CHAPTER II

LITERATURE REVIEW

1. Biology and Ecology of *M. rosenbergii*

The giant freshwater prawn, *M. rosenbergii*, as the name indicates, it is the large prawn and live in fresh water for most of its life. It is a commercially important species in tropical and subtropical countries.

1.1 Identification

The name of this species was firstly definited by De Man (1879) as *Macrobrachium rosenbergii*. The taxonomy of this prawn is shown as follow,

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Suborder	Natantia
Family	Palaemonidae
Genus	*Macrobrachium*
Spesies	*Macrobrachium rosenbergii*
Common name	giant freshwater prawn
	giant river prawn
	long-legged river prawn

Macrobrachium is the largest genus of the family Palaemonidae. There are about 200 species, which have been described in this genus. *Macrobrachium rosenbergii* (De Man) is the largest species of the genus. Most commercial culture of the genus had been base on *Macrobrachium rosenbergii*. There are two recognized subspecies in *Macrobrachium rosenbergii*, an eastern form and a western form. The range of the western form includes the east coast of India, the Bay of Bengal, the gulf of Thailand, Malaysia and western Indonesia. (Bruyn et al.,2004; Holthuis, 2000)

1.2 General morphology

The body of *M. rosenbergii* is usually greenish to brownish gray, sometimes more bluish color, and is darker in the larger specimens. There are irregular brown, gray and whitish streaks, which often placed somewhat on the longitudinal of the body. The orange spot is present on the articulations between the abdominal somites. The atennae are often blue. The chelipeds are also blue. All of these colors are brighter in the smaller than the larger prawns. The essential characteristic of *M. rosenbergii* is the great cheliped or the secondary walking legs of male prawn. The body consists of two distinct parts, the cephalothorax and abdomen, as shown in **Figure 2-1**.

The cephalothorax is form by the fusion of the cephalon and the thorax. The dorsal shield which covers the cephalothorax completely is the carapace. The cephalon has six appendages: 1,the eyes are stalked; 2,the first antennae or antennulae have three flagella as tactile organs; 3,the second antennae or antennae have single flagellum as sensory receptor; 4,the mandibles are specialized for grinding and crunching the hard part in the food; 5,the first maxillae or maxillulae are involved with food handling; 6,The second maxillae or maxillae assist in the handling of the food towards the mandibles and move the water over the gill. The mandibles and the first and the second maxillae are placed near the mouth opening and are termed mouthparts, which are small and are entirely covered by the next appendages. They play a role in the ingestion of food.

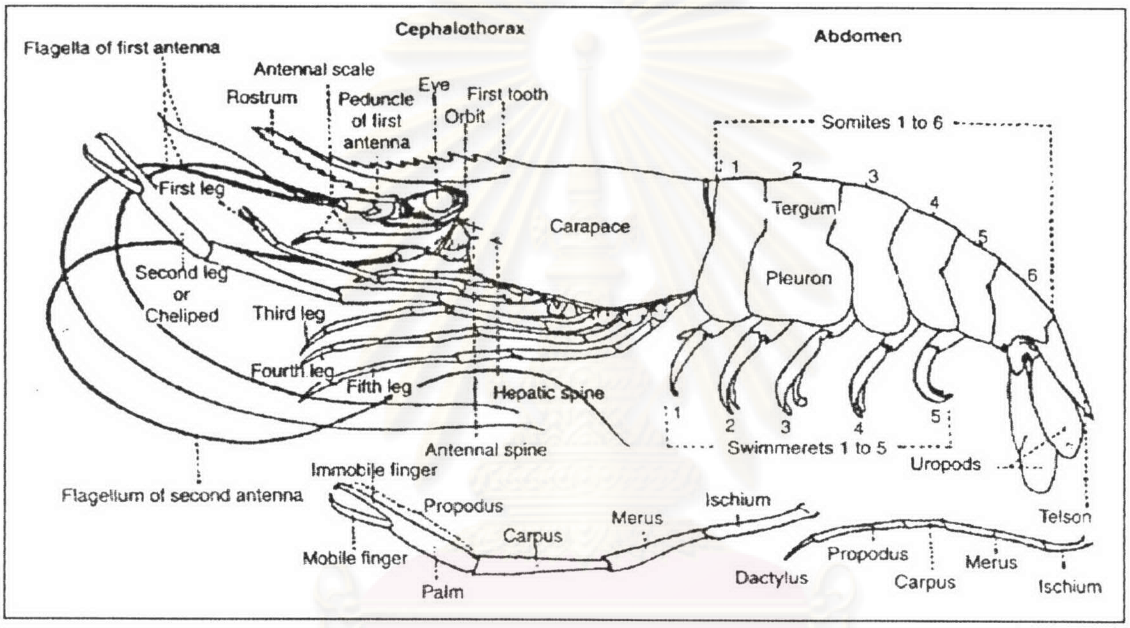


Figure 2-1. Morphology of *Macrobrachium rosenbergii*. (Source: Holthuis, 2000)

The thorax has eight pairs of appendages. The first three pairs of appendages are located between the mouths and are termed mouthparts, named maxillipeds I, maxillipeds II and maxillipeds III. They are utilized for feeding or food handling. The following five pairs of appendages are pereiopods or true legs. The first pereiopods or chelipeds consist of chelate and are small; they are utilized in capturing food. The second pereiopods or chelipeds consist of chelate. They are large and very robust, function as food capturing, enemies fighting and mating assistance. The third, the fourth and the fifth pereiopods are walking legs.

