



UNIVERSITI PUTRA MALAYSIA

**REPRODUCTIVE PERFORMANCE OF ORANGE MUD CRAB,
SCYLLA OLIVACEA (HERBST), BROODSTOCK FED SELECTED
FOODS**

JOSEPHINE DORIN AK MISIENG

T FP 2007 7



**REPRODUCTIVE PERFORMANCE OF ORANGE MUD CRAB, *SCYLLA*
OLIVACEA (HERBST), BROODSTOCK FED SELECTED FOODS**

By

JOSEPHINE DORIN AK MISIENG

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

February, 2007



DEDICATION

To the sacred memory of my mother
BERNADETTE NOED AK MUDAK,

To my husband
LIRONG YU ABIT,

To my children
HAVIT, JAMIE & JENNIFER,

To my
BROTHERS AND SISTERS,

Thank you



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

REPRODUCTIVE PERFORMANCE OF ORANGE MUD CRAB, *SCYLLA OLIVACEA* (HERBST), BROODSTOCK FED SELECTED FOODS

By

JOSEPHINE DORIN AK MISIENG

February 2007

Chairman: Associate Professor Mohd. Salleh Kamarudin, PhD

Faculty: Agriculture

This study was conducted to investigate the effects of selected food on the growth, ovarian development and ovarian maturity of the unilaterally eyestalk-ablated and unablated *Scylla olivacea* broodstock over 84 days in captivity. In this 2-factorial experiment, chopped trash fish, chopped cuttlefish and shelled prawn were fed twice daily at 5% of biomass to unablated and unilaterally eyestalk-ablated immature female *S. olivacea*. Mortality and moulting were recorded daily. The measurements of the mud crabs' body weight, carapace width and ovarian biopsy were recorded weekly.

Food and unilateral eyestalk ablation had significant effects on the growth of the *S. olivacea* broodstock, in terms of body weight and carapace width gain. Chopped trash fish performed at par with chopped cuttlefish for the growth of the broodstock while the unilateral eyestalk ablation gave a superior growth to normal broodstock in terms of body weight and carapace width gain.

The interaction of food and eyestalk ablation had significant effects on the duration of Stage II and III of the ovarian development with shelled prawn and unilaterally eyestalk ablation appeared to give the shortest period of ovarian development in the broodstock (10.1 days of Stage II and 10.9 days of Stage III).

The effects of food, eyestalk ablation and their interactions were not significant on the ovarian maturity but food had significant effects on the ovarian development after the first mating. Chopped cuttlefish showed significantly better effects for the broodstock to reach the Stage IV of ovarian maturity after mated. Female mud crabs fed with chopped trash fish resulted in 66.64% mating while those fed with chopped cuttlefish showed 83.28% of mating success. Both diets showed significantly better effects in promoting mating process of the broodstock. Apparently, *S. olivacea* matures at a much smaller size than *S. serrata*, *S. paramamosain* and slightly smaller than *S. tranquebarica*. The broodstock needs diets of different nutritional values for their growth at different phases of ovarian development and maturity.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PRESTASI PEMBIAKAN INDUK KETAM BAKAU, *SCYLLA OLIVACEA* (HERBST), YANG DIBERI MAKANAN TERPILIH

Oleh

JOSEPHINE DORIN AK MISIENG

Februari 2007

Chairman: Profesor Madya Mohd. Salleh Kamarudin, PhD

Faculty: Pertanian

Kajian ini dilakukan untuk menyiasat kesan makanan terpilih ke atas tumbesaran, perkembangan ovari dan pematangan ovari induk ketam bakau *Scylla olivacea* yang telah dipotong sebelah mata dan tanpa pemotongan tangkai mata semasa ditenak dalam kurungan selama 84 hari. Dalam eksperimen 2-faktorial ini, daging ikan dan daging sotong yang dicincang serta isi udang diberikan sebanyak dua kali sehari pada 5% biojisim kepada induk *S. olivacea* betina belum matang yang dipotong sebelah tangkai mata dan tanpa pemotongan tangkai mata. Bilangan kematian dan bersalin kulit ketam bakau direkod setiap hari. Penyukatatan berat badan, lebar cengkerang dan biopsi ovari direkod sekali setiap minggu.

