Current Status of Freshwater Prawn Culture in the Mekong River Delta of Vietnam

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Abstract

The Mekong Delta of Vietnam has been well-known as a region rich in aquatic resources with a high potential for aquacultural development. The region harbors an abundance of aquatic species and a wealth of natural water bodies. Widespread commercial aquacultural development in the Mekong Delta has increased greatly starting from the last decade. In this region, the giant freshwater prawn, *Macrobrachium rosenbergii*, is a crustacean species of economic significance and a major target of aquaculture activity. *M. rosenbergii* may be cultured either semi-intensively in canals and ponds, or extensively in a manner integrated with rice farming. This species commands high market value, and its culture has the potential to raise income levels in the Mekong Delta. However, limited supply of natural seed and technological problems relating to artificial seed production are serving as constraints to the further development of this industry. The Japan International Research Center for Agricultural Sciences and Cantho University College of Agriculture are currently engaging in collaborative research relating to the improvement of seed production technology for *M. rosenbergii*. This manuscript addresses the current status of seed production and commercial culture of *M. rosenbergii* in the Mekong Delta in this context.

Additional key words: giant freshwater prawn, aquaculture, farming systems, seed production

Research background

The Japan International Research Center for Agricultural Sciences (JIRCAS) and Cantho University's College of Agriculture are presently engaged in collaborative research aiming to promote the further development of freshwater prawn culture in the Mekong Delta of Vietnam. The joint study is focused on improving existing seed production technology for the giant freshwater prawn, *Macrobrachium rosenbergii*. Under this study, current topics of research include the control of female reproduction under artificial conditions through the manipulation of environmental and nutritional parameters, and the elucidation of mechanisms of disease outbreak in hatcheries. Basic studies are being carried out on JIRCAS premises in Tsukuba and applied research is being conducted on-site in Vietnam. Up until present, there has been an exchange of personnel between Cantho University and JIRCAS in order to implement these studies.

This research is being implemented as the fisheries aspect of an international comprehensive research project between JIRCAS, Cantho University, and the Cuu Long Delta Rice Research Institute entitled "Evaluation and improvement of farming systems combining agriculture, animal husbandry, and fisheries in the Mekong Delta." The overall project, which was initiated in 1994 and is scheduled to be completed in 1999, examines how traditional practices of rice, livestock and fisheries production in the Mekong Delta have been integrated, and how these systems can be made more sustainable through technological improvement. *M. rosenbergii* culture is an important component of farming systems in the Mekong Delta, but there remain obstacles to its further aquacultural development. The information presented in this manuscript, which is a review of the current status of freshwater prawn culture in Vietnam, was surveyed in order to identify major problems for consideration in the implementation of collaborative research and to serve as general background for the project. The manuscript discusses the significance of freshwater prawn culture in the Mekong Delta, natural resources of *M. rosenbergii*, status of hatchery and commercial culture operations, and the structure of rice-prawn combined farming systems and addresses some aspects of collaborative research between JIRCAS and Cantho University in this context.

Aquaculture in the Mekong Delta

The Mekong Delta of Vietnam possesses more than four million hectares of natural land area, of which water bodies excluding rivers comprise 954,350 ha. Of total water area, freshwater bodies total 641,350 ha or 67.2% of total water surface, and brackish water areas comprise 313,000 ha[18]. The flat lowland, moderate climate, and rich natural aquatic resources of the Mekong Delta provide favorable conditions for agricultural and aquacultural development in the region[10]. Freshwater aquaculture farming practices have been applied in the Mekong Delta since the early 1960's, but widespread commercial development has become more active only in the past decade. Aquaculture is either integrated with other farming enterprises such as in rice-fish, rice-prawn, orchard-fish, or orchard-prawn combined farming systems, or is implemented on a mono-culture basis, in ponds or in garden canals. Several species of fish, including common carp, tilapia and silver barb are cultured in the Mekong Delta. Among crustacean species, the giant freshwater prawn, *Macrobrachium rosenbergii* (Fig. 1), is widely targeted in freshwater areas.

