

## **Checklist of Gastropods from the Exclusive Economic Zone (EEZ), Sarawak, Malaysia**

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**Abstrak:** Kajian ini menyediakan senarai gastropod marin yang pertama dari perairan Zon Ekonomi Eksklusif (ZEE) Sarawak. Sampel gastropod dikumpul dari stesen yang terpilih di ZEE Sarawak. Operasi menunda menggunakan pukot tunda dengan saiz regangan 38 mm pada penghujung pukot. Operasi menunda dijalankan di kawasan melebihi 12 batu nautika dari pesisir pantai dan kawasan stesen dibahagi kepada tiga strata kedalaman iaitu, I) 20–50 m, II) 50–100 m dan III) 100–200 m. Sebanyak 23 spesies gastropod telah dikenalpasti sepanjang dua bulan kajian yang bermula dari 16 Ogos hingga 6 Oktober 2015 di mana ia terdiri daripada 8 superfamili, 15 famili dan 20 genus. Superfamili Tonnoidea diwakili 7 spesies, diikuti Muricoidea (5 spesies), Cypraeoidea (4 spesies), Buccinoidea dan Conoidea (2 spesies). Manakala lain-lain superfamili hanya diwakili satu spesies sahaja. Didapati hanya 3 spesies berada di 2 strata kedalaman iaitu *Melo melo*, *Murex aduncospinosus* dan *Tonna galea*. Selain daripada itu, didapati 9, 13 dan 4 spesies gastropod dijumpai masing-masing pada strata I, II dan III. Maklumat berkenaan taburan gastropod dengan perbezaan strata kedalaman di ZEE Sarawak sangat berguna dalam pengemaskinian pangkalan data diversiti spesies di Malaysia.

**Kata kunci:** Gastropod marin, Komposisi spesies, Strata kedalaman

**Abstract:** This study provides the first marine gastropod checklist from the Sarawak Exclusive Economic Zone (EEZ). Gastropod samples were collected from selected stations in the Sarawak EEZ using an otter trawl net with a stretched mesh size of 38 mm at the cod end. The trawling operations were conducted more than 12 nautical miles from the coast, and the area was divided into three depth strata: I) 20–50 m, II) 50–100 m and III) 100–200 m. A total of 23 gastropod species were identified during the two-month sampling period from 16 August until 6 October 2015, representing 8 superfamilies, 15 families and 20 genera. Superfamily Tonnoidea was represented by 7 species, followed by Muricoidea (5 species), Cypraeoidea (4 species), and Buccinoidea and Conoidea (both with 2 species). Other superfamilies were represented by a single species. Only 3 species were obtained in 2 depth strata, namely *Melo melo*, *Murex aduncospinosus* and *Tonna galea*. In addition, 9, 13 and 4 species of gastropods were found in strata I, II and III, respectively. The information on gastropod distributions at different depth strata in the Sarawak EEZ could be useful in updating the Malaysian species diversity database.

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**Keywords:** Marine gastropods, Species composition, Depth strata

## INTRODUCTION

The implementation of the Malaysian Exclusive Economic Zone (EEZ) in 1981 led to the extension of the fishing grounds beyond the traditional fishing area. The total EEZ area in Malaysia is 548,800 km<sup>2</sup>, and Sarawak, as the largest state in Malaysia, contains approximately 160,000 km<sup>2</sup> of the Malaysian EEZ (Jamil & Hadil 2012). The topography of the Sarawak seabed was identified in previous surveys and is composed of rocky bottoms and hard coral in addition to having sloping areas with a depth of more than 200 metres (Basir *et al.* 2012).

Mollusca is the second largest phylum, with approximately 200,000 living species that inhabit the land, mountains, rivers, seas and oceans (Ponder & Lindberg 2008). This phylum can be categorized into seven classes, and Gastropoda is the largest molluscan class (Aktipis *et al.* 2008). Gastropods are characterized by having a single shell with an operculum, but the shell is absent in some forms. Furthermore, they can be found in all marine environments, including extreme environments such as hydrothermal vents (Warén 2001).

