UNIVERSITI PUTRA MALAYSIA

BIOLOGY AND CHEMICAL COMPOSITIONS OF Plotosus canius HAMILTON, 1822 IN THE COASTAL WATERS OF PORT DICKSON, MALAYSIA

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By

BINTA ISYAKU USMAN

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

November 2014

DEDICATIONS

This thesis is dedicated to my Husband, Dr. Sabo Wada Dutse and my children; Umar, Aisha, Maryam and Usman

"Allah is indeed The Most Generous for it is He Who teaches by the pen and teaches man that which he knew not"

(QUR'AN96:3-5)

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

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Chairperson: S. M. Nurul Amin, PhD
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Plotosus canius, the Gray-eel catfish and locally known as "Sembilang or Semilan" in Malaysia, is a popular and well-known marine catfish with high commercial value and usually sold fresh in the markets. Literature on the fish is very scant, and the fish has now been reported to be declining in the wild. The present study was undertaken to investigate the population stock status, fatty acid and amino acid composition, feeding habits, reproductive cycle, sex ratio and fecundity of *P. canius* in the coastal waters of Kg. Telok, Port Dickson, Peninsular Malaysia between January and December 2012. The samples were collected from the local fishermen of the area during the "full moon" and were immediately stored in ice chest and transported to the laboratory for the various analyses. The data were analyzed using SPSS version 20, Minitab version 16 and FiSAT II software.

The length frequency distribution of *P. canius* implied that the total length ranged from 22.80 to 62.90 cm (mean ± SD, 38.34 ± 8.19 cm) for males and from 24.60 to 60.00 cm (39.06 ± 7.72 cm) for females. There was no significant difference observed between males and females in the size frequency distribution of *P. canius* (t-test, $p > 0.05$; Kolmogorov-Smirnov test: $d_{max} = 1.409$, $p > 0.01$). The negative allometric nature of growth was observed in both males ($b = 2.707$) and females ($b = 2.879$). Analysis of the relationships between TL and various morphometric characteristics of the fish showed that there was strong and significant ($R^2 > 0.805$, $p < 0.001$) relationship. The length frequency data of *P. canius* analyzed revealed that asymptotic length (L_∞) and growth coefficient (K) were estimated at 67.20 cm and 0.95 yr^{-1} respectively. The growth performance index (φ') was calculated as 3.63. Total mortality (Z), natural mortality (M) and fishing mortality (F) were estimated at 2.73 yr^{-1}, 1.43 yr^{-1} and 1.31 yr^{-1} respectively. The exploitation level (E) of *P. canius* was calculated as 0.48.

Examination of the stomach fullness revealed that 61.54% of the stomachs contained food at various degrees of fullness, while the remaining (34.46%) were empty. According to index of preponderance (Ip), the stomach contents of *P. canius* were composed of six major groups viz; fish and fish parts (38.00%), crustaceans (26.69%), molluscs (25.58%), sand and mud (6.68%), debris and detritus (2.99%) and unidentified items (0.06%). In the fish and fish parts group, fish eggs (37.49%)

was the dominant food item and this was followed by scales and other partly digested fish parts (0.36%) and small fish (0.15 %) respectively. Among the crustaceans group, *Portunus* spp was the dominant (1.59%), followed by *Neopisserma* spp (0.50%), *Charabdis* spp (0.42%), *Acetes* spp (0.39%) and *Sesarma* spp (0.07%). *Pholas* spp (1.87%) and *Anadara* spp (1.64%) were the dominant molluscs genera observed in the stomach of *P. canius*.

Examination of the proximate composition of the eggs, juvenile and adult of *P. canius* revealed that protein ranged between 16.39 and 25.04% (mean = 19.68 ± 4.68%) and fat was in the range of 3.65 and 5.10% (4.68 ± 0.93%). Nine essential amino acids namely; histidine, threonine, valine, methionine, isoleucine, leucine, phenylalanine arginine and lysine were observed in both the eggs, juvenile and adult of *P. canius*. Saturated fatty acids were the highest (61.62 – 77.25%, 66.95 ± 8.92%) followed by monounsaturated fatty acids (17.57 – 33.82%, 27.92 ± 8.99%), while polyunsaturated fatty acids were the least (4.56 – 5.64%, 5.13 ± 0.53%) in all the eggs, juvenile and adult.