M. rosenbergii is a commercially important freshwater prawn cultured extensively throughout Southeast Asia. In Vietnam, the annual production of this species varies between 5,000 to 8,000 tons[8]. However, these production statistics are based on total harvest from both aquaculture and conventional fishing activity, with actual production due to aquaculture estimated around 2,000 tons. Compared to an annual production of 50,000 tons of the saltwater species, *Penaeus monodon* or black tiger prawn[1,11], production of *M. rosenbergii*

Fig. 1. Photograph of *Macrobrachium rosenbergii*. *M. rosenbergii* is primarily a freshwater prawn species distributed throughout Southeast Asia. Adult prawns are usually harvested at a size of 30-100 g in the Mekong Delta, although larger individuals are also common. The photograph shows a prawn of about 35 g in body weight measuring 20 cm in total body length (from claws to tail).

appears extremely low. The Vietnamese Government is aiming to promote the culture of this species because of its high export value and potential to raise income levels of farmers in the Mekong Delta.

At present, *M. rosenbergii* culture in the Mekong Delta is mainly dependent on prawn juveniles collected from natural water bodies. Most farmers stock prawns at low density; thus, productivity is typically low, about 250-300 kg/ha in ponds and 150-180 kg/ha in rice-prawn systems[5,20]. Much of the culture of this species occurs in the Phung Hiep District of Cantho Province[12], and several districts in Angiang, Tiengiang and Vinhlong and Travinh Provinces[8].

Natural distribution of freshwater prawn species

Freshwater prawns of the *Macrobrachium* genus are observed worldwide. Such prawns have recently become more important as target species in the prawn-exporting countries. According to Thuong[17] and Duc[4], among nine species of freshwater prawn, *M. rosenbergii* is the largest in size. In Vietnam, this species is distributed from Nhatrang to the South, and is found mostly in the certain provinces including Cantho, Vinhlong Travinh and Soctrang[14]. Fig. 2 shows the natural distribution of *M. rosenbergii* in the Mekong Delta.

The yield of wild prawn based on conventional fishing changes throughout the year. Two periods of high prawn yield are normally observed from April to June and from August to October. The highest annual production level of *M. rosenbergii* (including cultured and exploited prawns) in the south of Vietnam was 10,140 tons in 1984[13]. The lowest yield of 5,720 tons was observed in 1989[14].

In the Mekong Region, *M. rosenbergii* appears to reproduce all year round, but major peaks occur between April and June and between August and October. According to observations up to now, productivity ranges from 5,376 to 161,520 eggs per gravid female. Egg mass size is about 7.5-8.2 g per prawn, and egg diameter ranges between 0.37 to 0.51 mm[13]. There is much diversification of body size among natural prawn populations. It is generally observed that the size of wild harvested prawn ranges from 20 to 40 g (52% of the population). Among farmed prawns smaller than 40 g, females are dominant (69% of individuals), while among larger-sized animals (80 g), males comprise 67%[14].

Status of hatcheries and commercial culture operations

Prior to 1975, *M. rosenbergii* natural populations were at high levels, and yields from natural sources were sufficient to support market demand. Therefore, aquaculture was not necessary to supplement overall production, and thus, stocking/culture activities did not commence on a standard basis until the early 1980's. At this time, some farmers began stocking juvenile prawns in ponds and rice fields, with the practice becoming more wide-spread in subsequent years.

At a current market price of ten dollars per kilogram, *M. rosenbergii* is a high-priced species with sufficient potential to raise income levels of those engaging in its culture. Income levels per capita in the Mekong Delta vary with province, but a value of 130 to 200 dollars per year may be fairly

