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Original Article

Study of diversity and morphometry in edible bivalves and gastropods from a coastal wetland in Sarawak♣

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Abstract

Diversity and morphometry of edible, bivalve and gastropod classes of molluscs were investigated from July 2010 to January 2012, for a particular set of bivalve species, at selected coastal divisions of Sarawak including Kuching, Sibu, Mukah, Bintulu, Miri, Limbang, and Lawas. A total of 41 edible species were recorded and identified from 11 families of gastropods represented by 21 species, and from 12 families of bivalves represented by 20 species. For bivalves, species of the family *Cyrenidae (Geloina erosa, G. expansa and G. bengalensis*) were the most widely distributed bivalve species. The gastropod family Potamididae (*Cerithidea obtusa, C. quadrata, C. rizophorarum* and *Telescopium telescopium*) was also commonly observed over the entire seven divisions. Species diversity was found to be highest in Bintulu division for both classes, having 13 species of gastropods and 11 species of bivalves. Jaccard's index showed high similarity amongst the edible bivalves for Limbang division with Miri division (0.75), and for Limbang with Lawas (0.75). For gastropods, Sibu versus Mukah showed high similarity (0.50). Morphometric study of the bivalves indicated that VPM/SL and LCT/SL features were applicable as an identification key to differentiate between *Geloina* spp. This morphometric identification key could be developed further for identification of other species in the mollusc family.

Keywords: edible gastropod, bivalve, diversity, distribution, Sarawak

1. Introduction

The State of Sarawak, Malaysia contains vast areas of wetlands, including brackish water, coastal marine, and mangrove areas. The state wetlands comprise 1.24 million hectares which covers 13% of the state's total land area (Page, 2011). This wetland supports extensive floral and faunal biodiversity. Molluscs are part of the faunal composition in the wetlands of Sarawak, and one of the most important protein resources to the surrounding human communities. Apart from providing good nutrition, molluscs play an important economic role in Sarawak.

The contribution of edible molluscs to local economies within Sarawak is high, but this resource has yet to be well documented. To the best of our knowledge, only a few studies have documented species of bivalves and gastropods occurring in Malaysia (Abdullah, Sidi, & Aris, 2007; Abu

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Hena *et al*., 2004; Hamli *et al*., 2015a, 2015b; Idris *et al*., 2011; Nakao, Nomura & Satar, 1989; Sallih, 2005). A prior study has recorded the edible mollusc distribution in the tropical region of Thailand (Nateewathana, 1995), but it is difficult to develop an accurate figure for local consumption of edible bivalve and gastropod species in Sarawak, Malaysia. This paper aims to investigate the diversity, morphological characteristics and habitats of edible molluscs to improve available information for the selected divisions in Sarawak. The bivalve and gastropod species are mainly found in wetland coastal waters of Sarawak, in the coastal divisions, hence this regional study provides valuable information on bivalves and gastropods, and could be used to further develop bivalve and gastropod fisheries in the future.

2. Materials and Methods

2.1 Study area

Samples were collected from native markets and fish markets from the selected seven divisions of Kuching: Mukah, Sibu, Bintulu, Sibu, Bintulu, Miri, and Lawas, in Sarawak. (Figure 1). Samples were preserved in ice-filled boxes and transferred to the laboratory for further analysis and study.

2.2 Species identification and morphometric study as a demarcation tool

The identification of bivalves was conducted following procedures common to a number of prior studies, namely Morton (1984), Poutiers (1998), Mass, O' Mullan, Lutz, and Vrijenhoek (1999), Yuh-Wen, Hon-Cheng, Sin-Che and Chaolun (2001), and Okutani (2017). Gastropod samples were identified following the studies by Nateewathana (1995), Kohler and Glaubrecht (2001), Poutiers (1998), Perez, Clark and Lydeard (2004), Tan and Clements (2008), and Mujiano (2009). Specimens of bivalves and gastropods were measured for their morphometric characteristics using a digital Mitutoyo Vernier caliper (±0.01mm) (Hamli *et al*., 2015a and Idris *et al*., 2008). A total of 20 characteristics (15 for bivalves and 5 for gastropods) were used to differentiate the species (Table 1; Figure 2).