The abdomen consists of six somites, which each of the first five somites consists of a pair of ventral appendages, called swimming legs or pleopods. In female, a numerous of eggs was carried under the abdomen by the pleopods. The sixth somite consists of uropods and tailson for a sudden forward movement and backward direction. It is very effective propulsive structure for reverse movement. (Ismael and New, 2000)

1.3 Distribution

The giant freshwater prawn is indigenous to the whole of the South and Southeast Asian area as well as in parts of northern Oceania and in the western of Pacific Islands. It is widely distributed throughout the tropical and subtropical zones of the world as Thailand, Indonesia, Malaysia, Vietnam, Berma, India, Israel and USA (Holtuis, 1980). In Thailand, they are widely distributed in most inland freshwater areas connected with rivers, lakes swamps, irrigation ditches, canals, ponds, as well as in estuarine areas (FAO, 2002; Ling, 1969). In Thailand, they are found in Phra Nakhon Si Ayutthaya, Chai Nat, Pathum Thani, Nonthaburi, Samut Songkhram, Samut Prakan, Suphan Buri, Ang Thong, Nakhon Pathom, Ratchaburi, Chumphon, Surat Thani, Nahhon Si Thammarat, Pttalung, Songkhla, Krabi and so on. (Bunjong, 1992; Yont, 1986)

1.4 Life cycle

M. rosenbergii lives in freshwater environments for most of its life. It requires brackish water in the initial state of the life cycle, it is widely found in water connected with the sea directly or indirectly. The larvae can survive in fresh water for the first five days but saline water is essential for survival after that (New, 1988). Due to the fact that its larval development must take place in brackish water, it is influenced by adjacent brackish water areas. Gravid females migrate downstream into estuaries, where the eggs hatch as free-swimming larvae. The eggs hatching until metamorphosis into postlarvae, the planktonic larvae pass through several stages. After metamorphosis of postlarvae, they migrate upstream towards freshwater and inhabit in freshwater until adult stage (Ling, 1969). The life cycle of *M. rosenbergii* is shown in **Figure 2-2**.

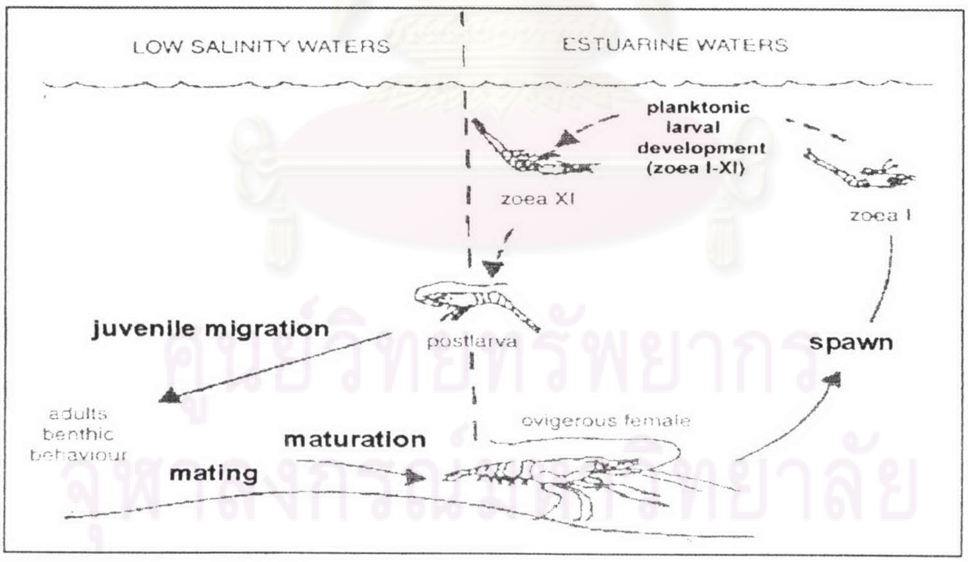


Figure 2-2. Life cycle of *Macrobrachium rosenbergii*. (Source: Holthuis, 2000)

M. rosenbergii females molt after ovarian maturation and then mate with male prawn. The eggs are bright orange and become gray-black before hatching. After hatching, the larvae generally utilize thoracic appendages to swim. They swim upside down, with the ventral side uppermost. The postlarvae resemble miniature adult prawns and swim forward, with the dorsal side uppermost (New and Singholka, 1985). Postlarvae are also able to walk, not only on the substratum but also crawling over stones at the shallow edges of rivers and in rapid. They become mainly clawing rather than free swimming animals. Postlarvae exhibit the good tolerance to a wide range of salinities, which is a characteristic of freshwater prawn. The juveniles exhibit nocturnal swimming activity and adult prawns are also active at night (Ismael and New, 2000).

