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DIVERSITY AND ABUNDANCE OF ICHTHYOPLANKTON IN MARUDU BAY,SABAH, MALAYSIA

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DIVERSITY AND ABUNDANCE OF ICHTHYOPLANKTON IN MARUDU BAY, SABAH, MALAYSIA

By

SADAF REZAGHOLINEJAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirement for Degree of Master of Science

August 2015

DEDICATED

TO

My Mother

A strong and gentle soul who taught me to trust in Allah, believe in hard work and that so much could be done with little

My Father

For earning an honest living for us and for supporting and encouraging me to believe in myself

My Best friends 'Nargess and Yashar'

Who have helped me so much during this study period

And finally my guide 'Dr Roushon Ara' who spent too much time teaching me to write my thesis and understanding in many moments of crisis

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DIVERSITY AND ABUNDANCE OF ICHTHYOPLANKTON IN MARUDU BAY, SABAH, MALAYSIA

By

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August, 2015

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Larval fish composition, spatio-temporal distribution, density, family richness, evenness and Shannon-Wiener index were determined by analyzing samples collected from the estuarine area of Marudu Bay, Sabah, Malaysia between October 2012 and September 2013. Five sampling stations were selected for the study. Each sampling station was approximately 1 km apart from each other. Monthly sampling was conducted at high tide during new moon period in daylight. Samples of fish larvae were collected using plankton net (350µm) through 20 min subsurface towing in each station. A flowmeter (Hydro-Bios) was attached to the net in order to determine the volume of the water filtered. In total 20 families of fish larvae belonging to 7 orders were identified from the estuarine ecosystem of Marudu Bay, Sabah, Malaysia.

A total of 3879 larval fishes were obtained from the estuarine area of Marudu Bay, Sabah, Malaysia. In total, 20 fish larvae families were identified with a mean abundance of 118.43 larvae per 100 m^3. Among them, 13 occurred in St-1, 16 in St-2, 17 in St-3, 12 in St-4 and 16 in St-5. Overall four families including Sillaginidae (44%), Engraulidae (14%), Mugilidae (12%) and Sparidae (10%) were the dominant in the study area. Sillaginidae was the most abundant family during the study period which was followed by Engraulidae, Mugilidae and Sparidae. The highest abundance of Sillaginidae was recorded in the month of October. Shannon Wiener index varied significantly different among the months and stations ($p < 0.05$). The highest mean density (294 individuals/100 m^3) of fish larvae was recorded in December at St-4.

Water quality parameters recorded were significantly different ($p < 0.05$) among the five stations except DO and pH ($p > 0.05$). It is found that five families (Engrualidae, Gobiidae, Mugilidae, Sparidae and Sillaginidae) were negatively and significantly correlated with temperature ($p < 0.01$). Sillaginidae ($r = 0.38$) showed significant ($p < 0.01$) positive correlation with salinity while it was negatively and significantly correlated with Centriscidae ($p < 0.01$). It was found that the five families (Engrualidae, Gobiidae, Mugilidae, Sparidae and Scatophagidae) were significantly correlated with salinity ($p < 0.05$). Centriscidae and Mugilidae were significantly correlated with dissolved oxygen ($p < 0.01$). However it was negatively correlated with Clupeidae ($p < 0.05$). Positive and highly significant correlations were found between pH and four families that included Clupeidae ($r = 0.34$, $p < 0.01$), Gobiidae ($r = 0.41$, $p < 0.01$), Mugilidae ($r = 0.67$, $p < 0.01$) and Sillaginidae ($r = 0.49$, $p < 0.01$). It was also shown that pH had a positive and significant correlation ($p < 0.05$) with four families (Platycephalidae, Engrualidae, Sparidae and Syngnathidae). Conductivity showed a negative and significant correlation with only Centriscidae ($p < 0.01$). The highest and most significant regression coefficient ($R^2 = 0.52$, $p < 0.05$) was seen in family Mugilidae where 52% of its abundance were influenced by water quality parameters.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperiuan untuk Ijazah Sarjana Sains

KEPELBAGAIAN DAN TABURAN IKTIOPLANKTON DI TELUK MARUDU, SABAH, MALAYSIA

Oleh

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Ogos, 2015

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Komposisi larva ikan, taburan kawasan dan masa, kepadatan, kepelbagaian dan kesamarataan famili dan indeks Shannon-Wiener telah ditentukan dengan menganalisis sampel yang dikumpul dari kawasan estuari Teluk Marudu, Sabah, Malaysia antara Oktober 2012 dan September 2013. Lima stesen persampelan dipilih bagi kajian ini. Setiap stesen persampelan berkedudukan kira-kira 1km antara satu sama lain. Persampelan bulanan dijalankan ketika arus pasang di siang hari pada masa bulan gelap.Sampel ikan dikutip dengan menggunakan pukat plankton (350µm) dengan menundanya di bawah permukaan air selama 20 minit bagi setiap stesen. Satu pengukur arus (Hydro-Bios) dipasang pada pukat untuk mencatat isipadu air yang ditapis. Sebanyak 20 famili larva ikan dari 7 order dikenal pasti dari ekosistem estuari Teluk Marudu, Sabah, Malaysia.