The overall sex ratio (males: females) of *P. canius* was observed to be 1:0.98 and did not differ significantly from the hypothetical ratio 1:1. Analysis of the annual variation of gonadosomatic index (GSI) showed that the major spawning activity in *P. canius* lasts between May and June in both sexes. 50% of males and females of *P. canius* were found to mature at sizes between 44 - 48 cm and 40 - 44 cm of total lengths respectively. Fecundity of the fish ranged from 642.26 to 1140.34 (943.05 ± 38.40) eggs per fish. The average fecundity per 1 kg of body weight was found to be 1225.89 eggs, and was established to show positive and significant relationship with body length ($R^2 = 0.8662$, $p < 0.05$), body weight ($R^2 = 0.8556$, $p < 0.05$) and ovary weight ($R^2 = 0.9527$, $p < 0.05$). The mean monthly GSI of females *P. canius* indicated positive and significant correlation with salinity ($r = 0.613$; $p < 0.05$). No significant correlation was observed between the mean monthly GSI and the remaining four variables (temperature, pH, dissolved oxygen and total suspended solids).

Overall it could be concluded that *P. canius* is carnivorous bottom feeder. , The ratio of essential to non-essential amino acids was found to be healthy. The major spawning period was between May and June and the status of exploitation (E = 0.48) was slightly below the optimum level in the coastal waters of Port Dickson, Malaysia.

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

BIOLOGI DAN KOMPOSISI KIMIA *Plotosus canius* HAMILTON, 1822 DI PERAIRAN PANTAI PORT DICKSON, MALAYSIA

Oleh

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Plotosus canius, dikenali dengan nama tempatan "Sembilang or Semilan" di Malaysia, adalah ikan keli laut yang disukai dan terkenal dengan nilai pasaran yang tinggi serta bisanya dijual segar di pasar. Rujukan berkenaan dengan ikan ini adalah agak kurang, dan ikan ini dilaporkan semakin berkurangan di habitat semulajadi mereka. Kajian ini telah dijalankan bagi menyelidik status stok populasi, komposisi asid lemak dan asid amino, tabiat pemakanan, kitaran pembiakan, nisbah jantina dan fekunditi *P. canius* di perairan pantai Kg. Telok, Port Dickson, Semenanjung Malaysia antara Januari dan Diember 2012. Sampel diperoleh dari nelayan tempatan ketika "bulan penuh" and segera disimpan di dalam kotak air batu dan dipindahkan ke makmal bagi pelbagai analisis. Data tersebut dianalisis dengan menggunakan SPSS versi 20, Minitab versi 16 dan perisian FiSAT II.

Taburan kekerapan panjang *P. canius* menunjukkan bahawa jumlah panjang adalah dari 22.80 hingga 62.90 cm (min ± SD, 38.34 ± 8.19 cm) untuk jantan dan dari 24.60 hingga 60.00 cm (39.06 ± 7.72 cm) untuk betina. Tidak ada perbezaan ketara didapati antara jantan dan betina dalam taburan kekerapan *P. canius* (ujian-t-, $p > 0.05$; uiian Kolmogorov-Smirnov: $d_{max} = 1.409$, $p > 0.01$). Keadaan alometrik negatif pada tumbesaran didapati pada kedua-dua jantan ($b = 2.707$) dan betina ($b = 2.879$). Analisis hubungan antara TL dan pelbagai ciri morfometrik ikan ini menunjukkan hubungan yang kuat dan ketara ($R^2 > 0.805$, $p < 0.001$). Data kekerapan panjang *P. canius* yang telah dianalisis mendedahkan bahawa panjang asimtotik (L_∞) dan koefisien pertumbuhan (K) dianggarkan sebanyak 67.20 cm dan 0.95 yr^{-1}. Indeks prestasi pertumbuhan (φ') dianggarkan sebanyak 3.63. Jumlah kematian (Z), kematian semulajadi (M) dan kematian tangkapan (F) telah dianggarkan kira-kira 2.73 yr^{-1}, 1.43 yr^{-1} dan 1.31 yr^{-1}. Tahap eksploitasi *P. canius* dikira sebanyak 0.48.