1.5 Reproduction

M. rosenbergii can be sexually distinguished with the first appearance of gonopores in juveniles, at carapace length of 5.9 mm in males and 7.6 mm in females. Male gonopores are situated at the base of the coxae of the fifth pereiopods and are covered by flaps, while female gonopores appear as oval apertures on the coxae of the third pereiopods and are covered with a membrane. Female prawns exhibit a typical brood chamber, formed by the first, second and third abdominal pleurae. (Nagamine and Knight, 1980). When Female prawns are fully mature, they can lay between 80,000 and 100,000 eggs in each spawning. Ovaries frequently ripen again while eggs are being carried in the brood chamber (O'donovan et al., 1984; New and Singholka, 1985).

Ripe females were recognized by the conspicuous orange gonads observable though the dorsal and lateral areas of the carapaces. Mating usually occurs within 24 hours of the pre-spawning moult of the female prawn (Rao, 1965). After this spawning occurs, courting and mating commence. The male prawn inserts a sperm mass into the ventral thoracic region of female prawn. Within a few hours after copulation, spawning is initiated though the gonopores into the brood chamber. The fertilization occurs externally. The eggs remain adhere to the female pleopod during the whole embryonic development, which lasts around 3 weeks to hatch (Ismael and New, 2000). Unfertilized eggs are normally lost within 2-3 days of spawning (Ling, 1969). This prawn species is able to spawn 3-4 times in one year under natural conditions (Wickins and Beard, 1974).

The ovarian development of *M. rosenbergii* can be classified into five stages, based on their size and colour, which can be observed through the carapace (Chang and Shih, 1995). Such stages reflect vitellogenesis such yolk product and accumulation. In stage I, the ovaries are white, corresponding to the previtellogenesis. In stage II, a small yellow mass of ovarian tissue can be observed dorsally in the carapace, consisting of pre- and vitellogenic oocytes. In stages III-IV, the ovaries are orange, corresponding to vitellogenesis. In Stage V, it is characterized by reddish ovaries, extending from behind the eyes up to the first abdominal segment. After the ovaries reach stage V, the females are ready to moult and spawn. (Ismael and New, 2000)

1.6 Feed and feeding

Larvae eat continuously. The diet of larvae is principally minute crustaceans, very small worms, and the larval stages of others crustaceans. Postlarval and adult *M. rosenbergii* are omnivorous. They ingest a variety of food items of both plant and animal origin. The common items of food include aquatic warms, small mollusks, aquatic insects, insect larvae, other crustaceans, flesh and offal of fish and other animals, grains, seeds, nuts, fruits, tender leaves, algae and aquatic plants. The first of the cheliped is the main organ for food capturing, but the second pair is also helpful if the pieces are large or live prey is caught. They are voracious feeders and cannibalistic. If food had been insufficient or overpopulation had been occurred, they may injure each other (New, 1988; Ismael and New, 2000).

2. Aquaculture of *M. rosenbergii*

Giant freshwater prawn aquaculture has exhibited a significant role in commercialization to supply the world market, especially in Asia. It was clear that the wild prawns are limited to supply for the great demand. The farming of giant freshwater prawn has become a crucial agricultural industry in both developed and developing countries. The production from the farming of *M. rosenbergii* has expanded considerably, mainly in Asia but also in South and North America.

As illustrated in **Table 2-1**, the total global production of farmed *M. rosenbergii* was increased from 21,030 mt in 1992 to 185,832 mt in 2001. During 1992-2001, Thailand plays an important part of the world major production of giant freshwater prawn which subordinated to China and India. Thai farmed freshwater prawn production was approximated to be around 8,900 mt during 1992-2001, it expanded from less than 10,000mt in 1992 to about 12,000 mt in 2001. (FAO, 2001)

Table 2-1. Farmed freshwater prawn (*Macrobrachium rosenbergii*) production (in metric tons) 1992-2001 (FAO, 2001)

