, 1758)	Granular ark	Thwe-gone/ Gin
13	*Saccostrea cucullata* (Born, 1778)	Hooded oyster	Sar-ka-mar
14	*Crassostrea gigas* (Thünberg, 1793)	Giant cupped oyster	Ka-mar
15	*Donax scortum* (Linnaeus, 1758)	Leather donax	Thae-kha-yu
16	*Mactra mera* Reeve, 1854	Plain trough shell	Pae-late-pyar
17	*M. violacea* Gmelin, 1791	Violet trough shell	Pae-late-pyar

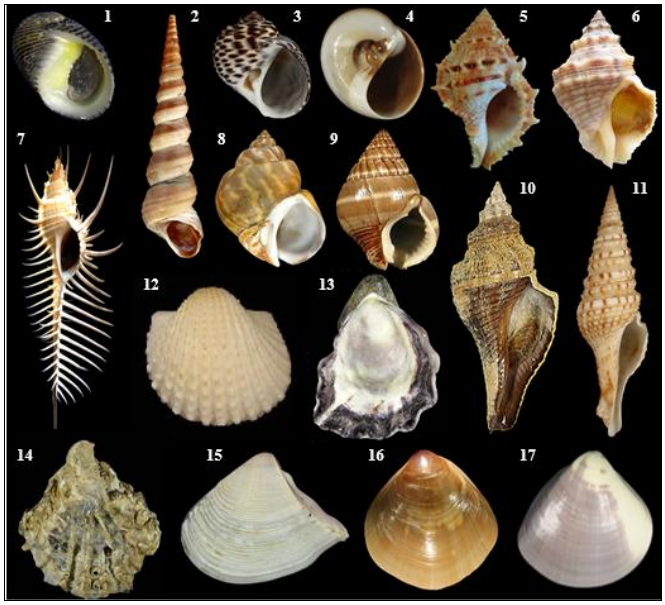

Fig 2(1-17): Intertidal gastropods and bivalves in study area. (1) *Nerita lineata* Gmelin, 1791, (2) *Turritella duplicata* (Linnaeus, 1758), (3) *Natica tigrina* (Röding, 1798), (4) *Polinices didyma* (Röding, 1798), (5) *Bursa elegans* (G. B. Sowerby I, 1835), (6) *Thais mutabilis* (Link, 1807), (7) *Murex pecten* Lightfoot, 1786, (8) *Babylonia formosae* (G. B. Sowerby II, 1866), (9) *Nassarius olivaceus* (Bruguière, 1789), (10) *Pugilina ternatana* (Gmelin, 1791), (11) *Turris unedo* Kiener, 1839, (12) *Anadara granosa* (Linnaeus, 1758), (13) *Saccostrea cucullata* (Born, 1778), (14) *Crassostrea gigas* (Thünberg, 1793), (15) *Donax scortum* (Linnaeus, 1758), (16) *Mactra mera* Reeve, 1854, (17) *M. violacea* Gmelin, 1791.

Description of shell characteristics in study area

Nerita lineata Gmelin, 1791

Shell shape	:	Neritic form
Spiral whorl	:	Apex is blunt, low, many concentric lines
Body whorl	:	Large, swollen with both side
Aperture type	:	Wide, broad, slightly rounded
Columella type	:	Thick or thin present, sometime absent
Operculum type	:	Calcareous
Umbilicus	:	Absent
Siphonal canal	:	Absent
Colouration	:	Yellowish background, many black spiral lines
Shell size	:	2.5 cm height, 3 cm width

Turritella duplicata (Linnaeus, 1758)

Shell shape	:	Turriform
Spiral whorl	:	Long and narrow but slightly broad to body whorl
Body whorl	:	Globose, short
Aperture type	:	Oval to rounded
Columella type	:	Narrow, slightly curve, thick
Operculum type	:	Chitinous form
Umbilicus	:	Absent
Siphonal canal	:	Absent
Colouration	:	Yellowish to pale orange, brownish with strong keel
Shell size	:	12 cm height, 2.5 cm width

Natica tigrina (Röding, 1798)

Shell shape	:	Naticoid form
Spiral whorl	:	Blunt, small
Body whorl	:	Globose, large, wide body whorl
Aperture type	:	Semi circular shape
Columella type	:	Thin and straight
Operculum type	:	Chitinous form
Umbilicus	:	Present, wide and deep
Siphonal canal	:	Absent
Colouration	:	Covered with many brown spots
Shell size	:	3 cm height, 3.5 cm width