Pemeriksaan kepenuhan isi perut mendedahkan bahawa 61.54% dari kandungan perut terdiri daripada pelbagai tahap kepenuhan, manakala baki (34.46%) adalah kosong. Mengikut indeks praponderan (Ip), kandungan perut *P. canius* adalah terdiri daripada enam kumpulan utama; ikan dan bahagian badan ikan (38.00%), krustasia (26.69%), moluska (25.58%), pasir dan lumpur (6.68%), debris dan detritus (2.99%) dan benda tidak dikenali (0.06%). Dalam kumpulan ikan dan bahagian badan faktor ikan, telur ikan (37.49%) adalah dominan dan ini diikuti dengan sisik dan bahagian ikan yang separa hadam (0.36%) dan ikan kecil (0.15 %). Di antara kumpulan krustasia, *Portunus* spp merupakan dominan (1.59%), diikuti oleh *Neopisserma* spp

(0.50%), *Charabdis* spp (0.42%), *Acetes* spp (0.39%) dan *Sesarma* spp (0.07%). *Pholas* spp (1.87%) dan *Anadara* spp (1.64%) pula merupakan genera moluska dominan yang dikesan di dalam perut *P. canius*.

Pemeriksaan komposisi proksimat telur, juvenil dan induk *P. canius* menunjukkan protein berjulat di antara 16.39 dan 25.04% (min = 19.68 ± 4.68%) dan lemak berjulat di antara 3.65 dan 5.10% (4.68 ± 0.93%). Sembilan asid amino; histidin, threonin, valin, methionin, isoleusin, leusin, phenylalanin, arginin dan lysin telah dikesan pada kedua-dua telur, juvenil dan induk *P. canius*. Asid lemak tepu merupakan yang tertinggi (61.62 – 77.25%, 66.95 ± 8.92%) diikuti asid lemak mono tak tepu (17.57 – 33.82%, 27.92 ± 8.99%), manakala asid lemak poli tak tepu merupakan yang paling sedikit (4.56 – 5.64%, 5.13 ± 0.53%) pada telur, juvenil dan induk.

Nisbah keseluruhan jantina (jantan: betina) *P. canius* diperhatikan sebanyak 1:0.98 and dan tidak ketara perbezaannya dari nisbah hipotetikal 1:1. Analisis tahunan kepelbagaian indeks gonadosomatik (GSI) menunjukkan bahawa aktiviti pembiakan utama bagi *P. canius* berlangsung dari Mei dan Jun bagi kedua-dua jantina. 50% jantan dan betina *P. canius* didapati matang pada saiz antara jumlah panjang 44 - 48 cm dan 40 - 44 cm. Fekunditi ikan ini adalah sekitar 642.26 hingga 1140.34 (943.05 ± 38.40) telur per ikan. Purata fekunditi per 1 kg berat badan adalah didapati sebanyak 1225.89 telur, dan menunjukkan hubungan positif dan ketara dengan panjang badan ($R^2 = 0.8662$, $p < 0.05$), berat badan ($R^2 = 0.8556$, $p < 0.05$) dan berat ovari ($R^2 = 0.9527$, $p < 0.05$). Min bulanan GSI bagi betina *P. canius* menunjukkan korelasi positif dan ketara dengan kemasinan ($r = 0.613$; $p < 0.05$). Tiada korelasi ketara didapati di antara min bulanan GSI dan empat baki parameter (suhu, pH, oksigen terlarut dan jumlah pepejal termendap).