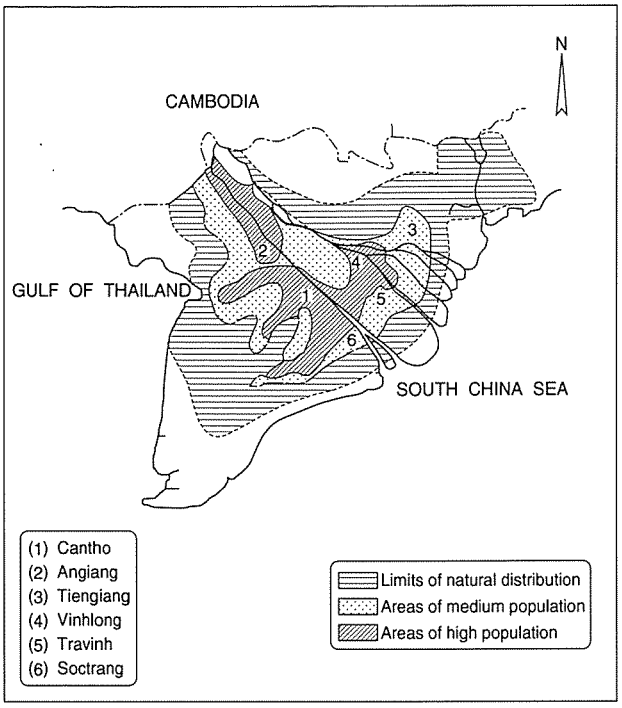

Fig. 2. Distribution of *Macrobrachium rosenbergii* populations in the Mekong Delta (redrawn from Thang, 1993). *M. rosenbergii* is found in most freshwater areas of the Mekong Delta, but populations are especially concentrated in central regions of the Delta. Horizontally-shaded areas show limits of natural distribution, while dotted areas and diagonally-shaded areas show areas of medium and high populations, respectively. Numbers indicate approximate locations of provinces where *M. rosenbergii* is found.

typical[3]. Against this background, many prawn farmers are earning from up to 1000 dollars per year in terms of net income[6,22]. This section discusses the current status of prawn seed supply and production, and how commercial culture is practiced in the Mekong Delta in context of semi-intensive culture and integrated farming systems.

a. Sources of juveniles: wild vs. artificial

Much of the commercial culture of *M. rosenbergii* is dependent on juvenile prawns collected from natural sources. Fishing gear such as brushwood, stow nets, straw nets, or shelter traps are commonly used for obtaining juvenile prawns. Brushwood gear consists of a bundle of tree branches placed in the river, in which juvenile prawns are entrapped (Fig. 3a). Stow net gear consists of a net placed across the river in a zig-zag fashion (Fig. 3b), while straw net gear consists of an enclosed net which is pulled by a boat (Fig. 3c). Shelter traps are square-shaped structures consisting of bamboo frames enclosed with netting (Fig. 3d). These are placed along the edges of rivers, and are periodically checked for prawn juveniles trapped inside[8]. The size and quality of obtained juveniles often differ according to fishing gear, and may range between 3 and 10 g. At present, the supply of natural freshwater prawn seed does not satisfy farmers' needs in terms of quantity and quality.

For the above reasons, the production of cultured freshwater prawn has been reduced while the demand for cultured products has increased. Therefore, it is considered increasingly necessary to provide a stable supply of artificial freshwater juveniles for aquaculture purposes. There still remain, however, many technical difficulties in providing sufficiently high quality artificially-produced juveniles for commercial culture operations. Artificial prawn seed which is currently produced is very limited in use because of its small size; this necessitates a longer culturing time to

