

**TEMPORAL VARIATIONS IN REPRODUCTION, GROWTH, CONDITION  
INDEX AND SOME POPULATION PARAMETERS OF *PERNA VIRIDIS*  
(LINNAEUS 1758)**

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**DOCTOR OF PHILOSOPHY  
UNIVERSITI PUTRA MALAYSIA**

**2007**

## **DEDICATION**

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

*To my wife and my children who have sacrificed so much for me  
to be whom I am today*

*To my brothers and sisters*

*and*

*To all my friends who supported me all those past years*

Abstract of thesis was presented to the Senate of University Putra Malaysia  
in fulfilment of the requirement for the degree of Doctor of Philosophy

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INDEX AND SOME POPULATION PARAMETERS OF *PERNA VIRIDIS*  
(LINNAEUS 1758)**

By

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**February 2007**

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The aim of this study was to investigate the temporal reproductive cycle, growth rate, sex ratio, spat fall densities, condition index and population parameters of *Perna viridis* in Sebatu, Malacca.

Condition Index (which relates tissue dry weight to shell volume), of the green mussel *P. viridis* was concurrently studied with the histological observations of the gonads. Monthly samples of *P. viridis* were collected from the same culture site. Variations in average monthly Condition Index ranged from 21.06 to 26.72 g/cm<sup>3</sup>. Rapid declining of the Condition Indices of the mussels was recorded in December, 2003 and January, 2004. This rapid declining indicates the spawning period which agrees with the results from the histological study.

Studies on the gametogenesis, size at sexual differentiation, and size at first maturity of *P. viridis* from Sebatu, Malacca were performed using histological sections. More than three hundred specimens of *P. viridis* between 14.96 and 113.52 mm in total shell length were examined. No gonadal development was observed in individuals smaller than 17 mm. Sexual differentiations began at 18 mm with incipient acini formation. Specimens larger than 20.0 mm had well-developed gonads at different stages of maturation. Size at first maturity was smaller than previously reported at other localities. Active gametogenesis was recorded throughout the study period, with all stages of development usually occurring simultaneously within the same sample population.

In the determination of gonadal index (GI), over 300 individuals were histologically prepared and analyzed. A clear fall in gonadal index was observed in the months of January and February, at this time most of the female were clearly spent. Their acini were almost empty of mature ova. Except of some residual ova, most of the surface area of the lumen of the acini were occupied with masses of cellular debris. A second fall in GI with less intense was observed again during the months of September and October. Gonadal index results show that spawning event in *P. viridis* is year around except during the months of May until August. The release of gamete between sexes was fairly synchronized, no differences in GI were observed between the male and female. 1000 specimen of *P. viridis* were used for sex ratio. The number of visually identified male, female and undetermined by looking at the mantle was 524, 412 and 64, respectively. The male: female

ratio was 0.79:1 by visual identification. 316 individuals were histologically identified for sex ratio. The number of identified male, female and undetermined individual was 161, 151 and 4. The histological male: female ratio was 0.94:1. Two hermaphrodites specimen were recorded during the months of June and September, 2004. Both specimens had the occurrence of the male and female gametes on only one side of the mantle. No trace of hermaphroditism was observed neither in the second side of the mantle nor the mesosoma.

Spat fall study of *P. viridis* was carried out from February, 2004 until December 2004 on collector ropes suspended from the same culture site. Spat fall of the mussels was active during the entire study period with two peaks, one main peak during the months of March to June and a second peak during the months of August to December. Average, maximum and minimum settlement densities were 11,389, 29,788 and 1649 spat per meter respectively. Maximum settlement densities were counted during the month of April, while the minimum settlement densities were counted during the month of August.

Population parameters like asymptotic length ( $L_{\infty}$ ), growth co-efficient (K), mortalities, exploitation level (E) and recruitment pattern of green mussel *P. viridis* from the same site have been studied. The study was carried out using the length frequency based analysis of FiSAT software to evaluate the growth parameters, mortality rates and exploitation level. Asymptotic length ( $L_{\infty}$ ) was 102.38 mm and growth co-efficient (K) was estimated at 1.50 yr<sup>-1</sup>.