Sejumlah 3879 ekor larva ikan telah diperolehi dari kawasan estuari Teluk Marudu, Sabah, Malaysia. Sebanyak 20 famili larva ikan dikenal pasti dengan purata taburan 118.43 larva per 100 m^3. Di antara mereka, 13 ada di St-1, 16 di St-2, 17 di St-3, 12 di St-4 dan 16 di St-5. Keseluruhannya empat famili termasuk Sillaginidae (44%), Engraulidae (14%), Mugilidae (12%) dan Sparidae (10%) adalah banyak di kawasan kajian.Sillaginidae merupakan famili yang terbanyak ketika tempoh kajian dan diikuti oleh Engraulidae, Mugilidae dan Sparidae.Taburan tertinggi Sillaginidae direkodkan pada bulan Oktober.Indeks Shannon-Wiener mempunyai perbezaan ketara antara bulan dan stesen ($p < 0.05$).Purata tertinggi kepadatan (294 individu/100 m^3) larva ikan direkodkan pada Disember di St-4.

Parameter kualiti air yang direkodkan mempunyai perbezaan ketara ($p < 0.05$) antara kelima-lima stesen kecuali DO dan pH ($p > 0.05$). Didapati lima famili (Engrualidae, Gobiidae, Mugilidae, Sparidae dan Sillaginidae) adalah berkeadaan negatif dan berkorelasi ketara dengan suhu ($p < 0.01$). Sillaginidae ($r = 0.38$) menunjukkan ($p < 0.01$) korelasi positif yang ketara dengan kemasinan manakala ia menunjukkan keadaan negatif dan berkorelasi ketara dengan Centriscidae($p < 0.01$). Adalah didapati lima famili (Engrualidae, Gobiidae, Mugilidae, Sparidae dan Scatophagidae) adalah berkorelasi ketara dengan kemasinan ($p < 0.05$). Centriscidae dan Mugilidae adalah berkorelasi ketara dengan oksigen terlarut ($p < 0.01$). Walau bagaimanapun ia berkorelasi negatif dengan Clupeidae ($p < 0.05$). Korelasi yang positif dan ketara tingginya telah didapati di antara pH dan empat famili temasuk Clupeidae ($r = 0.34$, $p < 0.01$), Gobiidae ($r = 0.41$, $p < 0.01$), Mugilidae ($r = 0.67$, $p < 0.01$) dan Sillaginidae ($r = 0.49$, $p < 0.01$). Didapati juga pH adalah berkorelasi positif dan ketara ($p < 0.05$) dengan empat famili (Platycephalidae, Engrualidae, Sparidae dan Syngnathidae).Konduktiviti menunjukkan korelasi yang negatif dan ketara dengan Centriscidae sahaja ($p < 0.01$). Koefisien regresi yang tertinggi dan paling ketara ($R^2 = 0.52$, $p < 0.05$) ditunjukkan oleh famili Mugilidae di mana 52% daripada jumlahnya dipengaruhi oleh parameter kualiti air.

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I certify that a Thesis Examination Committee has met on 28 August 2015 to conduct the final examination of Sadaf Rezagholinejad on her thesis entitled “Diversity and Abundance of Ichthyoplankton in Marudu Bay, Sabah, 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 Master of Science in Environmental Chemistry.

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5.9 Temporal variation of top four families in the study areas of Marudu Bay, Sabah, Malaysia 81

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BD	Body depth
BIONESS	Bedford institute of oceanography net and environmental sampling system
BL	Body length
D	Margalef Family Richness Index
DO	Dissolved Oxygen
H	Shannon-Wiener Diversity Index
J	Pielou's Evenness Index
MPS (YSI)	Multi-Probe System
N	Number of individuals
ORI	Ocean Research Institute
PRIMER	Plymouth Routines Multivariate Ecological Research
R^2 (r)	Regression coefficients
S	Sorensen's Index
S	Number of families
SE	Standard Error
SL	Standard Length
SPSS	Statistical Package for Social Science
TL	Total Length
U.S	United State

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The early life history of fish development is an important, independent part of ichthyological investigations. Studies on the species composition, abundance, spatial and temporal distribution of fish larvae provide valuable data on the locations and seasons of spawning, in particular, commercially important species. This knowledge allows an understanding of the life cycle, behaviour and migration of fish as well as providing important scientific information to evaluate the reproductive success of different fish (Chesalina *et al.,* 2013).

