UNIVERSITI PUTRA MALAYSIA

POPULATION BIOLOGY OF DOMINANT FISH SPECIES IN MATANG MANGROVE ESTUARIES, PERAK, MALAYSIA

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By

MOHD AZIM BIN MOHD KHATIB

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

June 2020

DEDICATION

To my parents who always kept praying for me to achieve my goal

To my brother and sister

To all my friends

and

To my wife and my daughter who supported me all the time

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree in Doctor of Philosophy

POPULATION BIOLOGY OF DOMINANT FISH SPECIES IN MATANG MANGROVE ESTUARIES, PERAK, MALAYSIA

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June 2020

Chairperson: S. M. Nurul Amin, PhD
Faculty: Agriculture

Matang Mangrove Estuaries, which are situated in the western shore of Peninsular Malaysia, are the main and important part of mangrove forest in Malaysia. In order to assess the stock status of the fishes in Matang Mangrove Estuaries, it is necessary to understand the key population parameters. The objective of this study is to determine several aspects of population biology of fishes over there such as species composition, spatio-temporal distribution, diversity indices, population dynamic parameters and feeding habits. The study was conducted between September 2015 and August 2016. There were three sampling stations and fish samples were collected by using push net from each station. In total, 39 fishes, 1 crab and 3 shrimp's species were identified from the study areas. Among them, five fish species (*Escualosa thoracata*, *Thryssa hamiltonii*, *Ambassis nalua*, *Stolephorus tri* and *Johnius belangerii*) were the most dominant (> 2%). The abundance of 10 species was found to be correlated (positive or negative) with the water quality parameters. The highest and significant regression coefficient was observed for *Nemipterus nemurus* which indicated that 37% of their abundance was influenced by the major water quality parameters and the remaining 63% by other unknown factors. The species richness index showed a significant variation within the monsoon and inter-monsoon seasons, peaking in the months of December - February and April – June. Shannon-wiener Index also clearly indicated two peaks in a year; with one peak in Febuary and another in June. The growth, mortality, exploitation and recruitment of the five dominant fishes (*E. thoracata, T. hamiltonii*, *A. nalua, S. tri* and *J. belangerii*) were estimated based on length-frequency data, using FiSAT software. In terms of length-weight relationships, *A. nalua*, *S. tri* and *J. belangerii* showed a negative allometric growth while *E. thoracata* and *T. hamiltonii* showed an isometric growth in the Matang Mangrove Estuaries. Recruitment pattern was continuous with two major peaks for *T. hamiltonii, A. nalua, S. tri* and *J. belangerii* while it was one major peak for *E. thoracata.* The exploitation level (E) of *E. thoracata, T. hamiltonii*, *A. nalua*, *S. tri* and *J. belangerii* were 0.41, 0.48, 0.51, 0.54 and 0.52, respectively. This indicates that the stock of *E. thoracata* and *T. hamiltonii* were 18% and 4% under-exploited, respectively. Meanwhile, the fisheries of *A. nalua*, *S. tri* and *J. belangerii* are found to be above the optimum level of exploitation (E > 0.50).

According to the simple resultant index (% Rs), plant (phytoplankton, algae and plant leave) and animal (zooplankton, unidentified fish parts, fish and crustacean parts) based diets contained 42.09% and 44.40% for *E. thoracata*, 50.11% and 38.24% for *T. hamiltonii*, 50.35% and 37.99% for *A. nalua*, 38.17% and 46.55% for *S. tri*, 25.35% and 58.86% for *J. belangerii*. Therefore, all observed five fish species could be considered as omnivorous based on stomach contents. The similarity between diets varied from 60-80% during the wet and dry season. During the dry season, stable carbon and nitrogen isotope values of the samples had less variation, indicating narrow dietary sources compared to the wet season where the distribution of their isotopic values was larger.

