

**NOTES ON *ACETES* SHRIMP'S LANDING STATUS
IN MALAYSIA ASSOCIATED WITH
MORPHOMETRIC CHARACTERIZATION AND
GENETIC IDENTIFICATION**



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

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STEPHENIE DEMIE ANAK KAWI

**THESIS SUBMITTED IN FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
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**BORNEO MARINE RESEARCH INSTITUTE
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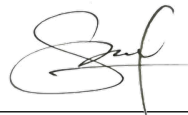
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DECLARATION

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

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Stephenie Demie Anak Kawi

25 November 2023

ABSTRACT

Acetes are tiny planktonic shrimps, which the locals refer as "*Udang Baring*" or "*Bubuk*" in their dialect. Studies on *Acetes* shrimps have primarily been conducted in Peninsular Malaysia and Sarawak and have focused on the distribution, diet composition, population, morphometric data, and genetic variation. Even though these shrimps are economically significant for human consumption and the aquaculture industry, there has only been a very limited amount of research done on this genus in Sabah waters. Understanding the population structure and genetic information is essential for managing and evaluating wild stock populations. In this study, the Department of Fisheries Malaysia's annual published landing data from nine Malaysian states—Perlis, Kedah, Pulau Pinang, Perak, Selangor, Melaka, Johor (West Johor and East Johor), Sarawak, and Sabah—were used to assess the landing status of *Acetes*. Overall, the findings indicated that annual landings have increased over the past 26 years, reaching a peak of 52569.00 tonnes in 2010. According to the data from the Department of Fisheries Malaysia, there has been a considerable decline in *Acetes* population landings during the previous few years in Malaysia. Overexploitation may have resulted from yields that were higher than the 900 000 tonnes which was considered to be the optimal yield. Additionally, *Acetes* species were gathered from the fishermen in four different Sabah water locations. Based on the identification keys provided by Omori (1975b), three species—*Acetes australis*, *Acetes erythraeus*, and *Acetes intermedius*—had been captured and recognised. For each species, measurements of the carapace length (CL), telson length (TLL), total length (TL), and wet weight (WW) were taken from 885 specimens and compared between species and sexes. *A. intermedius* is the largest of the three species, whereas *A. australis* has the lowest measurement and is often smaller than *A. erythraeus* and *A. intermedius*. Length-weight relationship observed was significantly high ($P=0.05$) except for females *A. erythraeus* ($P=0.403$). With the help of the mitochondrial cytochrome c oxidase subunit I (COI) gene, the three species were identified, evidenced by both morphological and molecular aspects. These species' average sequence divergence ranged from 7.20%—19.46%. Moreover, high bootstrap values consistently showed three monophyletic different clades based on phylogenetic trees constructed using Maximum Likelihood and Bayesian Inference

with the aligned COI gene, which are in agreement with the stated species. In conclusion, despite the possibility of overexploitation in some Malaysian states, the rising trend in *Acetes* landings demonstrated that the industry is receiving greater attention. The number of *Acetes* species in Malaysian seas had been increased to eight species, after the recent identification of three species in Sabah waters.



