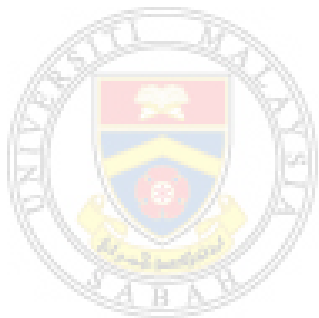


**TAXONOMIC, MOLECULAR AND LANDING
STATUS ASSESSMENT OF SPINY LOBSTER
(*Panulirus* spp.) DISTRIBUTION IN THE
WATERS OF SABAH AND PULAU LAYANG-
LAYANG, MALAYSIA**



NG WEI-LING

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**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
2023**

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UMS
UNIVERSITI MALAYSIA SABAH

**THESIS SUBMITTED IN FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE**

**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
2023**

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL : **TAXONOMIC, MOLECULAR AND LANDING STATUS ASSESSMENT OF SPINY LOBSTER (*Panulirus* spp.) DISTRIBUTION IN THE WATERS OF SABAH AND PULAU LAYANG-LAYANG, MALAYSIA**

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Tarikh : 23 May 2023

(Dr. Chen Cheng Ann)
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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, equitation, summaries and references, which have been duly acknowledged.

24 March 2023



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MY2021011T



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CERTIFICATION

NAME : **NG WEI-LING**
MATRIC NO. : **MY2021011T**
TITLE : **TAXONOMIC, MOLECULAR AND LANDING STATUS
ASSESSMENT OF SPINY LOBSTER (*Panulirus* spp.)
DISTRIBUTION IN THE WATERS OF SABAH AND
PULAU LAYANG-LAYANG, MALAYSIA**
DEGREE : **MASTER OF SCIENCE**
FIELD : **MARINE SCIENCE**
VIVA DATE : **24 MARCH 2023**



SUPERVISOR

Dr. Chen Cheng Ann

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Ng Wei-Ling

24 March 2023

ABSTRACT

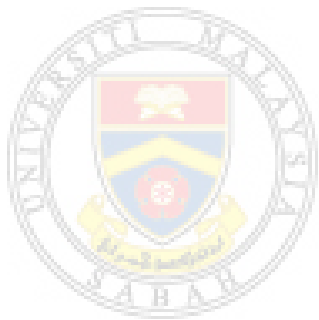
In comparison to other crustacean species, spiny lobsters of the family Palinuridae Latreille, 1802 are renowned on the international fishing market. In shallow tropical and subtropical waters (<100 m depth), *Panulirus* spp. is ubiquitous and abundant, yet knowledge on its range, biodiversity, and population abundance in Malaysia is limited. In addition, there are grave worries regarding the sustainability of their marine harvests due to anthropogenic pressures and climate change impacts on the ocean ecosystem. In the present study, a checklist of *Panulirus* spp. from the seas of Sabah and Pulau Layang-Layang was compiled using morphological identification and molecular identification utilising the Cytochrome oxidase I (COI) gene. The Department of Fisheries Sabah and the Meteorological Department of Sabah were consulted for information on spiny lobster landings and climate factors throughout a 30-year period (1990-2019). Recent research uncovered seven species: *P. ornatus*, *P. versicolor*, *P. longipes longipes*, *P. polyphgus*, *P. homarus homarus*, *P. femoristriga* (new record), and *P. penicillatus* (new record). The intra-species p-distance is 6%, validating the respective species, whereas the inter-species p-distance is >10%. Additionally, spiny lobster landings were high throughout the third decade of examined years (2010-2019), but landings were low during the first decade of studied years (1990-1999). Landings of spiny lobster varied significantly between stations ($p < 0.001$). Kudat (849.47 MT) had the largest total landing across the thirty-year study period, followed by Tawau (486.41 MT) and Kota Kinabalu (404.51 MT) (376.48 MT). The yearly landings of spiny lobsters were negatively correlated with both total rainfall and total wet days ($r = -0.257$, $p = 0.022$; $r = -0.253$, $p = 0.024$). Kota Kinabalu experienced the highest average rainfall (2,675.90 mm) across the thirty-year study period, resulting in the lowest landings of spiny lobsters. After over 20 years since the last survey in Sabah, the current study represents the most exhaustive record of the existing species of *Panulirus* spp. This study filled in the missing data of a valuable marine biodiversity group (spiny lobsters) in Malaysia, where the acquisition of biological knowledge is vital to the protection of the world's natural resources and to the sustainable management of spiny lobster fisheries.

