THE COLLECTION OF CONIDAE FLEMING, 1822 (MOLLUSCA: GASTROPODA) IN SARAWAK NATURAL HISTORY MUSEUM

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ABSTRACT

This study focuses on the taxonomic study of the gastropod’s family, Conidae, in the Sarawak Natural History Museum based on their collection of specimens. A total of 27 specimens were identified, encompassing 15 species, namely Conus virgo, Conus miles, Conus hyaena, Conus furvus, Conus eburneus, Conus crosnieri, Conus amadis, Conus marmoreus, Conus geographus, Conus guinaicus, Conus lividus, Conus ebraeus, Conus patricius, and two unidentified species. A dichotomous key is formed according to the specimens found in the museum. It is hoped that this study serves as a basis for further work on gastropods, especially the family Conidae in Sarawak.

Keywords: Mollusc, Conidae, taxonomy, specimens, museum
INTRODUCTION

Cone shells belong to the diverse family of Conidae Fleming, 1822 (Dutertre and Lewis, 2013). Species of the family Conidae are easily identified through their distinctive cone shaped shells and patterned body (Kohn, 1990). In living marine invertebrates, members of Conidae form among the biggest single genera and are classified into three groups depending on their feeding habits (Gao et al., 2017). They are part of the marine gastropods that are carnivorous and predate on other invertebrates (Ravinesh et al., 2022).

In 1886, R.V. Awdry, the Private Secretary to the Rajah established one of the earliest museums in Borneo which was situated at Kuching after he was authorised to receive contributions for the proposed museum (Sarawak Museum Department, 2021). The established building was designed in 1888 and then extended further to its present form in 1911. It was then turned into a museum to display the natural history collection (Lene, 2020). In Kuching, the Natural History Museum is home to the shell collections and is the main section in this study (Sarawak Museum Department, 2021).

Morphological characteristics can change continuously. The taxonomic classification of several members of the Conidae family is extremely vague. Labels are critical for informing the researcher of what is in a museum, which includes information about origin, identification of the contents, and age (Hester, 2018). Unfortunately, labels can fade, or the specimen might even have been wrongly identified in the first place, reducing the group’s actual diversity. In this study, the identification procedure is crucial and must be completed quickly, as there is a possibility that some of the specimens might go extinct due to the rise in extinction rate or the data on the specimens being revised.

The objective of this study was to identify the Conidae species composition in Sarawak Natural History Museum’s collection and to provide a dichotomous key based on the shells in the museum’s collection.

Taxonomy

Taxonomy is a method of scientific classification for describing and naming organisms by grouping them into different levels of hierarchy (Henderson, 2003; Pachenik, 2010). As a basic premise in biology, generalisations about organisms are only attainable if the indefinite number of elements in science is classified. The element of taxonomy associated with giving taxa names is known as nomenclature (Ohl, 2014). According to Stevens (2003), this system, known as the Linnean hierarchy, helps us understand and categorize the diverse organisms we have on Earth. The level starts from species to genus, which then continues to family, order, class, phylum and finally kingdom. Taxonomy is also able to describe evolution that occurs over time. Figure 1 below shows the scientific classification for Conidae.
The dichotomous key is a tool used in taxonomy as a key to distinguish between species. It is a set of observations that describe the physical characteristics of different organisms. Dichotomous keys are produced and used solely for identification purposes and are recognised for projecting artificial and contrived associations by utilizing traits to distinguish various creatures (Griffing, 2011). Two choices are offered at each level of a dichotomous key, with each choice leading to an alternative until the organism is identified.

The key identification for Conidae species is their cone-shaped shells. The shell exterior is smooth for most species but can also include variable sculpture (Carpenter and Niem, 2001). The exterior also usually has a wide range of patterns and colours. It has a thin, long aperture with a smooth columella and labrum.

**Family Conidae Fleming, 1822**

*Distinctive Features of Conidae*

Conidae is a taxonomic family proposed by John Fleming (1822) under the superfamily Conoidea (Kohn, 1990). The family Conidae is an advanced group in the gastropod molluscs due to the possession of a highly developed venom apparatus (Goldman, 2020). According to the World Register of Marine Species (WoRMS), there are 875 recognized living species of Conidae and 9 main genera (MolluscaBase eds., 2022). The shell of Conidae typically resembles a cone, with the anterior being a narrow end and the wider side having the spire of the animal (Ravinesh et al., 2022). Cone shells have a vast array of colours and patterns even within a species, which makes them attractive to shell collectors (Flores-Garza et al., 2014).
Biology of Conidae

Most Conidae are active predators and feed on marine fish, other molluscs, and worms. Their sexes are also separate and have internal fertilization for reproduction (Carpenter and Niem, 2001). For spawning, female Conidae usually gather for spawning and lay their eggs in compressed conoform capsules connected in groups or rows by a smooth basal disk. According to Carpenter and Niem (2001), Conidae also has a variable-duration planktonic larval stage, which is rarely missing.