Total mortality was 1.44 yr<sup>-1</sup> for *P. viridis*. Natural mortality (M) and fishing mortality (F) were 1.67 yr<sup>-1</sup> and 0.81 yr<sup>-1</sup>, respectively. Exploitation level (E) of *P. viridis* was 0.32 while the maximum allowable limit of exploitation ( $E_{max}$ ) value was 0.43. The exploitation level (< 0.50) is below the optimum level which indicates the under fishing condition of *P. viridis* in the coast of Sebatu/ Malacca, Malaysia.

Average values recorded for temperature, dissolved oxygen, pH, and salinity were 29.44 °C, 6.06 mg/l, 7.92, 30.12 ppt respectively. Highest values recorded for temperature, dissolved oxygen, pH, and salinity were 32.17 °C, 7.61 mg/l, 8.44, 33.26 ppt respectively. Lowest values recorded for temperature, dissolved oxygen, pH, and salinity were 27.82 °C, 4.94 mg/l, 7.32, 27.93 ppt, respectively. Chlorophyll-a, and total suspended solids (TSS) ranged from 1.50 to 9.40 mg/l, and 0.0253 to 0.0733 g/l, respectively.

Incidences of pea crab *Arcotheres latissimus* (Burger, 1895) infestation in *P. viridis* at Sebatu was monitored from December 2003 until December 2004. Maximum infestation frequency was observed during the month of June. Size ranged of infested *P. viridis* from 19.26 to 92.18 mm. Wet weight of infested *P. viridis* ranged from 0.17 to 10.41 g. Wet weight of pea crabs ranged from 0.009 to 0.55 g.

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

**TEMPORAL BERMUSIM DALAM PEMBIAKAN, TUMBESARAN, INDEK  
KONDISI DAN BEBERAPA PARAMETER POPULASI BAGI *PERNA  
VIRIDIS* (LINNAEUS 1758)**

Oleh

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**Februari 2007**

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Tujuan penyelidikan ini dilaksanakan adalah untuk mengkaji tempoh kitaran reproduktif, kadar tumbesaran, nisbah jantina, densiti pemaotan spat, indek kondisi dan parameter populasi *Perna viridis* di Sebatu, Melaka.

Indeks kondisi (yang mengairkan berat tisu kering dengan ketumpatan cangkerang) kupang *P. viridis* telah dikaji bersama dengan kajian histologi gonad. Untuk kajian ini sampel bulanan telah dikumpulkan dari tapak kultur *P. viridis* yang sama. Perbezaan purata indeks kondisi bulanan adalah di antara 21.06 hingga 26.72 g/cm<sup>3</sup>. Penurunan ketara indek kondisi ke atas kupang dicatatkan pada Disember 2003 dan Januari 2004. Tempoh penurunan ketara indek kondisi ini menunjukkan musim peneluran di mana keputusan ini selaras dengan hasil kajian histologi.

Kajian gametogenesis, saiz pada pembezaan seks dan saiz kematangan pertama *P. viridis* dari Sebatu, Melaka telah dijalankan dengan hirisan

histology. Sebanyak tiga ratus spesimen *P. viridis* yang berukuran panjang cangkang di antara 14.96 dan 113.52 mm telah dikaji. Tiada perkembangan gonad dapat diperhatikan pada individu yang bersaiz kurang daripada 17 mm. Perbezaan seks bermula ketika spesimen bersaiz 18mm yakni bersamaan dengan pembentukan akini permulaan. Spesimen yang bersaiz lebih daripada 20.0 mm mempunyai gonad yang jelas pada pelbagai peringkat kematangan. Saiz pada kematangan pertama adalah lebih rendah berbanding dengan kajian yang telah dilaporkan di tempat-tempat lain. Gametogenesis yang aktif direkodkan disepanjang tempoh kajian, dengan semua peringkat perkembangan berlaku serentak dalam sample populasi yang sama.