Polinices didyma (Röding, 1798)

Shell shape	**:**	**Naticoid form**
Spiral whorl	:	Very low spiral with blunted apex
Body whorl	:	Large, solid and massive with smooth outer shell surface
Aperture type	:	Slightly rounded, narrow
Columella type	:	Thick with strong callus
Operculum type	:	Chitinous form
Umbilicus	:	Deep and narrow
Siphonal canal	:	Absent
Colouration	:	Pale yellowish brown, grayish white
Shell size	:	2 cm height, 2.5 cm width

Bursa elegans (G. B. Sowerby I, 1835)

Shell shape	:	Turbiniform
Spiral whorl	:	Low, sharp apex, narrow suture
Body whorl	:	Large, covered spiral blunted spines, strong longitudinal spiral threads
Aperture type	:	Oval or slightly long
Columella type	:	Long and thin
Operculum type	:	Chitinous form
Umbilicus	:	Present and shallow
Siphonal canal	:	Present, deep and narrow, curved backward
Colouration	:	Creamy white, bright yellowish brown
Shell size	:	7 cm height, 4.5 cm width

Thais mutabilis (Link, 1807)

Shell shape	**:**	**Turbiniform**
Spiral whorl	:	Apex is blunt, shallow sutures, narrow shoulders
Body whorl	:	Solid, large, covered with spiral lines
Aperture type	:	Rounded, narrow
Columella type	:	Strong and thick
Operculum type	:	Chitinous form
Umbilicus	:	Present, deep and wide
Siphonal canal	:	Present, short
Colouration	:	Brownish white, covered with black bands
Shell size	:	4 cm height, 2.5 cm width

Murex pecten Lightfoot, 1786

Shell shape	:	Fusiform
Spiral whorl	:	Low spiral with blunted apex
Body whorl	:	Large, wide, low spiral line present and distinct longitudinal spines
Aperture type	:	Rounded and narrow
Columella type	:	Strong and thick
Operculum type	:	Chitinous form
Umbilicus	:	Present and shallow
Siphonal canal	:	Present, long like groove
Colouration	:	Yellowish white
Shell size	:	7.5 cm height, 4 cm width

Babylonia formosae (G. B. Sowerby II, 1866)

Shell shape	:	Naticoid form
Spiral whorl	:	Low, slightly deep and narrow shoulder
Body whorl	:	Solid, large and covered with white and brown path, suture is deep
Aperture type	:	Narrow and oval

Columella type	:	Strong and thick
Operculum type	:	Chitinous form
Umbilicus	:	Oval and narrow
Siphonal canal	:	Present
Colouration	:	Brownish white patch
Shell size	:	4 cm height, 2.5 cm width

Nassarius olivaceus (Bruguière, 1789)

Shell shape	:	Naticoid form
Spiral whorl	:	Narrow apex, spiral with shallow groove
Body whorl	:	Thick and slightly swollen
Aperture type	:	Oval and narrow
Columella type	:	Thin, straight
Operculum type	:	Chitinous form
Umbilicus	:	Absent
Siphonal canal	:	Present and slightly short
Colouration	:	Brownish grey to yellowish
Shell size	:	3.5 cm height, 1.7 cm width

Pugilina ternatana (Gmelin, 1791)

Shell shape	:	Fusiform
Spiral whorl	:	Short , apex is blunted, broad shoulder with short spin
Body whorl	:	Large, solitary, massive erect huge spine
Aperture type	:	Wide and thick
Columella type	:	Thin and curve
Operculum type	:	Chitinous form
Umbilicus	:	Present (distinct when mature)
Siphonal canal	:	Present, long and slightly straight
Colouration	:	Yellowish grey to dark grey
Shell size	:	8 cm height, 4.5 cm width

Turris unedo Kiener, 1839

Shell shape	:	Turriform
Spiral whorl	:	Slightly long, narrow to apex, distinct longitudinal ribs
Body whorl	:	Narrow , short
Aperture type	:	Thin and straight
Columella type	:	Calcareous
Operculum type	:	Oval and thin,
Umbilicus	:	Absent
Siphonal canal	:	Present, curve to backward
Colouration	:	Grayish yellow to gray
Shell size	:	6 cm height, 2.3 cm width

Anadara granosa (Linnaeus, 1758)

