UNIVERSITI PUTRA MALAYSIA

INFLUENCE OF HETEROGENEOUS INDIVIDUAL GROWTH ON MALE FRESHWATER PRAWN Macrobrachium rosenbergii DE MAN FOR SUSTAINABLE MONOSEX CULTURE

MST. RUBIA BANU

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By

MST. RUBIA BANU

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

December 2014

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DEDICATION

To
My parents,
Md. Jaidul Hoque Prodhan
Arzina Begum
Thank you for your love, doa and support

My brother and sisters
Md. Shariful Hoque Prodhan
Afsana Easmin Dristy
Jarin Anjum Diba
Thank you for your encouragement and enjoyment

My beloved husband
Md. Reazul Islam
Thank you for your love, understanding and patience

And

My in laws
Thank you for your understanding and patience

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

INFLUENCE OF HETEROGENEOUS INDIVIDUAL GROWTH ON MALE FRESHWATER PRAWN *Macrobrachium rosenbergii* DE MAN FOR SUSTAINABLE MONOSEX CULTURE

By

MST. RUBIA BANU

December 2014

Chairman: Annie Christianus, PhD
Faculty: Agriculture

Males of freshwater prawn *Macrobrachium rosenbergii* grow faster and larger than females. There has been a significant problem which appeared in all-male culture, namely their heterogeneous individual growth (HIG) pattern. Three different morphotypes of male prawn are found at harvest, namely blue-clawed male (BC), orange clawed male (OC) and small male (SM). Sometimes as much as 50% of harvested prawns remain undersized SM, which is one of the major impediments in freshwater prawn farming and its profitability. The purpose of this study was to investigate the effects and methods to minimize HIG occurrence in male prawns.

This study was conducted at the hatchery unit at Universiti Putra Malaysia. Juveniles of *M. rosenbergii* collected from Negeri Sembilan were used for all experiments. In the first experiment, three stocking densities of all-male prawns viz., 20, 30 and 40 juvenile m^{-2} were carried out in triplicates. After 4 months of culture, BC, OC and SM were counted from each treatment. It was found that the highest survival rate combined with good yield performance was from 20 m^{-2} stocking density with 21% BC, 62.5% OC and 16.5% SM respectively.

In the second experiment, male juveniles *M. rosenbergii* were segregated into BC, OC and SM, and cultured in isolation in fiberglass tanks at 5 m^{-2} for 80 days. SM population had the highest growth rate with three times growth increment, followed by the OC and BC population. The SM population had 100% survival rate with an average specific growth rate (SGR) of 1.22 % wt/day (average harvested individual

weight 29 g); the OC and BC population had 72% survival rate with an average SGR of 1.01 and 0.43 (42 g and 30 g) respectively. The wet weight gain of prawns was significantly greater for OC males (23.87 g) compared with SM (19.57 g) and BC males (6.31 g). Impacts of isolated culture on population structures were much more pronounced in the SM population than in the other morph cohorts.

In the third experiment, groups of small male (SM) *M. rosenbergii* juveniles were subjected to two treatments: bilateral eyestalk ablation and unablated/controls. Variation in individual growth rate of bilaterally ablated prawns was higher when compared with unablated prawns. In particular, the SGR of bilaterally ablated prawns (1.90%) was significantly higher than unablated prawns (1.15%). The absolute weight of ablated prawns was twice that of the controls. The growth trend of SM prawns at the end of the experiment was significantly increased compared with controls until the end of the experiment. These results suggested the potency of bilateral eyestalk ablation in enhancing growth rates might be limited due to high mortalities of the ablated prawns.

In the last experiment, male juveniles of *M. rosenbergii* were subjected cold shock and hormonal treatments. Individual growth of male juveniles was homogenous for the cold shock treated group (CLS) but was heterogeneous for the 17α methyl testosterone hormone treated (MH) and the control (CO) groups. The morphotypes of male prawns were significantly different in all treatments. It was observed 59% of BC males with small blue claws in the CLS treatment while 45 and 30 % BC males with large blue claws in MH and CO treatments, respectively. Average growth of prawn was not significantly different in all treatments including controls but the size of blue claw was smaller in the CLS treatment compared to others.