Makanan dan pemotongan sebelah tangkai mata memberikan kesan signifikan ke atas tumbesaran induk *S. olivacea* dari segi peningkatan berat badan dan lebar cengkerang. Daging ikan yang dicincang memberikan kesan yang setara dengan daging sotong yang dicincang ke atas tumbesaran induk manakala pemotongan sebelah tangkai mata menunjukkan pertumbuhan yang lebih baik berbanding dengan induk normal.

Interaksi antara makanan dan pemotongan sebelah tangkai mata juga memberikan kesan signifikan ke atas tempoh Tahap II dan III dalam perkembangan ovari dengan isi udang serta pemotongan sebelah tangkai mata menghasilkan tempoh perkembangan ovari yang paling singkat (10.1 hari bagi Tahap II dan 10.9 hari bagi Tahap III).

Makanan, pemotongan sebelah tangkai mata serta interaksinya tiada kesan signifikan ke atas kematangan ovari induk ketam tetapi makanan memberikan kesan signifikan ke atas perkembangan ovari induk ketam selepas mengawan. Daging sotong yang dicincang menunjukkan kesan yang lebih baik untuk induk ketam mencapai Tahap IV kematangan ovari selepas mengawan. Induk ketam bakau yang diberi makan daging ikan yang dicincang menunjukkan 66.64% induk tersebut mengawan manakala induk ketam bakau yang diberi makan daging sotong yang dicincang menunjukkan 83.28% induk tersebut berjaya mengawan. Kedua-dua diet ini menunjukkan kesan signifikan yang lebih baik dalam menggalakkan proses mengawan induk ketam bakau. Ketam betina *S. olivacea* matang pada saiz yang lebih kecil daripada *S. serrata*, *S. paramamosain* dan kecil sedikit daripada *S. tranquebarica*. Induk ketam bakau didapati memerlukan diet dengan nilai nutrien yang berlainan untuk peringkat tumbesaran yang berlainan pada setiap fasa perkembangan dan pematangan ovari mereka.

ACKNOWLEDGEMENTS

I would like to extend my most sincere gratitude and deep appreciation to Associate Professor Dr. Mohd. Salleh Bin Kamarudin for providing me with invaluable guidance, objective criticism and encouragement throughout the course of the study.

I am also indebted to the member of my supervisory committee, Associate Professor Dr. Che Roos Bin Che Saad, for his constructive suggestions and guidance during the study period.

I would like to express my gratitude to the Dean of the Faculty of Agriculture and the Dean of Graduate School, Universiti Putra Malaysia who helped me in every possible way.

I also appreciate the assistance of Professor Ghizan Salleh, Dr. Mustaffa Kamal, Dr. Annie Christianus, En. Halim, En. Jasni, En. Fakhrudin, En. Muhd. Ikwanuddin, En. Kamil, En. Khairul Hayadi, En. Mohd. Zafri, colleagues and well-wishers who were instrumental in the successful completion of the project.

The financial supports given by the Sarawak Tunku Abdul Rahman Foundation, Malaysia is gratefully acknowledged.

Words are not enough to express my heartfelt feelings to my family for always providing me with their untiring guidance and supports. My husband, Lirong and children Havit, Jamie and Jennifer have extended their moral support and encouragement to me all the while in striving towards this achievement.



I certify that an Examination Committee met on _____ to conduct the final examination of Josephine Dorin ak Misieng on her Master of Science thesis entitled “The Reproductive Performance of the Orange Mud Crab *Scylla olivacea* (Herbst) Fed with Selected Food” 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:



This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Mohd. Salleh Kamarudin, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Che Roos Saad, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD

Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 JUNE 2007

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 concurrently submitted for any other degree at UPM or other institutions.