Taxonomic studies of molluscs in Peninsular Malaysia and Sabah began in the early 1930s by the British. They recorded every gastropod that was collected from Batu Cave, Selangor (Laidlaw 1932), and Mount Kinabalu, Sabah (Laidlaw 1937). Furthermore, from 1973 to 1974, an intensive survey of marine mollusc diversity was conducted by Purchon on the east and west coasts of Peninsular Malaysia (Morris & Purchon 1981; Purchon & Purchon 1981; Way & Purchon 1981). This survey resulted in the collection of 301 specimens from the class Gastropoda, and these specimens are currently stored in the British Natural History Museum, London. Recently, several studies have been conducted on marine gastropods in Peninsular Malaysia by Aziz *et al.* (2001), Kee Alfian *et al.* (2005), Wong *et al.* (2008) and Siti-Balkhis *et al.* (2014). However, most of the recorded species were shown to inhabit the rocky shore, coral reefs and intertidal areas of an island, which are less than 3 nautical miles from the coast.

Meanwhile, in Sarawak, the taxonomic study of molluscs began in the early 1890s by the Dutch, and they collected gastropods inhabiting hills and rivers (Schepman 1895). There are a number of published studies on gastropods in Sarawak. For example, Hamli *et al.* (2013) reported that 21 species of edible gastropods are sold in wet markets around Kuching, Sibu, Mukah, Bintulu, Miri, Limbang and Lawas. In addition, gastropods living in coastal areas (Shabdin & Alfred 2007), mangrove forests (Shabdin & Hidir 2008) and intertidal habitat on island (Shabdin *et al.* 2014) have also been documented.

According to Wong and Arshad (2011), based on their collection of data from scientific writings, a total of 581 species of marine shelled Mollusca are listed in Malaysia (384 species from class Gastropoda). It seems that the number of species listed is far too small compared to other regions. In Japan, more than 6600 species of marine and brackish gastropods have been recorded (Poutiers 1998), while approximately 5000 to 6000 species of molluscs have been recorded for Panglao Island in the Philippines (Bouchet 2006). Although Malaysia

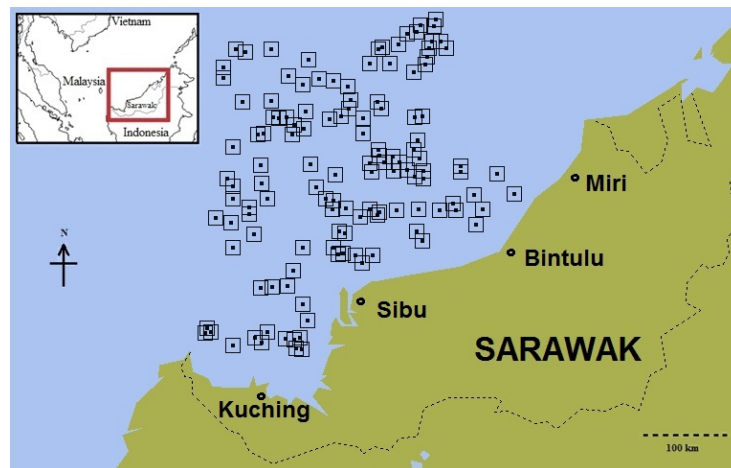
is known as part of a high biodiversity region, limited information is known on marine gastropods, especially in Sarawak. Thus, the recent findings from this study will contribute valuable information on gastropod species in the waters of Sarawak.

From July to October 2015, the Bintawa Fisheries Research Institute, Sarawak (FRI), Department of Fisheries (DoF), Malaysia, conducted National Demersal Fish Resource Surveys in Sarawak, Sabah and Labuan waters. During these surveys, invertebrates were part of the by-catch. This paper provides a species checklist and locations of the marine gastropods obtained from different depth strata in the Sarawak EEZ.

## MATERIALS AND METHODS

### Study Area

Samples were collected at 153 trawling stations in the Sarawak EEZ (Figure 1). The sampling stations were selected by the FRI, DoF Malaysia. The survey was carried out using the research vessel *MV SEAFDEC 2*, owned by the Southeast Asian Fisheries Development Centre (SEAFDEC), based at the SEAFDEC Training Department, Bangkok, Thailand. A research team from the Universiti Malaysia Sarawak (UNIMAS) was invited to join the survey. Invertebrate organisms that were trapped together with fish (main survey) in the net were collected, sorted and measured. Otter trawling (mesh size 38 mm at the cod end) was used for the bottom trawl sampling, and the surveyed areas were more than 12 nautical miles from the coast of Sarawak. The sampling area was divided into three different depth strata, i.e., I) 20–50 m, II) 50–100 m and III) 100–200 m. The samples of gastropods collected were labelled together with the coordinates and depths at which they were trawled.