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

PENGARUH TUMBESARAN INDIVIDU TIDAK SERAGAM KE ATAS UDANG GALAH *Macrobrachium rosenbergii* JANTAN DE MAN UNTUK KULTUR MONOSEK YANG MAMPAN

Oleh

MST. RUBIA BANU

Disember 2014

Pengerusi: Annie Christianus, PhD
Fakulti: Pertanian

Udang galah *Macrobrachium rosenbergii* jantan membesar lebih cepat dan lebih besar dari betina. Satu masalah yang ketara pada kultur keseluruhan-jantan adalah disebabkan oleh corak tumbesaran individu tidak seragam (HIG). Tiga jenis morfologi berbeza udang galah jantan didapati semasa penuaian hasil, iaitu jantan dengan cakar biru (BC), jantan cakar oren (OC) dan jantan kecil (SM). Kadangkala sebanyak 50% dari udang yang dituai bersaiz kecil SM menjadi halangan utama dalam penternakan udang galah dan keuntungannya. Tujuan kajian ini adalah untuk mengkaji kesan dan kaedah untuk mengurangkan HIG dalam udang galah jantan.

Kajian dijalankan di unit hatceri, Universiti Putra Malaysia. Juvenil *M. rosenbergii* didapati dari Negeri Sembilan digunakan untuk semua eksperimen. Dalam eksperimen pertama, tiga kadar pelepasan stok udang galah jantan iaitu 20, 30 dan 40 juvenil m^{-2} dijalankan dalam tiga replikasi. Selepas 4 bulan kultur, BC, OC dan SM dikira untuk setiap rawatan. Didapati bahawa kemandirian tertinggi dengan hasil yang terbaik adalah dari rawatan kadar pelepasan stok 20 m^{-2} dengan 21% BC, 62.5% OC dan 16.5% SM masing-masingnya.

Dalam eksperimen kedua, juvenil jantan *M. rosenbergii* diasingkan kepada BC, OC dan SM, dan dikulcur secara berasingan dalam tangki gentian kaca pada 5 m^{-2} untuk 80 hari. Populasi SM memberikan tumbesaran yang terbaik dengan pertumbuhan tiga kali ganda, diikuti oleh populasi OC dan BC. Populasi SM memberikan kemandirian 100% dengan purata kadar tumbesaran spesifik 1.22 % berat/hari (purata berat

individu yang dituai sebanyak 29 g); populasi OC dan BC memberikan kemandirian 72% dengan purata SGR 1.01 dan 0.43 (42 g dan 30 g) masing-masingnya. Peningkatan berat basah udang ketara lebih tinggi pada jantan OC (23.87 g) berbanding jantan SM (19.57 g) dan BC (6.31 g). Kesan kultur berasingan ke atas struktur populasi adalah lebih ketara pada populasi SM berbanding dengan yang lain. Dalam eksperimen ketiga, kumpulan juvenil jantan kecil (SM) *M. rosenbergii* dikenakan dua rawatan; ablasi dua tangkai mata dan tanpa ablasi/kawalan. Variasi dalam tumbesaran individu udang yang diablasi adalah lebih tinggi berbanding tanpa ablasi. SGR udang yang diablasi (1.90%) ketara lebih tinggi berbanding udang tanpa ablasi (1.15%). Berat mutlak udang yang diablasi adalah dua kali lebih tinggi berbanding kawalan. Corak tumbesaran udang SM meningkat dengan ketara di akhir eksperimen berbanding dengan kawalan. Keputusan ini menunjukkan potensi ablasi dua tangkai mata udang dalam meningkatkan kadar tumbesaran adalah terhad akibat dari kadar kematian yang tinggi pada udang yang diablasikan.

Dalam eksperimen terakhir, juvenil jantan *M. rosenbergii* diberi rawatan kejutan sejuk dan hormon. Tumbesaran individu juvenil udang menjadi seragam untuk kumpulan yang diberi kejutan sejuk (CLS) tetapi tumbesaran adalah tidak seragam untuk kumpulan yang dirawat dengan hormon 17α metil testosteron (MH) dan kawalan (CO). Jenis morfologi udang jantan ketara berbeza dalam semua rawatan. Terdapat 59% jantan BC dengan cakar biru yang kecil dalam rawatan CLS manakala 45 dan 30 % jantan BC dengan cakar biru yang besar dalam MH dan CO masing-masingnya. Purata tumbesaran udang adalah tidak ketara pada semua rawatan termasuk kawalan tetapi saiz cakar biru adalah lebih kecil pada CLS berbanding dengan rawatan yang lain.

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May Allah bless you all! Thank you very much.

