ABUNDANCE OF THE GENUS *CONUS* LINNAEUS 1758 (GASTROPODA: CONIDAE) FROM ANDREW BAY IN RAKHINE COASTAL REGION

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Abstract

Andrew Bay is ecologically and biologically significant marine area in Rakhine Coastal Region. This research is the first attempt to photo-document, record, and determine the relative abundance of *Conus* species in Rakhine Coastal Region. This study was carried out in three study sites of Andrew Bay in 2014. There were a total of 879 cone shells collected encompassing 30 known species. Most of the number of cone shells was found in Pearl Island which constitutes about 60.5% of the entire collection. The most abundant species are *C. arestophanes*, *C. vinctus*, and *C. mustelinus*. While the rare species include *C.* marmoreus, *C. betulinus*, *C. ferrugineus*, *C. vexillum*, and *C. nussatella*, and the rarest among those species are *C. miles*, *C. quercinus*, *C. tessulatus*, and *C. virgo* with only one specimen collected. Moreover, the diversity of cone shells found along the world oceans were also described.

Keywords: *Conus* species, relative abundance, Andrew Bay, Rakhine Coastal Region.

Introduction

In Myanmar, there were 40 species of *Conus*, of which 30 species namely *C. imperialis* Linnaeus, 1758; *C. zonatus* Bruguière, 1792; *C. litteratus* Linnaeus, 1758; *C. eburneus* Bruguière, 1792; *C. leopardus* Rödiing, 1798; *C. crassus* Sowerby, 1857; *C. ebraeus* Linnaeus, 1758; *C. prytanis* Sowerby, 1882; *C. achatinus* Gmelin, 1791; *C. monile* Bruguière, 1792; *C. vitulinus* Bruguière, 1792; *C. miles* Linnaeus, 1758; *C. vexillum* Gmelin, 1791; *C. flavidus* Lamarck, 1810; *C. geographus* Linnaeus, 1758; *C. aulicus* Linnaeus, 1758; *C. episcopus* Bruguière, 1792; *C. omaria* Bruguière, 1792; *C. textile* Linnaeus, 1758; *C. textile verriculum* Reeve, 1848; *C. gloriamaris* Chemnitz, 1777; *C. tigrinus* Sowerby, 1858; *C. betulinus* Linnaeus, 1758; *C. figulinus* Linnaeus, 1758; *C. quercinus* Solander, 1786; *C. hyaena* Hwass, 1792; *C. blanfordianus* Crosse, 1867; *C. striatus* Linnaeus, 1758; *C. tulipa* Linnaeus, 1758 and *C. terebra* Linnaeus, 1758 were identified but 10 species were unidentified up to species level by Soe Thu (1980).

The family Conidae is one of the major groups of gastropod animals which are mainly characterized by the possession of intense venom apparatus and highly predacious and nocturnal in feed and feeding habits (Gugulothu, Raveender, Shah and Koteswar 2017). They normally have a toxicant sting, which they use for their predatory activity on their prey, such as polychaete annelids, echiurans, small fishes, and other gastropods (Kohn et.al 1999) as mentioned by Lee and Park (2014). Moreover, cones are characterized by the possession of a venom gland and a highly modified radular tooth that they use as a harpoon to inject venom into their prey (Díaz et.al 2005; Puillandre, Duda, Meyer, Olivera and Bouchet 2015).

The genus *Conus* Linnaeus 1758, is considered to be the most species-rich modern marine genus, with more than 500 extant and several hundred extinct species (Rockel, Korn and Kohn 1995; Duda, Kohn and Palumbi 2001) as cited in Harasewych (2014). However, Tucker and Tenorio (2009) in (Lee and Park 2014) stated that it contains more than 600 extant species. But, as of 2014, from 30 valid species known to Linnaeus, the recent accepted number of species stands at 803 based from World Register of Marine Species (WoRMS).

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They occur mainly in the tropical zone of all world oceans, although the majority of species concentrate in the Indo-Pacific and western Pacific regions (Keen 1971; Walls 1979; Duda *et.al* 2008) as cited by (Lee and Park 2014). These live in the tropical and warm temperate seas of the world, from the intertidal to depths of almost 1,000 m (Puillandre *et.al* 2015). Cone shells inhabit various types of sea bottom substrates, including rocky grounds, sand or mud plains, coral reefs and seagrass beds, and reach from the intertidal zone to more than 1,000 m of depth (Dance and Cosel 1977) in (Díaz *et.al* 2005).

