UNIVERSITI PUTRA MALAYSIA

DIVERSITY, BIOLOGICAL AND ECOLOGICAL ASPECTS OF MARINE BAITWORMS, WITH AN EMPHASIS ON A POLYCHAETE Marphysa moribidii (IDRIS, HUTCHINGS, ARSHAD 2014) FROM MORIB MANGROVE AREA, MALAYSIA

IZWANDY BIN IDRIS

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By

IZWANDY BIN IDRIS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

December 2014

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DEDICATIONS

To my wife, Wan Iryani Wan Ismail, who has been standing by my side throughout my postgraduate studies and since being together for the past 12 years. Not to forget our daughters, Nurul Iffah and Nurul Izzah Natheema for them to endure the lack of quality time during my study period

To my parents and siblings, especially my mother whom I want to make her proud of her son's achievement

To my mother in law who have made her daughter a very supportive wife

and finally

To all who believe in me

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

DIVERSITY, BIOLOGICAL AND ECOLOGICAL ASPECTS OF MARINE BAITWORMS, WITH AN EMPHASIS ON A POLYCHAETE *Marphysa moribidii* (IDRIS, HUTCHINGS, ARSHAD 2014) FROM MORIB MANGROVE AREA, MALAYSIA

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IZWANDY BIN IDRIS

December 2014

Chairman: Professor Aziz bin Arshad, PhD

Faculty: Agriculture

The commercial value of marine baitworms from Class Polychaeta in Malaysia is not fully explored. It was previously researched by selected, local and foreign researchers. Hence, the objectives of the present study are to identify taxonomically polychaete species used as baitworms in Peninsular Malaysia, and to examine the biology and ecology of the dominant species.

The study was performed in two phases; the first phase was to systematically identify polychaete species used as baitworms in Peninsular Malaysia. The second phase focused on the biology and ecology of a dominant species from June 2011 to December 2012 at the Morib mangrove area in Selangor, Peninsular Malaysia. Random transect quadrats across three designated tidal flat areas were used to collect samples.

A total of seven polychaete species were identified in this study, namely *Marphysa moribidii* sp. nov., *M.* cf. *sanguinea*, *Halla okudai*, *Diopatra claparedii*, *Namalycastis rhodochorde*, *N.* cf. *abiuma* and *Perinereis* cf. *nuntia*. *Marphysa moribidii* sp. nov. was named and described in this study while *M.* cf. *sanguinea*, *N.* cf. *abiuma* and *P.* cf. *nuntia* had close similarities with the existing species. All species are new records in Malaysia with the exception of *D. claparedii* and *N. rhodochorde* which were previously reported in Kedah and Sabah respectively. *Marphysa moribidii* sp. nov. is the dominant baitworm species collected by the bait diggers and have a wide distribution across the west coast of Peninsular Malaysia.

The population of *M. moribidii* sp. nov. in Morib mangroves, was mostly confined in the upper tidal flat (UTF) area, particularly within the patchy microhabitat, which was identified as polychaete niche (PN). The microhabitat was characterised by having a high percentage of total organic matter, water content, silt and very fine sand. It was also located around the stilt roots of *Rhizophora apiculata*, providing protection from potential predators. Allometry analyses indicate that the growth of the species followed an allometric pattern. The maximum life span (t_{max}) was two years with growth constant (K) of 1.5 $year^{-1}$. The Bhattacharya and NORMSEP analyses concluded that there were two major spawning events occurred in 2012, although the von Bertalanffy Growth Function (VBGF) was only able to detect one spawning event.

The male and female ratio was close to 1:1. The gametogenesis processes were asynchronous in both sexes. Fecundity data revealed that there were two spawning seasons occurred during the study period.

Marphysa moribidii sp. nov. exhibited subsurface deposit feeding with high percentage of organic matter found in its intestinal contents. It also practices selective feeding by consuming a higher percentage of very fine sand compared to other sediments size classes. This sediments size class was chosen by *M. moribidii* sp. nov. for its high surface volume ratio which allowed more surfaces for organic coatings.