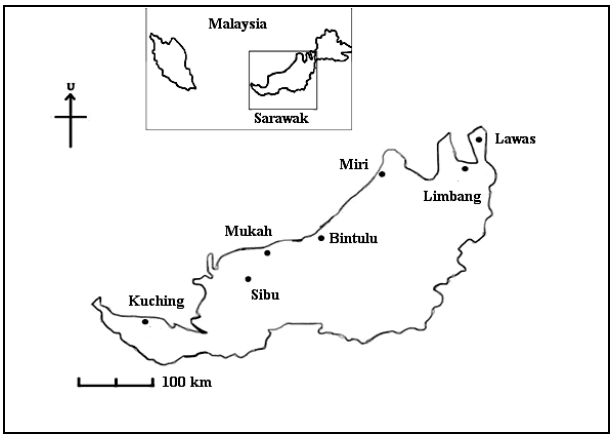

Figure 1. Sampling locations in seven divisions of Sarawak

The current morphometrics focused only on a single genus of bivalves, the *Geloina* genus (*G erosa*, *G. expansa*, *G. bengalensis.*), with a total of 436 mature individuals. The sum of 15 shell morphometrics, numbered one through fifteen (Table 1) were measured, and were then divided by the shell length to convert the measurements to a proportion ratio by size, for each *Geloina* species.

2.3. Statistical analysis

Measurements of the collected species from the selected Sarawak divisions were correlated with geographical source to establish a distribution pattern. Similarities in

Table 1. Morphometric characteristics used for bivalve identification with their abbreviations (*=Additional characteristic used during study period)

Measurement number	Abbreviation	Details
1	SL	Distance from the anterior margin to posterior margin
2	SH	Distance between ventral margin and umbo
3	SW	Distance from left shell to the right shell
4	LL	Ligament length
5	UL	Distance from umbo to posterior margin
6	AL	Distance from the posterior part of umbo to the anterior margin of the shell
7	PL	Distance from the posterior part of umbo to the posterior margin of the shell
8	LCT	Length from anterior cardinal tooth to posterior cardinal tooth
9	LPAS	Distance from anterior adductor muscle scar to posterior adductor muscle scar
10	PW	Wide of posterior adductor muscle scar
11	AW	Wide of anterior adductor muscle scar
12	PVM	Distance from ventral margin to pallial line
13	PAPM	Distance from posterior adductor muscle scar to posterior margin of the shell
14	AAAM	Distance from anterior adductor muscle scar to anterior margin of the shell
15	VPM	Ventral posterior margin length
16	sl	Shell length
17	sw	Shell width
18	al	Aperture length
19	aw	Aperture width
20	op	Outer lip thickness

species numbers within the respective divisions were evaluated as either present (1), or absent (0) based on Jaccard's Index (Ludwig & Reynolds, 1988).

$$\text{Jaccard's Index} = A/(A+B+C)$$

Where A = total number of species present in both communities
B = the number of species present in community 1 but not at community 2
C = the number of species present in community 2 but not at community 1

The samples from the *Geloina* species, from the study areas in the present study, were chosen for morphometric differentiation within species by scrutinising shell proportion ratio using analysis of variance (ANOVA) with general linear model (GLM), using the statistical analysis computer software (SAS) version 9.1 (SAS Institute, 2004).

3. Results and Discussion

3.1 Distribution

A total of 41 edible species from 12 families of bivalves representing 20 species (Table 2), and from 11 families of gastropods representing 21 species (Table 3) were recorded and identified from the seven divisions of Sarawak (Figures 3 and 4). Cyrenidae (Bivalve) and Potamididae (Gastropod) families were widely distributed in seven and six divisions, respectively. Bintulu division presented the greatest variety of bivalves and gastropods with a total of 24 species (13 gastropods, and 11 bivalves) recorded, while Sibu division presented only minor variation.