Conidae is a very popular family among gastropods due to its rarity and beautiful color. Many fishermen families among coastal villages are actively engaged in the collection of these shells and also in the shell handicraft industry. They are widely used for making dolls, fantasy flower sculptures of gods, etc (Sary *et.al* 2014).

They are undoubtedly one of the most unmistakable groups due to its characteristic conic shell and variety of colors. Cone shells are the most popular collectable shells among amateur and professional conchologists, and the shells of rare species may reach exorbitant prices (Díaz *et.al* 2005). The striking shell patterns have long attracted a large cadre of collectors. They are also economically important because shell collectors and commercial traders have established active markets for their shells globally (Cabrera 1984). In the seventeenth century, cone shells were among the most valuable of natural history objects (Olivera and Corneli 2014). Nowadays, several *Conus* peptides are widely used research tools in neuroscience and some other potential therapeutic agents. Its venom becomes increasingly important in medicine and neurobiology (Craig, Bandyopadhyay and Olivera 1999).

Cone snails are therefore important to biodiversity since they have evolved into one of the largest of all marine genera. Likewise to biopharmaceutics because they offered unparalleled opportunities in the development of novel drugs. Lastly, to economics since their shells provide income to poor fishing communities through sales to tourists, traders and a global business in the specimen shell trade (Peters, Leary, Hawkins, Carpenter and Roberts 2013).

The Rakhine Coastal Region has a coastline stretching about 740 km facing the Bay of Bengal which possesses marine fishery resources. Andrew Bay (Lat. 18˚25′ N, Long. 94˚15′ E) is one of the unique ecosystem in Rakhine Coast where is a huge habitat with rich biodiversity. However, no studies were conducted yet, nor published research about the diversity of cone shells in Andrew Bay. But there's already evidence of over gleaning and exploitation of coastal resources in the bay. Therefore, studying and documenting them is very important before they become extinct. The objectives of current study are 1) to identify the diversified species of cone shells; and 2) to investigate the species abundance of cone shells population in their natural habit. Establishing baseline data about this species is also necessary for future researches.

Materials and Methods

This study on the relative abundance of *Conus* species along Andrew Bay was carried out in 2014. The collection of specimen was conducted from the three sampling sites of Andrew Bay, namely; Pearl Island, Tha-byu Gyaing and Maung-shwe-lay Gyaing (Fig. 1). Specimens were collected from the tidal flats, seagrass beds, rocky intertidal areas, sandy shores and beaches through reef walking and gleaning or hand picking. Live and dead *Conus* species were gathered. Species collected were photo documented and recorded. In the identification process, the book entitled "FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific (Volume 1) Seaweeds, Corals, Bivalves and Gastropods" was utilized. Other supplementary websites were also visited for its verification such as www.gastropods.com, www.bily.com, indopacific seashells.com, conchylinet.com and the World Register of Marine

Species (WoRMS). To determine the relative abundance of each species, the scale shown in Table 1 which was adopted from Slimming and Jarrett (1970) and Jackson (1995) as indicated in (Agombar, Dugdale and Hawkswell 2003) was utilized.

Table 1 Scale used to record the relative abundance of shells collected in Andrew Bay over the period of study

Scale	Relative abundance	Number of specimens found during the period
1	Rare	1 to 4
2	Uncommon	5 to 8
3	Occasional	9 to 20
4	Fairly common	21 to 30
5	Common	31 to 99
6	Abundant	100 or more