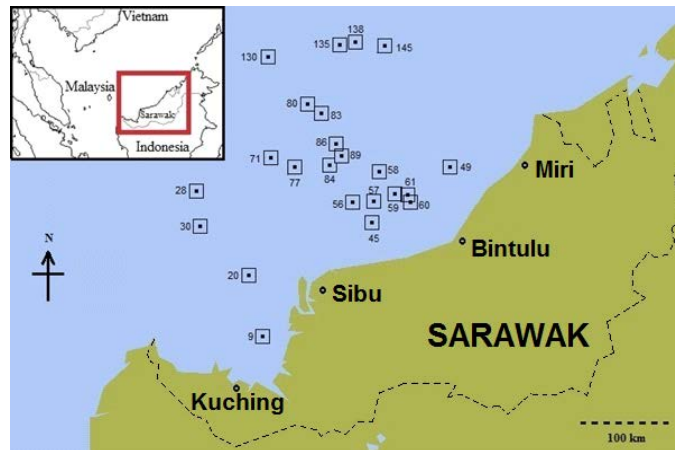
**Figure 1:** All sampling stations during the two-month (16 Aug – 6 Oct) survey in Sarawak EEZ in 2015.

### Species Identification

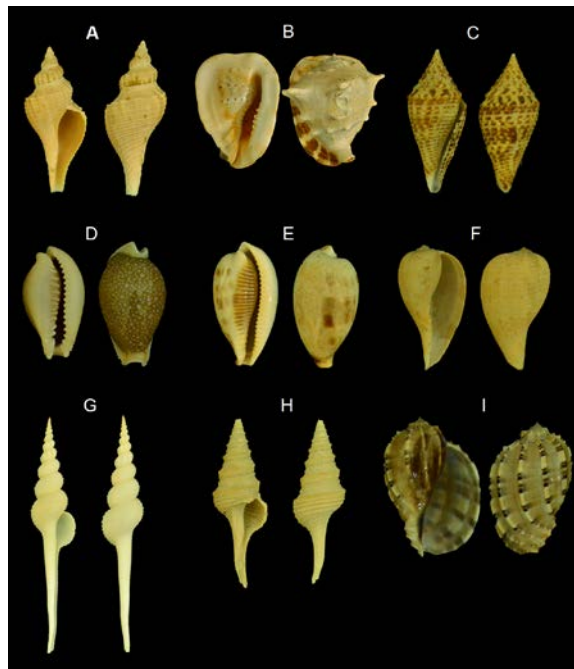
All samples were identified to the lowest possible taxonomic level based on identification keys by Abbott & Dance (1982), Oliver (1992), Abbott (2002), Dance (2002) and Oliver (2004). The validity of each species identification was checked against the World Register of Marine Species (WoRMS) (WoRMS Editorial Board 2016). Photographs were captured using a Nikon D7000 DSLR (Shinagawa, Tokyo, Japan) following the orientation of the seashell illustrations by Abbott & Dance (1982), and the photographs were kept as records. Morphometric data, such as shell length and width, were measured using a dial caliper accurate to  $\pm 0.01$  mm to aid in species identification. The voucher specimens were stored in a freezer ( $-20^{\circ}\text{C}$ ) during the field survey. After the identifications were complete, the samples were placed into 10% formalin for 2 weeks, which was then replaced with 70% ethanol for long-term preservation. Representatives of the samples were deposited in the Aquatic Invertebrata Museum, Department of Aquatic Science, Faculty of Resource Science and Technology, UNIMAS.