I certify that a Thesis Examination Committee has met on 19th December 2014 to conduct the final examination of Mst. Rubia Banu on her thesis entitled " Influence of Heterogeneous Individual Growth (HIG) on Male Freshwater Prawn *Macrobrachium rosenbergii* de Man for Sustainable Monosex Culture" 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 Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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This thesis was 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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- the research conducted and the writing of this thesis was under our supervision;
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Name of Chairman of Supervisory Committee: Dr. Annie Christianus
Name of Member of Supervisory Committee: Dr. Amy Halimah Rajaee
.

Signature: _____.
Name of Member of Supervisory Committee: Dr. Natrah Fatin Binti Mohd Ikhsan

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%	percent
α	Alpha
^{o}C	Degrees Celcius
g	Gram
h	Hour
ha	Hectare
Kg	Kilogram
L	Liter
m	Miter
mg	Miligram
mM	Milimolar
min	Minute
ml	Mililitre
ppt	Parts per thousand
s	Second
t	Tonnes
Yr	Year

CHAPTER 1

INTRODUCTION

1.1 General background

The expert of the Food and Agriculture Organization (FAO) was Shao-Wen Ling who discovered that the survival of the giant freshwater prawn (*Macrobrachiumrosenbergii*) larvae was possible in brackish environment. This achievement was at Marine Fisheries Research Institute in Penang, Malaysia in 1961.In 1965,Takuji Fujimura commenced his research in Hawaii, with the introduction of freshwater prawn (*M. rosenbergii*) broodstock from Malaysia and developed the commercial culture of freshwater prawn (Ling and Costello, 1979). The World Aquaculture Society had granted honorary to these two as life membership of the Society as well as called them 'Fathers' of freshwater prawn farming in 1974 (Shao-Wen Ling) and 1979 (Takuji Fujimura) for their work.

According to FAO data on *M. rosenbergii* (FAO, 2009),it reports that the production of *M. rosenbergii* in 2007 was over 99% of global farmed production in Asia, while the other major producing regions are South America and Central America.The five major producing countries of Asia are China (56.3% of 2007 global production), Thailand (12.5%), India (12.3%), Bangladesh 11% and Taiwan (4.5%). According to the FAO data, the production of only three other countries exceeded 200t of production in 2007: Iran (258t), Malaysia (246 t) and Brazil (230t). Now the trend has changed in the last decades. Though marine capture fisheries constitute 86.9% of Malaysia's fish production, coastal fisheries remain a major contributor. However, production from deep sea fisheries sector in the Exclusive Economic Zone (EEZ) is still expanding (DOF, 2010). According to the Food and Agriculture Organization (FAO, 2009), the world fish harvested in 2008 consisted 88.9 million tonnes captured by commercial fishing in wild fisheries, plus 55.9 million tonnes by fish farms. In addition, 14.8 million tonnes were produced from aquaculture. Overfishing and pollution are destroying the ocean ecosystem at an accelerating pace and of concern the world's fish and seafood could disappear by 2048 (FAO, 2009). Thus, aquaculture is an alternative, the average contribution of aquaculture to per capita fish available for human consumption increased from 14 % in 1986, 30 % in 1996 and to 47% in 2006, and is expected to reach 50% in the next few years (FAO, 2008).

Aquaculture plays a pivotal role within the NKEA (National Key Economic Area), which is at the core of the Malaysian Government's Economic Transformation Programme (ETP). The programme serves to stimulate economic activity towards attaining high income, sustainability and inclusiveness for the nation. With global demand for aquaculture products expected to increase above 635 million tonnes in 2020 from the present 251 million tonnes, potential for growth is excellent. The

aquaculture production was at 194,139 tonnes (USD 308 million) in 2003 contributing approximately 20% of the total value of the aquaculture production in Malaysia. Aquaculture has become an important way of increasing local yield for food security and to increase export revenues in Malaysia. While aquaculture currently contributes less than 0.2 percent to the gross domestic production (GDP), the fact that it accounts for no less than 20% of the overall fisheries production in Malaysia, a proportion that will only grow larger in the future, is testimony to its considerable importance. The Department of Fisheries has set its target on four entry point projects (EPP), namely, an integrated cage aquaculture project, a mini estate in seaweed production, seed industry development and replication of Integrated Zone for Aquaculture-IZAQ. These 4 EPP's are predicted to provide 35,100 jobs. The investment of private sector will total MYR 2.57 billion whilst the input of the public sector will be 346.25 million. Theaquaculture production target will encompass food commodities (giant freshwater prawn, marine shrimp, marine finfish and mollusc) with total up to 507,558 tonnes and values of MYR6,325 million. With the zoning of aquaculture area (AIZ) projected aquaculture production will reach 730,000 metric tonnes with a value of MYR7 billion in 2015.