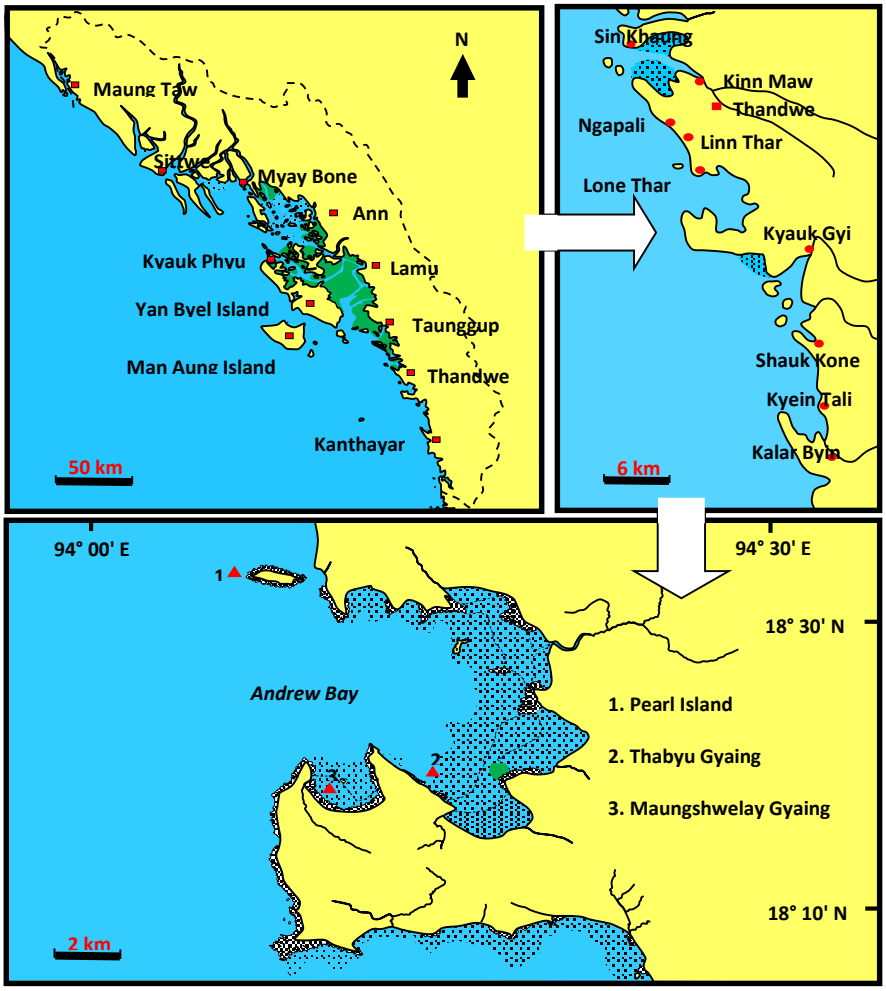

Figure 1 Map showing the sampling sites of cone shells in Andrew Bay

Results and Discussion

A total of 879 cone shells were collected belonging to 30 different *Conus* species. Of which 532 individual cones or 60.5% were found in Pearl Island, 217 or 24.7% came from Tha-byu Gyaing and 130 or 14.8% came from Maung-shwe-lay Gyaing. From the 30 different species

recorded, there were 25 species found in Pearl Island, 23 from Tha-byu Gyaing, and 22 from Maung-shwe-lay Gyaing. Based on the relative abundance, three species were classified as abundant namely; *C. arestophanes*, *C. vinctus*, and *C. mustelinus*. Six species were categorized as common which include *C. ebraeus, C. rattus, C. striatus, C. stercusmuscarum, C. capitaneus, and C. monachus*. Only one species was categorized as fairly common which is the *C. glans*. Seven species of cones were categorized as occasional. These are *C. lividus, C. muriculatus, C. omaria, C. textile, C. varius, C. thalassiarchus, and C. zeylanicus*. Four species were classified as uncommon, which include *C. imperialis, C. eburneus, C. terebra, and C. virgo*. Lastly, nine species were considered as rare which include *C. marmoreus, C. betulinus, C. ferrugineus, C. vexillum, C. nussatella, C. miles, C. quercinus, C. tessulatus,* and *C. virgo* (Table 2 and Fig. 2 to 5).