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ABSTRAK

NOTA STATUS PENDARATAN UDANG ACETES DI MALAYSIA DENGAN PENCIRIAN MORFOMETRIK DAN PENGENALAN GENETIK

Acetes adalah sejenis udang planktonik kecil yang lebih dikenali sebagai "Udang Baring" atau "Bubuk" mengikut dialek penduduk tempatan. Kebanyakan kajian mengenai udang *Acetes* yang telah dijalankan sebelum ini adalah di Semenanjung Malaysia dan Sarawak dan tertumpu kepada taburan, komposisi diet, populasi, data morfometrik dan variasi genetik. Walaupun udang ini penting dari segi ekonomi bagi kegunaan manusia dan juga industri akuakultur, hanya sedikit penyelidikan mengenai genus ini di perairan Sabah. Untuk mengurus dan menilai populasi stok liar udang ini, adalah penting untuk kita memahami struktur populasi dan maklumat genetik. Dalam kajian ini, data tahunan pendaratan dari sembilan negeri —Perlis, Kedah, Pulau Pinang, Perak, Selangor, Melaka, Johor (Johor Barat and Johor Timur), Sarawak, and Sabah— yang diterbitkan oleh Jabatan Perikanan Malaysia telah digunakan untuk menilai status pendaratan udang *Acetes*. Secara keseluruhan, kajian mendapati bahawa pendaratan tahunan bagi udang ini telah meningkat dalam tempoh 26 tahun dan mencapai kemuncak sebanyak 52569.00 tan pada tahun 2010. Merujuk kepada data Jabatan Perikanan Malaysia, terdapat penurunan yang ketara dalam pendaratan populasi *Acetes* untuk beberapa tahun kebelakangan di Malaysia. Eksploitasi berlebihan mungkin berpunca daripada hasil tangkapan yang melebihi 900,000 tan yang dianggap sebagai hasil tangkapan optimum. Selain itu, spesis *Acetes* telah dikumpulkan daripada nelayan di empat lokasi perairan Sabah yang berbeza. Berdasarkan kunci pengenalan yang disediakan oleh Omori (1975b), tiga spesis —*Acetes australis*, *Acetes erythraeus*, dan *Acetes*

intermedius— telah ditemukan dan diidentifikasi. Bagi setiap spesies, ukuran jumlah Panjang (TL), panjang karapas (CL), panjang telson (TLL) dan berat basah (WW) telah diambil daripada 885 spesimen dan dibandingkan antara jantina. *A. intermedius* adalah yang terbesar daripada tiga spesies, manakala *A. australis* mempunyai nilai ukuran terendah dan selalunya lebih kecil daripada *A. erythraeus* dan *A. intermedius*. Hubungan panjang-berat yang didapati adalah tinggi ($P=0.05$) kecuali bagi udang betina *A. erythraeus* ($P=0.403$). Berdasarkan mitokondria gen cytochrome c Oxidase subunit I (COI), ketiga-tiga spesies ini telah diidentifikasi, sekaligus mengukuhkan hasil penemuan dari aspek morfologi dan molekul. Purata perbezaan jujukan spesies ini adalah diantara 7.20%—19.46%. berdasarkan pokok filogenetik yang dibina menggunakan Kemungkinan Maksimum (Maximum Likelihood) dan Inferens Bayesian (Bayesian Inferens), nilai bootstrap didapati tinggi dan konsisten serta menunjukkan tiga klad monofiletik yang berbeza, selaras dengan spesies yang telah diidentifikasi. Kesimpulannya, walaupun terdapat kemungkinan eksploitasi berlebihan di beberapa negeri di Malaysia, trend peningkatan pendaratan Acetes menunjukkan bahawa industri ini semakin mendapat perhatian besar. Bilangan species Acetes di perairan Malaysia juga telah meningkat kepada lapan spesies, hasil daripada penemuan dan pengecaman tiga spesies di perairan Sabah baru-baru ini.

LIST OF CONTENTS

	Page
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vii
LIST OF CONTENTS	ix
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiv
LIST OF APPENDICES	xv
CHAPTER 1: INTRODUCTION	1
1.1 Introduction	1
CHAPTER 2: LITERATURE REVIEW	4
2.1 Landing of <i>Acetes</i> in Malaysia	4
2.2 <i>Acetes</i> spp.	5
2.2.1 Morphology	5
2.2.2 Classification	6
2.2.3 Identification of <i>Acetes</i>	8
2.2.4 Length-Weight Relationships (LWRs)	10
2.2.5 Genetic prospects regarding <i>Acetes</i> in Malaysia	11
2.2.6 Geographical distribution of <i>Acetes</i> spp.	14
2.2.7 Life cycle of <i>Acetes</i>	18
2.2.8 Ecology of <i>Acetes</i>	18
2.2.9 Commercial values of <i>Acetes</i>	19
CHAPTER 3: MATERIALS AND METHODS	21
3.1 Landing status of <i>Acetes</i> in Malaysia	21
3.1.1 Data harvesting	21
3.1.2 Selection of study scope	22
3.1.3 Landing data analyses	22
3.2 Morphometric characterization	22
3.2.1 Sample collection and preservation	22
3.2.2 Species and sexes identification	23
3.2.3 Morphometric data collection	29
3.2.4 Morphometric data analyses	29
3.3 Length-weight relationship	30
3.4 Genetic identification	31
3.4.1 Total genomic DNA extraction	31