ABSTRAK

TAXONOMIC, MOLECULAR AND LANDING STATUS ASSESSMENT OF SPINY LOBSTER (*PANULIRUS SPP.*) DISTRIBUTION IN THE WATERS OF SABAH AND PULAU LAYANG LAYANG, MALAYSIA

Udang karang dari keluarga Palinuridae Latreille, 1802 ialah krustasea terkenal berbanding spesies krustasea yang lain. *Panulirus spp.*, tersebar luas dan banyak di perairan tropika dan subtropika cetek (<100m kedalaman) tetapi maklumat sumber udang karang di Malaysia mengenai taburan, biodiversiti, dan kelimpahan populasi adalah terhad. Di samping itu, terdapat kebimbangan serius tentang kemampuan hasil tuaian mereka dari laut akibat tekanan antropogenik dan kesan perubahan iklim ke atas ekosistem lautan. Dalam kajian ini, senarai semak *Panulirus spp.* dari perairan Sabah dan Pulau Layang-Layang telah ditubuhkan melalui pengenalan morfologi dan pengenalan molekul dengan menggunakan analisis gen Cytochrome oxidase I (COI). Data tentang pendaratan udang karang dan pembolehubah iklim dalam tempoh 30 tahun (1990-2019) telah diperoleh daripada Jabatan Perikanan Sabah dan Jabatan Meteorologi Sabah. Sebanyak tujuh spesies udang karang: *P. ornatus*, *P. versicolor*, *P. longipes longipes*, *P. polyphgus*, *P. homarus homarus*, *P. femoristriga* (rekod baru) and *P. penicillatus* (rekod baru) telah dikenal pasti. *P*-distance intra-spesis ialah <6%, mengesahkan spesies berikut manakala *p*-distance inter-spesis ialah >10%. Tambahan pula, pendaratan udang karang adalah tinggi pada dekad ketiga tahun kajian (2010-2019) manakala pendaratan rendah diperhatikan pada dekad pertama tahun kajian iaitu 1990-1999. Pendaratan udang galah menunjukkan perbezaan yang ketara antara stesen ($p < 0.001$). Kudat (849.47 MT) mempunyai jumlah pendaratan tertinggi bagi 30 tahun yang lepas. Pendaratan tinggi seterusnya diikuti oleh Tawau (486.41 MT) dan Kota Kinabalu (376.48 MT). Ujian korelasi menunjukkan korelasi negatif antara pendaratan tahunan udang karang dengan jumlah hujan serta jumlah hari basah ($r = -0.257$, $p = 0.022$; $r = -0.253$, $p = 0.024$). KK mengalami purata hujan tertinggi (2675.90 mm) sepanjang 30 tahun kajian, oleh itu, mempunyai pendaratan udang karang yang paling rendah. Kajian semasa adalah rekod terkini dan paling lengkap mengenai spesies *Panulirus spp.* yang ada di Sabah selepas hampir 20 tahun jurang daripada tinjauan lepas. Kajian ini bukan sahaja memperkayakan senarai biodiversiti marin laut Malaysia tetapi pengetahuan biologi yang diperolehi juga

berkait kuat dengan keazaman untuk melindungi kekayaan semula jadi dunia serta penting untuk pengurusan perikanan mampan udang karang.



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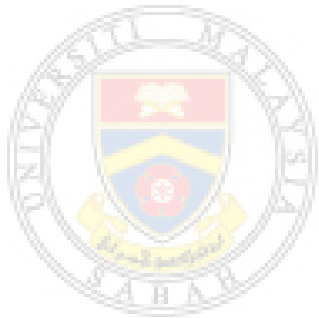
LIST OF CONTENTS