Q = mt
V = US$'00

Country	1992 mt	1993 mt	1994 mt	1995 mt	1996 mt	1997 mt	1998 mt	1999 mt	2000 mt	2001 mt
Argentina	2	7	13	12	20	22	...	...	...	...
Bangladesh	...	...	...	...	...	...	...	9 008	6 465	7 000
Brazil	650	700	700	341	46	446	279	227	4 531	5 380
Brunei Darsm	1	0	0	0	0	0	-	0	0	0
China	-	-	-	-	37 363	42 851	61 868	79 055	97 420	128 338
China, Taiwan	7 665	5 475	6 556	8 467	7 354	7 554	8 165	7 223	8 149	6 859
Colombia	55	10	10	-	-	-	-	-	-	-
Costa Rica	7	10	13	15	78	78	87	90	8	10
Dominica	4	1	2	2	2	3	3	3	4	4
Dominican Rp	164	739	961	86	90	27	87	16	82	62
Ecuador	850	850	850	800	800	800	800	800	800	800
El Salvador	8	9	9	10	21	14	16	17	9	3
Fuji Islands	6	85	87	91	93	40	20	2	5	5
Fr Guiana	-	-	-	-	-	7	18	25	25	25
Fr Polynesia	11	8	8	6	4	4	2	2	1	1
Grenada	-	-	-	0	0	0	0	1	3	0
Guadeloupe	35	40	26	30	30	20	14	20	14	14
Guam	0	0	0	0	0	0	0	0	0	0
Guatemala	35	32	76	99	5	75	52	43	46	50
Guyana	-	-	-	-	-	-	-	-	-	0
Honduras	0	0	0	0	0	0	0	0	0	0
India	455	178	311	...	178	1 500	3 900	7 000	16 600	24 230
Iran	-	-	-	-	-	-	-	-	-	23
Israei	3	3	3	0	0	0	0	0	-	-
Jamaica	30	30	30	40	40	40	40	40	10	10
Malawi	3	5	5	5	0	0	0	0	0	0
Malaysia	94	52	46	79	114	143	281	653	1 338	752
Martinique	38	42	40	40	35	44	25	20	19	19
Mauntius	55	42	63	53	62	44	28	25	31	19
Mexico	167	175	124	92	90	112	37	32	45	48
Myanmar	...	...	...	...	...	...	...	...	...	...
NewColedonia	0	0	0	0	0	0	0	0	0	0
Panama	5	5	0	3	2	1	0	0	0	0
Peru	1	1	212	100	31	23	45	16	13	6
Peurto Rico	199	112	100	20	1	2	...	7	12	13
Reunion	3	3	4	4	4	4	3	2	3	0
St Lucia	1	2	1	1	1	1	1	0	0	0
Senegal	6	10	11	20	25	21	20	50	50	50
Solomon Is	-	-	-	-	-	-	-	-	-	-
Suriname	0	0	0	0	0	0	0	0	0	0
Thailand	10 306	9 204	10 124	7 792	8 000	7 856	4 764	8 494	9 917	12 067
USA	147	159	159	-	-	-	-	-	-	44
Venezuela	22	25	13	31	30	30	...	...	...	...
Zimbabwe	2	-	-	-	-	-	-	-	-	-
total Q	21 030	18 014	20 557	18 239	54 959	61 762	80 555	112 871	145 600	185 832
V	105 371	118 924	145 029	145 689	238 243	255 234	303 374	454 798	521 769	638 593

3. Sex differences

In immature stage, the sexually undifferentiated *M. rosenbergii* has no morphological and structural difference in both internal and external sex characteristics (Nagamine and Knight, 1980). For the sexually mature males *M. rosenbergii* can be distinguished from females. The reproductive organs of this prawn species are located in the cephalothorax. The female and male internal reproductive organs of *M. rosenbergii* are shown in **Figure 2-3** and **Figure 2-4**, respectively. The male external morphology of *M. rosenbergii* and details of the appendix masculine are represented in **Figure 2-5** and **Figure 2-6** respectively.

3.1 Female *M. rosenbergii*

3.1.1 Internal sex characteristics

3.1.1.1 The appearance of a pair of oviducts.

3.1.1.2 The disappearance of the androgenic gland.

3.1.1.3 The ovarian development can be observed through the carapace.

3.1 2. External sex characteristics

3.1.2.1 The appearance of female gonopores located at the third pereopods

3.1.2.2 The appendix interna is appeared at the second of pleopod but the appendix masculina is disappeared.

3.1.2.3 The carepace and cheliped are smaller

3.1.2.4 The size is smaller

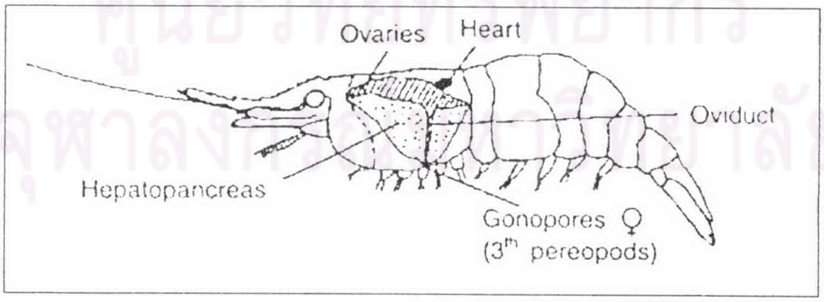


Figure 2-3. The female internal reproductive organ of *Macrobrachium rosenbergii*