3.4.2	Polymerase Chain Reaction (PCR)	31
3.4.3	Agarose Gel Electrophoresis, Staining and Visualisation of DNA	32
3.4.4	Template purification and sequencing	33
3.4.5	DNA sequence alignment and analysis	33
3.4.6	Phylogenetic analysis	33
CHAPTER 4: RESULTS		35
4.1	Landing status of <i>Acetes</i> in Malaysia	35
4.2	Species identification and sexes of <i>Acetes</i>	39
4.2.1	<i>Acetes australis</i> Colefax, 1940	42
4.2.2	<i>Acetes erythraeus Nobili, 1905</i>	45
4.2.3	<i>Acetes intermedius</i> Omori, 1975	49
4.3	Sex ratio and species composition	52
4.4	Morphometric analysis	53
4.5	Length-weight relationship	62
4.6	Genetic identification	65
4.6.1	DNA analysis of <i>Acetes</i> samples	65
4.6.2	Cytochrome C Oxidase Subunit I (COI) Gene	66
4.7	Phylogenetic analyses	67
4.7.1	Phylogenetic tree	67
4.7.2	Pairwise genetic distance and Time of divergence	68
CHAPTER 5: DISCUSSION		70
5.1	Landing status of <i>Acetes</i> in Malaysia	70
5.2	Species distribution	71
5.3	Species identification	73
5.3.1	<i>Acetes australis</i>	74
5.3.2	<i>Acetes erythraeus</i>	75
5.3.3	<i>Acetes intermedius</i>	75
5.4	Morphometric analysis	76
5.4.1	Sex ratio	76
5.4.2	Size dimorphism	76
5.5	Length-weight relationship (LWRs)	77
5.6	Genetic identification of <i>Acetes</i> sp.	78
CHAPTER 6: CONCLUSION		81
REFERENCES		82
APPENDICES		99

LIST OF TABLES

		Page
Table 2.1	: List of distinct <i>Acetes</i> species around the world and their synonyms	7
Table 2.2	: Locality of <i>Acetes</i> shrimp in Malaysian coastal waters	15
Table 3.1	: Number of <i>Acetes</i> samples from the sampling locations	23
Table 3.2	: Key to the sexes of genus <i>Acetes</i> (provided by Omori, 1975b)	24
Table 3.3	: Key species to the male of genus <i>Acetes</i> (modified from Omori, 1975b)	24
Table 3.4	: Key species to the female of genus <i>Acetes</i> (modified from Omori, 1975b)	28
Table 3.5	: Number of <i>Acetes</i> spp. used in genetic analysis in each sampling location	31
Table 4.1	: Pearson correlation of <i>Acetes</i> landing years with states in Malaysia	39
Table 4.2	: Total length (TL), carapace length (CL) and wet weight (WW) for males and females of <i>Acetes australis</i> , <i>Acetes erythraeus</i> and <i>Acetes intermedius</i>	55
Table 4.3	: Results of Kruskal-Wallis <i>H</i> -test for the comparison among <i>A. australis</i> , <i>A. erythraeus</i> and <i>A. intermedius</i> . Test was conducted for males (M), Females (F) and combine sexes (B) relatively	60
Table 4.4	: Pairwise comparisons among <i>Acetes</i> species for Total Length (TL), Carapace Length (CL), Telson Length (TLL) and Wet Weight (WW) based on Kruskal-Wallis <i>H</i> Test (X^2) with P-values being corrected by Bonferroni method ($P = 0.05$)	61
Table 4.5	: Length-Weight Relationship (Growth Pattern) of <i>Acetes</i> species in current study	63
Table 4.6	: Parameters of length-weight relationship (a and b) for both sexes of each species in the genus <i>Acetes</i> from different geographical locations	64
Table 4.7	: BLAST result of <i>Acetes</i> samples with existing data from GenBank (%)	66
Table 4.8	: Nucleotide composition (%) of COI gene amplified for each <i>Acetes</i> species	67
Table 4.9	: Average percentage nucleotide sequence divergence (%) estimated using Kimura's Two Parameter (K2P). The values in parentheses are the range of the nucleotide sequence divergence and intraspecific variation for each species are in bold	69