Mollusc species presence in this study were low when compared to Printrakoon, Wells and Chitramvong (2008), or to other prior studies, because the current study focused on edible species alone. Printrakoon *et al*. (2008), Frith, Tantanasiriwong and Bathia *et al*. (1976) and Brandt (1974) recorded 47, 43 and 56 species of mangrove, coastal, and estuarine molluscs, respectively, in Thailand. Macintosh, Ashton and Havanon (2002) found 34 species of molluscs in the Ranong biosphere reserve in Thailand. Jiang and Li (1995) recorded 52 species of molluscs in the Jiulong river estuary, China. However, the above studies were taxonomic diversity and distribution studies, rather than studies specific to edible molluscs in specified coastal, tropical wetlands. The current study indicates that the diversity of edible molluscs in this region is on the low side, although Somchai (1995) reported that gastropods were a major class of molluscs with a high market value on Phuket Island, Thailand.

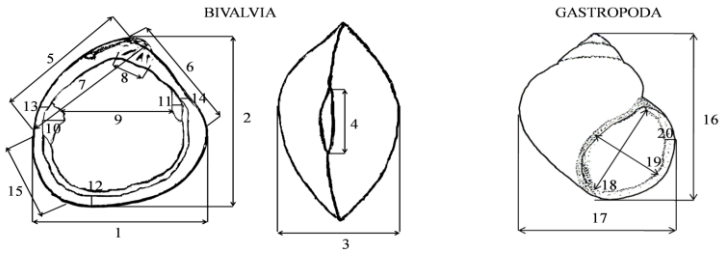

Figure 2. Measurements of shell characters for bivalvia and gastropoda (adopted from Mass *et al*., 1999; Ramesh and Ravichandaran, 2008). Note: 1(SL), 2(SH), 3(SW), 4(LL), 5(PL), 6(AL), 7(UL), 8(LCT), 9(LPAS), 10(PW), 11(PW), 12(PVM), 13(PAPM), 14(AAAM), 15(VPM) 16(sl), 17(sw), 18(al), 19(aw), 20(op)

Table 2. Checklist and distribution of edible bivalve species from eight divisions in Sarawak, Malaysia

Family	Species	Habitat	Kuching	Sibu	Mukah	Bintulu	Miri	Limbang	Lawas
Veneridae	*Circe scripta*	Salt water	-	-	-	+	-	-	-
	Paratapes undulatus	Salt water	-	-	+	-	-	-	-
	Meretrix meretrix	Salt water	-	-	-	+	-	-	-
	Meretrix lyrata	Salt water	+	-	-	-	-	-	-
Solenidae	*Solen regularies*	Salt water	+	-	-	-	-	-	-
	Solen lamarckii	Salt water	+	-	-	-	-	-	-
	Pharella acutidens	Brackish water	+	-	-	-	-	-	-
Cyrenidae	*Geloina bengalensis*	Brackish water	+	+	-	+	+	+	-
	Geloina erosa	Brackish water	-	+	+	+	+	+	+
	Geloina expansa	Brackish water	-	-	-	+	+	+	+
Unionidae	*Sinanodonta woodiana*	Fresh water	-	-	-	+	+	-	-
	Pilsbryoconcha exilis	Fresh water	-	-	-	-	+	-	-
Arcidae	*Tegillarca granosa*	Salt water	+	-	-	+	-	-	-
Myoida	*Pholas orientalis*	Salt water	+	-	-	-	-	-	-
Gluconomidae	*Gluconome virens*	Salt water	+	-	-	-	-	-	-
Pectinidae	*Amusium pleuronectes*	Salt water	+	-	-	+	-	-	-
Placunidae	*Placuna plcenta*	Salt water	-	-	-	+	-	-	-
Ostreidae	*Crassostrea lugubris*	Salt water	-	-	-	+	-	-	-
Mytilidae	*Arcuatula arcuatula*	Salt water	-	-	-	-	-	-	+
Isognomonidae	*Isognomon ephippium*	Salt water	-	-	-	+	-	-	-

