BIO-DYNAMICS AND LIFE CYCLE OF SHRIMP (*PENAEUS SEMISULCATUS* DE HAAN), IN BUSHEHR COASTAL WATERS OF THE PERSIAN GULF

By

NASSIR NIAMAIMANDI

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

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DEDICATION

This thesis is dedicated to

My wife,

Noushin Farhadi

Your motivation, sacrifice and support during the period of my academic mission are appreciated.

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

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Chairman: Associate Professor Aziz bin Arshad, PhD

Faculty: Science

Shrimp fisheries in the Persian Gulf have a long history. The trawl fishery for penaeid prawn developed along the mid-northern coasts of the Persian Gulf (Bushehr waters) beginning in 1960. From 1998 to 2004 shrimp landings have fluctuated between 480t and 2700t per year. The major species of penaeid prawn, in terms of catch (>80%) and economic importance, in the Persian Gulf (including Bushehr waters) is *Penaeus semisulcatus,* commonly known as the green tiger prawn. More than 2000 vessels and 33000 fishermen from the Bushehr study area have participated in the shrimp fishery each season (August-September) over the last decade. In the Arabian side of the Persian Gulf, *P. semisulcatus* has been now become the most important single component species. Despite of commercial importance, there has been very little published research in the biology this species. In the study area, Bushehr waters, shrimp fishery is only controlled during open season. Because of lack of any data, there is no any prohibition and restricted areas in the nursery and spawning grounds and also the fluctuations of shrimp resources are unknown.

The present study was carried out in Bushehr coastal waters during 2003-2005 and describes the bio-dynamics and life history of *P. semisulcatus.* Monthly sampling of shrimp was collected by R/V Lavar II for 15 months from January 2003 to March 2004 from 50 fixed stations. Carapace length (CL) frequency was used to estimate growth, mortality and exploitation rates for males and females using FiSAT statistical analyses software. The Von Bertalanffy growth parameters were estimated as K = 1.6 $^{Year-1}$ and 2.2 $^{Year-1}$ and $L\infty$ = 38 mm and 50.4 mm for males and females, respectively. Estimated annual mortality rates for males were Z = 6.4, F= 4.3, and M = 2.11. While females were Z = 8.2, F = 5.8, and M = 2.41. Exploitation rates for males and females were E = 0.67 and E = 0.70, respectively. Relatively high values of total mortality and exploitation rates were obtained, suggesting this species is overexploited. The maximum ages calculated were 20 months for males and 15 months for females.

Gonad maturity results indicated that the major spawning activity for *P. semisulcatus* within the study area occurs during winter and early spring, with an additional minor peak evident in autumn. These periods coincided with seasonal rainfall in the Bushehr study area. Size at 50% maturity (L50%) was 40.6 mm carapace length (CL). Less than 5% of females were smaller than 24 mm CL. Mature shrimps aggregated in the middle and southern regions of study area at depths of 20-30 m. The areas of Imam Hassan, Genaveh and Helleh represented the most important spawning grounds in Bushehr waters. A sex ratio of 0.84 (male/female) occurred over the study period.

A total of 2571 prawn were tagged and released using a green color polyethylene steamer tag during the 15 month survey. From these, 68 recaptures were reported during August-September of 2003-04, of which four were omitted from analysis due to lack of information. Maximum recapture depths were 16-20 m and 26-30 m for males and females, respectively. The majority of recaptures indicated that these prawn moved at speeds of < 2 km/day. Maximum speed was recorded 3-4 km/day for males and 2 km/day for females. Around 70% of the tagged shrimp were recaptured within 20 km of their release locations, while approximately 10% of them traveled a linear distance > 50 km. The maximum recorded distance was 127 km after 95 days of release for a female shrimp. The maximum time at-liberty was 381 days for a female that moved 20 km. Tag recapture data indicated shrimp generally moved to the northern area (Bahrekan) where waters were greater in depth.