Table 2 Relative abundance of *Conus* species in Andrew Bay

No.	Species	Sampling site			Total count	Relative abundance description
		St. 1	St. 2	St. 3		
1	*Conus arestophanes* (Sowerby II, 1857)	63	71	0	134	A
2	*Conus betulinus* (Linnaeus, 1758)	0	0	3	3	R
3	*Conus capitaneus* (Linnaeus, 1758)	16	7	9	32	C
4	*Conus ebraeus* (Linnaeus, 1758)	49	11	20	80	C
5	*Conus eburneus* (Hwass in Bruguiere, 1792)	0	1	7	8	U
6	*Conus ferrugineus* (Hwass in Bruguière, 1792)	2	0	1	3	R
7	*Conus glans* (Hwass in Bruguiere, 1792)	12	6	5	23	F
8	*Conus imperialis* (Linnaeus, 1758)	6	2	1	9	U
9	*Conus lividus* Hwass in Bruguière, 1792	7	6	4	17	O
10	*Conus marmoreus* (Linnaeus, 1758)	1	2	1	4	R
11	*Conus miles* (Linnaeus, 1758)	0	0	1	1	R
12	*Conus monachus* (Linnaeus, 1758)	26	2	3	31	C
13	*Conus muriculatus* (Sowerby II, 1833)	10	6	0	16	O
14	*Conus mustelinus* (Hwass in Bruguière, 1792)	82	20	16	118	A
15	*Conus nussatella* (Linnaeus, 1758)	0	3	0	3	R
16	*Conus omaria* (Hwass in Bruguière, 1792	8	2	5	15	O
17	*Conus pulicarius* (Hwass in Bruguière, 1792)	2	0	0	2	R
18	*Conus quercinus* (Lightfoot, 1786)	0	0	1	1	R
19	*Conus rattus* (Hwass in Bruguiere, 1792)	55	5	10	70	C
20	*Conus stercusmuscarum* (Linnaeus, 1758)	26	17	10	53	C
21	*Conus striatus* (Linnaeus, 1758)	39	8	15	62	C
22	*Conus tessulatus* (Born, 1778)	1	0	0	1	R
23	*Conus textile* (Linnaeus, 1758)	9	3	2	14	O
24	*Conus thalassiarchus* (Sowerby II, 1834)	2	6	4	12	O
25	*Conus terebra* (Born, 1778)	4	0	2	6	U
26	*Conus varius* (Linnaeus, 1758)	5	8	0	13	O
27	*Conus vinctus* (Adams, 1855)	102	22	7	131	A
28	*Conus virgo* (Linnaeus, 1758)	2	1	3	6	U
29	*Conus vexillum* (Gmelin, 1791)	1	1	0	2	R
30	*Conus zeylanicus* (Gmelin, 1791)	2	7	0	9	O
	Total	**532**	**217**	**130**	**879**	

Symbol: St. 1 = Pearl Island; St. 2 = Tha-byu Gyaing; St. 3 = Maung-shwe-lay Gyaing; A = Abundance; C = Common; F = Fairly common; O = Occasional; R = Rare; U = Uncommon.

Andrew Bay in Rakhine Coastal Region is a haven of a rich diversity of marine organisms. Unraveling this diversity had posed a tremendous challenge. Marine mollusc studies are still among those that are overseen by many researchers. To date, there is still a lack of basic information such as diversity and species checklist that make it impossible to assess the rate of population lost among existing marine molluscs (Tabugo, Pattuinan, Sespene and Jamasali 2013).

This study was able to record 879 total count of cone shells collected from the coastal areas of the Andrew Bay and initially identified 30 different species. The abundant species were *C. arestophanes*, *C. vinctus* and *C. mustelinus* while the rare species were *C. miles*, *C. quercinus*, *C. tessulatus* and *C. virgo*. Lastly, the rarest *Conus* species recorded were *C. miles*, *C. quercinus*, *C. tessulatus* and *C. virgo* with only one specimen collected throughout the duration of the study. The sampling site of Pearl Island has the most number of *Conus* species observed and collected Maung-shwe-lay Gyaing has the least. There's a great possibility that more species will still be discovered especially in deeper waters and with exhaustive sampling and method used in gathering shells.

There were several studies conducted by different authors from different localities about the diversity of this species. Kohn (1978) reported 70 *Conus* species from Sri Lanka and 64 species in Maldives and Chagos; Subba Rao (1991) reviewed the Conids of Andaman and Nicobar Islands, recorded about 45 *Conus* species; Rockel *et.al* (1995) gave a detailed note on world living *Conus* and documented 316 valid species along with several subspecies and forms from the tropical Indo-Pacific region; Richmond (1999) documented 198 species of Conidae from Western Indian Ocean; Nguyen (2005) recognized 122 species in Vietnamese waters and the Conidae documented from the Philippines was 287 species (Poppe 2008) as mentioned by (Gugulothu, Raveender, Shah and Koteswar 2017). This is summarized in Table 3.