According to Arshad *et al.* (2012) a great understanding of fish larvae is often the best technique to provide information of major value to fisheries management, fisheries science and marine biologists. Fish larvae can be a useful sign on the condition and health of an aquatic environment (Deepananda and Arsecularatne, 2013). The organization of larval fish identification is necessary not only to manage fisheries, but to monitor the aquatic ecosystem through inventory of fish or ichthyoplankton taxa in the target waters (Kawaguchi, 2003). The survival of fish larvae are based on biological patterns such as food availability, spawning areas and predation which affects the distribution, abundance and diversity of larval fishes(Moser and Smith, 1993; Olivar*et al*., 2010; Ooi and Chong, 2011). The nearshore coastal fish larvae assemblages are complex both in relation to species composition and distribution patterns (Ara *et al*., 2011).

The spatial-temporal variability in fish abundance has mainly been related to meteorological, environmental (temperature, salinity and turbidity) and oceanographic seasonal features (regional oceanography and upwelling events) (Hernandez-Miranda *et al.,* 2003). A recent approach to investigate the ichthyoplankton spatial patterns has been to identify larval fish assemblages and relate their occurrence and variability to the biology of the component species and to the pelagic ecosystem in which they occur (Moser and Smith, 1993). The spatial and temporal distribution of fish larvae may provide spawning strategies to the physical and biological processes (Ooi and Chong, 2011). The composition of larval fish assemblages varies spatially and temporally because of the behavior of larvae (Gray and Miskiewicz, 2000), and due to oceanographic transport and mixing processes (Auth, 2008). Nonetheless, the spatial and temporal variation in estuarine assemblages, particularly for tropical mangrove systems, is still poorly understood and little is known about the mechanisms by which larval fishes are recruited to and concentrated in estuaries (Ooi and Chong, 2011).

Many fish species found in mangrove estuaries are however, commonly known to be euryhaline, and represent one phase of their life history pattern where the adults occur in marine waters (Blaber and Milton, 1990; Chong, 2005). Some researchers have suggested that most euryhaline fishes enter estuaries as juveniles or postlarvae after spending their larval stage in offshore waters where adults normally spawn (Sarpedonti and Chong, 2008; Bell *et al*., 1984). Estuaries play a role in energy transfer between the river and sea, which is especially important for many commercial fishes whose larvae and juveniles are dependent on the estuary as a nursery and feeding ground (Tzeng and Wang, 1992). Estimates indicate that nearly 90% of all marine organisms spend some portion of their life cycle within mangrove systems (Adeel and Pomeroy, 2002). Since early life stages are a particularly vulnerable phase, it is hypothesized that marine fish larvae and juveniles migrate into estuarine habitats to make use of the high food abundance and refuge against predators, in order to maximize survival (Frank and Leggett, 1983). Estuaries are typically considered to be unstable systems due to their highly variable abiotic conditions, such as temperature and salinity (Faria *et al*., 2006). Three general categories of fish are found in estuaries: marine fishes that use estuaries seasonally (temporary estuarine residents), those that complete their entire life history within the estuarine system (residents), and those that enter the estuary on rare occasions or are occasionally found in low numbers near inlets (Lenanton and Potter, 1987). Many marine fishes, including those that are not resident species, spawn in or near productive coastal bays estuaries (Chute and Turner, 2001).

Estuaries are important as nurseries for the larvae and juveniles of many estuarine and marine fish species (Ooi and Chong, 2011). Most estuary-dependent marine fishes enter these systems during the postflexion stage of their larval phase (Ooi and Chong, 2011; Whitfield, 1999). Some species remain in these nursery estuaries until they are sexually mature (Ooi and Chong, 2011). For the management of estuarine mangroves, baseline information (including species composition, diversity and biomass of the estuarine fish community) have been documented in many mangrove estuaries found in tropical areas (Haedrich and Haedrich, 1974; Austin, 1971; Odum and Heald, 1972; Blaber and Milton, 1990; Beckley, 1984; Bell *et al*., 1984; Robertson and Duke, 1987). These studies indicated that most fish populations in the mangrove estuary are relatively short-lived, euryhaline and represent one phase of an inshore-offshore migration life history pattern.