Morphological Characteristics of Conidae

Key features help us identify certain species quicker due to their own distinctive features, which differ between each family. There are some important sets of shell characters which include color pattern, size, shape and sculpture. Conidae gastropods feature solid, cone-shaped shells with short or medium spires and large, narrow body whorls that taper smoothly from the shoulder to the siphonal notch. Most species have smooth shell exteriors, although others have slight sculpting, such as tiny spiral cords. Both the labrum and the columella are smooth, and the aperture is quite long and thin (Carpenter and Niem, 2001). Conidae shell interiors have been completely altered and lack inner walls.

Morphological Measurement

Morphological measurements are an important form of quantitative analysis. For this study, the measurements that were taken were the length and width of the shell as shown in Figure 2. Shell measurements are taken using a vernier calliper on a plain black board with a scale of 10cm and 15cm. Typically, cone snails can be up to 250 mm in diameter and as small as 4 mm in length (Dutertre and Lewis, 2013).
Distribution of Conidae

Most species of Conidae are confined to tropical and subtropical areas of the Atlantic, Indian and Pacific Oceans, with the majority distributed in the tropical waters of the Indo-Pacific region (Peters et al., 2013). Few species such as Californiconus californicus, have adapted to lower-temperature water and can be found on the North American Pacific coast (Figure 3) (Gao et al., 2017). Their inhabitation occurs in shallow waters ranging from tidal flats down to a depth of several hundred meters in various microhabitats (Abalde et al., 2019). Not only that, but cone snails are also one of the most diverse and dominant predators in coral reef habitats (Franklin et al., 2010). Most of the species are usually linked to coral reefs, while others prefer sand, rocks, or coral rubble substrates (Kohn, 1956). The members of this family are unusually diverse and occupy various marine habitats. They inhabit subtropical and tropical oceans around the world, at depths ranging from the intertidal to hundreds of metres. These snails prefer to live in shallow water on sandy bottoms and are frequently seen near shallow reefs (Puillandré et al., 2014).
Figure 3: A map of distribution of cone snails worldwide (Gao et al., 2017).

**Ecological Importance of Conidae**

The gastropods are involved in maintaining ecological functions in intertidal and subtidal habitats together with other marine organisms. Peters *et al.* (2013) stated that the cone snails have an important role in biodiversity as they have evolved into one of the largest genera in marine life. For example, species abundance, high regional diversity, and the rather uniform trophic position of *Conus* as primary carnivores make the genus ecologically important (Franklin *et al*., 2010). Not only that, but a few species of Conidae exhibit potential in pharmacological resources as an exciting new source of bioactive peptides (Lewis *et al*., 2004). However, according to Peters *et al.* (2013), habitat destruction and anthropogenic disruption, particularly from urban pollution, tourism, and coastal development, are dangers to cone snail species.

**Toxins in Conidae**

Cone snails have an extendable radula that is modified into a hollow harpoon-like that they use to inject venom into their prey (Franklin *et al*., 2007; Kohn, 1956). They generally eat marine worms, small fish, and even other molluscs by immobilising them with unique venoms. Cone snails have previously been responsible for at least a few deaths, as some Conidae species have venom that is toxic to humans and is powerful enough to kill a human being (Franklin *et al*., 2010). However, they do not prey on humans, but they will sting when they are disturbed. The majority of the Conus species are specialised predators and the protruding radular apparatus is altered into a venom-injecting mechanism for prey capture (Hermitte, 1946).
Sarawak Natural History Museum

History of the Sarawak Natural History Museum’s Mollusc Collection

Mr. Edgar E. Smith of the British Museum has identified a consignment of more than 50 seashells. These coast’s shells were accumulated for several years and are well-known (Sarawak Museum Report, 1906). In 1910, a collection of marine shells presented by Mr. T. Lewis of Broketown was sent to Dr. R. Hanitsch, Director of Raffles Museum, Singapore, to be identified (Sarawak Museum Report, 1910). The whole collection of Mollusca was organised based on a crucial work which is taxonomy classification, and labels that are neatly printed were used to distinguish the several families.