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

BIOLOGI POPULASI BAGI IKAN YANG DOMINAN DI MUARA PAYA BAKAU MATANG, PERAK, MALAYSIA

Oleh

MOHD AZIM BIN MOHD KHATIB

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Muara Paya Bakau Matang yang terletak di Pantai Barat Semenanjung Malaysia, adalah bahagian yang utama dan penting bagi hutan paya bakau di Malaysia. Walau bagaimanapun, hampir kesemua kajian perikanan yang telah dilakukan di sini bersifat asas. Untuk mengkaji status stok ikan di Muara Paya Bakau Matang, adalah perlu untuk memahami kunci bagi parameter populasi. Objektif kajian ini adalah untuk menghitung beberapa aspek biologi populasi ikan di kawasan kajian seperti komposisi spesies, taburan musim-tempat, indeks kepelbagaian, parameter dinamik populasi dan tabiat pemakanan. Kajian ini telah diadakan di antara September 2015 dan Ogos 2016. Terdapat tiga stesen persampelan dan bagi setiap stesen, sampel ikan telah dikumpul dengan menggunakan pukat sorong. Secara keseluruhannya, 39 spesies ikan, 1 spesies ketam dan 3 spesies udang telah dikenal pasti daripada kawasan kajian. Di antara mereka, lima spesies ikan (*Escualosa thoracata*, *Thryssa hamiltonii*, *Ambassis nalua*, *Stolephorus tri* dan *Johnius belangerii*) adalah yang paling dominan (> 2%). Taburan bagi 10 spesies didapati sealiran (positif atau negatif) dengan parameter air. Regresi koeffisi yang tertinggi telah dikesan pada *Nemipterus nemurus* di mana menunjukkan 37% daripada taburan ikan ini dipengaruhi oleh parameter air yang utama manakala baki 63% adalah datang dari faktor yang tidak diketahui. Indeks kekayaan species telah menunjukkan kepelbagaian yang ketara di dalam musim tengkujuh dan musim antara tengkujuh, memuncak pada bulan Disember-Febuari dan April-Jun. Indeks Shannon-wiener juga jelas memaparkan dua puncak dalam satu tahun; dengan satu puncak pada Febuari dan satu lagi pada Jun. Pertumbuhan, kematian, eksploitasi dan pembiakan bagi lima ikan dominan (*E. thoracata*, *T. hamiltonii*, *A. nalua*, *S. tri* dan *J. belangerii*) telah dihitung berdasarkan data frekuensi panjang, dengan menggunakan perisian FiSAT. Bagi hubungan panjang-berat, *A. nalua*, *S. tri* dan *J. belangerii* telah menunjukkan pertumbuhan allometrik negatif manakala *E. thoracata* dan *T. hamiltonii* telah menunjukkan pertumbuhan isometrik di Muara Paya Bakau Matang. Pola pembiakan adalah berterusan dengan dua puncak bagi *T. hamiltonii*, *A. nalua*, *S. tri* dan *J. belangerii*, manakala hanya satu puncak utama bagi *E. thoracata*. Tahap eksploitasi (E) bagi *E. thoracata*, *T. hamiltonii*, *A. nalua*, *S. tri* dan *J. belangerii* adalah 0.41,

0.48, 0.51, 0.54 dan 0.52, secara berturutan. Ini menunjukkan bahawa stok bagi *E. thoracata* dan *T. hamiltonii* adalah 18% dan 4% tidak dieksploitasi, secara berturutan. Selain itu, perikanan bagi *A. nalua*, *S. tri* dan *J. belangerii* adalah didapati melebihi tahap optimum eksploitasi (E = 0.50). Mengikut indeks keputusan (% Rs), diet tumbuhan (phytoplankton, alga dan daun tumbuhan) dan diet haiwan (zooplankton, bahagian ikan yang tidak dikenal pasti, ikan dan bahagian krustasia) mengandungi 42.09% dan 44.40% bagi *E. thoracata*, 50.11% dan 38.24% bagi *T. hamiltonii*, 50.35% dan 37.99% bagi *A. nalua*, 38.17% dan 46.55% bagi *S. tri*, 25.35% dan 58.86% bagi *J. belangerii*. Oleh yang demikian, kesemua lima ikan yang dikaji boleh dianggap sebagai omnivor berdasarkan kandungan perut. Persamaan antara diet-diet adalah berjulat dari 60-80% ketika musim hujan dan kering. Ketika musim kering, nilai-nilai isotop karbon dan nitrogen stabil pada sampel mempunyai kepelbagaian yang lebih sedikit, dan ini menunjukkan sumber diet yang terhad berbanding musim hujan di mana taburan nilai-nilai isotopik adalah lebih besar.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree in Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
b	Growth coefficient of length-weight relationship
CI	Confidence interval
C_i	Percentage numerical abundance
CPUE	Catch per unit effort
D	Family richness
DO	Dissolved oxygen
E	Exploitation rate
ELEFAN	Electronic Length Frequency Analysis
FiSAT	FAO ICLARM Stock Assessment Tools
FAO	Food and Agriculture Organization
F_{pi}	Percentage frequency of occurrence
H	Shannon -Wiener of diversity
J	Pielou's evenness index
K	Growth co-efficient of VBGF
$L\infty$	Asymptotic length
L_{max}	Predicted extreme length
M	Natural mortality
ML	Mid length
N	Number of individuals
PRIMER	Plymouth Routines In Multivariate Ecological Research
R^2	Regression coefficient
Rs	Simple resultant index
SE	Standard error
SPSS	Statistical Package for Social Science
TL	total length
Wt	Weight
Z	Total mortality
^0C	Degree Celsius