Dalam penentuan indeks gonad (GI), lebih daripada 300 individu digunakan dalam penyediaan dan penganalisaan histologi. Penurunan indeks gonad yang ketara diperhatikan berlaku pada bulan Januari dan Februari, di masa ini kebanyakan betina adalah 'spent'. Akinos hampir kosong daripada ovum yang matang. Kecuali sedikit lebihan ovum, kebanyakan permukaan kawasan lumen akinos dipenuhi dengan jisim sel debris. Penurunan GI kali kedua yang kurang ketara berlaku pada bulan September dan Oktober. Hasil kajian indeks gonad menunjukkan *P. viridis* mampu bertelur sepanjang tahun kecuali pada bulan Mei hingga Ogos. Perlepasan gamet antara kedua seks berlaku serentak, tiada perbezaan indeks gonad diperhatikan di antara jantan dan betina. Bagi penentuan nisbah seks, 1,000 individu *P. viridis* telah digunakan. Bilangan jantan, betina dan 'tidak dapat ditentukan' yang dikenalpasti dengan pemerhatian melalui tisu mantel adalah masing-masing



pada jumlah 524, 412 dan 64i. Nisbah jantan:betina ialah 0.79:1 melalui pemerhatian mata kasar. Sebanyak 36 individu telah dikenalpastikan secara histologi bagi penentuan nisbah seks. Bilangan jantan, betina dan 'tidak dapat ditentukan' adalah masing-masing berjumlah 161, 151 dan 4. Nisbah seks mengikut cara histologi adalah 0.94:1. Pada bulan Jun dan September 2004 dua spesimen hermaphrodit dijumpai, dimana kedua-dua sampel mengandungi gamet jantan dan betina pada sebelah mantel sahaja. Tiada kesan hermaphrodisme dapat diperhatikan pada sebelah kedua mantel maupun mesosoma.

Kajian pemaotan *P. viridis* telah dijalankan dari Februari 2004 hingga Disember 2004 pada tali pemungut yang digantung pada tapak kajian yang sama. Pemaotan kupang ini aktif sepanjang tempoh kajian, dengan bulan Mac-June dan August-December mencatatkan pemaotan yang paling tinggi. Purata, maksimum dan minimum ketumpatan pemaotan adalah masing-masing pada jumlah 11,389, 29,788 dan 1649 spat/meter. Densiti maksimum dicatat pada bulan April dan minimum pada bulan Ogos 2004.

Kajian parameter-parameter populasi seperti panjang asimtotik (L), pekali tumbesaran (K), mortaliti, paras eksploitasi dan corak rekrutmen juga telah dilakukan pada *P. viridis* di tempat yang sama. Kajian ini dilakukan menggunakan analisis kekerapan panjang oleh perisian FiSAT untuk menilai tumbesaran, kadar mortaliti dan paras eksploitasi. Panjang asimtotik (L) ialah 102.38 mm dan pekali tumbesaran (K) dianggarkan 1.50 thn<sup>-1</sup>. Jumlah mortaliti untuk *P. viridis* ialah 1.44 thn<sup>-1</sup>, manakala mortaliti biasa 1.67 thn<sup>-1</sup>

dan mortaliti penangkapan pula 0.81 thn<sup>-1</sup>. Paras eksploitasi (E) pada *P. viridis* ialah 0.32 manakala nilai eksploitasi maksimum yang dibenarkan (Emaks) adalah 0.43. Paras eksploitasi di Sebatu, Melaka (<0.50) berada di bawah paras optimum yang menunjukkan keadaan kurang eksploitasi sumber ini.

Kajian juga mencatatkan nilai purata suhu sebanyak 29.37°C, oksigen 6.02 mg/l, pH 7.96 dan saliniti 30.41 ppt. Nilai maksimum dan minimum untuk suhu ialah 32.17 °C dan 27.82°C, oksigen 7.61 mg/l dan 4.94 mg/l, pH 8.18 dan 7.70, saliniti 33.26 ppt dan 28.13 ppt. Nilai klorofil a tercatat diantara 1.50 hingga 9.40mg/l dan TSS dari 0.0253 hingga 0.0733 g/l.