Keseluruhannya dapat disimpulkan bahawa *P. canius* dalah pemakan dasar karnivor. Nisbah antara asid amino penting dengan tidak penting didapati berada dalam keadaan baik. Tempoh pembiakan utama adalah antara Mei dengan Jun status eksploitasi ($E = 0.48$) adalah berada bawah sedikit dari tahap optimum di kawasan perairan pantai Port Dickson, Malaysia.

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In the name of Allah, the most beneficent, the most eternally merciful. Thank you Dear Lord for enabling me to submit this thesis.

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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 of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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a	Intercept/ constant
AA	Amino acid
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
b	Coefficient of length-weight relationship/ slope
B	Both sexes
BDA	Body depth at anus
B/R	Relative biomass-per-recruit
CA	Cluster analysis
CC	Chemical composition
CI	Confident of interval
cm	Centimeter
Cn	Composition by number
CRD	Completely randomized design
Cw	Composition by weight
DFA	Discriminant function analysis
DO	Dissolved oxygen
E	Exploitation rate
E_{max}	Maximum allowable limit of exploitation
E-50	Exploitation level at which 50% of the relative biomass-per-recruit
EAA	Essential amino acid
ED	Eye diameter
EL	Eye length
ELEFAN	Electronic Length Frequency Analysis
ES	Egg size
F	Fishing mortality
FAA	Flavour amino acids
FAMEs	Fatty acid methyl esters
FAO	Food and agriculture organization
FiSAT	FAO ICLARM Stock Assessment Tools
FO	Frequency of occurrence
GC	Gas chromatography
GSI	Gonadosomatic index
GW	Total weight of ovary
HL	Head length
HPLC	High pressure liquid chromatography
HW	Head width
IOL	Inter orbital length
Ip	Index of preponderance
IUCN	International Union for Conservation Of Nature
K	Growth coefficient of VBGF
Kg.	'Kampung'
L_C	Length at first capture
L_∞	Asymptotic length
L_{max}	Predicted extreme length
LLR	Length-length relationship
LWR	Length-weight relationship

M	Natural mortality
mm	Millimeter
MUFA	Monounsaturated fatty acid
MG	Mouth gape
MSY	Maximum Sustainable Yield
N	Sample size
n-3	Omega-3
n-6	Omega-6
NEAA	Non-essential amino acid
PAD	Pre anal distance
PCA	Principal component analysis
PDD	Pre dorsal distance
POL	Post orbital length
PPD	Pre pectoral distance
PUFA	Polyunsaturated fatty acid
PVD	Pre ventral distance
R^2	Coefficient of determination
Rn	Response surface
SD	Standard deviation
SE	Standard error
SFA	Saturated fatty acid
SL	Standard length
SNL	Snout length
Sp.	Species
SPSS	Statistical package for social science
TL	Total length
TSS	Total suspended solids
TW	Total weight
T_{max}	Maximum life span
UPM	Universiti Putra Malaysia
USFA	Unsaturated fatty acid
Y	Estimated annual catch
Y/F	Average standing stock
Y/R	Relative yield per recruit
Y/U	Total annual catch
Z	Total mortality
φ’	Growth performance index
%	Percentage
<	Less than
>	More than
^0C	Degree Celsius

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of the study

Plotosus canius Hamilton, 1822 (Gray-eel catfish or catfish eel), is a member of the family plotosidae locally called 'Sembilang or Semilan' in Malaysia. The fish is native to South-east Asia and Australia (Mohsin and Ambak, 1996; Ferraris, 2007) and is easily recognized by its long, eel-like and sub-cylindrical body that is tapered and flattened near the tail region. It possesses four long pairs of barbels; with the nasal barbel extending well behind the eye and almost reaching the nape and has no stripes on its body (Mohsin and Ambak, 1996; Gupta and Gupta, 2006). The fish primarily found in marine habitat but sometimes can be caught in brackish or fresh water habitats (Riede, 2004). According to Kottelat (2001), *P. canius* occur in coastal seas and fresh or brackish waters. Juveniles are commonly found to form compact aggregates, thus resulting in very tight shoals with about 50 juvenile fish (Mohsin and Ambak, 1996; Ambak *et al.*, 2010). It has been found to live on or near the bottom of the sea and migrate between sea and fresh water (Riede, 2004).