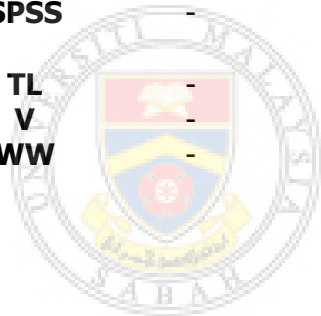
LIST OF FIGURES

		Page
Figure 2.1	: Male <i>Acetes</i> shrimp with part labelled (Adapted from Wong, 2013)	6
Figure 2.2	: Diagram showing relationships of the genus <i>Acetes</i> based on morphological character following Omori (1975b)	10
Figure 2.3	: <i>Acetes</i> spp. distribution in Malaysian waters	15
Figure 2.4	: Major global fishing grounds of <i>Acetes</i> (adopted from Omori, 1975b)	20
Figure 3.1	: States in Malaysia where the <i>Acetes</i> landing data used for present study	21
Figure 3.2	: Sampling location of <i>Acetes</i> spp.	23
Figure 3.3	: Illustration of petasma of male <i>Acetes</i> (provided by Omori, 1975b)	27
Figure 3.4	: Illustration of third thoracic sternite of female <i>Acetes</i> (provided by Omori, 1975b)	28
Figure 3.5	: Measurement of Total Length (TL), Carapace length (CL) and Telson length (TLL)	29
Figure 3.6	: PCR Thermal Cycle	32
Figure 4.1	: Annual landings of <i>Acetes</i> spp. in Malaysia	36
Figure 4.2	: Annual landing of <i>Acetes</i> spp. in nine different states in Malaysia	36
Figure 4.3	: Total numbers of fishing gears used to catch <i>Acetes</i> spp. in Malaysia	37
Figure 4.4	: Average landing of <i>Acetes</i> spp. by type of fishing gears	37
Figure 4.5	: Multidimensional Scaling (MDS) on <i>Acetes</i> landing years	38
Figure 4.6	: Cluster analysis on <i>Acetes</i> landing years	39
Figure 4.7	: Male specimen of <i>Acetes</i> viewed under light microscope	40
Figure 4.8	: Head of <i>Acetes</i> viewed under light microscope	41
Figure 4.9	: Apex of telson of <i>Acetes</i> viewed under light microscope	41
Figure 4.10	: (a) Capitulum of petasma of male <i>A. australis</i> viewed under light microscope (200µm); (b) Head of capitulum of petasma of male <i>A. australis</i> viewed under SEM microscope (500µm)	42
Figure 4.11	: Drawing of capitulum of petasma of male <i>A. australis</i>	43
Figure 4.12	: Appendix of masculina of <i>A. australis</i> viewed under light microscope	43
Figure 4.13	: Drawing of appendix of masculina of <i>A. australis</i>	44
Figure 4.14	: Third thoracic sternite of female <i>A. australis</i> viewed under light microscope	44
Figure 4.15	: Drawing of third thoracic sternite of female <i>A. australis</i>	45

Figure 4.16	:	(a) Capitulum of petasma of male <i>A. erythraeus</i> viewed under light microscope (200µm); (b) Head of capitulum of petasma viewed under SEM microscope (300µm)	46
Figure 4.17	:	Drawing of capitulum of petasma of male <i>A. erythraeus</i>	46
Figure 4.18	:	Appendix of masculina of <i>A. erythraeus</i> viewed under light microscope	47
Figure 4.19	:	Drawing of appendix of masculina of <i>A. erythraeus</i>	47
Figure 4.20	:	Third thoracic sternite of female <i>A. erythraeus</i> viewed under light microscope	48
Figure 4.21	:	Drawing of third thoracic sternite of female <i>A. erythraeus</i>	48
Figure 4.22	:	Capitulum of petasma of male <i>A. intermedius</i> viewed under light microscope	49
Figure 4.23	:	Drawing of capitulum of petasma of male <i>A. intermedius</i>	50
Figure 4.24	:	Appendix of masculina of <i>A. intermedius</i> viewed under light microscope	50
Figure 4.25	:	Appendix of masculina of <i>A. intermedius</i> (drawing)	51
Figure 4.26	:	Third thoracic sternite of female <i>A. intermedius</i> viewed under light microscope	51
Figure 4.27	:	Drawing of third thoracic sternite of female <i>A. intermedius</i>	52
Figure 4.28	:	Species composition of <i>Acetes</i> found in Sabah waters	53
Figure 4.29	:	Size range distribution of males and females <i>A. australis</i>	56
Figure 4.30	:	Size range distribution of males and females <i>A. erythraeus</i>	57
Figure 4.31	:	Size range distribution of males and females <i>A. intermedius</i>	58
Figure 4.32	:	Size range distribution of <i>A. australis</i> , <i>A. erythraeus</i> and <i>A. intermedius</i>	59
Figure 4.33	:	Gel electrophoresis of extracted DNA from <i>Acetes</i> spp. Lane M: 1 kb DNA ladder; Lane 1-10: DNA extracts. (1% Agarose gel, TBE buffer, 90V, 45 mins)	65
Figure 4.34	:	Gel electrophoresis of PCR products amplified from <i>Acetes</i> spp. Lane M: 100bp DNA ladder; Lane 1-16: PCR products; Lane 17: Negative control. (1% Agarose gel, TBE buffer, 90V, 45 mins)	65
Figure 4.35	:	Bayesian inference (BI) tree of <i>Acetes</i> spp. and outgroup based COI gene. Probability values at the nodes represent bootstrap values for Maximum Likelihood (ML)	68