Table 3 Summary of the studies conducted about the diversity of *Conus* species in different places around the world

Authors	Place	No. of Cone Species	Year
Kohn	Sri-Lanka, Maldives and Chagos	134	1978
Subba Rao	Andaman and Nicobar Islands	45	1991
Rockel *et.al*	Indo-Pacific Region	316	1995
Richmond	Western Indian Ocean	198	1999
Nguyen	Vietnamese Waters	122	2005
Poppe	Philippines	287	2008
Dolorosa *et.al*	Tubbataha Reef, Palawan	21	2015
Present study	Andrew Bay, Rakhine Coastal Region	30	2014

Conclusion

The present study initially listed 30 species of cone shells (Family Conidae) in Andrew Bay, Rakhine Coastal Region. The most number and kinds of *Conus* species observed in Pearl Island. From those species, the most abundant are *C. arestophanes*, *C. vinctus* and *C. mustelinus*. While the rare species include *C. marmoreus*, *C. betulinus*, *C. ferrugineus*, *C. vexillum* and *C. nussatella* and the rarest among those species are *C. miles*, *C. quercinus*, *C. tessulatus* and *C. virgo* with only one specimen collected. This initial record may increase with future researches, especially in deeper waters. Thus further study is recommended to enrich it. The diversity of *Conus* species observed suggests that it could be a good biodiversity indicator, thus awareness and conservation may be done.