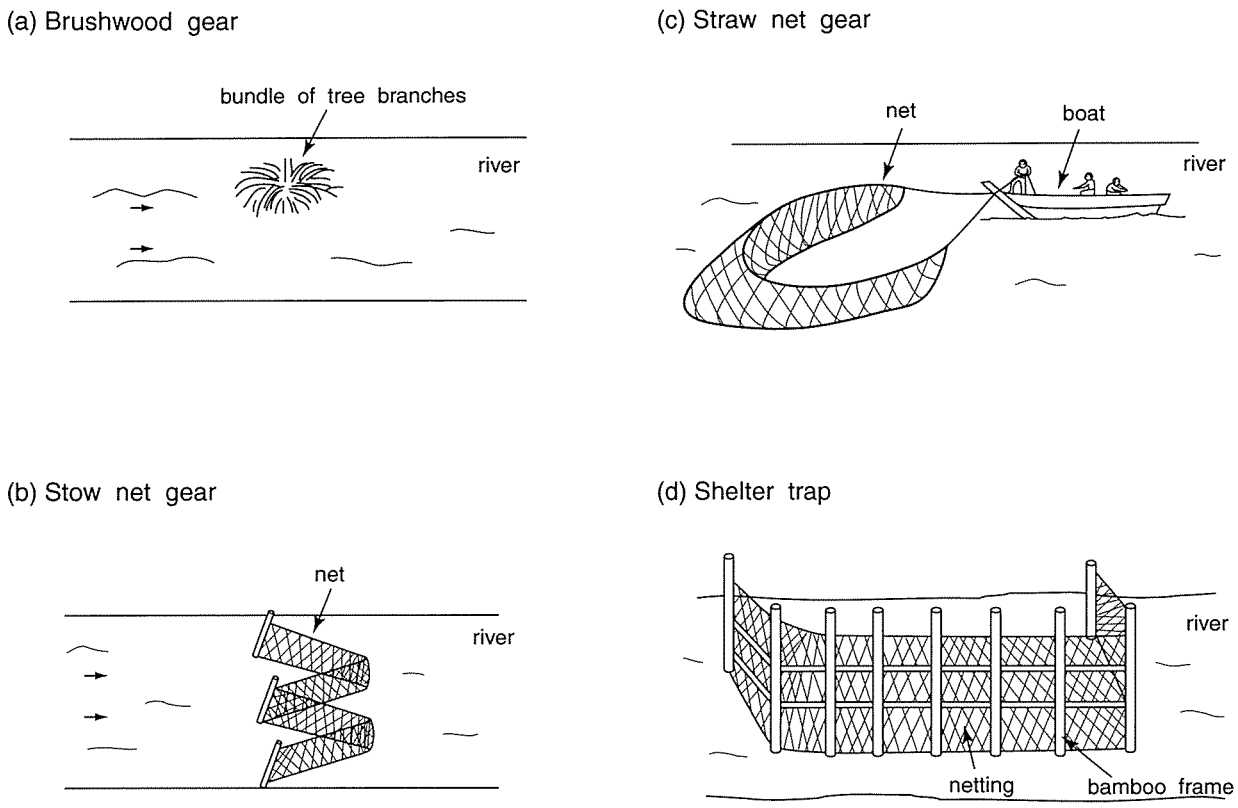

Fig 3. Schematic diagrams of fishing gears used for obtaining juvenile *Macrobrachium rosenbergii*. (a) Brushwood gear. (b) Stow net gear. (c) Straw net gear. (d) Shelter traps. The size and quality of obtained juveniles often differ according to fishing gear, and may range between 3 and 10 g. More detailed explanations are given in the text.

reach market size. Furthermore, the costs of buying artificial seed are high, and this is not acceptable to many farmers.

In order to solve some of these problems, and meet the culturists' needs for prawn seed, several Vietnamese universities and government research institutes have carried out experiments to propagate *M. rosenbergii* in a hatchery situation. Although adult *M. rosenbergii* dwells primarily in freshwater areas, it migrates to brackish water for purposes of spawning; newly-hatched larvae require a certain degree of salinity for survival[9]. Therefore, hatchery techniques necessitate the use of brackish water, and there are different strategies for utilizing brackishwater in hatchery operations. Along these lines, three basic types of water maintenance systems have been examined by the Research Institute for Aquaculture No. 2 (RIA2), Ministry of Fisheries for application in the Mekong Delta: a) green-water system; b) clear-water recirculation system, and c) clear-water open system. In system a), larval-rearing water has an induced density of green planktonic algae, which helps to control blooms or organisms harmful to prawn larvae, and also acts as a buffer against ammonia build-up. System b) involves the use of biological filtration to conserve water and energy. This system, which is a closed system, is suitable for hatcheries located away from the coastline, or when supplies of brackish water are limited. Finally, in system c), larval-rearing water does not contain green algae, and daily exchange of water, temperature control, and water chlorination are practiced.

In early work on water maintenance systems, results were limited and survival rates were very low. The work of Khoan in the early 1980's[7] using a green-water system exhibited positive results. Thang working in the late 1980's to the early 1990's[14,15] also received favorable results but cited difficulties with this procedure relating to (i) culturing algae and maintaining *Chlorella*, (ii)

controlling water environment, and (iii) controlling disease. A clear-water recirculation procedure (closed system) which was applied with a $7m^3$ tank at the Vungtau Giant Freshwater Prawn Hatchery in 1987[15] achieved a 36% survival rate. This procedure requires high-level techniques, modern equipment and good managerial skills. For these reasons, it is difficult to apply this system broadly in the Mekong Delta. Thereafter, a clear-water open system was tested experimentally from 1984 to 1989[16]. The advantages of this system are that it is easy to operate, allows high rearing density, and provides high yields. However, a large amount of water and labor input is needed.