| | Page |
|--|------|
| TITLE | i |
| DECLARATION | ii |
| CERTIFICATION | iii |
| ACKNOWLEDGEMENT | iv |
| ABSTRACT | v |
| <i>ABSTRAK</i> | vi |
| LIST OF CONTENTS | viii |
| LIST OF TABLES | x |
| LIST OF FIGURES | xi |
| LIST OF SYMBOLS | xiii |
| LIST OF ABBREVIATION | xiv |
| LIST OF APPENDICES | xv |
| CHAPTER 1 : INTRODUCTION | 1 |
| 1.1 Background | 1 |
| 1.2 Problem Statement | 3 |
| 1.3 Significant of Study | 4 |
| 1.4 Objectives | 4 |
| CHAPTER 2 : LITERATURE REVIEW | 5 |
| 2.1 Spiny Lobsters (<i>Panulirus</i> spp.) | 5 |
| 2.2 Habitat Preference and Distribution | 9 |
| 2.3 Genetic Profile | 10 |
| 2.4 Reproduction of <i>Panulirus</i> spp.: Seasonality vs Physiology | 12 |
| 2.5 Landing Status in Sabah | 15 |
| 2.6 Pulau Layang-Layang | 16 |
| 2.7 Threats | 17 |

| | |
|---|----|
| CHAPTER 3 : MATERIALS AND METHODS | 20 |
| 3.1 Sample Collection | 20 |
| 3.2 Laboratory Analysis | 22 |
| 3.2.1 Morphological Identification | 22 |
| 3.2.2 DNA Extraction, PCR Amplification and Sequencing | 22 |
| 3.3 Data Analysing | 23 |
| 3.3.1 Genetic Profile | 23 |
| 3.3.2 Landing Data Analysis | 24 |
| | |
| CHAPTER 4 : RESULTS | 25 |
| 4.1 <i>Panulirus</i> spp. in Sabah and Pulau Layang-Layang Waters | 25 |
| 4.1.1 Keys to <i>Panulirus</i> spp. Identified in Sabah and Pulau Layang-Layang Waters (Modified From Chan, 1998) | 26 |
| 4.2 Morphology Description | 28 |
| 4.2.1 <i>Panulirus ornatus</i> (Fabricius, 1798) | 28 |
| 4.2.2 <i>Panulirus versicolor</i> (Latreille, 1804) | 31 |
| 4.2.3 <i>Panulirus longipes longipes</i> (A. Milne-Edwards, 1868) | 34 |
| 4.2.4 <i>Panulirus femoristriga</i> (Von Martens, 1872) | 37 |
| 4.2.5 <i>Panulirus homarus homarus</i> (Linnaeus, 1758) | 40 |
| 4.2.6 <i>Panulirus polyphagus</i> (Herbst, 1793) | 43 |
| 4.2.7 <i>Panulirus penicillatus</i> (Olivier, 1791) | 46 |
| 4.3 Genetic Profile | 48 |
| 4.4 Landing Status | 52 |
| | |
| CHAPTER 5 : DISCUSSION | 58 |
| 5.1 <i>Panulirus</i> spp. in Sabah and PLL Waters | 58 |
| 5.2 Molecular Phylogeny | 60 |
| 5.3 Landing Status | 62 |
| | |
| CHAPTER 6 : CONCLUSION | 65 |
| | |
| REFERENCES | 67 |
| | |
| APPENDICES | 85 |

LIST OF TABLES

| | Page |
|--|------|
| Table 2.1 : Description of <i>Panulirus</i> sp. commonly found in East Indian Ocean and West Pacific Ocean. | 7 |
| Table 4.1 : Checklist of <i>Panulirus</i> spp. identified in Sabah and Pulau Layang-Layang waters. | 25 |
| Table 4.2 : Intra- and inter-species pairwise p-distances of the seven recorded <i>Panulirus</i> sp. in this study | 51 |
| Table 4.3 : One-way ANOVA between stations. | 53 |
| Table 4.4 : Results of Pearson's correlation test on the landing of spiny lobsters and climate parameters (Total rainfall - TOTRF; Total Wet Days - TOTWD; Average Temperature - AVTEM; Average Humidity - AVHU) | 54 |