In the shallow study areas, post-spawning sampling of juvenile *P. semisulcatus* was carried out during July, November and December 2003 and January, February, April, June, July 2004 and February and March 2005. Some stations that recorded a depth of less than 10 m were trawled using a small vessel equipped with a small beam trawl. A total of 748 juvenile *P. semisulcatus* of less than 15 mm CL were collected. These juveniles were observed in July and November 2003 and April and June 2004. The CL of juveniles ranged from 3 mm to 15 mm and minimum of mean of CL were 4.5 mm in November and maximum 9.6 mm in July. Observed locations of juveniles were around vegetated sites at Mottaf (southern region) and Helaileh (middle region), although a few juveniles were also collected in the non-vegetated areas. Within these nursery grounds, 47% of marine fauna included other marine species such as fishes of Sparidae and Platycephalidae family, crabs, shells and other penaeid shrimp species such as *Metapenaeus affinis* and *M. stebbingi*. Seasonal abundance of juveniles was greatest during the warmer months (from April to November) and very few were captured during the colder seasons (from December to May).

The study also used Random Amplified Polymorphic DNA (RAPD) analysis to compare the genetic diversity of the population of prawn, *P. semisulcatus*. The results showed that the genetic diversity is not significantly different and it was confirmed that this species should be identified as one population in the Bushehr waters.

In the present study mature shrimp were dominant from December through March, while juvenile stages were observed generally from April through July. Exploitation rates of *P. semisulcatus* suggest that fishing activities should be regulated during spawning periods and within the nursery grounds.

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

BIODINAMIK DAN KITAR HIDUP UDANG (*PENAEUS SEMISULCATUS* DE HAAN), DI KAWASAN PERAIRAN PANTAI BUSHEHR TELUK PARSI

Oleh

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Ogos 2006

Pengerusi: Profesor Madya Aziz bin Arshad, PhD

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Penangkapan udang di Teluk Parsi mempunyai sejarah yang panjang. Penangkapan secara pukat tunda bagi udang penaeid telah dimulak dan dibangunkan sepanjang kawasan pantai utara tengah Teluk Parsi (Pantai Bushehr) pada 1960. Dari 1998 ke 2004, pendaratan udang berubah-ubah dalam lingkungan 480t dan 2700t setahun. Spesies utama udang penaeid dalam penangkapan (>80%) dan mempunyai kepentingan ekonomi di Teluk Parsi (termasuk kawasan Pantai Bushehr) ialah *Penaeus semisulcatus*, biasanya dikenali sebagai udang harimau hijau. Lebih daripada 2000 bot tangkapan dan 33,000 nelayan dari kawasan kajian di Bushehr telah menjalankan aktiviti penangkapan udang setiap musim (Ogos-September) sejak beberapa abad yang lalu. Di sebelah perairan Arab Teluk Parsi, *P. semisulcatus* telah menjadi satu-satunya spesies yang paling penting. Walaupun ia mempunyai kepentingan komersil, tetapi hanya terdapat sedikit sahaja hasil penyelidikan yang melaporkan tentang aspek biologi spesies ini. Dalam kawasan kajian pantai Bushehr, penangkapan udang hanya dikawal semasa musim tangkapan. Oleh sebab kekurangan maklumat, maka tidak terdapat sebarang penyekatan dan kawasan larangan di tempat asuhan dan kawasan pembiakan dan juga perubahan sumber udang juga adalah tidak diketahui.

Kajian ini dilakukan di kawasan Pantai Bushehr sepanjang tahun 2003-2005 dan ianya menghuraikan tentang biodinamik dan kitar hidup udang *P. semisulcatus*. Pensampelan udang dilakukan setiap bulan dengan menggunakan bot penyelidikan R/V Lavar II dari Januari 2003 hingga Mac 2004 selama 15 bulan di 50 stesen tetap. Frekuensi panjang karapas (CL) digunakan untuk menganggar

pertumbuhan , mortaliti dan kadar eksploitasi bagi udang jantan dan betina dengan menggunakan perisian analisis statistik FiSAT. Parameter pertumbuhan Von Bertalanffy telah masing-masing dianggarkan pada K = 1.6$^{tahun-1}$ dan 2.2$^{tahun-1}$ dan L∞ = 38 mm dan 50.4 mm bagi individu jantan dan betina. Kadar mortaliti tahunan yang dianggarkan bagi individu jantan ialah Z = 6.4, F = 4.3 dan M = 2.11. Manakala untuk individu betina ianya pada Z = 8.2, F = 5.8 dan M = 2.41. Kadar eksploitasi bagi individu jantan dan betina adalah masing-masing E = 0.67 dan E = 0.70. Keputusan juga mendapati jumlah nilai mortaliti dan kadar eksploitasi yang tinggi, dan ini mengunjur yang spesies ini telah dieksploitasikan melebihi tahap optimum. Umur maksimum yang dikira ialah 20 bulan untuk jantan dan 15 bulan untuk betina.