In summary, several aspects covering the systematics, biology and ecology of marine baitworms, in particular, *M. moribidii* sp. nov. in Peninsular Malaysia, have been documented in this study. Results obtained indicated that the biology and ecology of *M. moribidii* sp. nov. in Morib mangrove were interrelated. Moreover, the biological characteristics of *M. moribidii* sp. nov. meet all the criteria for commercial baitworm species. Nevertheless, more studies are needed to grasp a better understanding of the species, to allow correct resource management and to carefully consider the possibility of rearing the species in an artificial environment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KEPELBAGAIAN SERTA ASPEK BIOLOGI DAN EKOLOGI UMPUN-UMPUN UMPAN MARIN, DENGAN TUMPUAN KEPADA 'POLYCHAETE' *Marphysa moribidii* (IDRIS, HUTCHINGS, ARSHAD 2014) DARI KAWASAN PAYA BAKAU MORIB, MALAYSIA

Oleh

IZWANDY BIN IDRIS

Disember 2014

Pengerusi: Professor Aziz Arshad, PhD

Fakulti: Pertanian

Nilai komersil umpun-umpun umpan marin dari Kelas 'Polychaeta' di Malaysia masih tidak dikaji dengan lengkap. Ini kerana kajian awal ke atas 'polychaete' dijalankan secara selektif oleh penyelidik tempatan dan luar negara. Matlamat kajian ini adalah untuk mengenalpasti melalui taksonomi spesis 'polychaete' yang digunakan sebagai umpun-umpun umpan marin di Semenanjung Malaysia dan memahami biologi dan ekologi spesies umpun-umpun umpan marin yang utama.

Kajian dijalankan melalui dua fasa; fasa pertama untuk mengenalpasti spesies 'polychaete' yang digunakan sebagai umpun-umpun umpan marin di Semenanjung Malaysia. Fasa kedua pula melibatkan kajian ke atas biologi dan ekologi satu spesies dominan di kawasan bakau Morib bermula dari Jun 2011 sehingga Disember 2012. Sampel dikutip menggunakan keadah kuadrat transek rawak merentasi tiga kawasan dataran pasang surut yang ditetapkan terlebih awal.

Tujuh spesies 'polychaete' dikenalpasti melalui kajian ini iaitu *Marphysa moribidii* sp. nov., *M.* cf. *sanguinea*, *Halla okudai*, *Diopatra claparedii*, *Namalycastis rhodochorde*, *N.* cf. *abiuma* dan *Perinereis* cf. *nuntia*. *Marphysa moribidii* sp. nov. adalah spesies yang baru diberi nama dan dicirikan melalui kajian ini. *Marphysa* cf. *sanguinea*, *N.* cf. *abiuma* dan *P.* cf. *nuntia* pula mempunyai persamaan dengan

spesies yang telah dikenalpasti. Selain daripada *D. claparedii* dan *N. rhodochorde* yang masing-masing telah direkodkan di Kedah dan Sabah, spesies 'polychaete' yang dijumpai dalam kajian ini direkodkan buat pertama kali di Malaysia. *Marphysa moribidii* sp. nov. merupakan spesies dominan yang diambil oleh pencari umpun-umpun umpan marin dan mempunyai taburan terluas di persisiran pantai barat Semenanjung Malaysia.

Populasi *M. moribidii* sp. nov. di kawasan bakau Morib kebanyakannya bertumpu di kawasan 'upper tidal flat' (UTF), khususnya di habitat mikro yang dikenali sebagai 'polychaete niche' (PN). Mikro habitat ini mempunyai ciri seperti peratusan kandungan bahan organik, air, selut serta pasir sangat halus yang tinggi. Ia juga berada di dalam kawasan akar jangkang *Rhizophora apiculata*, dipercayai memberikan perlindungan kepada *M. moribidii*. Analisis alometri menunjukkan bahawa corak pertumbuhan *M. moribidii* sp. nov. adalah alometrik. Jangka hayat maksimum *M. moribidii* sp. nov. di kawasan bakau Morib (t_{max}) ialah dua tahun dengan kadar pertumbuhan (K) sebanyak 1.5 tahun^{-1}. Analisis 'Bhattacharya' dan 'NORMSEP' menunjukkan terdapat dua musim peneluran utama berlaku dalam setahun. Walaupun begitu, 'Fungsi Pertumbuhan von Bertalanffy' (VBGF) hanya dapat mengesan satu musim peneluran sahaja.

Nisbah di antara jantan dan betina menghampiri 1:1. Proses gametogenesis berlaku secara tidak berturutan di dalam kedua-dua jantina. Analisis data fekunditi mendapati terdapat dua musim peneluran berlaku sepanjang tempoh kajian dijalankan.

Marphysa moribidii sp. nov. mengamalkan pemakanan deposit bawah permukaan berdasarkan kepada kadar peratusan bahan organik yang tinggi dijumpai di dalam kandungan saluran pemakanannya. Spesies ini turut mengamalkan pemakanan memilih berdasarkan dengan peratusan kandungan pasir sangat halus yang lebih tinggi berbanding dengan sedimen kelas lain di dalam saluran pemakanan. Sedimen kelas ini mempunyai nisbah permukaan dan isipadu yang tinggi berbanding dengan sedimen kelas lain bagi pelekatan selaput organik.