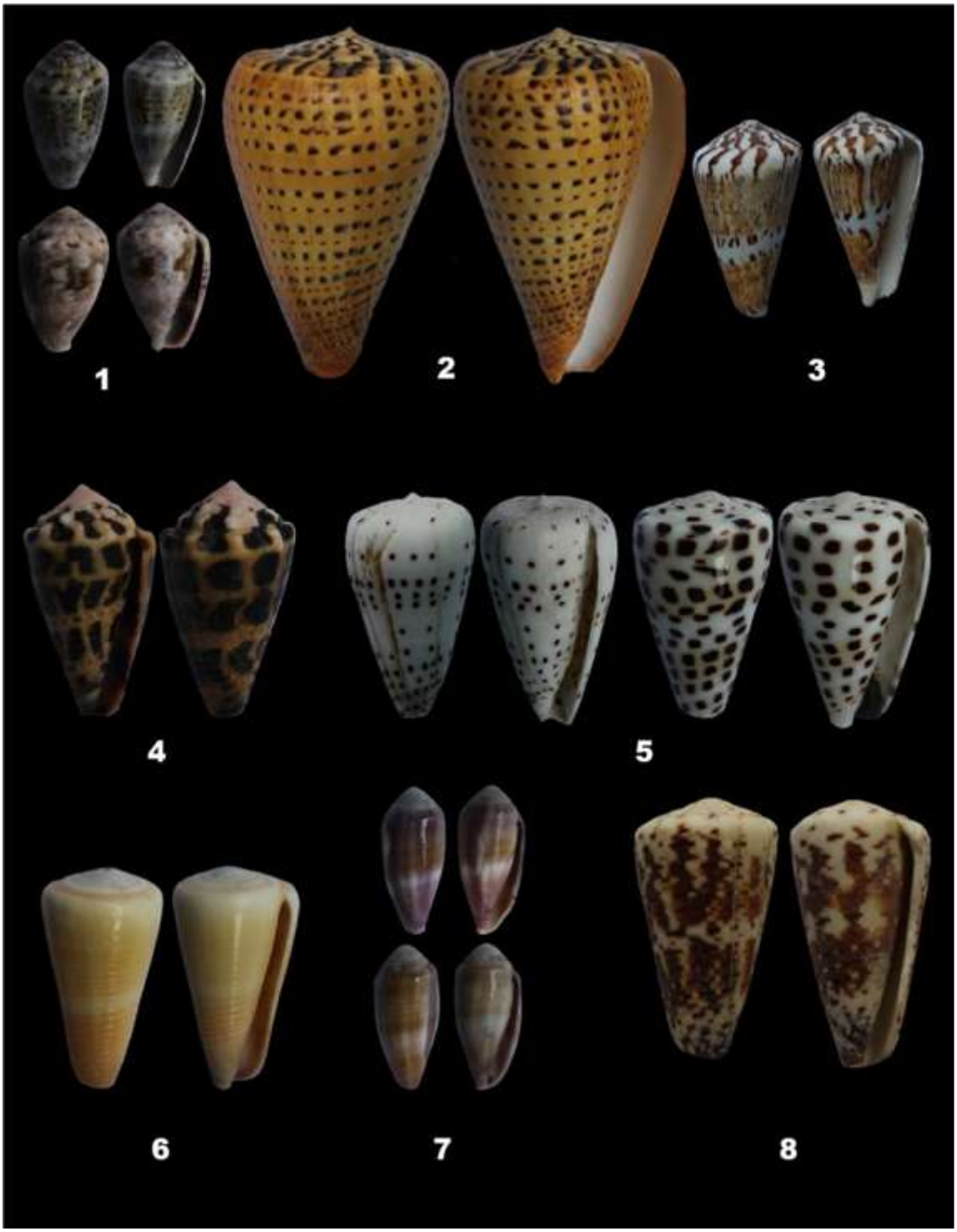

Figure 2 (1-8): *Conus* species found in Andrew Bay. 1) *Conus arestophanes*; 2) *C. betulinus*; 3) *C. capitaneus*; 4) *C. ebraeus*; 5) *C. eburneus*: 6) *C. ferrugineus*; 7) *C. glans*; 8) *C. imperialis*.

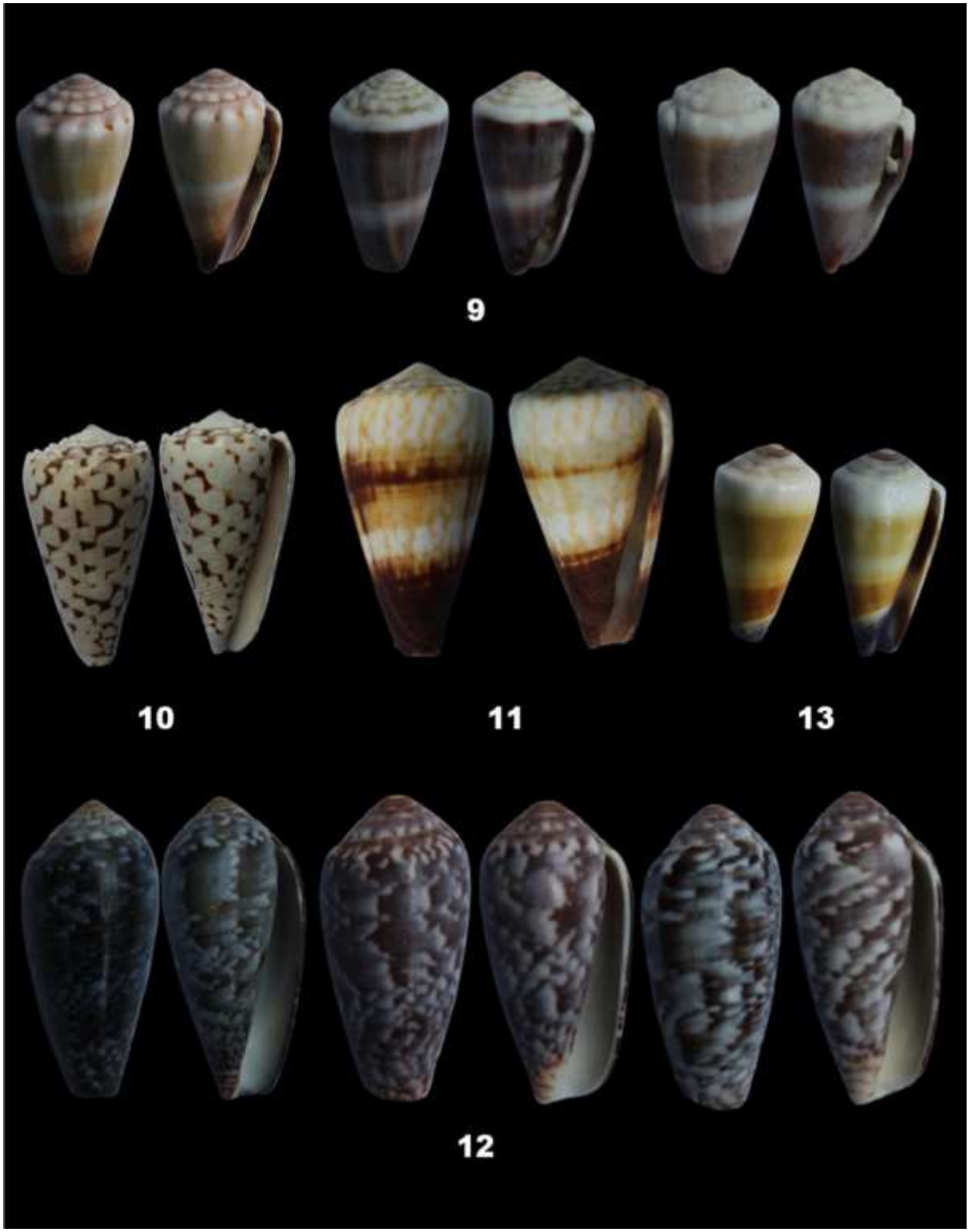

Figure 3 (9-13): *Conus* species found in Andrew Bay. 9) *Conus lividus*; 10) *C. marmoreus*; 11) *C. miles*; 12) *C. monachus*; 13) *C. muriculatus*.