### RESULTS AND DISCUSSION

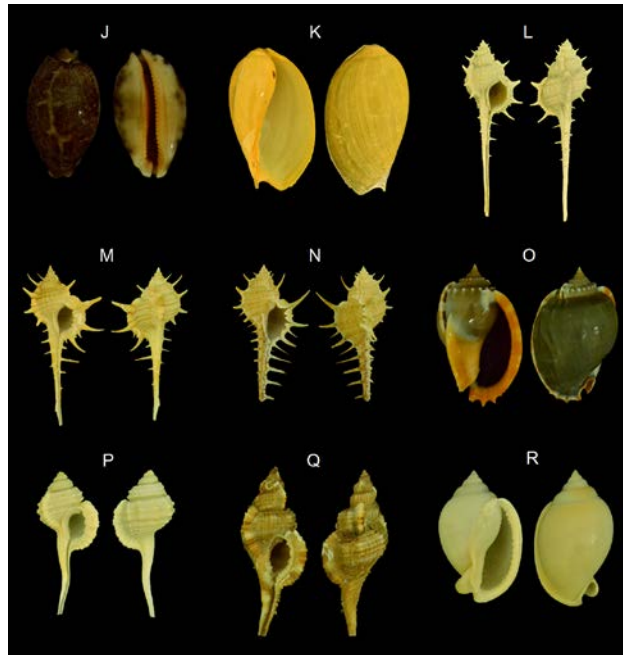
Out of 153 stations trawled, gastropods were found at only 23 stations (Figure 2). A total of 23 species belonging to 20 genera, 15 families and 8 superfamilies were identified (Figure 3a; 3b; 3c, Table 1) from the Sarawak EEZ, consisting of the superfamilies Buccinoidea, Conoidea, Cypraeoidea, Ficoidea, Muricoidea, Stromboidea, Tonnoidea and Xenophoroidea. Nine species of gastropods were collected from stratum I, 13 species from stratum II and 4 species from strata III, as shown in Table 2. The highest number of species was obtained from stratum II (13 species), followed by stratum I (9 species) and strata III (4 species). Each species had different meristic characteristics (Table 3), and these characters were useful for the identification process for most of the specimens collected. Superfamily Tonnoidea was the most commonly found taxon and was represented by seven species, *Cassis cornuta*, *Phalium glaucum*, *Ranularia caudata*, *Reticutriton pfeifferianus*, *Semicassis glabrata*, *Tonna galea* and *Tonna tessellata*. This was followed by Superfamily Muricoidea, which included five species, *Harpa articularis*, *Melo melo*, *Murex aduncospinosus*, *Murex concinnus* and *Murex ternispina*. Superfamily Cypraeoidea consisted of four species, *Erosaria miliaris*, *Erronea pulchella*, *Leporicypraea mappa* and *Volva volva*. Superfamily Buccinoidea included two species, *Aeneator comptus* and *Fusinus colus*. Superfamily Conoidea included two species, *Conus praecellens* and *Gemmula speciosa*. Superfamilies Ficoidea, Stromboidea and Xenophoroidea were each represented by a single species, which were *Ficus filosa*, *Tibia fusus* and *Stellaria solaris*, respectively.



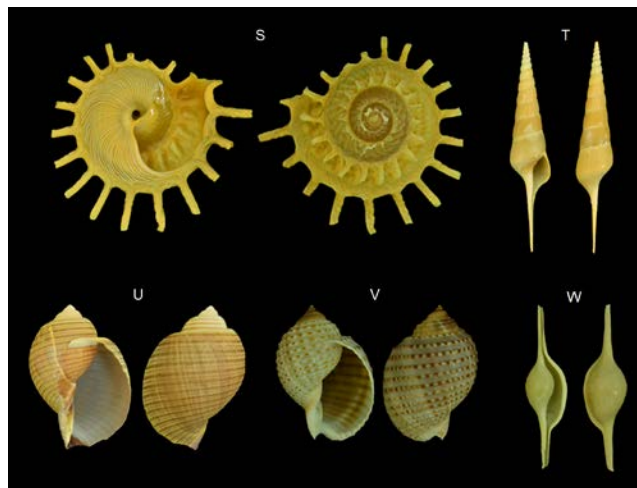
**Figure 2:** Sampling stations where gastropods were found during the surveys in Sarawak EEZ in 2015.



**Figure 3a (A-I):** Gastropods from Sarawak EEZ, (A) *Aeneator comptus*, 60.2 mm shell length, (B) *Cassis cornuta*, 230.7 mm shell length, (C) *Conus praecellens*, 43.1 mm shell length, (D) *Erosaria miliaris*, 46.8 mm shell length, (E) *Erronea pulchella*, 33.0 mm shell length, (F) *Ficus filosa*, 36.0 mm shell length, (G) *Fusinus colus*, 150.5 shell length, (H) *Gemmula speciosa*, 64.4 mm shell length and (I) *Harpa articularis*, 65.0 mm shell length.