JOSEPHINE DORIN AK MISIENG

Date: 12 APRIL 2007



TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENTS	viii
APPROVAL	ix
DECLARATION	xi
LIST OF TABLES	xv
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS	xviii
 CHAPTER	
I INTRODUCTION	1
II LITERATURE REVIEW	11
The Biology, Culture and Nutrition of <i>Scylla olivacea</i>	11
Taxonomy	11
Distribution	12
Ecology	12
Life Cycle	13
Reproduction	13
Fecundity	15
Size at Maturity in <i>Scylla</i> sp.	16
Eyestalk Ablation in Crustaceans	16
Water Quality for <i>Scylla olivacea</i>	18
Nutrition in Mud Crab	18
III MATERIALS AND METHODS	20
Location of Study	20
Fiberglass Experimental Tanks	20
Seawater Treatment	20
Experimental Orange Mud Crabs	21
Experimental Food	22
Crude Protein	22
Crude Fat	25
Moisture Determination	25
Ash	26
Crude Fiber	26
Nitrogen-Free Extract (NFE)	27
Gross Energy Determination	27
Experimental Design	29
Broodstock Sampling	30
Moulting	30
Growth	30
Survival	31
Ovarian Development and Ovarian Maturity	32

Duration of the Different Stages of Ovarian Development	33
Reaching the Stage IV of the Ovarian Development after the First Mating	33
Carapace Width (CW) at Maturity of Stage III and Stage IV	34
Water Quality Monitoring	34
Statistical Analyses	34
IV RESULTS	36
Proximate Analyses	36
Water Quality Monitoring	36
Moulting Frequency	38
Growth and Survival	40
Ovarian Development	45
Ovarian Maturity	51
Mated and Reaching Stage IV	53
Size of Broodstock at Stage III and Stage IV of Ovarian Maturity	55
V DISCUSSION	57
VI SUMMARY	74
BIBLIOGRAPHY	76
APPENDICES	81
BIODATA OF AUTHOR	90

LIST OF TABLES

Table	Page
1 Proximate composition of selected food for <i>Scylla olivacea</i> broodstock (g/100g dry weight).	24
2 Proximate analyses of mature and immature female <i>S. olivacea</i> broodstock whole body including exoskeleton (g/100g dry weight).	37
3 Means for the frequency of moulting in unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	39
4 Means for initial and final body weights (BW) and carapace width (CW), BW and CW gains of unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	42
5 The survival rate of unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	44
6 Means for ratings of ovarian development stages of unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	47
7 Means for the duration of the ovarian development stages of unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	48
8 Means for the ratings of the stages of the ovarian maturity of unilaterally eyestalk-ablated and unablated <i>S. olivacea</i> broodstock fed with selected food for 84 days in fiberglass tanks.	52
9 Broodstocks mated and reached Stage IV after mated (%).	54
10 Carapace width (CW) at maturity of Stage III and Stage IV (mm).	56
11 Percentage of mud crab species composition sampled (14,000 crabs) from June, 1998-July, 1999 (Abdullah, 2001)	81
12 The Stage of Ovarian and Embryonic Development for <i>Scylla</i> sp. as Determined by Robertson and Kruger (1994)	

	and Dat (1999).	82
13	Raw Data on the Survival of Unilaterally Eyestalk-ablated and Unablated <i>S. olivacea</i> Broodstock	83
14	The Total Weight (g) of Selected Food given to the Unilaterally Eyestalk-ablated and Unablated <i>S. olivacea</i> Broodstock.	84
15	The Visual Rating for the Assessment of the Stages of Ovarian Development for <i>Scylla olivacea</i> .	85
16	The Visual Rating for the Assessment of the Stages of Ovarian Maturity for <i>Scylla olivacea</i> .	86
17	Pearson Correlation Analysis on the Number of <i>Scylla olivacea</i> Broodstock Successfully Mating against Broodstock Reached Stage IV the after First Mating.	87
18	Pearson Correlation Analysis between the Size of <i>Scylla olivacea</i> Broodstock at Maturity of Stage III and Stage IV.	88
19	Pearson Correlation Analysis between Moulting and Ovarian Development of <i>Scylla olivacea</i> Broodstock Fed with Selected Food.	89