%	Percentage
<	Less than
>	More than

CHAPTER 1

GENERAL INTRODUCTION

1.1. Background of the study

Matang Mangrove Estuaries which is situated in the northern part of Peninsular Malaysia is dominantly surrounded with mangrove vegetations, making it rich with numerous types of commercially important fish species and thus has a critical role for providing food resources and generating income for local residents (Affendy & Chong, 2006). The mangrove fisheries in Matang are dominated by shrimps' capture, mainly from penaeid family, are the prized catches for local communities over there as they constitute higher marketing prices and demands, although there are numerous species of valuable fish and crab that are also available abundantly in the mangrove waters (Kiso & Mahyam, 2003; Chong 2007). Meanwhile, aquaculture activities, especially the culture of oyster by attaching the spat at submersible poles and the culture of finfish (grouper and catfish) in the cage are becoming trendy and popular day by day for nearby residents of these mangrove areas as they realized that they cannot sustain their living by only continuously and solely relied on fishing activities (Alongi *et al.*, 2003; Chong, 2005).

Species composition of commercial fishes are important in estimating nations' performance in capture fisheries. One of important habitat for estuarine fish and their juvenile are mangrove areas, as hundreds of studies had been conducted since 1950s until now in order to assess and understand the distribution and diversity of them over there (Faunce & Serafy, 2006). The study of species composition in tropical and sub-tropical mangrove estuaries nowadays have reached new level of achievement where they contribute significantly in the socio-economic field (Barbier & Strand, 1998; Meynecke *et al.*, 2007; Nagelkerken & Faunce, 2007). For instance, the estuarine areas that are accessible toward mangrove forests usually had the highest level of fish composition per hectare, with the yield from fish catch become main source of food and income for local communities (Cappo *et al.*, 1998; Grasso, 1998; Barbier, 2000; Lee, 2004; Manson *et al.*, 2005).

Species diversity and distribution of fish is one of the most important aspects in stock assessment of mangrove fishes as it provides thorough and precise information on the composition of fish species and populations (Gunderson, 1993; Helser & Hayes, 1995). Modern methodologies and technologies nowadays have helped researchers by improving the accuracy and reliability of the diversity and distribution data (Andrew & Mapstone, 1987; Morrisey *et al.*, 1992). Some of the parameters and analysis that are essential toward this topic are species composition, catch-per-unit-effort, diversity indices (Shannon-Wiener index, species evenness and richness), Principal Component Analysis (PCA), Canonical Component Analysis (CCA) and Multi-Dimensional Analysis (MDS). Generally, the analysis of species diversity and abundance can be done by using Microsoft Excel, Statistical Package for the Social

Science (SPSS), as well as PRIMER (Plymouth Routines Multivariate Ecological Research) software as described by Clarke & Warwick (1994).