Kajian kematangan gonad telah menunjukkan bahawa aktiviti pembiakan utama bagi *P. semisulcatus* berlaku semasa musim sejuk dan awal musim bunga, dan satu puncak minor tambahan di musim luruh. Semua tempoh ini telah dikaitkan dengan musim hujan di kawasan kajian Bushehr. Saiz kematangan 50% (L50%) ialah pada 40.6 mm panjang karapas (CL). Didapati yang kurang daripada 5% betina kecil daripada 24 mm CL.
Udang yang matang bertumpu di sektor tengah dan selatan kawasan kajian pada kedalaman 20-30 m. Kawasan Imam hassan, Genavah dan Helleh adalah antara kawasan pembiakan penting di Pantai Bushehr. Nisbah jantina 0.84 (jantan/betina) didapati sepanjang waktu kajian.

Sejumlah 2571 udang telah ditanda dengan menggunakan tanda 'steamer' polietelina berwarna hijau dan dilepaskan di sepanjang 15 bulan tinjauan. Daripada jumlah ini, 68 ekor telah di tangkap semula semasa bulan Ogos-September 2003-04 dan empat telah diabaikan daripada analisis disebabkan kekurangan maklumat. Kedalaman maksimum tangkapan semula masing-masing adalah pada 16-20 m dan 26-30 m untuk individu jantan dan betina. Majoriti daripada tangkapan semula menunjukkan bahawa udang ini bergerak pada kelajuan <2 km/hari. Kelajuan maksimum telah dicatatkan pada 3-4 km/hari bagi jantan dan 2 km/hari bagi betina. Lebih kurang 70% udang yang ditanda telah ditangkap semula dalam lingkungan 20 km dari tempat yang dilepaskan, manakala lebih kurang 10% daripada mereka bergerak dalam satu perjalanan garis lurus >50 km. Jarak maksimum yang dicatatkan ialah 127 km selepas 95 hari pelepasan oleh seekor udang betina. Masa bebas maksimum yang dicatatkan ialah 381 hari bagi satu betina yang bergerak sejauh 20 km. Data tangkap-tanda-lepas-tangkap semula menunjukkan udang pada umumnya bergerak ke arah utara (Bahrekan) di mana air adalah lebih dalam.

Di kawasan kajian yang berkedalaman cetek, pensampelan peringkat juvenil *P. semisulcatus* telah dilakukan pada Julai, November dan Disember 2003 dan Januari, Februari, April, Jun, Julai 2004 dan Februari dan Mac 2005. Stesen yang dicatatkan mempunyai kedalaman yang kurang daripada 10 m telah dipukat dengan menggunakan satu bot tangkapan yang dilengkapi dengan satu pukat 'beam'. Sejumlah 748 juvenil *P.semisulcatus* yang kurang daripada 15 mm CL telah dikumpulkan. Juvenil ini telah direkodkankan pada bulan Julai dan

November 2003 serta April dan Jun 2004. Panjang karapas (CL) juvenil berjulat antara 3 mm hingga 15 mm dan min CL yang minimum ialah 4.5 mm semasa November dan maksimumnya pula 9.6 mm pada bulan Julai. Juvenil dicatatkan pada tempat yang bervegetatif di Mottaf (bahagian selatan) dan Helaileh (bahagian tengah), walaupun begitu terdapat juga juvenil yang dikumpulkan di tempat tidak bervegetatif tetapi dengan jumlah yang sedikit.