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LIST OF FIGURES

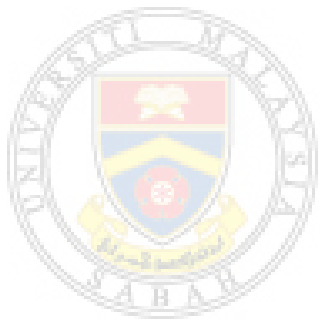
| | | Page |
|------------|---|------|
| Figure 2.1 | : General shape of a <i>Panulirus</i> sp. with its technical terms and measurements. | 6 |
| Figure 3.1 | : Surveyed sites in Sabah waters: (1) Menumbok, (2) Kuala Penyu, (3) Pulau Tiga Park, (4) Tunku Abdul Rahman Park, (5) Tun Mustapha Marine Park, (6) Lahad Datu, (7) Semporna. (8) Pulau Layang-Layang; Lobster landing stations: (a) Kota Kinabalu, (b) Kudat, (c) Tawau. | 21 |
| Figure 4.1 | : A specimen of <i>Panulirus ornatus</i> collected from Semporna, Sabah, Malaysia. Scale bar, 100mm. | 28 |
| Figure 4.2 | : <i>Panulirus ornatus</i> (Fabricius, 1798), Semporna, Sabah, Malaysia (female, CL: 71.68 mm.: a. Anterior carapace; b. Abdomen, dorsal view; c. Antennular plate; d. Thoracic sternum; e. Abdomen, lateral view; f. Antennal peduncle, ventral view. Scale bars, 20mm) | 29 |
| Figure 4.3 | : A specimen of <i>Panulirus versicolor</i> collected from Pulau Layang-Layang, Malaysia, Malaysia. Scale bar, 100mm. | 31 |
| Figure 4.4 | : <i>Panulirus versicolor</i> (Latreille, 1804), Pulau Layang-Layang, Malaysia (Female, CL: 79.46 mm.: a. Anterior carapace; b. Abdomen, dorsal view; c. Antennular plate; d. Thoracic sternum; e. Abdomen, lateral view; f. Antennal peduncle, ventral view. Scale bars, 20mm) | 32 |
| Figure 4.5 | : A specimen of <i>Panulirus longipes longipes</i> collected from Menumbok, Sabah, Malaysia. Scale bar, 100mm | 34 |
| Figure 4.6 | : <i>Panulirus longipes longipes</i> (A. Milne-Edwards, 1868), Menumbok, Sabah (Female, CL: 79.04 mm.: a. Anterior carapace; b. Abdomen, dorsal view; c. Antennular plate; d. Thoracic sternum; e. Abdomen, lateral view; f. Antennal peduncle, ventral view. Scale bars, 20mm) | 35 |
| Figure 4.7 | : A specimen of <i>Panulirus femoristriga</i> collected from Semporna, Sabah, Malaysia. Scale bar, 100mm | 37 |
| Figure 4.8 | : <i>Panulirus femoristriga</i> (Von Martens, 1872), Semporna, Sabah (Female CL: 47.3 mm.: (a) Anterior carapace, dorsal. (b) Antennular plate, dorsolateral. (c) Thoracic sternum, ventral. (d) Thoracic sternum, ventral. (e) Abdomen, right lateral. Scale bars, 2 cm.) | 38 |

| | | |
|-------------|---|----|
| Figure 4.9 | : A specimen of <i>Panulirus homarus homarus</i> was collected from Kuala Penyu, Sabah, Malaysia. Scale bar, 100mm | 40 |
| Figure 4.10 | : <i>Panulirus homarus homarus</i> (Linnaeus, 1758), Kuala Penyu, Sabah (Female: CL: 73.56 mm.: (a) Anterior carapace, dorsal. (b) Antennular plate, dorsolateral. (c) Thoracic sternum, ventral. (d) Thoracic sternum, ventral. (e) Abdomen, right lateral. Scale bars, 2 cm) | 41 |
| Figure 4.11 | : A specimen of <i>Panulirus polyphagus</i> was collected from Semporna, Sabah, Malaysia. Scale bar, 100mm | 43 |
| Figure 4.12 | : <i>Panulirus polyphagus</i> (Herbst, 1793), Semporna, Sabah (Female: CL: 69.36 mm.: (a) Anterior carapace, dorsal. (b) Antennular plate, dorsolateral. (c) Thoracic sternum, ventral. (d) Thoracic sternum, ventral. (e) Abdomen, right lateral. Scale bars, 20 mm) | 44 |
| Figure 4.13 | : A specimen of <i>Panulirus penicillatus</i> collected from Pulau Layang-Layang, Malaysia. Scale bar, 100mm | 46 |
| Figure 4.14 | : <i>Panlirus penicillatus</i> (Olivier, 1791), Pulau Layang-Layang, Malaysia (Male, CL: 107.8 mm.: a. Anterior carapace; b. Abdomen, dorsal view; c. Antennular plate; d. Thoracic sternum; e. Abdomen, lateral view; f. Antennal peduncle, ventral view. Scale bars, 20 mm) | 47 |
| Figure 4.15 | : Maximum-likelihood (ML) tree inferred from the partial mitochondrial COI sequences of 89 species of <i>Panulirus</i> , with <i>Parribacus antarcticus</i> as outgroup. Values of the nodes correspond to bootstrap values, only values >50% are shown. Clade I (Blue); Clade II (Red); species collected in this study (Green). | 50 |
| Figure 4.16 | : Percentage of gear used by stations in spiny lobster fisheries between 1990-2019. Kota Kinabalu (KK); Kudat (KDT); and Tawau (TWU). | 52 |
| Figure 4.17 | : Annual spiny lobster landing coincides with total rainfall (TOTRF): (a) Kota Kinabalu (KK); (b) Kudat (KDT); (c) Tawau (TWU). | 55 |
| Figure 4.18 | : Annual spiny lobster landing coincides with total wet days (TOTWD): (a) Kota Kinabalu (KK); (b) Kudat (KDT); (c) Tawau (TWU). | 56 |
| Figure 4.19 | : Total rainfall (TOTRF) coincides with total wet days (TOTRF). (a) Kota Kinabalu (KK); (b) Kudat (KDT); (c) Tawau (TWU). | 57 |