Note: (+) = Present, (-) = Absent

Table 3. Checklist of gastropod species from eight divisions in Sarawak

Family	Species	Habitat	Kuching	Sibu	Mukah	Bintulu	Miri	Limbang	Lawas
Neritidae	*Nerita chamaeleon*	Salt water	-	-	-	+	-	-	-
	Nerita articulata	Brackish water	+	-	+	-	-	-	-
	Nerita albicilla	Salt water	-	-	-	+	-	-	-
	Clithon retropictum	Brackish water	-	+	-	-	-	-	-
Potamididae	*Cerithidea rizophorarum*	Brackish water	+	+	+	-	-	+	-
	Cerithidea obtusa	Brackish water	+	+	+	-	+	-	-
	Cerithidea quoyii	Brackish water	-	-	-	-	-	-	+
	Telescopium telescopium	Brackish water	-	-	-	-	-	-	+
Ampullariidae	*Pomacea bridgesii*	Fresh water	-	-	-	+	-	-	-
	Pilla ampullacea	Fresh water	+	-	-	+	+	+	-
Trochidae	*Trochus radiatus*	Salt water	-	-	-	+	-	-	-
	Monodonta labio	Salt water	-	-	-	+	-	-	-
Pachychilidae	*Brotia costula*	Fresh water	-	-	-	+	-	-	-
	Tylomelania helmuti	Fresh water	-	-	-	+	+	-	-
Thiaridae	*Melanoides costellaris*	Fresh water	+	-	-	-	-	-	-
	Blanocochlis glandiformis	Fresh water	-	-	-	+	-	+	-
Planaxide	*Planaxis sulcatus*	Salt water	-	-	-	+	-	-	-
Turbinidae	*Turbo crasus*	Salt water	-	-	-	+	-	-	-
Muricidae	*Tylothais virgata*	Salt water	-	-	-	+	-	-	-
Volutidae	*Melo melo*	Salt water	-	-	-	+	-	-	-
Melampidae	*Ellobium aurisjudae*	Brackish water	+	-	-	-	-	-	-