Giant freshwater prawn, *M.rosenbergii* is among the commercial aquaculture species being given high priority by Department of Fisheries, Malaysia as food and food products for consumption and export. It is also being emphasised by this research group due to more and continuous development needed in various aspects of this giant freshwater prawn industry. The output of farmed giant freshwater prawn (*M. rosenbergii*) which was less than 3,000 tonnes 30 years ago expanded tremendously and had risen to almost 420,000 tonnes, with a value of USD 2.13 billion in 2008. Farmed production of *M. rosenbergii* constituted over 51% of the global total. However, production trendsfor cultured giant freshwater prawn in Malaysia fell 218% from 627 million tonnes in 2003 to 197 million tonnes in 2006 while in parallel rapidly expanding in Asia particularly in China, India and Thailand, though Malaysia pioneered the breeding of this species in the late 50's. The fall in its production as compared with other freshwater species like tilapia and catfish (keli) among others was due to decliningsupply of quality broodstock, low productivity, low culture technology and a high dependence on imported food for larval stages (DOF, 2011).Therefore, to successfully compete, Malaysia must invest in research areas that will help to intensify and sustain the production of farmed giant freshwater prawn so that it is environmentally non-degrading, economically viable and socially acceptable. Recent report by DOF (2011) revealed that Malaysia has achieved 100% self-sufficiency in fish production (mainly contributed by capture fisheries and culture of high valued marine species). Moreover, the MYR2.4 billion contributed by balanced values for import and export from Malaysian aquaculture production showed that there is a need to increase freshwater culture production particularly for giant freshwater prawn. An increase in cultured freshwater prawn, *M.rosenbergii,* not only will likely improve livelihoods, but also provides a cheap source of protein and will towards to increase export revenues for the Malaysian economy.

Giant freshwater prawn, *M. rosenbergii* is indigenous to the whole of South and South-East Asia, together with northern Australia and the western Pacific islands (New, 1988) as well as to Malaysia.It isthe largest species in the genus and recently,

most commercial culture has been based on this species (New, 2010). Prawn is one of the most attractive species in aquaculture for their high value and demand in the international market. Males of freshwater prawn grow faster and reach alarge size at harvest than females of the same species. Crustacean species exhibit bimodal growth patterns in which males exhibit superior growth to females or vice versa (Hartnoll, 1982). According to Cohen et al. (1988), stocking of all-male gave higher market yields, increased average weights, higher calculated income per unit area and shorter time to harvesting in monoculture condition in earthen ponds. However, all-male stocking yielded an increase in 18% in net income in polyculture (Sagi and Aflalo, 2005). Thus, monosex culture of all male populations could be an economically advantageous.Experimental trials in Israel (Cohen et al., 1983; Sagi et al., 1986; Hulata et al., 1988) and India (Nair et al., 2006) and recent observations in Bangladesh (Asaduzzaman et al., 2006a,b; Kunda et al., 2007), havedisclosed that culture of all-male prawn resulted in higher production than mixed sex or all female cohorts. However,as prawn prices are size dependent, the size composition of prawn at harvest is a very important consideration issues for the profitability of its culture (Karplus et al., 1986). The male population of *M. rosenbergii* exhibits heterogeneous individual growth (HIG). So, heterogeneous individual growth of mature male at harvest is one of the major obstacles for increasing the profitability in the farming of *M. rosenbergii*(Karplus et al., 2000; Ranjeet and Kurup, 2002).The growth rates of remains small prawns can be enhanced by periodic selective harvesting of large blue-clawed (BC) and orange-clawed (OC) males and large females (Malecha, 1983), which is one of the approaches to manipulate prawn population structure (Karplus et al., 1986;Karplus, 2005). The selective harvesting of BC and OC male prawns at 2-3 weeks intervals might be a suitable biotechnology for countries with warm climates which was reported by Sagi and Aflalo (2005).

1.2 Current status of freshwater prawn in Malaysia

The giant freshwater prawn, *Macrobrachiumrosenbergii* (de Man), locally known as ‘udanggalah’, is distributed from north-west India to Vietnam, Philippines, Papua New Guinea and Northern Australia (Jee, 1998). It is the largestt freshwater prawn in the world, with males growing to sizes> 320mm and weighing over 200g (Ling, 1969a). The first recognized output of farmed giant river prawn (*M. rosenbergii*) production recorded in FAO statistics appeared in 1970 (FAO, 2008). World production of the prawn in 2007 was 458,564 tonnes, of which 246 tonnes came from Malaysia (New, 2010). The global production status of *M. rosenbergii* is showed in Table 1.1.