There has been high rate of consumption of marine fishes among the rural and urban adults in Malaysia. The daily prevalence consumption rate of marine fish among rural adults has been estimated to be at 51% and 34% for urban adults (Norimah Jr *et al.*, 2008). This is an indication that consumption of marine fish in Malaysia is very high. *P. canius* is important both commercially, being sold fresh at the market (Gomon, 1984; Mohsin and Ambak, 1996; Ambak *et al.*, 2010) and as a source of food (Nurnadia *et al*., 2011). In Malaysia, it has been reported to be mostly harvested by small scale fishermen and being usually sold fresh in villages and coastal towns, hence the real harvest data may not be revealed in the official statistics as such the official catch statistics could be regarded as gross underestimation (Leh *et al*., 2012). This fish was mentioned to be among the ten most commonly marine fishes preferred to be eaten by Malaysians (Osman *et al*., 2001). Also, Nurnadia *et al.* (2011) revealed *P. canius* to be among the five fish that are commonly consumed from Malacca Straits of Malaysia. The fish is highly priced and good for eating (Gupta and Gupta, 2006; Ambak *et al.*, 2010).

The fishery sector has been recognized as a as a source of income and livelihood for lots of people around the globe (Chowdhury *et al*., 2011). It has provided full time employment to about 1.2 million people globally, out of which the marine fishery sub-sector provided employment to about 0.5 million people (DOF, 2010). There is increased dependence on marine and coastal resources by humans (Berkes *et al*., 2001), this has thus results to the dwindling of the captured marine fisheries resources (DOF Bangladesh, 2010). There is also need of increasing concern on basic aspects of biology in marine fish (Mace, 1994; Murawski *et al*., 2001). Knowledge of reproduction, feeding and other basic aspects of biology of any fish according to McAllister *et al*. (2000) are very useful parameters in the management of any fish stock .

1.2 Statement of the problem

The population of the earth is increasing at all times, as such food demand is increasing. To sustain this demand, the exploitation of wild stocks of marine organisms has intensified substantially. The fish production has attained a level that no further increase from the coastal waters is feasible. Also, natural stocks have been exploited to their utmost limits and this resulted to over fishing (Godfray *et al*., 2010; Burgess *et al*., 2013; Islam *et al*., 2013, Molfese and Hall-Spencer, 2014). Marine fisheries are very vital worldwide source of food and livelihoods. However, in recent times issues related to habitat destruction and fish stock depletion have threatened many fishery resources and the fishery industry at large. This is particularly true in the case of the *P. canius* and the related fishery stocks. In such circumstances, the conservation and fishery management turn out to be the need of the time.

It has been reported that *P. canius* stocks throughout their range have declined due to overfishing, illegal fishing, indiscriminate fishing of brood stocks and juveniles, fast degradation of marine habitat, land development, agricultural activities and introduction of the alien species (Khan *et al*., 2002; Ahmed and Haque, 2007). Although, the status of this fish has not been assessed in the IUCN red list (IUCN, 2013), it has been declared endangered in Bangladesh and India (Mukhopadhyay, 1994; IUCN Bangladesh, 2000; Mijkherjee *et al*., 2002).

Availability of information on the biology of any fish species plays a vital role in its conservation and management. However, very little information in terms of literature on this fish is available both from the national and international perspective. Most studies on basic biology of this fish have only been carried out in a small number of areas from other countries of its distribution (Sinha, 1981, 1984, 1986a, 1986b; Khan *et al*., 2002; Ahmed and Haque, 2007). Presently, only the work of Leh *et al.* (2012) on the feeding habit of *P. canius* was found from Malaysia. Effective management and conservation of *P. canius* stocks require knowledge on aspects of its biology. This is clear indication for more research on this fish, so as to understand some aspect of its basic biology which could be very useful in the management and conservation of this fish.