LIST OF SYMBOLS

°C - Degree Celsius

% - Percent



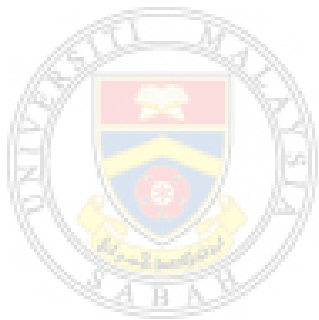
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LIST OF ABBREVIATION

| | | |
|--------------|---|---|
| ANOVA | - | Analysis of Variance |
| AVHU | - | Average annual humidity |
| AVTEM | - | Average annual temperature |
| AW | - | Abdomen width |
| CL | - | Carapace length |
| cm | - | centimetre |
| COI | - | Cytochrome C Oxidase subunit 1 |
| COT | - | Crown-of-Thorns |
| CW | - | Carapace width |
| DOF | - | Department of Fisheries |
| g | - | gram |
| KDT | - | Kudat |
| KK | - | Kota Kinabalu |
| MT | - | Metric Ton |
| mm | - | Millimetre |
| NE | - | North East |
| PLL | - | Pulau Layang-Layang |
| SPSS | - | Plymouth Routines in Multivariate Ecological Research |
| SW | - | South West |
| TL | - | Total length |
| TOTRF | - | Total rainfall |
| TOTWD | - | Total wet days |
| TWU | - | Tawau |

LIST OF APPENDICES

| | Page |
|---|------|
| Appendix A : Taxon Sampled from NCBI GenBank | 85 |
| Appendix B : Measurements of Spiny Lobster Specimens and BLAST Results. | 87 |
| Appendix C : Intra- and inter-species pairwise p-distances of <i>Panulirus</i> spp. | 89 |
| Appendix D : Spiny Lobster Landing and Climate Variables | 90 |
| Appendix E : ANOVA Post Hoc Test | 94 |



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CHAPTER 1

INTRODUCTION

1.1 Background

'Lobsters' commonly refers as the clawed lobsters of the Family Nephropidae, though there are other related groups such as the spiny/rock lobsters, slipper lobsters, reef lobsters, and the blind lobsters. Spiny lobsters (Decapoda: Achelata: Palinuridae) are large (body length up to 60cm), long-lived (>10 years) crustacean that occur in a wide range of habitats and depths (Phillips, 2008), inhabiting the substrate in the form of holes, coral cracks and the bottom of a rocky beach (Booth, 2001; Setyanto *et al.*, 2019). The home range of these lobsters is from the coastline to the continental shelf boundary (Lipcius *et al.*, 2001). The family Palinuridae comprises 54 extant species/subspecies arranged in 12 genera (Chan, 2010) which the most diverse genus is *Panulirus* White (1847), with 23 species/subspecies listed in World Registered Marine Species (WoRMS), last update by Sammy in 2021. Whilst, a total of 21 spiny lobster species was reported in International Union for Conservation of Nature and Natural Resources (IUCN) red list in 2022 red list but nine species are currently categorized as "Data Deficient" and the other 12 species are "Least Concern".