The Vungtau hatchery, located southeast of Ho Chi Minh City, is the first hatchery for *M. rosenbergii*, and was built by the Mekong River Commission and the Vietnamese Government. Construction was completed in 1987, and this hatchery thus became the largest station in the region. The main production procedure applied in this hatchery is the clear-water open system, which appears to be a suitable procedure for the Mekong Delta, especially near coastal zones. There are four other national hatcheries for *M. rosenbergii* in Vietnam: Nhabe outside of Ho Chi Minh City, Gocong in Tiengang Province, Long My in Cantho Province, and Travinh in Travinh Province. The Long My hatchery is the newest of the five and is still under construction. Annual production capacities for these national hatcheries range from 4,000,000-5,000,000 post-larvae per year for the Vungtau and Nhabe hatcheries, and 2,000,000 to 3,000,000 post-larvae per year for the other hatcheries; however, most hatcheries are not operating at full capacity due to low survival rates and technical constraints, which include securing good-quality broodstock and controlling the outbreak of disease. There is, however, a demand for artificially-produced seed; thus it is urgent to improve quality and decrease price, so that culturists will not have to depend on wild juveniles.

One of the major obstacles in securing a stable source of broodstock relates to the control of maturation of the female under conditions of captivity. In the wild, female prawns do not usually become gravid until reaching a size of 20-40 g. Eggs obtained from these females are usually of good quality and provide high survival rates after hatching. However, females of hatchery origin which are cultured as broodstock often begin carrying eggs very early, even at a size of 7-10 g. This leads to eggs and larvae of poor quality, and over successive generations, females mature even more precociously. Thus, at present, in hatchery operations, it is necessary to use broodstock collected from nature (20-50 g individuals are mostly used). Resources for spawners are declining due to over-exploitation, and the dependence of such wild broodstock in hatchery operations is limiting the ability of hatcheries to meet the needs of the aquaculture industry.

Research between JIRCAS and Cantho University is examining how rearing conditions in the hatchery may contribute to precocious reproductive development in female *M. rosenbergii*. Preliminary work has focused on the effects on reproduction and growth of typical feeding regimens practiced in the Mekong Delta, and has revealed that manipulation of fatty acid and essential amino acid (EAA) contents in the diet can be used to control growth and reproductive development (Hien et al., in preparation). In this study, artificial pellets, which are used by some farmers, had high contents of lipids which are known to promote ovarian development, while trash fish had high contents of EAA's, particularly lysine, which promote growth. In a second phase of these joint studies, the effects of water quality, temperature and salinity will be examined. In addition, basic studies at JIRCAS are being conducted to elucidate the physiological mechanisms of reproduction in *M. rosenbergii* in parallel to on-site studies in Vietnam. In particular, research at JIRCAS is being focused on the hormonal control of vitellogenin (yolk-protein) synthesis and uptake in relation to ovarian development[23] and mechanisms of osmoregulation in relation to salinity adaptation[24].

Regarding disease, bacteria-related diseases

caused by *Vibrio* sp. are frequently a cause of mass mortality in the hatcheries, and such outbreaks seriously hamper the ability of a hatchery to provide a stable supply of juvenile prawns. However, very little is know concerning such mechanisms of disease outbreak and only a small amount of relevant literature is available. JIRCAS and Cantho University have also initiated research in this area as it relates to improving seed production technology. Experimental studies are being conducted at the Long My Hatchery in Cantho Province. Other types of disease, such as viral infection which occurs frequently in saltwater species such as *Penaeus monodon* and *P. japonicus*, has not been observed in *M. rosenbergii*. Disease outbreak is generally confined to the hatcheries, and is ordinarily not a problem in culture operations. However, it is sometimes observed that prawns under culture are infected by filamentous algae, and are prevented from undergoing normal molting and development. This is mainly seen under stagnant water conditions and is caused by the internal accumulation of wastes in the culture pond.

