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

STEPHENIE DEMIE ANAK KAWI

BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
2023

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

STEPHENIE DEMIE ANAK KAWI

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

IJAZAH : **SARJANA SAINS**

BIDANG : **SAINS MARIN**

Saya **STEPHENIE DEMIE ANAK KAWI**, Sesi **2018-2023**, mengaku membenarkan tesis Sarjana ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

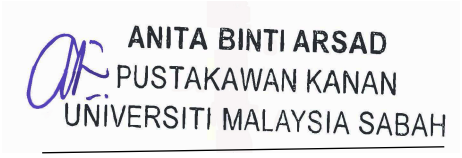
1. Tesis ini adalah hak milik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat Salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat Salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisai/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan Oleh,



STEPHENIE DEMIE ANAK KAWI
MY1811007T

(Tandatangan Pustakawan)

(Dr. Chen Cheng Ann)
Penyelia

Tarikh : 20 Jun 2023

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.

25 November 2022

Stephenie Demie Anak Kawi

MY1811007T

CERTIFICATION

NAME	**:**	**STEPHENIE DEMIE ANAK KAWI**
MATRIC NO.	**:**	**MY1811007T**
TITLE	**:**	**NOTES ON *ACETES* SHRIMP'S LANDING STATUS IN MALAYSIA ASSOCIATED WITH MORPHOMETRIC CHARACTERIZATION AND GENETIC IDENTIFICATION**
DEGREE	**:**	**MASTER OF SCIENCE**
FIELD	**:**	**MARINE SCIENCE**
VIVA DATE	**:**	**25 NOVEMBER 2022**

CERTIFIED BY;

Signature

SUPERVISOR
Dr. Chen Cheng Ann

_____

ACKNOWLEDGEMENT

First of all, I am very grateful and thankful to God Almighty, the author of knowledge and wisdom for His unending blessings. I would have not been able to complete this study without His will.

My gratitude also goes to my supervisor, Dr. Chen Cheng Ann. Thank you for the continuous support, guidance and inspiration. His kind supervision has helped me a lot at various stages of my study. It was a great honour to work under his supervision.

To my friends, fellow lab mates and others who in one way or another providing stimulating discussions for the past few years and shared their support, either morally or physically, thank you.

To my pillars of strength; abak and mak, my deepest gratitude for their unconditional love and encouragement. My heartfelt thanks to my caring and loving husband, Wei Hoong for his countless love and support. It was a great comfort and relief to know that I always have someone to lean on especially when the times get rough while completing this task.

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.

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. Kebanyakkan 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 spesis, 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 spesis, manakala A. australis mempunyai nilai ukuran terendah dan selalunya lebih kecil daripada A. eryhtraeus 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 spesis ini telah diidentifikasi, sekaligus mengukuhkan hasil penemuan dari aspek morfologi dan molekul. Purata perbezaan jujukan spesis 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 spesis yang telah diidentifikasi. Kesimpulannya, walaupun terdapat kemungkinan ekploitasi 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 spesis, hasil daripada penemuan dan pengecaman tiga spesis di perairan Sabah baru-baru ini.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

LIST OF APPENDICES

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 "*cincaluk*" 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

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; FA0, 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.

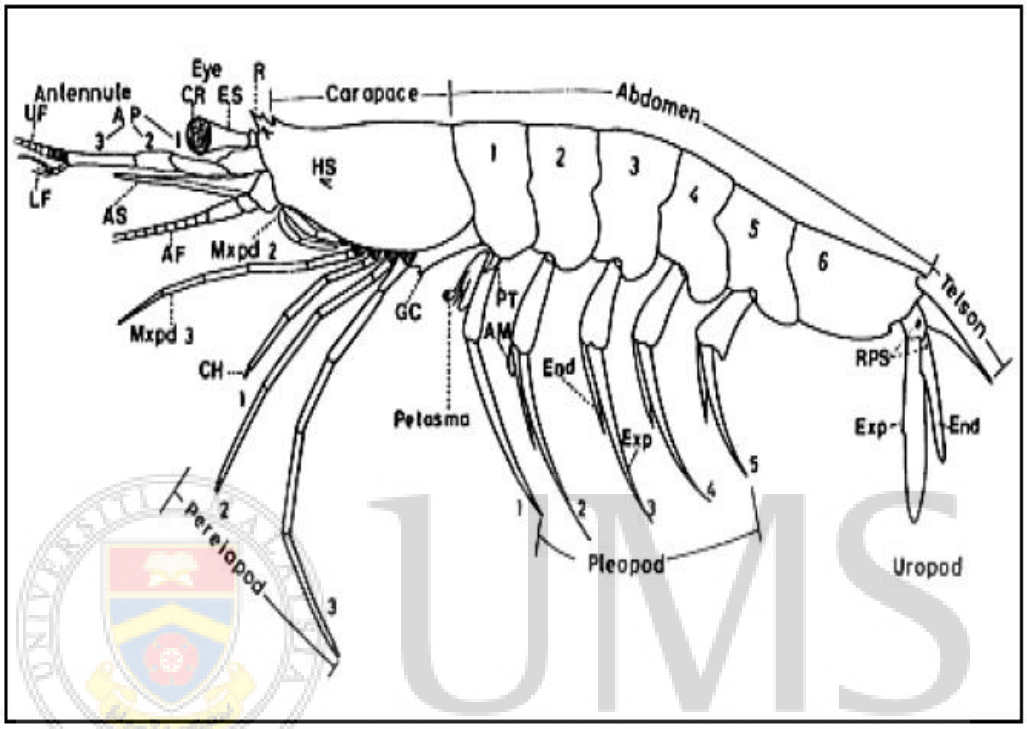
2.2.1 Morphology

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