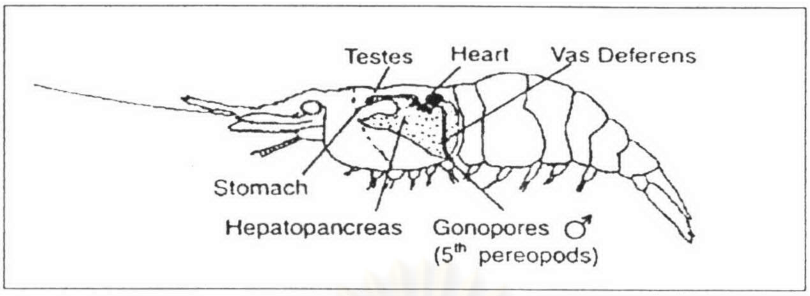


Figure 2-4. The male internal reproductive organ of *Macrobrachium rosenbergii*

3.2 Male *M. rosenbergii*

3.2.1. <u>Internal sex characteristics</u>

3.2.1.1 The appearance of a pair of testes and spermatophores.

3.2.1.2 The androgenic gland is appeared.

3.2.2. <u>External sex characteristics</u>

3.2.2.1 The appearance of male gonopores located at the fifth pereopods

3.2.2.2 The appendix masculina adjacent to the appendix interna of the second of pleopod, which disappears in female, as illustrated in Figure 5 and 6

3.2.2.3 The mature chelipeds are greatly larger and stronger than female.

3.2.2.4 The size is distinct larger and carapace length is longer

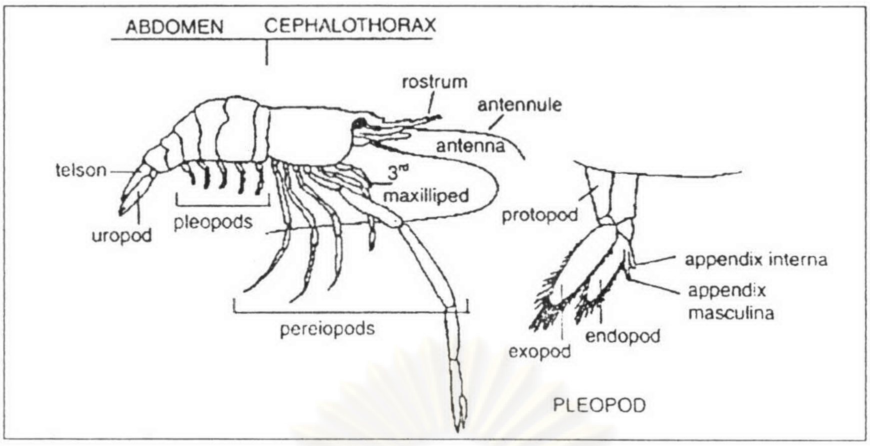
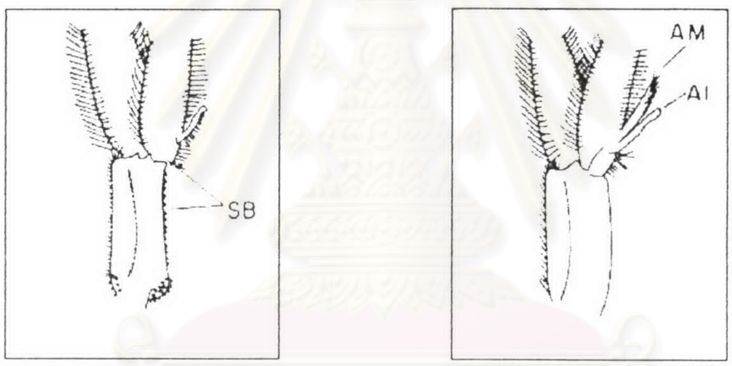


Figure 2-5. The male external morphology of *Macrobrachium rosenbergii* and details of the second pleopod (The appendix masculina)



(a) (b)

Figure 2-6. Second pleopods of sexually mature male and female *Macrobrachium rosenbergii* (a) The sexually mature female second pleopod. (b) The sexually mature male second pleopod. AM is appendix masculine, AI is appendix interna and SB is setal buds.

4. Structure of mature population

Both sexes of *M. rosenbergii* have similar size frequency distributions in populations of immature prawns (Ra'anan and Cohen, 1985). As the individual mature, the size distributions become quite different for males and females (Cohen et al., 1981).

4.1 Size distribution

The freshwater prawn *M. rosenbergii* demonstrates dramatic variation in size and growth rates of individuals soon after metamorphosis of larvae into the postlarvae form (Wickins, 1972; Foster and Beard, 1974). Although the average growth is conversely associated to density, the wide variation in growth rate is believed to be induced primarily by intrinsic factors such as genetic differences, hatching order or age at metamorphosis (Ra'anan and Cohen, 1984). Male and female prawns show the distinctly different size distribution patterns. Female prawns perform normal size distribution whereas male prawns exhibit bi-normal size distribution. The male population consists of two groups, the former is smaller than the female prawns and the latter is larger than the female prawns. Size composition of the harvested population is significant for the viability of prawn culture, since prawn prices are size dependent (Fujimura and Okamoto, 1972).