Daripada kajian tempat asuhan, sebanyak 47% faunanya terdiri daripada spesies marin lain seperti ikan daripada famili Sparidae dan Platycephalidae, ketam, kerang-kerangan dan spesies udang penaeid lain seperti *Metapenaeus affinis* dan *M. stebbingi*. Kelimpahan juvenil yang paling banyak adalah pada bulan-bulan yang lebih panas (dari April ke November) dan jumlah yang sedikit dapat ditangkap pada musim sejuk (dari Disember ke Mei).

Kajian ini juga menggunakan "Random Amplified Polymorphic DNA" (RAPD) analisis untuk membandingkan kepelbagaian genetik dalam populasi udang *P. semisulcatus*. Keputusan kepelbagaian genetik tidak menunjukkan perbezaan bererti dan ini memastikan bahawa spesies ini patut dikenalpasti sebagai satu populasi sahaja di kawasan pantai Bushehr.

Dalam kajian ini, udang matang didapati dominan pada Disember hingga Mac, manakala fasa juvenil pada umumnya diperhatikan pada April hingga Julai. Kadar eksploitasi *P. semisulcatus* mengesyorkan yang aktiviti penangkapan udang harus dikawal terutamanya semasa waktu pembiakan dan juga di tempat asuhan.

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I certify that an Examination Committee has met on 25 August 2006 to conduct the final examination of Nassir Niamaimandi on his Doctor of Philosophy thesis entiteled " Bio-Dynamics and Life Cycle of Shrimp (*Penaeus semisulcatus* De Haan) in Bushehr Coastal Waters of the Persian Gulf" 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 relevent degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the 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 acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

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NASSIR NIAMAIMANDI

Date: 24 August 06

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R/V	**Research Vessel**
K	**Growth Coefficient**
L∞	**Asymptotic Length**
FiSAT	**Fish Stock Assessment Toll**
F	**Fishing Mortality**
M	**Natural Mortality**
Z	**Total Mortality**
E	**Exploitation Rate**
FAO	**Food and Agriculture Organization**
CPUE	**Catch Per Unit Effort**
hp	**hours power**
UNDP	**United Nation Development Program**
ELEFAN	**Electronic Length Frequency Analysis**
CL	**Carapace Length**
TL	**Total Length**
mtDNA	**mitochondrial DNA**
RFLP	**Restriction Fragment Length Polymorphism**

PCR-SSCP	**Single Standard Conformation Polymorphism**
EST	**Sea Surface water Temperature**
ESP	**Explained Sum of Peaks**
ASP	**Available Sum of Peaks**
SST	**Sea Surface Water Temperature**
Lat	**Latitude**
Log	**Longitude**
Lt	**Length at time t**
T_{max}	**Maximum age**
C	**Amplitude of oscillation**
WP	**Winter Point**
W	**Weight**
Ø	**fi prime**
ppt	**part per thousand**
L50%	**Length at 50% Maturity**
X^2	**Chi-Square**
PFI	**Population Fecundity Index**
GPS	**Global Positioning System**
RFLP	**Restriction Fragment Length Polymorphism**
%	**Percentage**
∑	**Summation**
≈	**Approximately**
m	**Meter**
cm	**Centimeter**

mm	**Millimeter**
ml	**Milliliter**
g	**Gram**
kg	**Kilogram**
nm	**Nautical Mile**
ph	**Hydrogen ion**
e.g	**For example**
hp/day	**Hource Power Per Day**
cm/sec	**Centimeter Per Second**
h	**Hour**
<	**Less than**
>	**More than**
°C	**Degree Celsius**
Per.com	**Personal communication**
Rmp	**round per minute**
EDTA	**Ethylane Diamine Tetracetic Acid**
mm	**milimoul**
SDS	**Sodium Dodecil Solphat**
PCI	**Phenol, Chloroform, Isoamil alchohol**
nm	**nanomolar**
OD	**Optic Density**
TBR	**Tris Br**
ng/µl	**nanogram/microlitre**
PCR	**Polymorase Change Reaction**

bp	**base pair**
min	**minute**
µg	**microgram**
DNA	**Deoxyribonucleic acid**
V	**Volt**
UV	**Ultra Violet**