LIST OF ABBREVIATIONS

µL	-	Microlitre
BI	-	Bayesian inference
bp	-	Base pair
CL	-	Carapace length
COI	-	Cytochrome c oxidase subunit (I) gene
DNA	-	Deoxyribonucleic acid
DOF	-	Department of Fisheries
K2P	-	Kimura 2 parameter
LWR	-	Length-weight relationship
MEGA	-	Molecular Evolutionary Genetics Analysis
ML	-	Maximum likelihood
mm	-	millimeter
NJ	-	Neighbour-joining
PCR	-	Polymerase Chain Reaction
SPSS	-	Statistical Packages for Social Science
TL	-	Total length
V	-	Volt
WW	-	Wet Weight

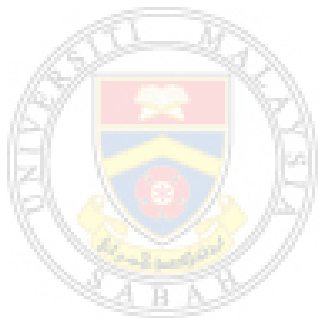


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LIST OF APPENDICES

Appendix A	: Blast results of <i>Acetes</i> spp. obtained from Sabah waters with existing data from GenBank	Page 99
Appendix B	: ENSO events in Malaysia (modified from Tangang <i>et al.</i> , 2017)	100



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CHAPTER 1

INTRODUCTION

1.1 Introduction

A small planktonic shrimp known as sergestid shrimps, *Acetes* spp., are found in tropical and subtropical inshore and neritic waters (Holthius, 1980; Omori, 1975a; Pathansali, 1966). These prawns, which range in size from 10 - 40 mm, are known locally in Malaysia as "*Udang Baring*," "*Udang Geragau*," and "*Bubok*" (Omori, 1975b; Wong, 2013). In the warmer months, *Acetes* shrimps are widely distributed and typically travel in large swarms near to the beach (Nataraj, 1947). These shrimps are economically significant throughout Asia and east Africa for human consumption, where they were used for local delicacies like "*belacan*" and "*cincajuk*" as well as being consumed in fresh or dried form (Pathansali, 1966; Othman *et al.* 2020; Wong, 2013). *Acetes* are also used as a feeding material in agriculture and aquaculture (Amin, 2008a; Deshmukh, 1991; Holthius, 1980). They were also being used to lower the cost of brine shrimp cyst generation and are typically administered to larval and adult shrimps as well as used in artificial fish feed formulations (Xiao and Greenwood, 1993). They also play a significant function as prey and predator in the food web of coastal water (Xiao & Greenwood, 1993).