Since December 1924, the museum has had no curator up until February 20, 1925. Hence, Dr. Mjoberg, a curator from 1915 to 1923, was credited as a collector for the huge number of specimens added to the museum’s collection that were unique even to Borneo and replaced some specimens that had faded. Small collections have been sent to specialists, but no further feedback has been received from them since its last report, and nothing has been contributed (Sarawak Museum Report, 1925).

MATERIALS AND METHODS

Study Site

The mollusc specimen data and pictures were retrieved on February 17, 2022, from the Sarawak Natural History Museum (SNHM). The museum is located in Kuching, capital city of Sarawak state (1° 33’ 20” N, 110° 20’ 37” E) (Figure 4 and Figure 5).

Figure 4: Map of Sarawak and the location of the Sarawak Natural Museum.
Conidae Study

Sorting and Documentation

In total, 20 boxes of gastropod specimens that belonged to the museum were sorted and kept in the specimen plastics (Figure 6). Other materials include latex gloves used for handling the specimens and a camera for capturing photographic documentation of the specimen. The measurement of length (l) and width (w) for each Conidae specimen was performed using the vernier callipers (Figure 7).
Species Identification

Photographs for each specimen are documented in the documentation form provided by the Sarawak Museum Department. The identification process was conducted based on their morphological characteristics by referring to identification key such as Carpenter and Niem (2001). The collection in the Sarawak Natural History Museum will first be checked to see which mollusc specimens are still unidentified. The overall condition of the shell should also be analysed, and any defects found must be recorded. A form of measurement in millimetres (mm) will be included in the photograph so that the morphological measurements can be recorded later. A digital vernier calliper was used to take the width (w) and length (l) of the specimen. Another example of measurement is placing a scale under or beside the mollusc specimen. After taking photographs of the specimens, they are sorted according to their box number for further identification.

RESULTS

Specimens in the Sarawak Natural History Museum Collection

A total of 27 specimens comprising 15 species of Conidae were identified (Figure 8). Table 1 shows the list of Conidae species presented in the SNHM collection according to their box number. Species verification was done by referring to updated references such as catalogues and journals by Tenorio et al. (2007), Tenorio (2019), Kohn (2007), Natural History Museum Rotterdam (2022), Kohn and Anderson (2006), Gao et al. (2017), The Bailey-
Matthews Shell Museum (n.d.) and Puillandre and Tenorio (2017). In addition, the validity of species names was checked by referring the WoRMS website (WoRMS Editorial Board, 2023). Figure 9 showed a dichotomous key for the family Conidae identified in the SNHM collection.

**Table 1**: List of Conidae species in Sarawak Natural History Museum (SNHM).

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Species name</th>
<th>No. of individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1M3</td>
<td>Conus virgo Linnaeus, 1758</td>
<td>1</td>
</tr>
<tr>
<td>B1M13</td>
<td>Conus miles Linnaeus, 1758</td>
<td>1</td>
</tr>
<tr>
<td>B1M15</td>
<td>Conus furvus Reeve, 1843</td>
<td>1</td>
</tr>
<tr>
<td>B1M28</td>
<td>Conus hyaena Hwass, 1792</td>
<td>1</td>
</tr>
<tr>
<td>B1M32</td>
<td>Conus eburneus Hwass, 1792</td>
<td>2</td>
</tr>
<tr>
<td>B4M26</td>
<td>Conus crosnieri Tenorio, Monnier &amp; Puillandre, 2018</td>
<td>2</td>
</tr>
<tr>
<td>B6M3</td>
<td>Conus miles Linnaeus, 1758 (duplicate)</td>
<td>1</td>
</tr>
<tr>
<td>B6M13</td>
<td>Conus amadis Gmelin, 1791</td>
<td>1</td>
</tr>
<tr>
<td>B6M15</td>
<td>Conus marmoreus Linnaeus, 1758</td>
<td>2</td>
</tr>
<tr>
<td>B6M17</td>
<td>Conus geographus Linnaeus, 1758</td>
<td>1</td>
</tr>
<tr>
<td>B6M19</td>
<td>Conus guinensis Hwass, 1792</td>
<td>2</td>
</tr>
<tr>
<td>B7M11</td>
<td>Conus sp.</td>
<td>1</td>
</tr>
<tr>
<td>B7M16</td>
<td>Conus lividus Hwass, 1792</td>
<td>4</td>
</tr>
<tr>
<td>B7M26</td>
<td>Conus ebraeus Linnaeus, 1758</td>
<td>3</td>
</tr>
<tr>
<td>B8M4</td>
<td>Conus sp.</td>
<td>1</td>
</tr>
<tr>
<td>B8</td>
<td>Conus patricius Hinds, 1843</td>
<td>3</td>
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</tbody>
</table>
Figure 8: Species of family Conidae in the Sarawak Natural Museum (Scale Bar: 1 mm).
Figure 9: Dichotomous key for Conidae species in Sarawak Natural History Museum.
DISCUSSION