Freshwater prawn farming has a special significance for Malaysia, where Shao- Wen Ling’s pioneer studies were made. Interest was strong in the late 1970s and the 1980s, when developments included the establishment of 2 government hatcheries (1981) and a 40 ha farm in Selangor. However, the volume of production from commercial farming has been relatively modest and extremely variable. A decade ago, production was expected to increase (New, 2000), judged by the increased demand for PL and juveniles and the number of new and expanded farms (e.g. 20 ha in Selangor and 60 ha in Negeri Sembilan). The high prices achieved for prawns were reported to be

turning the attention of farmers away from finfish. In 1999, a large (1200 ha) eel farm in Pahang that had been facing difficulties in obtaining sufficient elvers was reported to have made a decision to convert some of its ponds to freshwater prawn culture. Other favorable factors included the more ready availability of commercial aquafeeds in Malaysia, together with increasing support from government, university and private sectors (national farmers associations). In fact, national production showeda marked increase, doubling from 281 t in 1998 to 653 t in 1999 and doubling again to 1338 t in 2000. However, between 2001 and 2005, average output was less than half the peak level and was very variable (average 549 t/yr; range 317 to 752 t/yr). FAO data show that production levels fell markedly to only 194 t in 2006 but had recovered to 246 t by 2007. The latest official data show a production level of 334.44 tons in 2011 (DOF, 2011). The production of *M. rossenbergii*in last decade showed in Table 1.3.

Table 1.1:The production (tonnes) of farmed giant freshwater prawns (*M. rosenbergii*) 1998-2007(FAO 2009)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bangladesh	5751	5394	5504	9471	9559	10 200	17 123	19 609	20 810	23 240
Brazil	279	227	450	450	450	450	363	370	373	230
China	55 502	69 565	84 891	111 282	98 383	75 376	84 965	85 541	93 695	124 520
India	3900	7000	16 600	24 230	30 500	35 870	38 720	42 820	30 115	27 262
Indonesia		–	–	–	400	246	290	1009	1199	989
Malaysia	281	653	1338	752	535	627	317	514	194	246
Taiwan	8165	7223	8149	6859	7026	10 045	10 039	10 515	9878	8316
Thailand	4764	8494	9917	13 310	15 393	28 151	32 583	28 740	25 353	27 650
USA		–	–	44	54	49	38	218	218	200
Vietnam[a]	2918	2544	3513	4933	5552	5961	6247	5200	5482	7900
Others	498	409	327	286	284	384	370	626	584	621
Totals	**82 058**	**101 509**	**130 689**	**171 617**	**168 136**	**167 359**	**191 055**	**195 162**	**187 901**	**221 174**

[a] Reported under the statistical category 'freshwater crustaceans nei'.

Table 1.2: Total volume (tonnes) and value of all farmed freshwater prawn 1998-2007(FAO 2009)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Quantity (t)	82 089	101 550	217 855	258 356	254 644	387 962	399 820	422 764	392 639	458 564
Value (US$ '000)	364 088	407 728	701 978	82 977	838 071	1 228 547	1 540 406	1 673 748	1 584 850	1 857 825

Source: (New, 2010)

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Source: (New, 2010)

Table 1.3: Annual production of freshwater prawn in Malaysia 2001- 2011.

Year	Quantity(tonnes)	Changes
2001	752.00	-586.00
2002	535.00	-217.00
2003	627.00	+92.00
2004	317.00	-310.00
2005	514.00	+197.00
2006	194.00	-320.00
2007	246.00	+52.00
2008	355.50	+109.50
2009	551.60	+196.10
2010	619.22	+67.62
2011	334.44	- 284.78

(Source: New, 2010and Annual Report DOF, Malaysia 2008-2011)

Despite the many introductions of *M. rosenbergii* globally and a considerable level of activities in a worldwide, there was relatively small production of farmed freshwater prawns of any species outside Asiauntil 2009.However, there still remains a significant potential for expansion. Though, global production of *M. rosenbergii* in 2007 was over 221000 t, 2.7 times greater than a decade earlier, production in Malaysia had decreased to almost half in 2011 compared with 2010. The limiting factor was said to be the supply of good quality juveniles. In addition, many causes contributed to a significant decrease in the production of *M. rosenbergii* in Malaysia over the last decade these include quality seed production of hatchery, low survival rates and poor nurseriesfor PLs, inadequate feed supply and disease etc.