Seven *Acetes* species, including *A. erythraeus*, *A. indicus*, *A. intermedius*, *A. japonicus*, *A. serrulatus*, *A. sibogae*, and *A. vulgaris*, have been identified in Malaysian coastal waters (Amani *et al.*, 2011a; 2011b, 2011c; Longhurst, 1970; Omori, 1975b; Pathansali, 1966). So far, total of 14 *Acetes* species have been described globally. *Acetes* shrimps have contributed to the fisheries' production for many years, amounting to over 1.7 million tonnes in 2017 (DOF, 2001-2010). According to the DOF, between 2001 and 2010, the west coast of Peninsular Malaysia accounted for

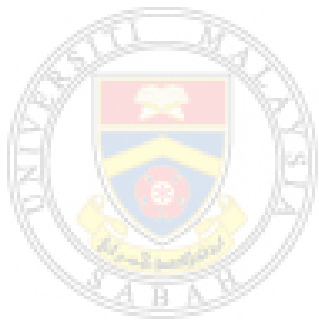
75% of its landings. Despite being heavily exploited, little is known about this shrimp from research aspect. The earlier research on *Acetes* shrimps in Malaysia concentrated on the distribution, diet composition, population, and life cycles (Amani *et al.* 2011a, 2011b, 2011c; Amin *et al.* 2008, 2009a, 2009b, 2009c, 2009d, 2010, 2011; Arshad *et al.*, 2007, 2008, 2012; Aziz *et al.*, 2010; Jamil *et al.*, 2019; Othman *et al.*, 2020; Wong, 2013). The Peninsular Malaysian *Acetes* fishery has been the subject of several succinct accounts (Ahamad, 1993; Johnson, 1976; Tham, 1950; Omori, 1975b).

Additionally, studies on *Acetes'* morphometric analyses had been concentrating on off-shore trawling activities (DOF, 2001-2010; Wong, 2013; Wong *et al.*, 2015) and in-shore catches (Amin *et al.*, 2009b, 2009c; Amin *et al.*, 2010a; Arshad *et al.*, 2012). Aziz *et al.* (2010) had used RAPD technique to study on the population characterization of *A. japonicus* from Kedah and Melaka coastal waters where the study revealed that the population of *A. japonicus* from Kedah and Malacca is not ancestrally close unlike the population from Perak and Kedah. Meanwhile, Wong *et al.* (2017) used the mitochondrial cytochrome c oxidase subunit 1 (COI) to identify four *Acetes* species (*A. indicus*, *A. serrulatus*, *A. sibogae* and *A. japonicus*) sampled along the west coast of Peninsular Malaysia. Hassan and Othman (2021) reported that phylogenetic trees of *A. erythraeus* and *A. serrulatus* from Sarawak waters were reciprocally monophyletic which were also identified using mitochondrial cytochrome c oxidase subunit 1 (COI). More specifically, the majority of these research were conducted in Peninsular Malaysia and Sarawak, with only one study—covered by Omori (1975b)—being conducted in Sabah.

Ecological and biological data should be gathered to help with the assessment and management of the animals in order to achieve long-term sustainable production (Allendorf & Luikart, 2006; Wong, 2017). At the moment, there are few ecological data on *Acetes*, and it is unclear how these desirable species are being exploited. Also lacking were studies on the *Acetes* that live in the waters off Sabah. Therefore, the objectives of this study are to

- i. to determine the landing status of *Acetes* in Malaysia

- ii. to characterize the species of *Acetes* spp. in Sabah waters using morphology identification
- iii. to infer *Acetes* species relationship using COI gene



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CHAPTER 2

LITERATURE REVIEW

2.1 Landing of *Acetes* in Malaysia

Fisheries have long been a significant source of animal protein for many countries, including Malaysia. It is crucial to gather ecological and biological data in addition to catch and effort data in order to maintain the shrimp population (Mat Piah *et al.*, 2018; Rhodes & Sadovy, 2002). However, these data still contain inaccurate information about *Acetes* spp. Abu Talib *et al.* (2013) and McClenachan (2009) advised using historical landing data as the first step to investigate the utilisation trends of the desirable species from a fisheries perspective for such species that experienced noteworthy decline previously according to the ecological data collection. Furthermore, the entire fishing output in Malaysia in 2017 was 1.7 million tonnes, and the demand is continuously rising (FAO, 2020).