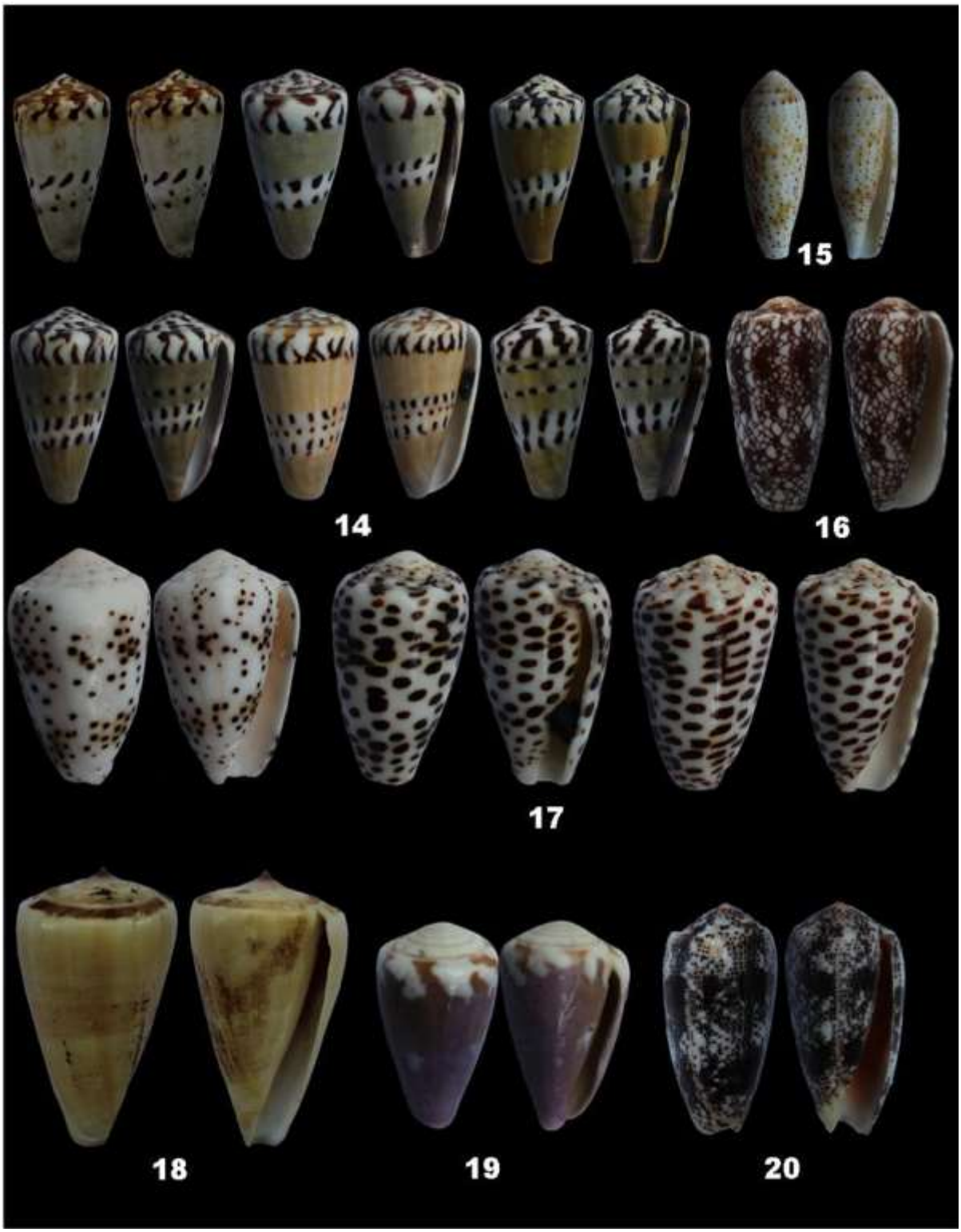

Figure 4 (14-20): *Conus* species found in Andrew Bay. 14) *Conus mustelinus*; 15) *C. nussatella*; 16) *C. omaria*; 17) *C. pulicarius*; 18) *C. quercinus*; 19) *C. rattus*; 20) *C. stercusmuscarum*.