Shell shape	:	Solid, thick, equivalve, broadly oval shape
Umbonal type	:	Hook like
Muscular scar	:	Present
Ligament	:	Internal
Outer layer	:	White parallel ribs, 2 or more layer teeth
Inner layer	:	Smooth and white
Teeth pattern	:	Granulated, small similar teeth
Pallial sinus	:	Present
Colouration	:	White to yellow brown
Shell size	:	12 cm height, 2.5 cm width

Saccostrea cucullata (Born, 1778)

Shell shape	:	Oyster like, circular to oval
Umbonal type	:	Large, no sculpture
Muscular scar	:	Close to pallial line
Ligament	:	Internal
Outer layer	:	Rough with thick
Inner layer	:	Pearly white
Teeth pattern	:	Converging toward
Pallial sinus	:	Present
Colouration	:	Internally white, external purple, black, brown,
Shell size	:	4 cm height, 2.5 cm width

Crassostrea gigas (Thünberg, 1793)

Shell shape	:	Wide oval, thick and very rugose
Umbonal type	:	Prominent and enrolled
Muscular scar	:	Single, dark
Ligament	:	Internal
Outer layer	:	Hard and oval
Inner layer	:	Concave, quite deep and cup-shaped
Teeth pattern	:	Sharp erosive, asymmetric
Pallial sinus	:	Present
Colouration	:	Whitish, inner shell white, deep purple outermost shell
Shell size	:	4 cm height, 3.5 cm width

Donax scortum (Linnaeus, 1758)

Shell shape	:	Trigonal
Umbonal type	:	Darker hues
Muscular scar	:	Present, both side posterior and interior
Ligament	:	External
Outer layer	:	Radiating line
Inner layer	:	White, purplish, polished
Teeth pattern	:	Two cardinal tooth
Pallial sinus	:	Present
Colouration	:	Dark green, variation color
Shell size	:	4 cm height, 6 cm width

Mactra mera Reeve, 1854

Shell shape	:	Oval, triangular shape
Umbonal type	:	Prominent and elevated
Muscular scar	:	Two subequal adductor
Ligament	:	Internal brown
Outer layer	:	Thick smooth
Inner layer	:	Whitish
Teeth pattern	:	Interior cardinal teeth, V- shaped
Pallial sinus	:	Short and oval
Colouration	:	White, brown
Shell size	:	4 cm height, 5 cm width

Matra violacea Gmelin, 1791

Shell shape	**:**	**Large, thin, absolutely radiate**
Umbonal type	:	Prominent and elevated
Muscular scar	:	Present, same side anterior and posterior
Ligament	:	Internal, well develop
Outer layer	:	Smooth with spiral line
Inner layer	:	Smooth
Teeth pattern	:	Cardinal tooth present
Pallial sinus	:	Rounded, shallow and non-confluent
Colouration	:	Violet
Shell size	:	2.5 cm height, 3.5 cm width

Table 2: Habitats of some intertidal gastropods and bivalves in study area

Species	Habitats characterization
Nerita lineata Gmelin, 1791	Very common in the upper part of shores, often in crevices and pits of rock benches, or on branches of littoral trees overhanging the water.
Turritella duplicata (Linnaeus, 1758)	On sub-tidal sand and mud bottoms.
Natica tigrina (Röding, 1798)	On sandy bottoms. Mainly sub-littoral, from shallow sub-tidal waters to a depth of about 30 m.
Polinices didyma (Röding, 1798)	On sandy to muddy bottoms. Intertidal to shelf zones.
Bursa elegans (G. B. Sowerby I, 1835)	Mud and muddy-sand bottoms.
Thais mutabilis (Link, 1807)	Common in various shallow water habitats, rocks, coral reefs, or clean to muddy sand bottoms.
Murex pecten Lightfoot, 1786	On sandy to muddy bottoms of coral reef areas and on the continental shelf.
Babylonia formosae (G. B. Sowerby II, 1866)	On sand and mud bottoms.
Nassarius olivaceus (Bruguière, 1789)	Very common on muddy sand flats.
Pugilina ternatana (Gmelin, 1791)	Common on soft bottoms. Sub-littoral and offshore, mainly at depths between 10 to 50 m.
Turris unedo Kiener, 1839	Common on sub-littoral muddy bottoms, to a depth of about 30 m.