1.2 Significant of the study

In the past 100 years since the birth of fisheries oceanography, research on the early life history of fishes, particularly the larval stage, has been extensive, and much progress has been made in identifying the mechanisms by which factors such as feeding success, predation, or dispersal can influence larval survival. However, in recent years, the study of fish early life history has undergone a major and, arguably, necessary shift, resulting in a growing body of research aimed at understanding the consequences of climate change and other anthropogenically induced stressors (Saville and Schnack, 1981; Leis, 1991). During the pelagic phase, egg and larval mortality is extremely high and only a tiny proportion of fish survive (Houde, 1987). Consequently, studies on the survival success (survival rate) of commercially important fishes are one of the main subjects of fisheries sciences (Kawaguchi, 2003). Larval recruitment and survival in the mangrove estuaries will thus have a strong bearing on the structure and abundance of the juvenile fish community (Ooi and Chong, 2011).
The largest mangrove area in the world is in Southeast Asia with 6.8 million hectares, with Indonesia having the most followed by Malaysia, Myanmar, Papua New Guinea and Thailand, respectively (Hanum *et al*., 2012). The mangrove forest is one of sixteen forest types found in Malaysia. Malaysia harbours approximately 12% of Southeast Asia's mangrove area and occurs mainly along the coasts of Sabah (57%), Sarawak (26%) and Peninsular Malaysia (17%). Marudu Bay and the northeast coast of Sabah, contain significant global biodiversity (Hanum *et al*., 2012). Mangroves occur both in estuaries and along open coastlines in Marudu Bay covering Kudat, Kota Marudu and Pitas dictricts. For example, Kota Marudu has approximately 9550 ha of mangroves (Hanum *et al.*, 2012). Mangrove forests, seagrass beds and coral reefs are important ecosystems along the coastline of Sabah. These ecosystems provide habitats and feeding grounds for many species, some of which are exploited for food (Biusing, 2001).

Mangroves estuaries are highly productive ecosystems that provide valuable habitats for fish. Mangroves support the conservation of biological diversity by providing habitats, spawning grounds, nurseries and nutrients for a number of animals. A wide range of commercial and non–commercial fish and shellfish also depend on these coastal forests (Hanum *et al.*, 2012). The highly productive nature of estuarine habitats and their role as nursery areas for fish in their early development are well documented for temperature and tropical estuarine habitats (Ara *et al*., 2011).

1.3 Statement of the problem

There is no previous work base on the status of fish larvae in the investigated area. The present study reports a better understanding on the distribution, abundance and diversity of ichthyoplankton in the waters of Marudu bay, Sabah. Information on the distribution and abundance of ichthyoplankton within an ecosystem will help a great deal in capture fisheries management and also on the location of fish and their breeding grounds in the estuary area (Kidwai and Amjad, 2001). Mangroves, seagrass beds, coral reefs, and estuaries are important habitats that function as nursery areas for many fish larval species. Estuaries play a main role in the life cycles of many marine fish species by providing nursery habitats for their juveniles (Beck *et al.*, 2001). Many fish larvae and juveniles migrate into estuaries because these ecosystem habitats support a high abundance of food and low predation pressure (Huijibers *et al.*, 2008).

The fisheries of Marudu Bay is very diversified, comprising crustaceans, molluscs and both pelagic and demersal fishes, due to their suitable coastal habitat that include coral reefs, mangroves, creeks and seagrass beds (Hanum *et al.*, 2012).). Marudu bay is an important breeding area for commercial fisheries for both fin fish and prawns in mangroves (Hanum *et al.*, 2012). In Murudu Bay, fishery activities have been gradually decreasing because of heavy fishing pressure and the effect of the environmental changes in Marudu estuaries (Arshad *et al*., 2012). The local people in Marudu bay are usually involved in fishing activities and there are about 1000 fisher man and their family members are directly engaged in this sector (Arshad *et al*., 2012). The total fisheries production during 2003 to 2009 from Marudu estuary and the adjacent coastal areas were estimated to be about 83,000 to 95,000 kg/year (Arshad *et al*., 2012).

1.4 Objective of the study

The aim of the general objectives was to identify the species of fish larvae and to compare this study with studies of other researchers in order to understand the diversity and abundance of fish larvae in Marudu Bay, Malaysia. Therefore, this study also covers specific objectives as follows:
1) To identify the fish larvae up to family level found in the Marudu Bay, Sabah.
2) To determine the fish larval composition, abundance, spatial-temporal distribution and diversity (Shannon-Wiener Index, richness and evenness).
3) To examine the effect of abiotic factors such as temperature, salinity, dissolved oxygen, pH and conductivity on fish larval distribution and abundance.

1.5 Organization of the thesis

This thesis is organized as follows. Chapter 1 gives a description of the diversity and abundance of fish larvae and their nursery ground, significance of the study, problem statement, importance of fisheries in Marudu Bay and general and specific objectives. Chapter 2 provides a literature review on the same topic. The general method and materials is presented in chapter 3. The experimental results of the study are reported in chapter 4, 5 and 6 and cover all statistical analysis. This thesis also contains chapter 7 that contains the general discussion, conclusions and recommendation.

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