Acetes have been recorded from both West and East Malaysia (DOF, 2001-2017). However, the landings were primarily concentrated on Malaysia's west coast, where Selangor and Perak were the main fishing hubs and 75% of all *Acetes* were caught in Malaysia (Wong, 2017). *Acetes* shrimps frequently gather in an obvious group close to the coast, where they are mostly caught using fixed bag nets or push nets (Omori, 1975b). Additionally, *Acetes* have been found to be caught using stake nets, beach seines, purse seines, and boat seines (Deskmukh, 2004; FAO, 2001; Omori, 1975b). *Acetes* are also being fished commercially utilising trawls at a distance of greater than five nautical miles (DOF, 2001-2017; FAO, 2000).

It should be emphasised that the offshore regions accounted for the majority of the *Acetes* landings in Malaysia. Moreover, according to records, during the fishing season, small-scale fishermen in Miri, Sarawak, were able to catch about 100

kilogrammes of *Acetes* prawns, which they were able to sell for RM7 to RM8 per kilogramme (Chen *et al.*, 2021).

2.2 *Acetes* spp.

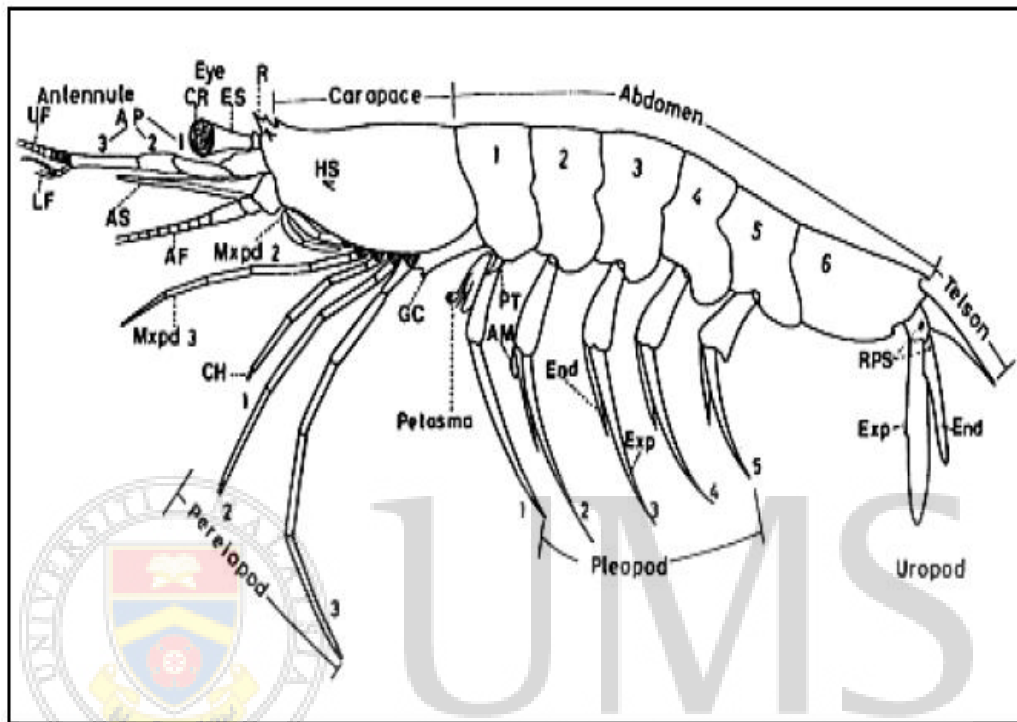
2.2.1 Morphology

The *Acetes* shrimp's body size ranges from 10 - 40 mm (Omori, 1975b). It possesses a thin, transparent body as well as stalked, nearly spherical, intensely pigmented black eyes (Ball *et al.*, 1986; Colefax, 1940). They have short, sharp rostrums that may or may not have one or two dorsal denticles (Omori, 1975b). Xiao and Greenwood (1993) reported that they also have five somites in the cephalon (head) area, which include the first pair of antennae, the second antennae, the maxillules, the maxillae, and the mandibles. Hepatic and supraorbital spines are both fully formed (Hansen, 1919). Antennules have a second peduncular joint and are small; nevertheless, females' third joints are considerably longer than males' (Colefax, 1940). According to Kishinouye (1928), the upper flagellum is longer and thicker than the lower flagellum, which has 10–12 joints. In males, the lower antennular flagellum has a clasping organ.