Panulirus species is widespread and numerous in shallow tropical and subtropical waters (<100m in depth) of both hemispheres (Radhakrishnan *et al.*, 2019) on both rocky and coral substrates. Lobsters can also be found in sea depths more than 100 metres (Lipcius *et al.*, 2001). They remain concealed during the day and are active to forage at night - nocturnal, with no fixed diet by eating on specific prey exclusively, but typically browse on sand regions for a variety of food items

(Chan, 1998; Childress & Jury, 2013; Senevirathna *et al.*, 2017; Setyanto *et al.*, 2019). Furthermore, due to the overlapping of habitat preferences (e.g. rocky habitat, reef habitats), occurrence of two or more *Panulirus* species living in sympatry is common in different region throughout the world (Briones-Fourzán & Lozano-Álvarez, 2013).

In addition, spiny lobster is one of the world's most valuable fisheries resources (Phillips, 2008). It is actively exploited as a result of its high value on international markets and is subject to intense pressure as a result of inadequate implementation of fishing and marketing rules (Radhakrishnan *et al.*, 2019). *Panulirus* species is important in the niche live reef fish trade (LRFT) markets in Hong Kong, Taiwan and Singapore (Busing & Chio, 2004). Lobster fisheries are also important for Indonesian economy (Setyanto *et al.*, 2019). Besides that, the exports of spiny lobsters in 2001 in Malaysia were 0.6% of total fish exports while Sabah accounts for the most annual live spiny lobster exports (Busing & Chio, 2004). In 2002, Tawau and Semporna were accounted for 53% of total landings, while Kudat alone accounted for 45% of 2002 landings, and Kota Kinabalu was only accounted for 2% of total landings in 2002 (Busing & Chio, 2004). The majority of spiny lobster fishing in Sabah occurs around small islets to big islands and offshore shoals with vast surrounding coral reefs that range in depth from 9 to 18 metres.

Apart from their economic importance, they are important component of the marine ecosystems, playing pivotal roles as a prey and a predator yet, the information of spiny lobster resources in Malaysia on the distribution, biodiversity, and population abundance is scarce due to the lack of surveys conducted with only one species recorded (*P. polyphagus*) in Johor strait (Ikhwanuddin *et al.*, 2014). According to Busing & Chio (2004), there are five species of *Panulirus* being recorded in Sabah water which included *P. longipes*, *P. versicolor*, and *P. ornatus* while the other two species were unidentified. On the other hand, Pulau Layang-Layang (PLL) which located about 300 km North-west of Sabah (Nasir & Adibah, 2017) was reported with pristine reef condition due to its remoteness (Zainuddin *et al.*, 2000). Benthic communities in PLL is relatively intact and accessible in diving operations according to Asner *et al.* (2017) but studies on the benthic communities were scarce. Merely few studies has been conducted on benthic invertebrates such as amphipod (Lowry *et al.*, 2017), echinoderm (Lane *et al.* 2000; Nasrulkhakim *et al.*, 2010; Saupi *et al.*,

2010; Woo *et al.*, 2010), giant clam (Neo *et al.*, 2017), and others. Nonetheless, there is no study even conducted on spiny lobsters (*Panulirus* spp.) in PLL.

In addition, lobster fisheries management in Sabah is frequently disregarded to safeguard and maintain the sustainability of lobster resources (Setyanto *et al.*, 2019), resulting in a downward trend over the years due to causes such as overfishing and reef habitat deterioration. The unregulated coastal development also causes pollution at coastal water (Busing & Chio, 2004). In addition, land reclamation work was conducted at PLL and a permanent island over part of the atoll was constructed in 1983. A navy station and a holiday resort were then built on the island and the island became a very popular diving destination in the South China Sea (Poon, 2015), yet, scientific studies regarding benthic invertebrate communities were lacking. No baseline data was available for spiny lobsters to detect the trend in PLL. Therefore, this project aimed to gain knowledge in the distribution of spiny lobster in Sabah and also the first study on spiny lobster in PLL. In addition, the dwindling wild spiny lobster stock necessitated research into the state of landings in Sabah, giving baseline data to enhance the sustainable management of wild spiny lobster in Sabah.