The planning and management of aquatic species resources cannot be acheived until an understanding of various population parameters such as asymptotic length (L_∞) and growth coefficient (K), mortality (natural and fishing) and exploitation level (E) is obtained. There are many tools in estimating various population parameters and status of stocks. Of these, FiSAT (FAO-ICLARM Stock Assessment Tools) is often used to estimate population parameters of fishes and shrimps (Amin *et. al.*, 2008; Jayawardane *et. al.*, 2003; Papaconstantinou & Kapiris, 2001; Tuaycharden *et. al.*, 1988) as it only requires length-frequency data. It is imperative that any fish stock can be assessed via this technique within 1 year if sufficient length-frequency data is available.

Knowledge of feeding habits of a fish is an indispensable tool in the categorizing fish with respect to their diet, mode of feeding and how they feed (Allison & Sikoki, 2013). In addition, information would be very applicable for the protection of the species in particular, and the ecosystem at large (Turan *et al.*, 2005; Alhassan & Ansu-Darko, 2011). Hence, the analysis of stomach content and stable isotopes from selected dominant fish species (spatial and temporal) would reveal the primary sources of autotrophic production for these species, and the trophic linkages within the food web (Sheaves & Molony, 2000; Mazumder *et al.*, 2011).

1.2. Statement of the problems

Matang Mangrove Estuaries which is situated at northern part of Peninsular Malaysia is generally 95% of the forest is inundated during tidal shifts (Gan, 1995). There are approximately 8,653 ha of mudflats adjoining the forest in the foreshore and between islands (Sasekumar *et al.*, 1994). About 85% of the forests are productive forests (logging and timber activities) while the remaining 15% are use for aquaculture purpose where the numerous rivers and waterways have shown to be important nursery areas for commercially-valuable marine organisms like fish and prawns (Sasekumar *et al.*, 1994; Chong, 2006; Chew *et al.*, 2007). The coastal area (< 30 nautical miles from shore) is a major contributor to the total annual marine production in Peninsular Malaysia (Anon, 2009). Thus, This study area is one good example of a specific single location in Malaysia where numerous studies can be carried out in various field of fisheries.

Several fisheries studies of adult fish have been conducted in Matang Mangrove Estuaries as the area is started to face deforestation problems (Khoo, 1990; Sasekumar et al., 1994; Hayase & Muhammad Fadzil, 1999; Chong, 2005). Apart from that, the research of fish larvae had been also carried out in past years (Kiso and Mahyam, 2003; Ooi and Chong, 2011). However, those previous studies were only in fundamental level, meaning that those studies were mainly about species

composition and distribution. Thus, the findings were not sufficient enough in assessing the detail status of fisheries in the study area. Furthermore, the lack of fisheries data in this area will hamper the authority in making constructive decision in sustainably managing the mangrove fisheries and the local residents. If this kind of problem persist, the status of Matang Mangrove Estuaries as the main sanctuary for mangrove fish in Malaysia will be threatened continously.

Hence, the present study was commenced and so far act as the pioneer of scientific study in Matang Mangrove Estuaries that are comprehensively describe about the stock status of adult fish. Realizing the importance of fisheries in Matang Mangrove Estuaries in term of ecologically and economically, the main objective of this study was to establish the update record of species composition, as well as diversity and population biology of dominant adult fish species in Matang Mangrove Estuaries, Malaysia as well as to share the information with respected authorities and researchers for management purposes and extending population studies.

1.3. Objectives of the study

The general objective of the study was to document the assessment of exploited fisheries stock in Matang Mangrove Estuaries, Malaysia, for sustainable management. The following specific objectives were undertaken in order to achieve the overall objective of the study:

(a) to identify the fishes and crustaceans, up to the species level found in Matang Mangrove Estuaries, Malaysia.

(b) to determine the spatio-temporal distribution, catch-per-unit-effort and diversity of fishes and crustaceans in Matang Mangrove Estuaries, Malaysia.

(c) to estimate the population parameters such as asymptotic length (L_∞), growth co-efficient (K), fishing mortality (F), natural mortality (M), total mortality (Z), recruitment pattern and exploitation rate (E) of five dominant fish species in Matang Mangrove Estuaries, Malaysia.

(d) to determine the feeding habits based on the analyses of stomach content and stable isotope of five dominant fish species in Matang Mangrove Estuaries, Malaysia.

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