The first maxilla lacks a palp, whereas the second has a single, undivided lobe. Branchial lamellae and arthrobranchs are also visible (Hansen, 1919). The thorax has eight somites, which are made up of three pairs of maxillipeds and five pairs of pereopods. The abdomen has six somites, the first five of which have a pair of pleopods used for swimming forward and the sixth of which has uropods and telson (Xiao & Greenwood, 1993). The first three pleopod pairs are long and have a tiny chela. However, the fourth and fifth pereopods are completely absent in males save for a pair of protuberances called genital coxae. On the endopods and base of the uropods that are found in pairs, there are several red pigments visible (Chan, 1998; Holthuis, 1980). According to Okada (1928), the uropods are composed of a basal protopod, an inner endopod, and an outer exopod.

To differentiate between species, it is possible to compare the number of denticles on the rostrum behind the terminal point, the size of the eyes, the presence

of the procurved tooth between the bases of the first pair of pleopods, the shape of the telson, and the specific structure of the basis and coxa of the third pereopod (Wong, 2013). The sections of a male *Acetes* shrimp is labelled in Figure 2.1 (Omori, 1975b).



AM, appendix masculine; AF, antennal annular peduncle; AS, antennal scale; CH, chela; CR, cornea; End, endopod; ES, eye stalk; Exp, exopod; GC, genital coxa; HS, hepatic spine; LF, lower flagellum; Mxpd, maxilliped; PT, procurved tooth; R, rostrum; RPS, red pigment spots; UF, upper flagellum Omori, 1975b)

Figure 2.1 : Male *Acetes* shrimp with part labelled

Source : Adapted from Wong, (2013)

2.2.2 Classification

According to De Grave (2009), *Acetes* shrimps belong to the Phylum Arthropoda, Subphylum Crustacea, Class Malacostraca, Order Decapoda, and Family Sergestidae. There are 22 species of *Acetes* shrimps that have existed in this world since the first discovery of the genus by Milne Edwards (1830) from Ganges river in India. Nevertheless, only 14 species are recognised, according to De Grave (2009), because some species names are treated as analogous due to the similarity in descriptions. Colefax (1940) and Holthius (1980) both bolster this. Table 2.1 lists the various

Acetes species that exist in the world along with their synonyms. There are two subspecies of *A. americanus* and three subspecies of *A. sibogae*. Omori (1975b) regards the polytypic nature of these two species are due to the insufficient data and morphological divergence between distinct populations in the genus.

Table 2.1: List of distinct *Acetes* species around the world and their synonyms

	Distinct species	Synonym
	Indo-West	
1.	<i>Acetes chinensis</i> Hansen, 1919	
2.	<i>Acetes erythraeus</i> Nobili, 1905	<i>Acetes</i> sp. Hansen 1919
3.	<i>Acetes indicus</i> H. Milne Edwards, 1830	<i>Acetes spiniger</i> Hansen, 1919
4.	<i>Acetes intermedius</i> Omori, 1975	<i>Acetes disper</i> Hansen, 1919
5.	<i>Acetes japonicus</i> Kishinouye, 1905	<i>Acetes cochinchensis</i> Rao, 1968
6.	<i>Acetes johni</i> Nataraj, 1947	
7.	<i>Acetes natalensis</i> Barnard, 1955	<i>Acetes insularis</i> Kemp, 1917
8.	<i>Acetes serrulatus</i> (Kröyer, 1859)	
9a.	<i>Acetes sibogae sibogae</i> Hansen, 1919	
9b.	<i>Acetes sibogae australis</i> Colefax, 1940	<i>Acetes australis</i> Colefax, 1940
9c.	<i>Acetes sibogae sibogalis</i> Achuthankutty and George, 1973	<i>Acetes sibogalis</i> Achuthankutty and George, 1973
10.	<i>Acetes vulgaris</i> Hansen, 1919	
	Pacific America	
11.	<i>Acetes binghami</i> Burkenroad, 1934	
	Atlantic America	
12a.	<i>Acetes americanus americanus</i> Ortmann, 1893	<i>Acetes brasiliensis</i> Hansen, 1919
12b.	<i>Acetes americanus carolinae</i> Hansen, 1933	<i>Acetes carolinae</i> Hansen, 1933
13.	<i>Acetes marinus</i> Omori, 1975	
14.	<i>Acetes paraguayensis</i> Hansen, 1919	