1.2 Problem Statement

The value of spiny lobster is extremely great, however its management in Sabah are inadequate. There is a dearth of information for fisheries management regarding the distribution of spiny lobster species. Furthermore, there were places in Sabah such as Mantanani island where overfishing and destructive fishing led to the depletion of resources and deterioration of habitat (Reef Check Malaysia, 2020). Moreover, two out of five species of *Panulirus* sp. were unidentified in the Sabah water. The taxonomic status of many common and economically significant taxa has been revealed to be complexes of previously unrecognised species because often these species are difficult to distinguished based on morphological criteria. It is necessary to determine the distribution and availability of fisheries resources in addition to fishing effort in order to implement sustainable management methods. Moreover, no spiny lobster study has ever been conducted in PLL.

1.3 Significant of Study

Better understanding of the species distribution of spiny lobster (*Panulirus* spp.) in Sabah and surrounding waters is made possible by this project, and this insight will be essential for managing the spiny lobster's natural resource and fishing operations. Moreover, access to living samples from distant areas is sometimes restricted, leading to the the synonymization of groups of closely related species that are only distinguished by colour. The taxonomic status of numerous widespread and economically significant taxa will be determined with the help of molecular data. This investigation will also contribute to the genetic profile of *Panulirus* spp. in Sabah water and PLL, allowing for further taxonomic research.

1.4 Objectives

This study aims:

- To established a checklist of spiny lobsters (*Panulirus* spp.) in Sabah and Pulau Layang-Layang waters with the detailed illustration of the morphology characteristics.
- To identify the spiny lobsters (*Panulirus* spp.) in Sabah and Pulau Layang-Layang waters through genetic approach by using Cytochrome oxidase 1 subunit (COI) gene analysis.
- To determine the relationship between landing status of spiny lobsters (*Panulirus* sp.) and climate parameters in Sabah waters from 1990 to 2019 using secondary data from Department of Fisheries Sabah and Meteorological Department of Sabah.

CHAPTER 2

LITERATURE REVIEW

2.1 Spiny Lobsters (*Panulirus* spp.)

The genus, *Panulirus* White (1847), with common name, spiny lobster, is the most diverse genus in the Palinuridae family. There are 23 species/subspecies listed in the World Registered Marine Species (WoRMS), last update by Sammy in 2021. Whilst, a total of 21 spiny lobster species was reported in IUCN (2022) red list but nine species are currently categorized as "Data Deficient" and the other 12 species are "Least Concern".

The general characteristics of *Panulirus* spp. are having two distinct, widely separated tooth-like frontal horns visible between the anterior margin of the carapace; no rostrum; antennal flagella quite flexible, long, whip-like antennule flagella; longer than peduncle of antennule; and carapace is ornamented with spines and granules of various size. The legs of this genus are generally simple, which is without true pincer (Chan, 1998). Figure 2.1 shows the general shape of a *Panulirus* sp. with its technical terms and measurements while Table 1 showed the description of *Panulirus* sp. that commonly found in Indo-West Pacific.