4.2 Sex ratio

In prawn populations, the proportions of female prawns were higher than male prawns, when prawn were raised in different geographical areas at a wide range of densities, in earthen ponds (Smith et al., 1978; D'Abramo et al., 1986; Karplus et al., 1986; Lin and Boonyaratpalin, 1988; Siddiqui et al., 1995). Similarly, in the progeny of five crosses between normal males and females, the higher frequency of female prawns was occurred (Melacha et al., 1992). In another hand, when determined the sex in the progeny of two normal mating of prawns as soon as plausible to identify, there was an observation of equal sex balance (Sagi and Cohen, 1990).

4.3 Male morphotypes

In mature population of prawns, it was found that there are three distinct male morphotypes, namely blue claw male (BC), orange claw male (OC) and small male (SM), as shown in **Figure 2-7**. The proportion of BC, OC and SM in adult males is 50,40 and 10 percent, respectively. They sequentially perform the normal male transformation pathway from SM to OC and OC to BC (Kuris et al., 1987; Sagi and Ra'anan, 1988; Ranjeet and Kurup, 2002).

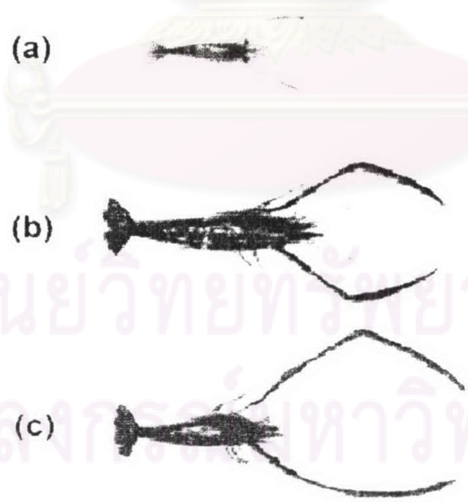


Figure 2-7. Three male morphotypes of *Macrobrachium rosenbergii*. (a) Small male (b) Orange claw male (c) Blue claw male (source: Ranjeet and Kurup, 2002)

Prawn size variation actually reflects a complex population structure, composed of three sexually mature male morphotypes. They differ in the morphology, physiology and behaviour, and transform one morphotype into another (Karplus et al., 2000). Blue claw males have extremely long second periopods (claws) that were deep blue in color (Ling, 1969). These males are dominant and territorial; sequester postmolt adult female prawns prior to mating. The orange claw males are also large, possess long claws but shorter than that of BC males. Their claws are usually orange in color. They are not territorial, have poor mating success. The remaining males are small males; they have short claws and are relatively unpigmented and translucent. They mate with females using sneak reproductive behaviour in the presence of BC males (Ra'anan and Sagi, 1985).

The midgut glands, the hepatopancreas, play a major role in food assimilation and mobilization of energy during moulting. Physiologically, it was suggested that their relative sizes are also reflect energy spent on somatic growth. The weight of midgut glands relative to body weight was found to be significantly larger in rapidly growing orange claw male than other morphotypes, while the slow growing SM and BC males had the lowest relative midgut gland weight (Sagi and Ra'anan, 1988).

5. Growth characteristics

Variation in growth of aquatic animals is also of practical interest, as it influences the harvest of fisheries and aquaculture systems. The giant freshwater prawn, *M. rosenbergii*, is particularly interesting with respect to the variation in growth and the role of size in the social structure of population. The model of growth of female prawn is quite different from that of male prawn.

5.1 Male growth characteristics

The growth of male prawns is depended on the process of morphotypic differentiation. The small male morphotype has low growth rate, while the orange claw male morphotype has a high growth rate. The orange claw males transform to the blue claw morphotype, when they exceed the largest blue claw in the population. After their blue claw morphotype transformation, the growth rate is slow, as illustrate in **Figure 2-8** (Ra'anan et al., 1991).

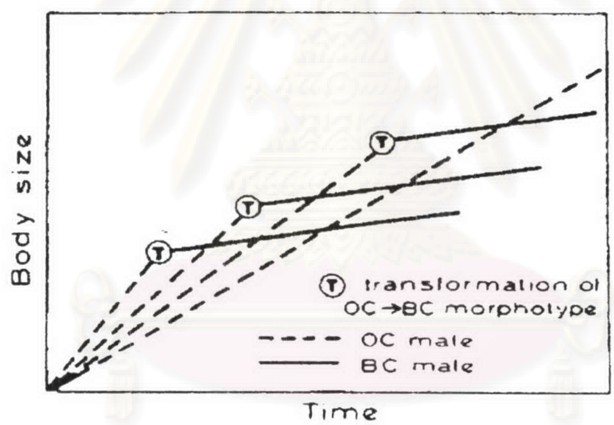


Figure 2-8. A model for relationship between maturation and growth in males (Source:Ra'anan et al., 1991)

Presumably, the large blue claw male acquire the better territories and more likely to sequester reproductive females for mating, more energy directed to fighting and guard female before mating, less energy is invested in growing. Orange clawed male, reproductive activity is low, has fast growing. Small male, the occurrence of sneak copulation with females that are guarded as part of a BC harem, more energy investment is in high mobility (Ra'anan and Sagi, 1985).