Kesimpulannya, beberapa aspek meliputi taksonomi, biologi dan ekologi umpun-umpun umpan marin terutamanya *M. moribidii* sp. nov. di Semenanjung Malaysia telah berjaya direkodkan di dalam kajian ini. Keputusan yang diperolehi menunjukkan biologi dan ekologi *M. moribidii* sp. nov. di kawasan bakau Morib adalah saling berkaitan. Selain itu, ciri biologi *M. moribidii* sp. nov. menepati semua kriteria yang perlu sebagai spesies yang mempunyai nilai komersil. Walau bagaimanapun, kajian lanjutan perlu dilakukan untuk memahami spesies ini dengan lebih mendalam bagi membolehkan pengurusan sumber yang tepat dan kemungkinan untuk penternakan di persekitaran buatan.

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Terima kasih, trimakassie, thank you, shukran, baie dankie, obregado, Спасибо.

I certify that a Thesis Examination Committee has met on 12 December 2014 to conduct the final examination of Izwandy bin Idris on his thesis entitled "Diversity, Biological and Ecological Aspects of Marine Baitworms, with An Emphasis on A Polychaete *Marphysa moribidii* (Idris, Hutchings, Arshad 2014) from Morib Mangrove Area, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Fatimah bt Md Yusoff, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Ahmad b Ismail, PhD
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Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

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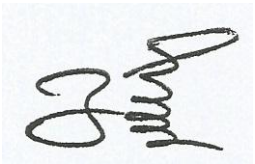
Professor
Faculty of Science
Kagoshima University Korimoto-1
(External Examiner)



ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 26 February 2015

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Aziz Arshad, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Japar Sidik Bujang, PhD
Professor
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Member)

Muta Harah Zakaria@Ya, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Zaidi Che Cob, PhD
Associate Professor
Marine Science Programme,
School of Environmental and Natural Resources Science
Universiti Kebangsaan Malaysia
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Signature: _____

Name of Member of Supervisory Committee: Assoc. Prof. Muta Harah Zakaria@Ya, PhD

Signature: _____

Name of Member of Supervisory Committee: Assoc. Prof. Zaidi Che Cob, PhD

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LIST OF ABBREVATIONS AND SYMBOLS

AM	Australian Museum
ANOVA	Analysis of variance
Bt.	Batu
BW	Body width at chaetiger 10 without parapodia
BW_{∞}	Asymptotic body width at chaetiger 10 without parapodia
cf.	Confer
cm	Centimeter
coll	collector
CPUE	Catch per unit effort
det	determinator
DO	Dissolved oxygen
ELEFAN	Electronic Length Frequency Analysis
FiSAT	FAO ICLARM Stock Assessment Tools
g	Gram
hr	hour
ind/m^2	Number of individuals per meter square
K	Growth coefficient of VBGF
Kg	Kampung
L_{∞}	Asymptotic length
L_{max}	Predicted extreme length
LTF	Lower tidal flat
MAGNT	Museum and Art Gallery of Northern Territory
MBW	Median body width at chaetiger 10
MgCl	Magnesium chloride
m	meter
mg/L	Milligram per liter
ml	mililiter
mm	milimeter
mV	milivolts
MTF	Middle tidal flat
N	North
NC	Number of chaetigers in complete sample
PCA	Principal component analysis
PN	Polychaete niche
PRIMER	Plymouth Routines In Multivariate Ecological Research
PSU	Practical Salinity Unit
PW	Peristomium width
R^2	coefficient of determination
SD	Standard deviation
SE	Standard error
SEM	Scanning electron microscope
Sg.	Sungai
SPSS	Statistical Package for Social Science
Tg.	Tanjung
TL	Total length
TOM	Total Organic Matter
USDA	United States Department of Agriculture

UTF	Upper tidal flat
VBGF	Von Bertalanffy Growth Function
WW	Wet weight
ZMB	Zoologische Museum in Berlin, Germany
oC	Celcius
µg/g	Microgram per gram
%	Percentage
>	More than
<	Less than

CHAPTER 1
GENERAL INTRODUCTION

1.1 Polychaeta in General

Polychaeta (Poly: many; chaeta: bristles) is a dominant Class under the Phylum Annelida. The Class is very diverse and has high commercial value to be exploited. Recent studies have promoted Polychaeta to the rank of Phylum, replacing the term Annelida, since the Class is growing, with more species classified under it (Struck *et al.*, 2011; Kvist and Siddall, 2013).

Polychaetes have vermiform (wormlike) bodies with three main segments: pre-segmental (anterior), repeated segments (metastomium) and pygidium (posterior). The main exterior identification characteristics of the species are the shapes and accessories of the anterior and metastomium. The variety of morphological features have divided the polychaetes into more than 80 families, with an additional 174 genera identified from fossils (Read and Fauchald, 2014).