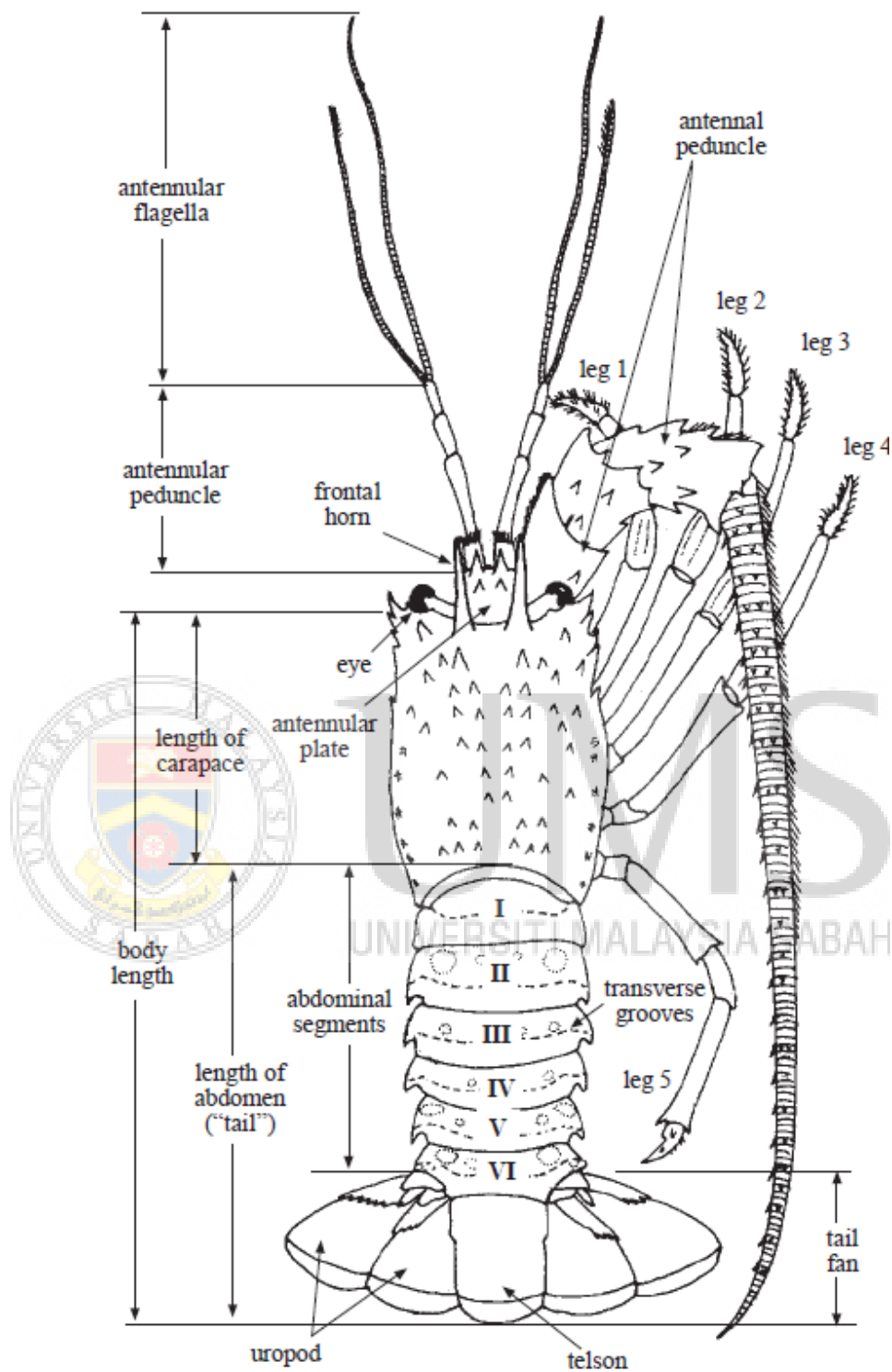


Figure 2.1 : General shape of a *Panulirus* sp. with its technical terms and measurements.

Source: : Chan (1998)

Table 2.1: Description of *Panulirus* spp. commonly found in East Indian Ocean and West Pacific Ocean.

| Species | Common name | Diagnosis | Reference |
|----------------------|-------------------------|---|------------------|
| <i>P. homarus</i> | Scalloped spiny lobster | Rostrum absent; antennae cylindrical and longer than body; anterior margin of carapace with two frontal horns; antennular plate with four equal, large well-separated spines arranged in a square; pleura of second to fifth abdominal segments ending in a strong tooth with denticles on posterior margin. Transverse groove on each abdominal segment, interrupted or complete in the middle with anterior margin formed into shallow or deep and large scallops. Legs 1-4 without pincers | (Holthuis, 1991) |
| <i>P. polyphagus</i> | Mud spiny lobster | Abdominal somites naked, smooth and without transverse grooves; no exopod on third maxilliped; the antennular plate with two strong spines; colour greyish-green with transverse white bands on posterior margin of the abdominal somites 2–5. Legs irregularly spotted | |
| <i>P. ornatus</i> | Ornate spiny lobster | Smooth and naked abdominal somites with colour varying from brownish or greenish-grey with utmost minute indistinct speckles. The large eyespot in the anterior half near the base of the pleura is accompanied by an oblique pale streak placed somewhat median of the eyespot; legs with very sharply defined irregular dark spots of bluish or brownish colour. Antennal flagella distinctly ringed. | |
| <i>P. versicolor</i> | Painted spiny lobster | Four strong spines on the antennular plate are arranged in a quadrangle. Carapace bluish-black in colour; antennal peduncles pink; antennular flagella white; white transverse bands on abdominal somites 2–5; streaks of white lines on legs. | |