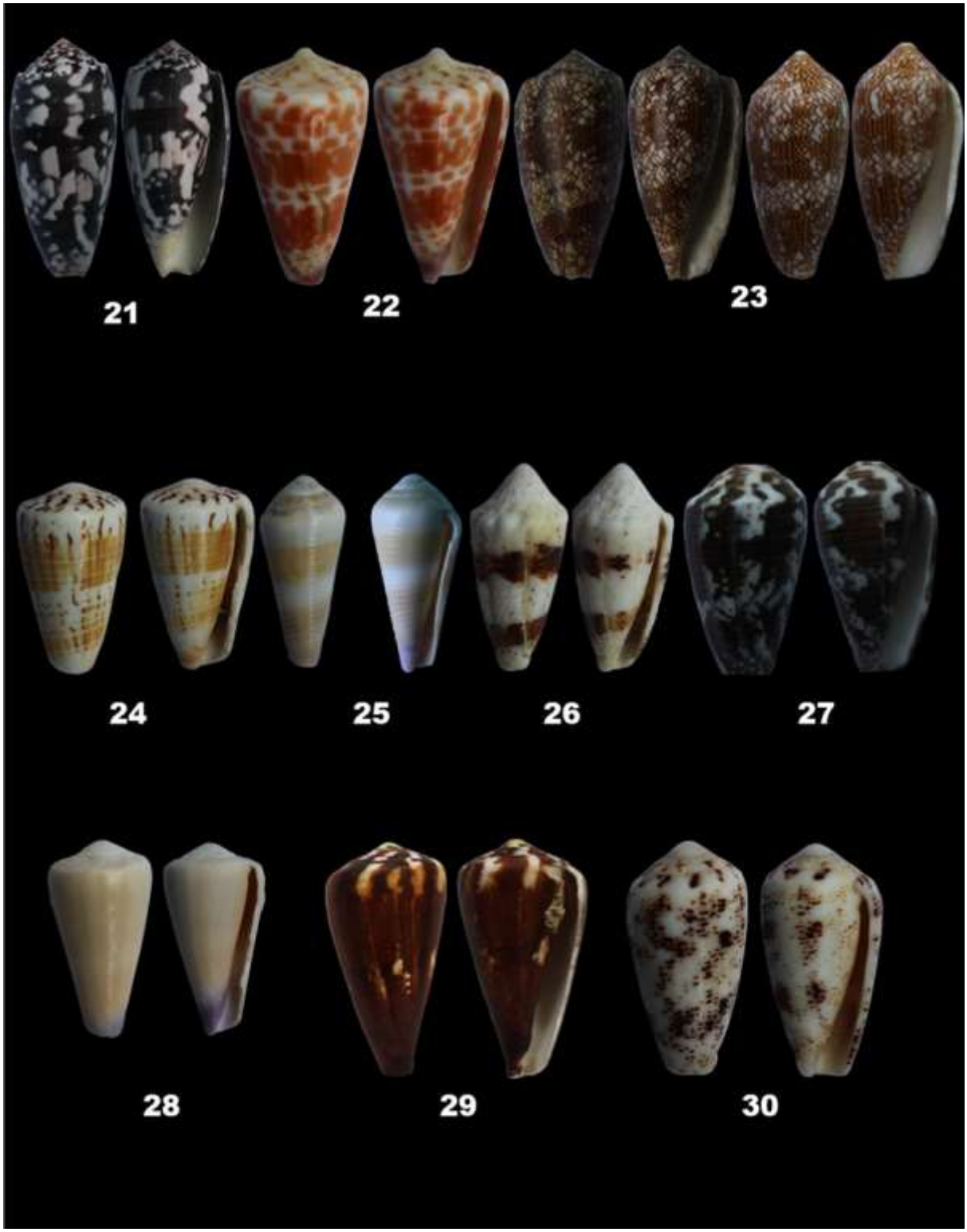

Figure 5 (21-30): *Conus* species found in Andrew Bay. 21) *Conus striatus*; 22) *C. tessulatus*; 23) *C. textile*; 24) *C. thalassiarchus*; 25) *C. terebra*; 26) *C. varius*; 27) *C. vinctus*; 28) *C. virgo*; 29) *C. vexillum*; 30) *C. zeylanicus*.

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