**Figure 3b (J-R):** Gastropods from Sarawak EEZ, (J) *Leporicypraea mappa*, 43.2 mm shell length, (K) *Melo melo*, 138.1 mm shell length, (L) *Murex aduncospinosus*, 91.9 mm shell length, (M) *Murex concinnus*, 61.8 mm shell length, (N) *Murex ternispina*, 62.2 mm shell length, (O) *Phalium glaucum*, 110.1 mm shell length, (P) *Ranularia caudata*, 51.8 mm shell length, (Q) *Reticutriton pfeifferianus*, 54.2 mm shell length and (R) *Semicassis glabrata*, 41.2 mm shell length.



**Figure 3c (S-W):** Gastropods from Sarawak EEZ, (S) *Stellaria solaris*, 80.0 mm shell width, (T) *Tibia fusus*, 98.9 mm shell length, (U) *Tonna galea*, 181.2 mm shell length, (V) *Tonna tessellata*, 90.8 mm shell length and (W) *Volva volva*, 87.8 mm shell length.

Table 1: Distribution of gastropods according to species and depth strata in Sarawak EEZ.

Superfamily	Family	Species	Depth (Metres)		
			Stratum I 20–50	Stratum II 50–100	Stratum III 100–200
BUCCINOIDEA	BUCCINIDAE	<i>Aeneator comptus</i> (Finlay, 1924)	-	-	+
	FASCIOLARIIDAE	<i>Fusinus colus</i> (Linnaeus, 1758)	-	+	-
	CONIDAE	<i>Conus praececellens</i> (Adams, 1855)	-	+	-
CYPRAEOIDEA	TURRIDAE	<i>Gemmula speciosa</i> (Reeve, 1843)	-	-	+
	CYPRAEIDAE	<i>Erosaria mifianis</i> (Gmelin, 1791)	-	+	-
		<i>Erronea pulchella</i> (Melvill & Standen, 1904)	-	+	-
FICOIDEA		<i>Leporicypraea mappa</i> (Linnaeus, 1758)	+	-	-
	OVULIDAE	<i>Volva volva</i> (Linnaeus, 1758)	-	+	-
	FICIDAE	<i>Ficus fibosa</i> (Sowerby, 1892)	-	+	-
	HARPIDAE	<i>Harpa articularis</i> (Lamarck, 1822)	+	-	-
	MURICIDAE	<i>Murex aduncospinosus</i> (Sowerby, 1841)	-	+	+
		<i>Murex concinnus</i> (Reeve, 1845)	+	-	-
STROMBOIDEA	VOLUTIDAE	<i>Murex temispina</i> (Lamarck, 1822)	+	-	-
	ROSTELLARIIDAE	<i>Melo melo</i> (Lightfoot, 1786)	+	+	-
	CASSIDAE	<i>Tibia fusus</i> (Linnaeus, 1758)	+	-	-
TONNOIDEA		<i>Cassis cornuta</i> (Linnaeus, 1758)	+	-	-
		<i>Phallium glaucum</i> (Linnaeus, 1758)	+	-	-
		<i>Semicassis glabrata</i> (Dunker, 1852)	-	+	-
	RANELLIDAE	<i>Ranularia caudata</i> (Gmelin, 1791)	-	+	-
		<i>Reticulitron pfeifferianus</i> (Reeve, 1844)	-	+	-
	TONNIDAE	<i>Tonna galea</i> (Linnaeus, 1758)	-	+	+
XENOPHOROIDEA	XENOPHORIDAE	<i>Tonna tessellata</i> (Lamarck, 1816)	+	-	-
		<i>Stellaria solaris</i> (Linnaeus, 1764)	-	-	-
	(+): Present, (-): Absent	Total	9	13	4