Polychaetes are found in every main habitat of the biosphere, including the terrestrial, freshwater, and marine (Foster, 1972; Rota, 1997; Glasby *et al.*, 2000). This wide habitat range has shaped the variability in biological and ecological aspects of the polychaete, to ensure the survival and sustainability of the species.

The distribution of polychaetes in the marine environment ranges from coastlines, including salt marshes and mangroves, to hydrothermal vents in deep water (Jones, 1985; Metcalfe and Glasby, 2008). Some species exhibit microhabitat preferences or patchiness; for example, the whale bone polychaete *Osedax* species, which is only found on whale carcasses and bone in the deep sea (Rouse *et al.*, 2004). Meanwhile, studies on the growth and lifespan of a number of polychaete species have revealed that the *r* (high growth rate, many offspring) and *k* (high carrying capacity, fewer offspring) life strategies are used, depending on environmental and biological pressures (Giangrande, 1997).

High polychaete diversity results in great variability in reproduction. Both sexual and asexual reproductive modes have been observed among species, even within the same genus (Wilson, 1991). In sexual reproductive mode, the male gamete can be classified into three types: 1. ect-aquasperm; 2. ent-aquasperm; and 3. introsperm, while the female oocytes are categorised into two forms: 1. extraovarian and 2. intraovarian (Jamieson and Rouse, 1989; Eckelbarger, 2006). However, asexual species can be grouped into two major modes: 1. paratomy and 2. architomy (Glasby *et al.*, 2000; Eckelbarger, 2005).

Seminal works by Fauchald and Jumars (1979) have divided polychaetes into 24 feeding habits. These habits were later pooled into four major groups, namely raptorial feeders, non-selective deposit feeders, selective-deposit feeders and filter feeders (Glasby *et al.*, 2000). Food particles are gathered using structures called buccal organs. There are additional feeding appendages that function to increase feeding efficiency, including palps, tentacles, and the tentacular crown (Fauchald and

Rouse, 1997). However, feeding habits are species oriented. Species within the same genus exhibit different feeding habits and strategies to increase nutrient absorption.

Polychaetes are prominent organisms in the marine ecosystem. Species roles include being a cardinal food source for migratory birds, bioremediators and bioerosion agents (Iwamatsu *et al.*, 2007; Stabili *et al.*, 2010; Hutchings, 2011).

Humans have exploited polychaetes in various ways, including as bioindicators for pollution (Dean, 2008), toxicological test organisms (Reish and Gerlinger, 1997), bait for recreational fishers (Olive, 1994), broodstock food to increase the quality of juveniles (Olive, 1999), and in some places, as source of food (Caspers, 1984; Fauchald, 1992). Species with commercial value have been harvested on a large scale to meet the demand. The commercial harvesting of the sandworm *Nereis (Alitta) virens* in Maine, USA, as an example, has occurred since the 1940s; in 2013, 107 metric tonnes were collected, valued approximately USD 1.32 million (Department of Marine Resources, 2013). In addition, several aquaculture farms culturing selected polychaete species, such as Topsy Baits B.V. from the Netherlands (Anonymous, 2014b), were set up to reduce the pressure on the market by providing a consistent supply of baitworms.

1.2 Justification for the Study

Studies on polychaete species in Malaysia are limited, and publications are mostly on general taxonomy and ecology (Nakao *et al.*, 1989; Ong, 1995; Sasekumar and Chong, 1998; Nishi, 2001; Abu-Hena *et al.*, 2006; Zaleha *et al.*, 2009). Specifically, no work has been done in any aspects of the commercial use of polychaetes in Malaysia, although demand and commercial harvesting exist.

This study was initiated to reduce the knowledge void and reignite research interest in polychaetes in Malaysia by focusing on polychaete species in Peninsular Malaysia. It will potentially provide economic value of attracting interest locally from both scientific and non-scientific communities.

1.3 Objectives of the Study

The overarching aim of this study is to have a scientific understanding of the dominant polychaete species used as baitworm in Peninsular Malaysia. Specifically, the principal objectives of this research, each presented in a separate chapter, are as follows:

1. To identify and describe of polychaete species used as baits for fishing in Peninsular Malaysia. This objective also includes the distribution, economical value and determination of dominant species (Chapter 5).
2. To determine habitat preferences and population structures of the identified dominant species at selected area (Chapter 6).
3. To understand the reproductive biology of the identified dominant species at selected area including sex ratio, gametogenesis, oocyte numbers and size (Chapter 7).

4. To assess the feeding habits of the identified dominant species at selected area including its feeding mode and selectivity (Chapter 8).

A supporting chapter (Chapter 4) that describes the physico-chemical parameters at a selected sampling location is included to support the results for objectives 2, 3 and 4.

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