1.3 Problem statement

1.3.1 Male morphotypes

The sexually mature males *M. rosenbergii* have been classified into three major morphotypes according to the size and color of the claws, and the robustness of their spines (Kuris et al., 1987).

1. Blue claw males (BC) which have extremely long blue colored claws (2^{nd}pereiopods) with longer and stronger spines than OC males.

2. Orange claw males (OC) which have golden colored claws. These are generally shorter and have shorter and less strong spines than those of BC males.

3. Small males (SM) which have small, slim, almost translucent claws.

There are also three intermediary forms between the transitions from the small male (SM) to the blue claw (BC) morphotypes which is gradual. These are referred to as weak orange claw (WOC), strongorange claw (SOC) and transforming orange claw (TOC). The OC is there sometimes called to as the strong orange claw (SOC), and an intermediate stage between SM and SOC, the weak orange claw male (WOC), has been identified in research work. Another intermediate form between the orange claw (OC) and the blue claw (BC) is referred as transforming orange claw (TOC) which is the last stage of the OC male before it transforms into BC male.Certainmorphotypes can be delineated according to external features these include the length and orientation of the spines on the claws which are less immediately obvious than claw color and size(Karplus et al., 2000).There are many varieties not only in internal morphology and physiology but also in molt frequency. Small males have comparatively large testes that serve as both produce and store sperm whereas those of BC act especially as a reservoir of sperm. Orange claw males, including three patterns WOC, SOC and TOC, pass through a series of gradual changes between SM and BC. The quantity of mature sperm found in the testes of SM decreases and approximately disappears in the early stages of OC. In addition, the production rate of spermatocytes increases since the SM transfers into the OC phase which represents frequent molting. The weight of midgut glands, mainly the hepatopancreas, is another distinguishable character. The weight of hepatopancreas is the greatest in the fast growing SOC, intermediate values in the WOC and the TOC males and the lowest in the slow-growing SM and BC males.

The size variation of males in prawn populations is a major obstacle to increase profitability in *M. rosenbergii* culture. The growth of many individuals is stunted in prawn populations especially under high-density culture (Karplus et al., 1986a, 2000). Newly metamorphosed postlarvae (PL) populations are comparatively homogenous in their size but size variation increases gradually within few weeks due to differences in growth rate of individuals. This is called heterogeneous individual growth (HIG).According to their relative growth rates, juveniles have been classified into two major groups these include jumpers and laggards. Jumpers are much fast-growing individuals that can be 15 times larger compared with population mode within 60 days after metamorphosis (Ra.anan and Cohen, 1984, 1985; Karplus and Hulata, 1995). They transform especially into BC and OC males while the laggards transform into SMs during grow-out system (Karplus et al., 1986, 1987). Morphology, physiology and behavior of these three sexually mature male morphotypes are not same and their development pathway (SM→ OC→ BC) is followed by each male prawn (Ra'anan and Cohen, 1985; Kuris et al., 1987; Ra'anan et al., 1991; Karplus et al., 2000). Size variation of male prawn has both a genetic and an environmental factor. The size heritability has been described to be a sexually dimorphic trait, with females containing significant genetic control (h^2~0.35) but that was found to be close to zero in males (Malecha et al., 1984).

All-male culture has been tried in Malaysia and other countries. A significant problem appeared in all-male culture, due to their heterogeneous individual growth (HIG) pattern. There are normally 50% of the male population contains the SM (5-20 g), 40% of the OC (30-180 g) males and 10% only of BC (up to 250 g) males at the harvested population in farms. Therefore, the economic viability and the profitability

of framing *M. rosenbergii* is largely depended on the relative proportion of BC and OC male morphotypes and their allied intermediary stages in the harvested population (Kurup et al., 1996). The reasons for HIG are still unknown. If this could be known, potentially management measures could potentially be developed to improve productivity and economic return for sustainable all-male prawn farming in Bangladesh, Malaysia and elsewhere in the region.

The present investigation was planned to examine heterogeneous individual growth (HIG) of male freshwater prawn *M. rosenbergii*, and the following objectives were proposed for this research:

1.4 General objectives

To study the effects of heterogeneous individual growth in culture of all male freshwater prawn.

1.4.1Specific objectives

1. To measure the effect of stocking density on male morphotypesin all-male culture system.

2. To study the growth performance and survival of SM, OC and BC in isolated culture.

3. To determine the effect of eyestalk ablation on growth performance and survival of SM males.

4. To determine the effect of cold shock and hormone treatment on male morphotypes.

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