**Table 2:** Summary of gastropod species, locations, depths and seabed types in Sarawak EEZ.

Strata	Depth	Station	Coordinates	Substrate	Species
I	20–50 m	9	N 02°05.79'- E 110°52.72'	Muddy, Sandy	<i>Melo melo</i>
		20	N 02°47.09'- E 110°43.09'	Muddy, Sandy	<i>Phalium glaucum</i>
		45	N 03°22.90'- E 112°07.85'	Muddy, Sandy	<i>Leporicypraea mappa</i> <i>Tonna tessellata</i>
		49	N 04°01.00'- E 113°00.79'	Muddy, Sandy	<i>Murex concinnus</i>
		56	N 03°37.17'- E 111°54.71'	Muddy, Sandy	<i>Murex ternispina</i>
		57	N 03°37.52'- E 112°09.19'	Muddy, Sandy	<i>Cassis cornuta</i>
		58	N 03°57.48'- E 112°12.75'	Muddy, Sandy	<i>Melo melo</i>
		59	N 03°42.75'- E 112°23.45'	Muddy, Sandy	<i>Melo melo</i> <i>Tibia fusus</i>
		60	N 03°37.09'- E 112°33.89'	Muddy, Sandy	<i>Melo melo</i>
		61	N 03°41.58'- E 112°32.06'	Muddy, Sandy	<i>Harpa articularis</i>
		II	50–100 m	28	N 03°44.36'- E 110°07.70'
30	N 03°20.68'- E 110°09.90'			Muddy, Sandy	<i>Reticutriton pfeifferianus</i>
71	N 04°06.89'- E 110°58.60'			Muddy, Sandy	<i>Semicassis glabrata</i> <i>Volva volva</i>
77	N 04°00.45'- E 111°14.77'			Muddy, Rocky	<i>Erronea pulchella</i> <i>Ficus filosa</i> <i>Fusinus colus</i> <i>Murex aduncospinosus</i> <i>Ranularia caudata</i> <i>Reticutriton pfeifferianus</i> <i>Semicassis glabrata</i> <i>Stellaria solaris</i>
80	N 04°43.22'- E 111°23.55'			Muddy, Sandy	<i>Conus praecellens</i>

(continued on next page)



Table 2: (continued)

Strata	Depth	Station	Coordinates	Substrate	Species
		83	N 04°36.94'- E 111°33.10'	Muddy, Sandy	<i>Tonna galea</i>
		86	N 04°16.24'- E 111°43.10'	Muddy, Sandy, Rocky	<i>Erosaria miliaris</i>
		89	N 04°08.37'- E 111°46.78'	Muddy	<i>Stellaria solaris</i>
III	100–200 m	130	N 05°15.30'- E 110°56.87'	Muddy, Sandy	<i>Gemmula speciosa</i>
		135	N 05°23.41'- E 111°45.68'	Muddy, Sandy	<i>Aeneator comptus</i>
		138	N 05°25.50'- E 111°56.23'	Muddy, Sandy	<i>Murex aduncospinosus</i>
		145	N 05°22.61'- E 112°16.53'	Muddy, Sandy	<i>Tonna galea</i>

According to the guide book of seashells by Abbott and Dance (1982) and Abbott (2002), the availability of gastropods species can be classified into four categories: 1) common, 2) moderately common, 3) uncommon and 4) rare. Based on this classification, the current study recorded 8 common species, *C. cornuta*, *E. miliaris*, *F. colus*, *H. articularis*, *M. ternispina*, *P. glaucum*, *S. solaris* and *V. volva*. This was followed by 2 moderately common species, *C. praecellens* and *T. fusus*. Furthermore, twelve gastropods were classified as uncommon species, *A. comptus*, *E. pulchella*, *F. filosa*, *G. speciosa*, *L. mappa*, *M. melo*, *M. aduncospinosus*, *M. concinnus*, *R. caudate*, *R. pfeifferianus*, *T. galea* and *T. tessellate*. Only *S. glabrata* was classified as a rare species.

In the present study, *M. melo* inhabited both strata I and II, while *T. galea* and *M. aduncospinosus* inhabited both strata II and III (Table 2). Other species were found to inhabit only a single stratum. *Melo melo* can only be found in the South China Sea, including Malaysia (Abbott & Dance 1982). The survey data show that *M. melo* was mostly found at stations 58, 59 and 60 in the water near Bintulu. This is the most probable reason why *M. melo* was sold in Bintulu Division (Hamli *et al.* 2013) and not in other markets around Sarawak.

The gastropod *E. miliaris* (family Cypraeidae) has been reported to be found throughout the Indo-Pacific region (Oliver 2004) and to inhabit shallows off South Bay, Hong Kong (Orr 1985). In contrast, in the present study, this species was found at 50-100 m depths, suggesting that it can live in deeper areas.

Ng and Wee (1994) assumed that *P. glaucum* is an endangered species in Singapore, as it purportedly had not been seen since 1970 and was also relatively scarce in Hong Kong waters (Orr 1985). The present study recorded the existence of *P. glaucum* in the Sarawak EEZ at depths of less than 50 m with sandy and muddy substrates.