LIST OF FIGURES

Figure		Page
1	Duration of ovarian development stages of <i>S. olivacea</i> broodstock fed with selected food.	50

LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

ANOVA	Analysis of variance
atm	Atmosphere pressure
BW	Body weight
BWG	Body weight gain
Cm	Centimeter
CW	Carapace width
CWG	Carapace width gain
°C	Degree Celcius g = gram
DMRT	Duncan's multiple range test
DO	Dissolved oxygen
EAA	Essential amino acids
EFA	Essential fatty acids
GE	Gross energy in kcal g ⁻¹ dry weight
H	Hours
H ₂ SO ₄	Sulphuric acid
Kg	Kilogram
L	Liter
m	Meter
mgL ⁻¹	Milligram per liter
ml	Milliliter
mm	Millimeter
mt	Metric tonnes
NaOH	Natrium hydroxide

NFE	Nitrogen-Free Extract
ppm	Parts per million
ppt	Parts per thousand
RM	Ringgit Malaysia
μm	Micrometer
wt.	Weight

CHAPTER I

INTRODUCTION

The Background of Study

The brackish water aquaculture industry has shown rapid development in the Southeast Asia region for the past 25 years, such as the pond culture of shrimp in Minh Hai Province, Vietnam; cage culture of marine fish in Indonesia and Malaysia; and recently the oyster culture in Terengganu, Malaysia. According to Keenan (1999a), the mud crab culture has been conducted for at least the past 145 years in China and for the past 45 years throughout Asia.

The mud crab (*Scylla* spp.) is an important fishery commodity in the Indo-Pacific countries. Various species of mud crab exist throughout tropical to warm temperate zones where they form the basis of small but important inshore fisheries. Also known as mangrove crabs, they are commonly associated with mangrove swamps and intertidal and subtidal muddy habitat. Their size, high meat yield and delicate flavour as well as the high nutrient contents (13.6 g protein/100 g crab meat, 3.8 g fat/100 g crab meat, 14.1 g ash/100 g crab meat and 68.1 g moisture/100 g crab meat) make the mud crab highly sought-after as a quality food item in the local and international market (Afrianto and Liviawaty, 1992). In the Philippines, mud crab culture is an important source of income among small-scale fishermen in coastal communities (Millamena and Quintio, 1999). In Indonesia, the mud crab has been an important fisheries commodity since the early 1980s (Cholik, 1999).



The mud crab (*Scylla* spp.) culture is widely practiced in most parts of South-East Asia (Hassan, 1995). In Vietnam, the culture of mud crabs has only been established and developed during the past 25 years, and is mainly located in coastal provinces (Dat, 1999). The culture and fattening of the mud crab (*Scylla serrata*) in Malaysia has been practiced since the late 1970s (Liong, 1993). Mud crab culture in Sematan, East Malaysia was started in the late 1980s, when farmers began to rear the crabs in small, shallow earth ponds in areas that were subjected to tidal influence (Chang and Abdullah, 1999).

The total mud crab production (captured fisheries and aquaculture) in the world were 31,781, 131,630 and 139,502 metric tonnes in 2002, 2003 and 2004 (FAO, 2006). The marked increases in production in 2003 and 2004 were due to the newly report on the mud crab aquaculture production in China. According to the Department of Fisheries Malaysia (2002), the estimated crab landings in Malaysia for 2002 were 11,235 metric tonnes (FAO 2006: Malaysian total crab production in 2004 13,251 metric tonnes). The estimated aquaculture production of mud crabs in brackish water ponds and cages were 34.52 mt and 233.72 mt respectively. The aquaculture production of berried females in brackish water cages were estimated at 44.22 mt. The productions of mud crab in brackish water cages are practiced in Perlis, Penang and Perak, while production in brackish water ponds is being practiced in Kedah and Penang only. The estimated retail value of the mud crab produced in brackish water ponds and cages were RM655.76 million and RM4,754.87 million respectively. Meanwhile, the estimated retail value of berried crabs produced in brackish water cages was RM1, 009.54 million. In Sarawak, the mud crab landings were 326.44 mt (2000), 284.87 mt (2001), 293.56 mt (2002),

240.54 mt (2003) and 173.62 mt (2004) respectively according to Department of Marine Fisheries of Sarawak (2000, 2001, 2002, 2003 and 2004). The average prices of mud crabs in Sarawak in 2000-2004 were ranging from RM9-RM12/kg.