Note : (+) = present; (–) = absent

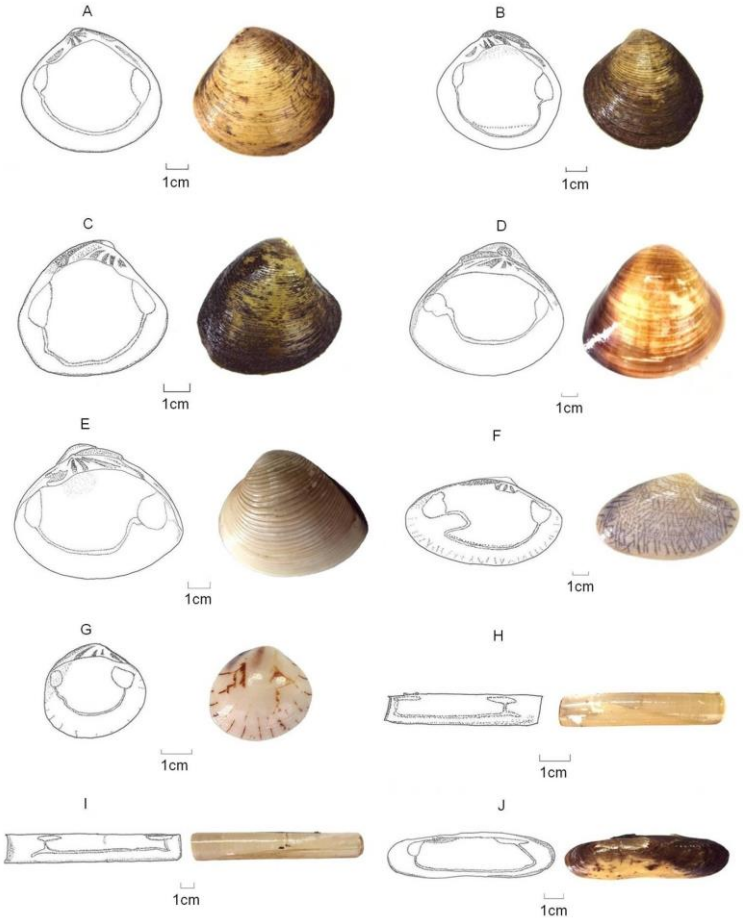

Figure 3. Edible bivalve species recorded from Sarawak: (A) *Geloina expansa*, (B) *Geloina erosa*, (C) *Geloina bengalensis* (D) *Meretrix meretrix* (E) *Meretrix lyrata* (F) *Paratapes undulatus* (G) *Circe scripta* (H) *Solen regularies* (I) *Solen lamacrkii* (J) *Pharella acutidens*

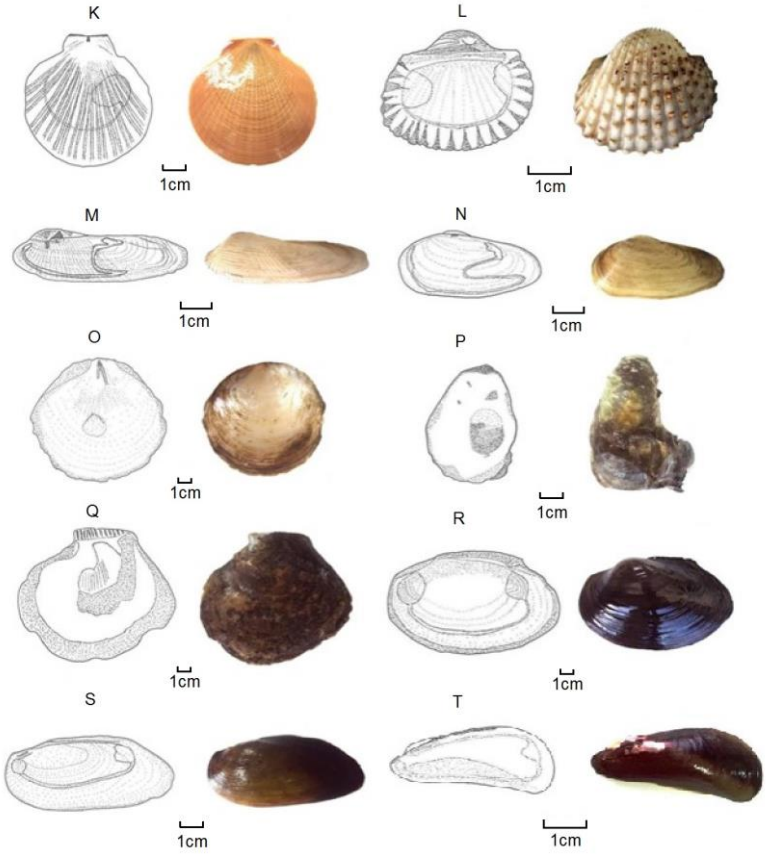

Figure 3. Continued (K) *Amusium pleuronectes*, (L) *Tegillarca granosa*, (M) *Pholas orientalis*, (N) *Gluconome virens*, (O) *Placuna placenta*, (P) *Crassostrea lugubris*, (Q) *Isognomon ephippium*, (R) *Sinanodonta woodiana*, (S) *Pilsbryoconcha exilis* (T) *Arcuatula arcuatula*

The marsh clams, *Geloina erosa* and *G. bengalensis* were both found within the sampling area. Within the Indo-Pacific area, they can be described under the subgenus *Geloina* (Morton, 1984), which subgenus is also distributed in the mangrove areas of China (Han *et al*., 2003), Australia (Wells, 1986) and Thailand (Printrakoon *et al*., 2008). Species *Geloina expansa* (Bivalvia), *Cerithidea rizophorarum*, and *C. obtusa* (Gastropoda) were found distributed within four divisions in Sarawak. Other gastropod and bivalve species were found within one to three divisions only. Presence of *G. erosa* and *G. bengalensis* in most of the study area was similar to their presence in mangrove areas of Sarawak.