Kewujudan ketam pea, *Arcotheres latissimus* (Burger, 1895) dalam badan *P. viridis* telah dipantau dari Disember 2003 hingga Disember 2004. Infestasi maksimum tercatat dalam bulan Jun keatas *P. viridis* yang bersaiz antara 19.26 hingga 92.18 mm. Berat basah *P. viridis* yang telah diinfestasi ialah di antara 0.17 hingga 10.41 g. Berat basah ketam pea pula ialah di antara 0.009 g hingga 0.55 g.

## **ACKNOWLEDGMENTS**

Praise be to Allah the Almighty for the strength, health, and peace of mind He provided me throughout this study and for giving me the confidence to submit this thesis.

I would like express my sincere gratitude to my supervisors, Assoc. Prof. Dr. Aziz Arshad for the support, continued guidance and valuable collaboration during the entire process of this thesis at UPM. Without whose quality and friendly supervision; this work would not have come to completion.

My special appreciation to my mother, my father, my wife, my sons, my daughters, and the rest of my family members and friends for all their invariable encouragement and support.

I would like to thank my thesis committee members for their advice, critical thought, thoroughness to this thesis and for the continues constructive discussions and suggestions. Special thanks goes to Assoc. Prof. Dr. Japar Siddik Bujang, Assoc. Prof. Dr. Siti Shapor Siraj, and Dr. Yap Chee Kong.

Several people were instrumental to the development of the methods and procedures of this project. I am grateful to Mr. Omidvar Farhadian and Mr. Perumal Kuppan for their encouragement, suggestions and technical

assistance. My special thanks goes to Mr. Khyrul Amri from Sebatu village for the assistance during field sampling.

My appreciation also goes to the Dean and staff of the Faculty of Science. I would like to express my sincere thanks again to Assoc. Prof. Dr. Siti Shapor Siraj, the Head of the Department of Biology and staff members for providing me with the suitable environment, facilities, and for their cooperation and friendly treatment throughout this study period. I am grateful to the Malaysian Government for financial support through the Malaysian Technical Cooperation Program (MTCP).

I would also like to express my gratitude to the many technicians, undergraduate, and graduate students who helped me throughout this study. I would especially like to thank My friends and lab mates Hanafi, Amin, Efrizal, Jimmey, Prabath, Jamal, Rozhan, Hazel, Helena, Natrah, Adila, Anarita, who have contributed in ways too numerous to list.

Thanks are also extended to Prof. Dato Dr. Mohamed shariff and Assoc. Prof. Dr. Hassan Daud for providing histological facilities. Special thanks go to Cik. Azzah for histological assistance at Veterinary Lab, Puan Norma and Puan Juita at Medical Faculty.

My sincere thanks is also extended to Dr. Steven Goddared and Dr. Hamed Al Oufi for their full support and endorsement toward me to pursue this PhD program. My sincere gratefulness goes to Mr. Khalid Al Hashimi, Harib Al

Habsi, Hussain Al Masroori, Khamis Al Riyamy, Mohamed Al Ghaithi, Mohamed Al Amri, Dr. Adnan Al Azri, Dr. Saud Al Jufaily, Dr. Fahad Saleh and the rest of my friends and colleagues at College of Agricultural and Marine Sciences at Sultan Qaboos University for their encouragement and support.

I certify that an Examination Committee has met on February 14<sup>th</sup>, 2007 to conduct the final examination of Said Mohammed Al Barwani on his Doctor of Philosophy thesis entitled "Seasonal Variations in Reproduction, Growth, Sex Ratio, and Condition Index in *Perna viridis* (LINNAEUS 1758) (Mollusca: Mytilidae)" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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

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## **DECLARATION**

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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**SAID MOHAMED AL BARWANI**

Date:



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