There are two aspects of mud crab culture in the world. They are the fattening of empty crabs and growing out of the seed crabs. Fattening is primarily conducted in small bamboo enclosures in ponds or rivers. According to Rattanachote and Dangwattanakul (1992), fattening must be completed prior to moulting to avoid mortality that reduces the productivity. Seed crabs are stocked and reared in enclosures for the grow-out practice. In about 4 to 7 months, marketable size crabs (300 g and above) are harvested and supplied to the market (Chang and Abdullah, 1999). Recently, another crab culture system has been recognized in Malaysia, Indonesia (Cholik, 1999) and southern Vietnam (Johnston and Keenan, 1999), i.e. the soft-shell crab or moulting crab culture. Moulting in the crabs is induced by removing the pinchers and walking-legs and the crabs are stocked in ponds. As soon as moulting occurs, the soft-shelled crabs are removed out of the ponds and kept frozen for sale to traders. The value of moulting soft-shell crabs is five to ten times higher than hard-shelled small crabs (Johnston and Keenan, 1999).

Grow-out system for mud crabs is usually pond-based, with or without mangroves. In 1992, the Inland Fisheries Division of the Sarawak Department of Agriculture introduced the pen culture system in logged areas of the mangrove swamps in Sematan. In this intensive culture system, the crabs are allowed to grow in their natural habitat in enclosures in the mangroves. Since its introduction, this ecologically friendly system has spread to a number of districts in Sarawak,

Malaysia and adopted in northern Australia and southern Vietnam. This can be one of the most exciting prospects for the mud crab aquaculture because of its potential role in the reestablishment and conservation of the mangrove forests. In the natural situation, a mutually beneficial relationship exists between mangroves and crabs. Crabs promote mangrove growth by increasing nutrient levels and facilitating nutrient recycling via defecation and mortality (Johnston and Keenan, 1999). The crabs benefit from the shelter and primary productivity of mangroves (Davis, 2004). Mud crabs are stocked in the crab pen that requires a small area of mangroves and the return is comparatively high for the artisanal fishermen. This provides the fishermen with a sustainable source of income (Chang and Abdullah, 1999). Meanwhile, in Mekong Delta, Vietnam, an extensive mud crab culture is carried out in the mangrove silviculture ponds with shrimps (Keenan, 1999a). Even though the culture and fattening of the mud crab (*Scylla* spp.) has been going on for 45 years, mud crab aquaculture has not reached even its optimum potential (Fortes, 1999). Liong (1993) also reported a sluggish development in this industry in Malaysia. The main factor limiting the development of this industry is the insufficient supply of the seed crab stock. This is made worsen when seedlings collected from the wild are now commonly used for soft-shell crab industry which is much more lucrative with a shorter culture period.

Statement of Problem

A major constraint to further develop mud crab culture is the insufficient supply of seeds (Millamena and Qunitio, 1999; Keenan, 1999a). Most crab farmers depend on the supply of seed crab caught from the wild by small-scale fishermen in coastal

areas. The supply becomes critical due to the loss of mangrove forest, seasonal availability of seeds, over-exploited of wild stocks and recent growth in crab culture operations including the soft-shelled crabs.