Similarly, the gastropods *F. colus*, *L. mappa*, *R. pfeifferianus*, *S. solaris* and *T. tessellate* were reported to be found in the waters of Singapore (Tan & Woo 2010). In this study, those five species were also present in the seabed of the Sarawak EEZ at depths of 29–74 m.

**Table 3:** Morphological characteristics of marine gastropods from Sarawak EEZ.

Species	Common name	Characteristics
<i>Aeneator comptus</i>	Ornamented Penion	Moderately thick, spire, striation, globose, axial rib, siphonal canal, light orange.
<i>Cassis cornuta</i>	Horned Helmet	Solid, heavy, low spire, angular shoulder 5 to 7, blunt spine, outer lip-thick, orange.
<i>Conus praececellens</i>	Admirable Cone	Moderately thick, cone-spire, upper half convex, dark brown streak, squarish spots.
<i>Erosaria miliaris</i>	Miliaris Cowries	Thick, ovate shell, convex base, white dots, have bluish grey centres, canal rim white.
<i>Erronea pulchella</i>	Cowries	Thick, rotund shell, convex base, brownish half base, small teeth, light brown.
<i>Ficus filosa</i>	Threaded Fig Shell	Moderately thick, low spire, globose at upper half body whorl, low siphonal canal, light brown.
<i>Fusinus colus</i>	Distaff Spindle	Moderately thick, high spire, channelled suture, long siphonal canal, white.
<i>Gemmula speciosa</i>	Splendid Turrid	Moderately thick, cone-spire, cordlet, deep spiral cord, striation, long siphonal canal, white.
<i>Harpa articularis</i>	Articulate Harp	Moderately thick, low spire, sharp apex, body whorl 14 ribs, band of dark brown-black on ribs.
<i>Leporicypraea mappa</i>	Map Cowrie	Thick, rotund shell, convex base, aperture straight, small teeth, dark brown.
<i>Melo melo</i>	Indian Volute	Thick, globose, low spire, inflated body whorl, no spines, almost semi-circular, yellow.
<i>Murex aduncospinosus</i>	Bent-Spined Murex	Thick, moderate spire, 4 or 5 axial ribs between varices, nodules at intersection, white.
<i>Murex concinnus</i>	Striking Murex	Thick, moderate spire, 2 horizontal brown line-whorl, no spine siphonal canal, light brown.
<i>Murex ternispina</i>	Black-Spined Murex	Thick, moderate spire, 6 large spiral ridges-whorl, 3 large and 6 small teeth, pale brown.
<i>Phalium glaucum</i>	Grey Bonnet	Thick, spire, smooth body whorl, round shoulder, thick lip, inside lip-25 teeth, whitish.
<i>Ranularia caudata</i>	Bent-Neck Triton	Thick, moderate spire, large shoulder, spire-deep suture, un-straight siphonal canal, white.
<i>Reticutriton pfeifferianus</i>	Pfeiffer's Hairy Triton	Thick, spire, elongated body whorl, deep suture, thick lip, small teeth, pale brown.
<i>Semicassis glabrata</i>	Smooth Bonnet	Thin, spire, large body whorl, lip thickened, spiral line at base, white.
<i>Stellaria solaris</i>	Sunburst Carrier-Shell	Moderately thick, low spire, protruding spine at periphery of whorls, oval aperture, light brown.
<i>Tibia fusus</i>	Shin-Bone Tibia	Moderately thick, high spire, spiral cord, surface smooth, long siphonal canal, light brown.
<i>Tonna galea</i>	Giant Tun	Thin, large shell, spire-deep suture, globose, body whorl-15 to 20 broad, chestnut brown.
<i>Tonna tessellata</i>	Spotted Tun	Fragile, low spire, globose, panultimate whorl 2 to 4 spiral ribs, columella twist, pale brown.
<i>Volva volva</i>	Shuttlecock Volva	Moderately thick, rolled-up pasta shape, long front and rear, outer lip thick, pale brown.

## CONCLUSION

This study recorded 23 species of gastropods living in the Sarawak EEZ, representing 8 superfamilies, 15 families and 20 genera. Nine species were found in stratum I (20–50 m), 13 species in stratum II (50–100 m) and 4 species in stratum III (100–200 m). The present study provides valuable information on gastropod distributions at different depth strata in the Sarawak EEZ, which could be useful for future studies.

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