b. Forms of commercial culture: semi-extensive culture and combined farming systems

At present, there are two farming types for culturing *M. rosenbergii*: in ponds and garden canals (semi-extensive) and in rice fields (extensive). In addition, there exists a more traditional form of culture, "fence culture," which will be discussed at the end of this section. In semi-extensive culture, ponds and canals on agricultural homesteads are cleared of debris and silt prior to stocking. Stocking density in this type of culture is about 4-6 juveniles/m^2. Available agriculture by-products and home-made feed, consisting of trash-fish, rice bran and vitamin supplements, are used to feed the prawns. Average yield in this system is about 300-500 kg/ha. However, higher yields are possible; experiments in 1980-1982 showed that when stocking 5 g juveniles for 5 months using home-made feed, the total prawn harvest was 600-750kg/ha[19]. Some farmers have applied polyculture of freshwater prawn and silver barb and obtained production levels of 2,100-3,000 kg of prawn and fish per hectare per year. However, this type of culture is not spreading because of the highly intensive level of capital required (construction costs, juvenile costs, feed and water supply/drain system required) and the necessity for workers with better management skills.

The culture of freshwater prawns in the rice field has become familiar to farmers in the Mekong River Delta. A typical rice-prawn farm in the Mekong Delta is shown in Fig. 4a. This type of culture is extensive, and is classified as a type of combined farming system, often referred to as "rice-prawn." In rice-prawn farming systems, farmers make use of canals surrounding their rice fields for prawn culture. Canal area generally covers about 15-20% of total area of the rice field. Water levels are ordinarily controlled in the range of 1-1.2 m in depth in the canal and 0.2-0.3 m depth on the rice field. During the wet season, 0.5-0.6 m water depth can be reached on the rice field. A schematic drawing representing this farming type is depicted in Fig. 4b. Juveniles are stocked often at a size of 5-10 g with a stocking density of 0.5-2 individuals/m^2. Stocking activities are often done from December to February. Most of the farmers do not provide feed to the prawns. Prawns are allowed to feed mainly on natural feeds occurring in the rice fields[21]. Some farmers, however, use agro-byproducts for prawns such as rice bran, broken rice, cassava, and coconut pulp. Feeding frequency is usually once per day and the feeding level is based on 1-3% of total estimated biomass of the prawns. However, this level of feed seems to be insufficient for this type of system[2].

The culture period in rice-prawn systems varies from 4 to 6 months depending on farming practices and available capital of the farming households. Prawn yield differs from place to place within a specific region. For instance, in the Thotnot District of Cantho Province, average production reaches 268 kg/ha. In Phunghiep District also in Cantho Province, production is about 100-200 kg/ha. Rice-prawn integrated

Fig. 4. (a). Rice-prawn farm in the Phunghiep District of Cantho Province, Mekong Delta. Rice-growing sections are surrounded by canals which have been prepared for the culture of *Macrobrachium rosenbergii*. Prawns are fed daily with agro-byproducts as described in the text and are harvested after 4 to 6 months. Vegetable crops are often grown on the canal dikes. In this farm, a bamboo structure which is used to support cucumber vines is seen extending from a dike (center of photograph).

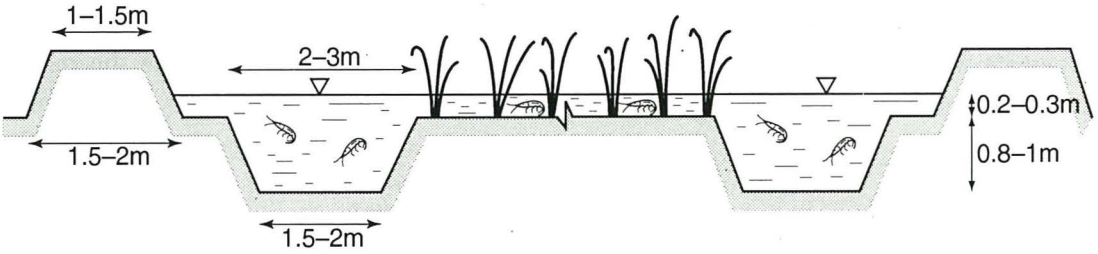

Fig. 4. (b). Transect drawing of a rice-prawn field. Canals surrounding the rice field are prepared as described in the text. Prawns are stocked in the canals, but can also be found within the rice fields as well.

farming systems have been indicated to be more effective in terms of rice production, than is mono-rice culture. In order to further increase the effectiveness of this system, farmers need to improve integrated farming techniques in their fields. *M. rosenbergii* is considered to be a suitable species for use in commercial polyculture. Farmers are trying to stock many species of fish including silver carp, tilapia, and common carp in their rice fields[21].