Specimen Collection

The specimens of family Conidae in the Sarawak Natural History Museum were identified as species from the genus *Conus*. There were total of 21 boxes of which 15 species with a total of 27 specimens from the family Conidae were not on display and placed in storage. The museum staff informed that the specimens in the collection have previously been sent for identification. However, due to unfortunate circumstances, they are now classified as unidentified as the specimens are either wrongly identified or the labels were misplaced, lost, smudged or the handwritings are illegible.

The species of specimens in the collections were also lectotypes. Lectotypes are specimens selected by a subsequent researcher to represent as if it’s the holotype. When the holotype was damaged or lost, or when no holotype was attributed to the species, lectotypes were determined from among the specimens accessible to the original publishing author of the scientific name (The New York Botanical Garden, 2003).

The museum should improve their preservation methods that could be more effective to conserve the original condition of the shells before and after storage. It is also recommended to store the molluscs as dry specimens because wet specimens take up extra storage space and must be monitored frequently to avoid the specimens from drying out (Martin, 2017). Before storing the specimens, Geiger *et al.* (2007) mentions that they must first be rinsed in distilled water to remove any impurities, soften mucus, and dissolve salts precipitated by ethanol. To ensure the specimen is fully clean and dry, 80-100% ethanol can be used to wash the specimens. The specimen must be fully dried as inadequate drying can affect the storage of the specimen in the long run. Any excess water can smudge labels and contribute to mold growth (Geiger *et al.*, 2007). As for storage, the dried specimens can be grouped according to their species in cardboard boxes made of acid free paper. The cardboard boxes should have glass covers for easy viewing. Each specimen must be labelled with an ethanol-resistant tag with all its essential information recorded on it and should not be in direct contact with the label (Nature Museum, 2021). The overall condition of most specimens was still good during the visit to the museum. The colours and shape of the shells were well maintained after preservation. However, certain shells that are much older were very fragile to hold and the shells are not that solid anymore. Few specimens have also faded in colour or have certain parts chipped off.
CONCLUSION

There are 15 species of the family Conidae found in the Sarawak Natural History Museum of Kuching. Out of 15 species, 13 species have been identified which are Conus virgo, Conus miles, Conus hyaena, Conus furvus, Conus eburneus, Conus crosnieri, Conus amadis, Conus marmoreus, Conus geographus, Conus guinaicus, Conus lividus, Conus ebraeus and Conus patricius. There are identified species that required further identification.

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We would like to thank the Sarawak Museum Department for the approval and access to the natural history specimens. Special thanks to the curators of Sarawak Museum Department, Dr. Awangku Shahrir Naqiuddin Awang Suhaili and Dr. Zakirah Mohamad Taufek who were involved in both field sampling and laboratory works. We also would like to thank the Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS) for providing research facilities and equipments throughout this study.

AUTHOR CONTRIBUTIONS

Ahmad Syafiq has conceived the ideas, designed and compilation, and led the writing of original draft; Nur Ilya Atiqah and Georgine Josslyn involved in writing, specimen identification and data analysis. All authors prepared, reviewed and approved the manuscript.

DECLARATION OF COMPETING INTEREST

All authors have participated in the drafting and revision of this paper and declare that there is no conflict of interest among the authors.

REFERENCES


**APPENDIX 1:** The documentation sheet used to document each specimen.

**DOCUMENTATION SHEET TEMPLATE: ZOOLOGY**

| Specimen Name: |
| Photograph (4 – 6 photos of different angles) |

| Natural History Classification |
| Kingdom: | Phylum: | Class: | Order: | Family: | Genus: | Species: |

| Object Name Information |
| Common English Name: | Scientific name: | Local name: | Number of copies of the species in storage: | Collection type: |

| Catalogue No.: | Specimen accession number |
| Date collected | Place collected |
| Gender | Nature of accession |
| Specimen type | Age |
| Specimen price | Current location (building) |
| Current shelf no | Current drawer/cabinet No. |

**Description and identification:**

Logbook description:

New description (by researcher):
<table>
<thead>
<tr>
<th>Dimension (cm) and weight</th>
<th>Height :</th>
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<td>Location of the object</td>
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<td>Current condition</td>
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<td>Documentary information &amp; cross references</td>
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<td>Form completed by</td>
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<td>Date</td>
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Sarawak Museum Department