1.3 Significance of the study

Availability of information on the biology of any fish species plays a vital role in its conservation and management. Effective management and conservation of *P. canius* stocks require knowledge of aspects of its biology. Understanding the length-weight and length-length relationships, condition factor, age and growth and population dynamics of *P. canius* are essential in describing its general life history and are more important from a management view point. Data on age and growth of this fish will be useful for understanding the age composition of the fish and the position of different class-years in its fisheries. It will also be vital in determining the mortality and survival rate of the different year-classes.

Information on diet and feeding of *P. canius* is vital for understanding of its ecological role and life history such as growth, breeding and migration. It is also important fisheries management and conservation. Without such knowledge, it may not be possible to apprehend the predicted changes that could rise from any natural

or anthropogenic intervention. Information on food habits of the fish could also be useful in the aquaculture of the fish in order to obtain the best growth at least time. Furthermore, understanding the chemical composition of the fish will reveal its quality and nutritional status. It will also be useful in in the formulation of the fish diets in aquaculture.

Investigation of reproductive biology is vital and required for the conservation and propagation of the fish. Several aspects of the reproductive procedure are usually employed either to catch the fish or to protect them if they are excessively vulnerable. Therefore, investigating aspects of reproductive biology of *P. canius* is indispensable and necessary prior to the measures adopted for its conservation and propagation. Understanding of its spawning period is one of the most essential requisites in its management and rational exploitation. Moreover, knowing the fecundity of *P. canius* can be used to evaluate its reproductive potential and will be very vital for successful commercialization. The information will also help greatly in offering advice for possible management possibilities to the fishery industry, fisheries managers, fishermen as well as the planners and policy makers.

In view of the commercial importance of *P. canius* to the Malaysians, study on age, growth, population dynamics, food habits, chemical compositions and reproductive biology of the fish from coastal waters of Kg. Telok, Port Dickson, Peninsular Malaysia is very essential in order to offer the much needed information for exploitation of its full potential for both capture and culture fisheries. Lack of attempt to manage the *P. canius* fishery resources in Malaysia can lead to its extinction, and this can affect the livelihood of the fishermen and the Malaysian coastal population at large.

1.4 Objectives of the study

1. To examine the population parameters and determine the stock status of *P. canius* from the coastal waters of Kg. Telok Port Dickson, Peninsular Malaysia.
2. To investigate the stomach contents and determine the food habits of *P. canius*.
3. To determine the proximate and chemical compositions of *P. canius*.
4. To determine sex ratio, sexual maturity, spawning season and fecundity of *P. canius.*

1.5 Outline of the thesis

The thesis is structured in the form of eight chapters.

i. Chapter 1: This chapter discussed the general introduction and background of the subject, the statement of the problem, significance of the study and finally ended with the thesis outline.

ii. Chapter 2: The chapter critically reviewed related and relevant literature on the basic aspects of biology, as well as chemical compositions of *P. canius*.

iii. Chapter 3: The general thesis methodology was presented in this chapter. The chapter explained the various methods used in this research and the statistical techniques used in the data analyses.

iv. Chapter 4: This chapter was based on the first objective of the research. It investigated the population parameters and stock status of *P. canius* from the coastal waters of Kg. Telok, Port Dickson, Peninsular Malaysia.

v. Chapter 5: Objective two of this research work was the basis of this chapter. It reported aspects of food habits of *P. canius.* An investigation of the stomach contents and seasonal variation in the diet of the fish was made and reported in this chapter.

vi. Chapter 6: This chapter answered the third objective of the study by explaining the chemical compositions of the fish. It reported the proximate, amino and fatty acid compositions of the egg, juvenile as well as the adult of *P. canius*.

vii. Chapter 7: This chapter was based on the fourth objective of the research. It examined aspects of reproductive biology, such as sex ratio, size at sexual maturity and spawning of the fish.

viii. Chapter 8: This chapter draws the conclusions of various chapters of the work and gives overall conclusions on this work. It also contained prospective suggestions and recommendations for future studies.

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