In addition, in the up-stream area of the Delta which belongs to Dong Thap Province, traditional "fence culture" is conducted during the flooding months. Farmers use barrier-nets made from bamboo to encircle specific areas and some prawns are trapped inside. Water is exchanged by the flows of flooding water. Prawns are fed based on natural sources of feed only brought in by water flows. Stocking density is about 20-30 individuals/m^2, and stocking size is 5-10 g; stocking period depends on flooding duration. Farmers can harvest approximately 1,000 kg/ha. However, this culture method is rarely seen now to the decreasing supply of natural prawn juveniles.

Conclusions

Current problems

Currently, the major problems encountered by farmers engaging in freshwater prawn culture can

be summarized as follows:

1. The most significant obstacle in establishing sustainable freshwater prawn culture is the decrease of seed supply due to the over-exploitation of natural resources. Moreover, artificial seed production is still not successful and can not meet the needs of the industry in terms of quality and quantity.
2. Disease is another major concern. Bacterial disease caused by *Vibrio* sp. is a major cause of larval mortality in hatcheries and is in obstacle to establishing a means of stable seed production.
3. Technical knowledge of farmers engaging in prawn culture is still at a low level. Most farmers culture this species based on their own experience and empirical knowledge obtained from other farmers. The low quality of feed and seed can also be considered as underlying problems which bring about low growth rates and large differences among prawn populations.

Focus for future work

In order to address the above problems, it is considered important to conduct basic studies which focus on how to improve artificial seed production of the giant freshwater prawn, aiming to increase quality and decrease price. More knowledge of basic physiology of *M. rosenbergii* and nutritional requirements are necessary in order to effectively control growth and reproduction under artificial conditions, and a better understanding of disease outbreak mechanisms in the hatchery is essential to increase larval survival rate. JIRCAS and Cantho University are currently addressing these areas through cooperative research. In addition, it is also necessitated to 1) improve nursery techniques for artificial juvenile prawns in order to provide larger, healthier juveniles for stocking activities; 2) improve feed technology based on the use of available agricultural by-products so that farmers can lower their costs of conducting prawn culture, and 3) develop a means of transferring new technical knowledge to farmers.

The overall production of cultured freshwater prawn still remains low in Vietnam, but this industry is considered to have a great deal of potential for further development if many of the current problems can be solved. *M. rosenbergii* is a desirable species which commands a high market price, and has already been seen, its culture has contributed to raising farmers' incomes in the Mekong Delta.

Acknowledgments

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ベトナム・メコンデルタにおける淡水エビ養殖の現状

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摘　要

ベトナムのメコンデルタは広大な平坦地とメコン河の豊富な水資源及び安定した熱帯性気候を有し，生物的生産が高い。水産養殖は昔から伝統的な方法で行われており，大規模な魚介類養殖は1980年代から積極的に始められた。養殖されている種類の中では淡水性の大型エビであるオニテナガエビが有望である。オニテナガエビは高価であり，水田を用いて稲の栽培と同時に養殖できるなど，農業との組み合わせが容易である。このため，メコンデルタの農家にとって淡水エビを養殖することにより生活水準を上げることができると期待されている。しかし，養殖の普及に伴って天然種苗の資源が不足してきており，人工種苗生産技術が未だ困難であることは，淡水エビ養殖のさらなる発展・普及の障害となっている。現在，国際農林水産業研究センターはカントー大学農科大学と国際総合プロジェクト「メコンデルタにおける農畜水複合技術体系の評価と改善」の一環としてオニテナガエビ種苗生産技術を改善するための共同研究を実施している。

キーワード：オニテナガエビ，水産養殖，ファーミングシステム，種苗生産