Larval rearing of mud crab workers has attempted for a long time (Fielder and Heasman, 1999). Most have limited success especially in the survival rate of the larva in large-scale culture. Although there were attempts to mass-produce crab seed at the National Prawn Fry Research and Production Center (NAPFRE) at Pulau Sayak, Kedah in the 1980s and the Sematan Crab Research Station operated by the Inland Fisheries Branch, Department of Agriculture, Sarawak, in 1995, there has yet to succeed in the mass production of mud crab seed in Malaysia (Tan, 1999). In most areas where the larviculture of mud crab is conducted, the source of eggs relies on gonadal maturation and spawning of broodstock in captivity (Mann *et al.*, 1999). Typically, sub-adult or adult female mud crabs are collected from the wild and maintained in tanks or ponds until ovulation occurs. Male crabs are required if sub-adult females are used since mating occurs only at the maturity moult and sperms are subsequently stored for long periods by the females after mating. The quality of the newly hatched larvae or their inherent variability is regarded as a significant factor influencing the success of hatchery production. Laboratory tests at Sematan Fisheries Research Station have shown that the eggs carried by the berried female crabs caught from the crab pens in the mangroves can hatch well (Chang and Abdullah, 1999). This suggests that mud crabs kept in the crab pens appear to breed freely and able to produce larvae of reasonable quality. Broodstock produced in captivity is preferred because shell disease is commonly observed in the wild

broodstock and the crabs are required to be cleaned and disinfected in a strong formalin bath for a period ranging from 1 hour to overnight (Davis, 2004).

Unfortunately, there is a lack in the knowledge of spawning, brooding and hatching of eggs under their natural conditions. Therefore, most information on these processes comes from crabs that are reared in the hatchery for research and small-scale production. Besides that, very little is known about the factors that influence larval quality for the mud crabs of the genus *Scylla* and attempts to consistently reduce the variability and maximize the quality of larvae have been largely unsuccessful (Mann *et al.*, 1999).

According to Djunaidah *et al.* (2003), the development of a reliable seed production technique, including domestication of broodstock, is clearly critically important for sustainable growth of the mud crab farming industry. Although the maturation and spawning of *Scylla* both in the wild and captivity have been observed year-round (Quinn and Kojis, 1987; Chang and Abdullah, 1999), patterns of seasonal reproductive activity of the mud crabs have also been observed worldwide (Le Vay, 2001; Davis, 2004). However, it has been reported that the supply of berried broodstock from the wild is unreliable (Mann *et al.*, 1999). This problem has to be solved to ensure a year-round supply of berried broodstock for the larviculture and crab seed production that will be supplied to potential mud crab farmers. Hence, it is important to produce good quality mud crab broodstock in captivity particularly in the controlled hatchery conditions and to study the broodstock nutrition as well as the management on the consistency of quality and reproductive performance of the broodstock.

The development of mud crab culture is also hampered by the lack of basic knowledge on growth and survival, stocking rate and other information related to culture systems including its nutritional requirements (Keenan, 1999a; Cholik, 1999; Fortes 1999). Hutabarat (1999) stated that in spite of the great potential for the mud crab culture development, the mud crab farmers are still facing a number of problems and constraints especially in feed for fattening because they are still depending on trash fish as a main food source which is inefficient, less precise and liable to cause water quality deterioration. According to Chang and Abdullah (1999), the survey of the crab pens in Sematan, Sarawak in 1992 and 1993 showed that the average quantity of trash fish used per pen was about 604 kg per culture period. The main problem in the use of trash fish is its availability especially during the monsoon season and the additional costs incurred on the supply of electricity and the freezer to store the trash fish. The Sematan Fisheries Research Station had tried using prawn pellet feed and found that the pellets were too small for the mud crabs (Chang and Abdullah, 1999). However, the diet gave a higher growth rate and faster gonadal development.

Currently, blue swimming crabs grown in both ponds and cellular systems (crabs grown in separate compartments) and fed on prawn pellets almost exclusively (Mann and Paterson, 2004) show high growth rates. A recent pilot grow-out of mud crabs conducted in Queensland, Australia tested crocodile pellets (a large and moist pellet containing blood meal and chicken waste) as an alternative feed but they proved ineffective unless cooked waste prawns were added to the diet (Mann and Paterson, 2004). The disadvantages of these pelletized diets have been observed such as a high loss of small particulate matter, low attractability. In addition, the