5.2 Female growth characteristics

The growth rate of immature females is relatively high. After maturation, growth slows considerably as depicted in **Figure 2-9** (Ra'anan et al., 1991). It is generally suggested that the small immature female prawns had high growth rates because more energy is invested in somatic growth; and the growth of the mature female prawns reduce during egg development, since much energy storage is converted to the oocytes development or the fertilized eggs carrying in the abdomen (Wickins and Beard, 1974).

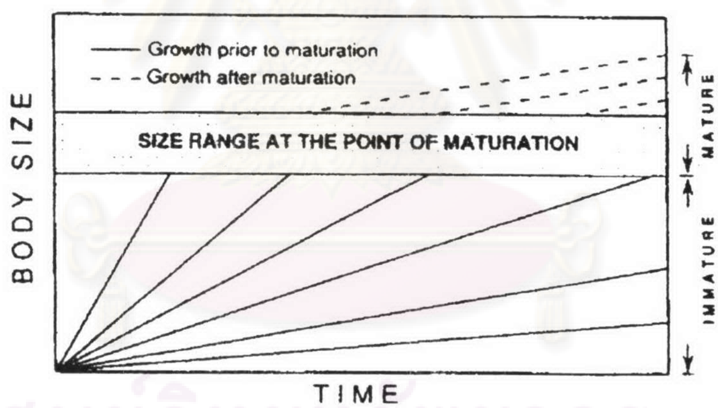


Figure 2-9. A model for relationship between maturation and growth in females (Source: Ra'anan et al., 1991)

6. Production development of size variation

Commercially, the sizes of prawns are size dependent, which strongly influence the quality and value of marketable product. For this reason, a major limiting factor for freshwater prawn culture was the prawn growth pattern and the size variation. The management of size variation of prawns was developed to reach the demand of marketable quality.

6.1 Selective harvesting

Prawns also tend to have greater size variation at harvest. The selective removal of the larger prawns is in order to manage the variable growth pattern of the prawns. The selective harvest of large prawns was considered to reduce competition for resources and promote increased growth rate among the remaining prawns (Fujimura and Okamoto, 1972). Contrarily, this method is inefficient in capturing all harvestable products in the pond at the same time. Commercial prawn populations should be optimally managed only by a complete harvest.

6.2 Monosex culture

Monosex culture of giant freshwater prawns with the only male populations produce higher yield than mixed population and all-female population. Besides, all-male group could reach the market size (≥30g) at a faster rate. The growth of female prawns is strongly inhibited by the presence of male prawns, resulting in the fact that females in the mixed group are extremely slow to reach the market size. Since a monosex culture population is inherently non-breeding, energy is diverted to growth, while female prawns in the mixed sex population convert energy directly to the fertilized egg in the abdomen about 3 weeks. (Sagi et al., 1986; Cohen, et al., 1988; Hulata et al, 1988). By contrast, the manual sexing of the monosex culture prior to stocking requires skillful workers, introduces extremely labor-intensive and is not applicable under farm condition.

6.3 Sex manipulation

The size of the prawn at harvest affects the market price. The male prawns are larger than females. They are more favorable for the farmers and much demand in the market (Sagi et al., 1986). Consequently, the tremendous potential in the farming of giant freshwater prawn probably focuses on the only male populations.

6.3.1 Androgenic gland implantation

Sex differentiation in decapods is controlled by the presence of the androgenic hormone, which induce the male characteristics. The development of the androgenic gland depends directly on male genotype (Charniaux-cotton and Payen, 1985). In *M. rosenbergii*, the androgenic gland plays a role in the regulation of male differentiation and in the inhibition of female differentiation. The ovarian differentiation of the gonadal rudiment takes places spontaneously in the absence of the androgenic hormone (Nagamine et al., 1980a; Sagi, 1988; Awari and Kiran, 1999; Sagi, 2001). In this prawn species, complete sex reversal was achieved by androgenic gland implantation into early stage immature female (Nagamine et al., 1980b). The undergone masculinized prawns prove to be capable of mating with normal female prawns and produce progeny (Sagi and Cohen, 1990; Melacha et al., 1992)