3.2 Similarity indices

Analysis of the similarity index, described above, showed high similarities for bivalves in Limbang and Miri (0.75), and in Limbang and Lawas (0.75), and a high but lesser similarity for edible gastropods in Sibu and Mukah (0.50). Similarities as low as 0.00 were observed for bivalves in Kuching versus Mukah divisions and in Lawas versus Kuching. Similarities were also as low as 0.00 for edible gastropods in Lawas versus Sibu, Lawas versus Mukah, Lawas versus Bintulu, Lawas versus Miri, Lawas versus Limbang, Bintulu versus Sibu and Bintulu versus Mukah divisions. The similarity indexes for edible bivalves and gastropods between each division could probably account for or be related to the presence of wide mangroves and muddy areas supporting suitable habitats for these molluscs. Furthermore, Puri, Namboothri and Shanker (2014) described that increasing similarity of gastropod communities showed a relationship with decreasing geographical distance between the study locations.

3.3 Morphometrics

Study of the 14 calculated ratios of morphometric characteristics for *Geloina erosa*, *G. expansa* and *G. bengalensis* indicated significant differences ($p<0.05$) for VPM/SL and LCT/SL (Table 4). Length of cardinal tooth in proportion to SL was recorded as significantly higher ($p<0.05$) for *G. bengalensis* when compared to the other species. For *G. erosa*, characteristics recorded no significant difference ($p>0.05$) when compared with *G. expansa*. *Geloina bengalensis* recorded significant difference ($p<0.05$) for VPM/SL since this characteristic is absent in *G. erosa* and *G. expansa*.

Previous study of different populations of Corbiculidae (*Corbicula fluminea*) showed shell height to be significantly correlated with shell length (Araujo, Moreno, & Ramo, 1993). Morton (1984) reported that width and height of *G. erosa* and *G. expansa* were extremely variable, which causes these characteristics to be unreliable for analysis of dimensional relationships. There are many reasons that can