Anadara granosa (Linnaeus, 1758)	On muddy bottoms, mainly in protected bays and estuaries, or in mangroves.
Saccostrea cucullata (Born, 1778)	Attached to various hard substrates, in marine, estuarine and mangrove areas, often in dense colonies.
Crassostrea gigas (Thünberg, 1793)	Attached to hard objects or growing in bunches, on various soft bottoms, especially in bays and estuaries with somewhat reduced salinity. Intertidal and shallow sub-tidal water.
Donax scortum (Linnaeus, 1758)	In muddy bottoms. Intertidal and shallow sub-tidal waters.
Mactra mera Reeve, 1854	In sandy bottoms.
M. violacea Gmelin, 1791	In sandy bottoms, at shallow sub-tidal levels.

Molluscs are for the most part of benthonic but gastropods have developed those pelagic groups: janthinids, heteropods and pteropods, all of which have been represented in Myanmar waters [7]. Bivalves are soft-bodied mollusks enclosed by two valves joined by an elastic ligament. The mollusks are very common in aquatic environments, including freshwater, brackish water, and saltwater [21].

In Myanmar, the earliest reports on marine shell fish had been reported by Mason [22- 24]. Consequently, Mann also reported on Burmese molluscs along three coastal waters of Myanmar [25]. In the 1980s, Mar Lar Myo Sein, Soe Thu and Aye Thida Thein reported a common species of brackish-water molluscs inhabit in Rakhine coastal region [8, 26-27]. Soe Thu had also recorded the diversity of seashells from Ngapali, Maungmagan and various localities of Myanmar coastal waters [28-30]. In the recent year 2019, Naung Naun Oo had studied Turban shells of Andrew Bay, southern Rakhine costal region [31].

In the Ayeyarwady Coastal Region, Aye Thant Zin *et.al* had been reported preliminary survey of gastropods and Pelecypods around the Sin-Ma village, Pathein Township [17]. In the year 2011, the spat collection grown out culture of oyster in Shwe Thaung Yan coastal area had been carried out by Htay Aung [32].

In Taninthayi Coastal Region, Kyaw Myint had published a checklist comprising 248 species of marine gastropods, bivalves and cephalopods in Moscos Islands. His reported list included 72 families but was not yet perfect checklist in Myanmar [33]. A systematic account on some marine gastropods, pelecypods (= Bivalves) and cephalopods in various localities of Myanmar had been carried out by Jar San reported morphology and distribution cephalopods in Mon coastal areas [34], Naung Naung Oo had conducted the study of the marine gastropods from the Mon Coastal area [35]. Moreover, Thaw Zin Naing Tun *et.al*, Phoo Thet Su Win, Sint Sint Hlaing, Khin Myo Thin, Su Pyae Tun, Aung Ko Latt, Aung Pyae Phyo and Win Win Nwe had studied about the estuarine and marine mollusks in their respectively along Myanmar coastal water [17, 36-43]. However, distribution pattern, habitat preferences and seasonal variation remained unknown to give much more information.

Currently reported all bivalves' species are providing not only harmony for intertidal habitats but also utilized food for local consumption. Bivalves are mostly found in mudflat while gastropods inhabit all types of habitats. In the sand beach, 2 species of bivalves; *Mactra mera* (Reeve, 1854), *M. violacea* (Gmelin, 1791) and 3 species of gastropods; *Turritella duplicata* (Linnaeus, 1758), *Natica tigrina* (Röding, 1798) and *Murex pecten* (Lightfoot, 1786) were collected, in which the highest number of *T. duplicata* (Linnaeus, 1758) are found in sandy beach. These species have been used to create ornamentation found in souvenir shop for selling local markets. The muddy sand habitat of Thae Chaung intertidal water, 6 species of gastropods and 4 species of bivalves were found. Maximum number of molluscs was recorded in this habitat. Local people have used *Pugilina ternatana* (Gmelin, 1791) as food for fishery purposes. Approach to the rocky fringe, *Nerita lineata* Gmelin, 1791 and *Thais mutabilis* Link, 1807 was recorded from different habitats at intertidal zone such as mudflat, sandy beach and tide pool, the lowest number of species occurred in this area.

Conclusion

A total of 17 species of molluscs were found in the present study area. The result might not represent the actual diversity because there was a preliminary checklist survey which represented a small scale area of northern Rakhine coast. However, this paper will help everybody who need fundamental checklist of molluscs species data. Extended study should be conducting seasonally collecting mollusks data in intertidal to deep water. Using advanced methods will evaluate specific value. Long term data collections supported to determine seasonal abundance and distribution to study the adaptation between mollusks diversity and environmental condition in study areas.

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