6.3.2 Homonal sex-reversal

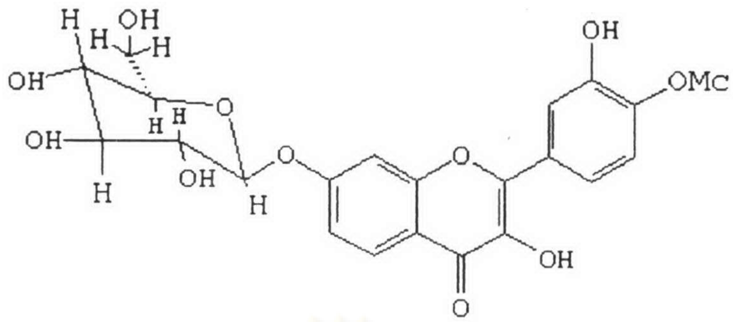
M. rosenbergii juveniles were fed hormone-free and hormone-treated diet. Methyltesterone was incorporated in the diets at 3 levels (25, 75 and 125mg hormone per kg feed) and administered 60 days. There was no growth difference in all treatment and did not achieve the expected sex-reversal (Antiporda, 1986). Fifty ppm methyltestosterone in microparticulate diet was treated to the larval prawns (7 days of age), compare to the control. After metamorphosis to be postlarval prawns, fed with particulate hormone-free diet. The result showed that 50 ppm methyltesterone in feed; and feeding it only in larval development did not resulted in sex reversal. It is suggested that effect of hormone is dose and time dependent. (Boonyaratpalin et al., 1987)

7. Kwao Krua plant

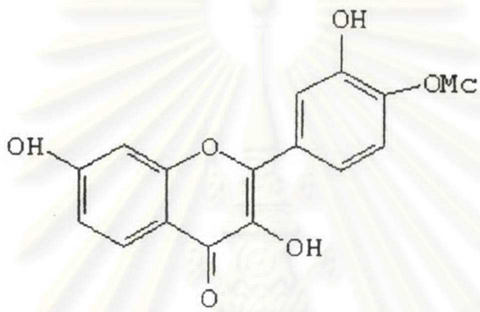
The kwao krua plants have believed as miracle herb and rejuvenating drug for a long time. There are three kinds of distinguished kwao krua plants, namely white kwao krua, red kwao krua and black kwao krua. White Kwao Krua (*Pueraria mirifica*), its tuberous root looks like a chain of round shape bulbs of various sizes connected to the next one via small root through the entire length of the root. Its crucial active compound is phytoestrogen. It is plant organic chemical which its action is the same as estrogen. The major phytoestrogen, deoxymiroestrol, acts consideribly estrogenic activity (Chansakawo et al., 2000). Black Kwao Krua (*Mucuna collettii*), the chemical constituents are Kaempferol, quercetin and hopeaphenol. They play a significant cAMP phosphodiesterase inhibitory activity. Inhibitoty concentration (IC_{50}) of kaempferol, quercetin and hopeaphenol are 281.83, 80.91 and 22.75 μg/ml, respectively. (Roengsumran et al, 2001)

Red Kwao Krua belongs to the plant in family Leguminosae, subfamily Papilionoideae, species *Butea superba*. It is chiefly found in forests of the northern and eastern regions of Thailand. It is a crawler which wraps itself around the large tree. There are tree leaves on one branch. Its flowers are yellowish oranges. The tuberous roots are long like the roots of a yam (Kruz, 1877; Brandis, 1990; Roengsumran et al., 2000; Kiratikunakorn and Pisutsin, 2001; Cherdshewasart, unpublished data). The tuberous root of *B. superba* was found to contain 5 groups of chemical constituents namely, carboxylic acid, steroid, steroid glycoside, flavonoid and flavonoid glycoside (Rugsilp, 1995). The stem of *B. superba* was found flavonoid glycoside (3,7 – dihydroxy – 4'- methoxyflavone 7 – O - α - L – rhamnopyranoside) (Yavada and Reddy, 1998)

The flavonoid (3,7,5,'- trihydroxy - 4'- methoxyflavone) and flavonoid glycoside (3,5'- dihydroxy - 4'- methoxyflavone – 7 – O - β – D – glucopyranoside) were effective in inhibiting cAMP phosphodiesterase at IC_{50} value of 190 and 58 μg/ml respectively. They stimulate the function of central nervous system and cells, induce vasolidation, increase the male sexual performance (Roengsumran et al., 2000) and improve erectile dysfunction in Thai male (Cherdshewasart and Nimsakul, 2003). In rat, feed the powder of *Butea superba* at the dose of 250 mg/kg/day was significantly increase the seminal vesicle weight and the testosterone level in serum of rats (Ketsuwan et al., 2002).



(a)



(b)

Figure 2-10. The structure formulae of chemical constituent in *Butea superba*. (a) 3,5' – dihydroxy – 4 – methoxy flavone – 7 – O - β - D – glucopyranoside. (b) 3,7,3' – trihydroxy - 4 – methoxyflavone.