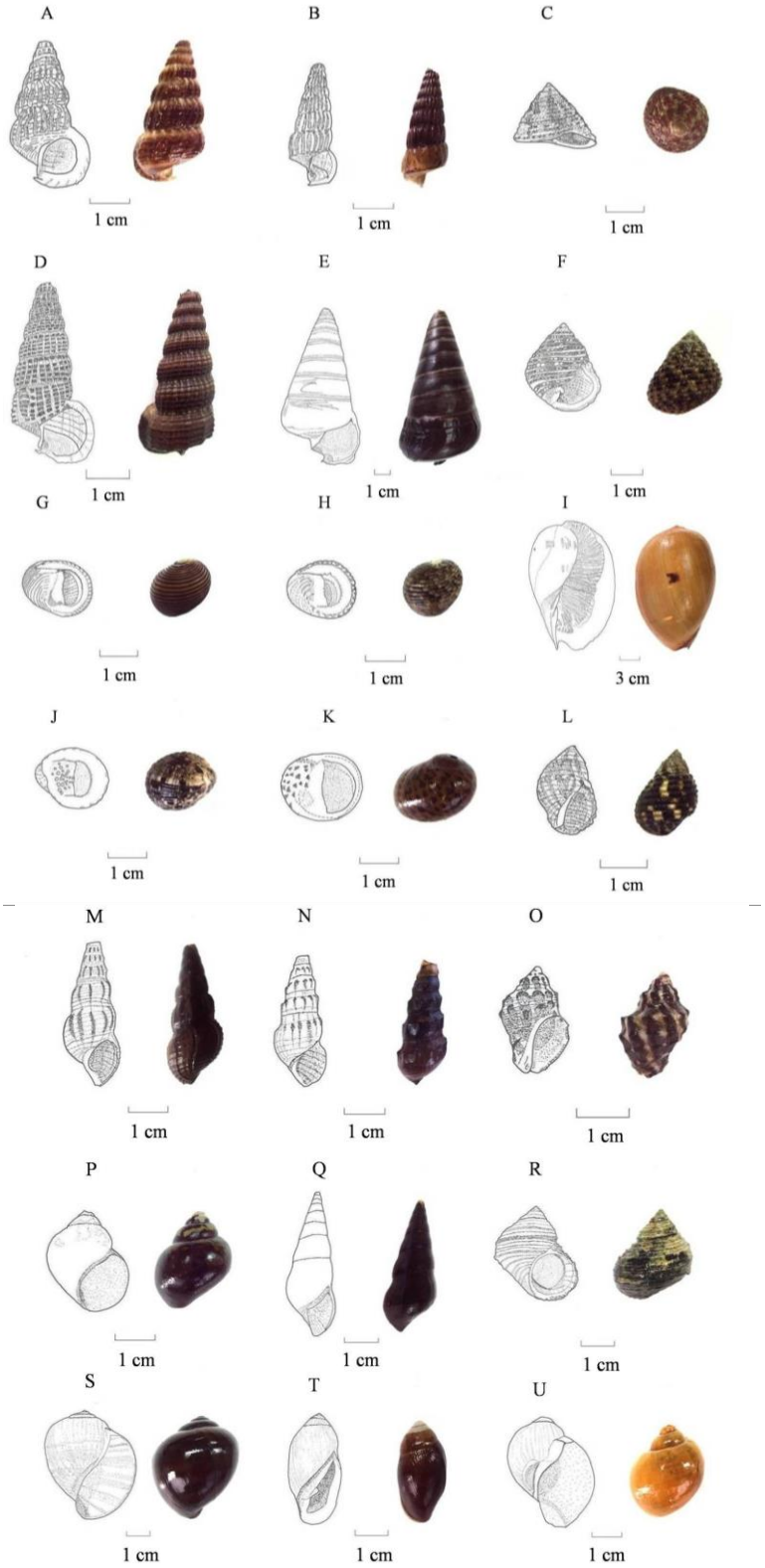

Figure 4. Edible gastropods from Sarawak; (A) *Cerithidea obtusa*, (B) *Cerithidea rizophorarum*, (C) *Trochus radiatus*, (D) *Cerithidea quoyii*, (E) *Telescopium telescopium*, (F) *Monodonta labio*, (G) *Nerita articulata*, (H) *Nerita chamaeleon*, (I) *Melo melo*, (J) *Nerita albicilla*, (K) *Clithon ritropictus*, (L) *Planaxis sulcatus*, (M) *Brotia costula*, (N) *Melanoides costellaris*, (O) *Tylothais virgata* (P) *Blanocochlis glandiformis*, (Q), *Tylomelania helmuti* (R),*Turbo crasus*, (S) *Pilla ampullacea*, (T), *Ellobium aurisjudae* and (U) *Pomacea bridgesii*

cause such outcome. Some bivalves grow to become higher and wider to overcome the turbulence and currents in the surrounding area (Hinch & Bailey, 1988). The mangrove habitats of this species are always affected by tides. Bivalve shell, especially from a mangrove area is vulnerable to the erosive effects of the acid mangal soil (Morton, 1984). Moreover, the presence of predators can also affect shell characteristics, as reported by Preston and Roberts (2006) for *Calliostoma zizyphinum.* Therefore, the current study did not depend on major dimensions (length, height and width) alone, but an additional characteristic was used to support differentiation between species. The supplementary features chosen were significant in morphometric assessment for gastropods and bivalves to reduce or remove attribution to impacts of the environment or/and predators.

4. Conclusions

The high number of edible bivalves and gastropods in Sarawak could be due either to habitat preferences of molluscs, or to over exploitation of the natural resource by local fishermen, e.g., due to rapid urbanization and customer demand. This may affect the total edible mollusc diversity within Sarawak. Diversity, abundance, and shell features of edible molluscs are significantly affected by changes in habitat. Therefore, fluctuations in environmental conditions generate changes in shell formation, which in turn influence species identification, while the current study was able to identify new shell characteristics to support discrimination between species exposed to abiotic variations. Further study is required to identify, monitor and classify the diversity and population status of edible molluscs in this region in support of conservation and management.

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