DEVELOPMENT OF FRESHWATER PRAWN *(Macrobrachium rosenbergii)* SEED PRODUCTION AND CULTURE TECHNOLOGY IN THE MEKONG DELTA REGION OF VIETNAM: A REVIEW OF THE JIRCAS PROJECT AT CANTHO UNIVERSITY

Marcy N. Wilder and Hiroshi Y. Ogata
Japan International Research Center for Agricultural Sciences
Tsukuba, Ibaraki 305-8686, Japan

Nguyen Thanh Phuong, Nguyen Anh Tuan, Tra Thi Thanh Hien, And Tran Ngoc Hai
College of Aquaculture and Fisheries,
Cantho University, Cantho City, Cantho Province, Vietnam

SUMMARY

The Mekong Delta of Vietnam is a region rich in aquatic resources having high potential for aquaculture development. Inland aquaculture in the Mekong Delta has greatly increased since the last decade. Fish culture carried out in combination with other agricultural activities such as animal husbandry and rice cultivation, and intensive aquaculture in ponds and cages have been the dominant forms of fish production. However, the giant freshwater prawn, *Macrobrachium rosenbergii*, has recently become a species of economic significance and the target of aquaculture activity in the Mekong Delta. *M. rosenbergii* is cultured throughout the region in the rice fields, ponds, orchard gardens and in pens along river banks. The major constraints in this industry are seed supply and culture techniques, becoming the major obstacles for the further development of the culture of this species.

In a collaborative research project implemented between the Japan International Research Center for Agricultural Sciences (JIRCAS) and Cantho University (CTU) since 1994, studies have been carried out on various aspects relating to the establishment of *M. rosenbergii* seed production and culture technology. The project is now in the middle of its second phase and has generated a great deal of scientific and practical information. This paper presents an overview of the achievements of this project.

INTRODUCTION

The Mekong Delta in the southern part of Vietnam covers 12% of the total area of the country and has great potential for increased agricultural and aquaculture production. The Delta possesses more than four million ha of natural land area, of which about 2.4 million ha are utilized for agriculture and aquaculture (NEDECO, 1991). The area of freshwater bodies total 641,350 ha or 67.2% of total water surface, but freshwater surface is usually enlarged by up to 1.7 million ha during the flooding period (Sam, 2001 and Dien and Anh, 2001).

The Mekong Delta is by far the most productive region having the highest potential for freshwater aquaculture development in Vietnam due to its favorable environmental conditions. Thus, most of Vietnam's freshwater aquaculture production occurs in this region. The major species cultured in Mekong Delta include Chinese carps and catfishes of the *Pangasius* genus.

However, a new important species in freshwater aquaculture is the giant freshwater prawn, *Macrobrachium rosenbergii*, pinpointed as one of the major target species of the aquaculture sector (Ministry of Fisheries, 1999). *M. rosenbergii* is naturally distributed in the Mekong Delta. In the past years, the natural yields of prawn seeds were sufficiently high, but recently, there has been a decline from natural resources. Thus, the Ministry of Fisheries of Vietnam has targeted the annual production of *M. rosenbergii* to be 60,000 mt utilizing 32,000 ha by the year 2010 (Decree No. 224/1999/QD-TTg.).

Additionally, the Vietnamese Government has also implemented a new policy known as the "restructuring of agricultural production and its products consumption" (Decree No. 09/2000/NQ-CP) allowing the conversion of unproductive rice land to aquaculture production, making the culture of *M. rosenbergii* more important to the nation's fisheries industry. The existing culture systems of *M. rosenbergii* include improved-extensive culture in rice fields, and semi-intensive and/or intensive culture in ponds, orchard canals and pens.

Before 2000, most of the commercial culture systems depended on juvenile prawns collected from natural water bodies, and for this reason, the freshwater prawn culture remained fairly underdeveloped. Initial studies relating to seed production for *M. rosenbergii* in Vietnam started in the early 80s, being pursued by scientists at various universities and research institutions (Hien et al., 1998). These endeavors resulted in various degrees of success, however, the mass production of *M. rosenbergii* seed remained difficult until the end of 1990s.

Recognizing this problem as a major limiting factor on the development of *M. rosenbergii* culture in the Mekong Delta, JIRCAS and Cantho University initiated a collaborative research in 1994, by examining the factors affecting the reproductive development of *M. rosenbergii,* and expanding this to a wider range of studies including larval rearing, feed development for larval and grow-out stages, larval diseases, culture in rice fields and orchard canals, and finally, technology transfer.

After about seven years, the project has achieved many significant results and has contributed greatly to the establishment of sustainable technology for freshwater prawn seed production, and this in turn is allowing the expansion of prawn-rice farming in the Mekong Delta region.

SEED PRODUCTION STUDIES

In order to establish appropriate seed production technology for *M. rosenbergii*, a number of studies have been conducted at JIRCAS and at the Cantho University. These include the following:

Basic studies on reproduction and osmoregulation

Studies at JIRCAS's Tsukuba, Japan premises have focused on the elucidation of reproductive and osmoregulatory mechanisms in *M. rosenbergii* with the aim of addressing problems related to broodstock development and larval rearing under captive conditions. In Vietnam, one of the major obstacles in securing a stable source of broodstock is poor maturation rate of the female prawn in captivity. In the wild, female prawns do not usually become gravid until 20-40 g. Eggs obtained from these females are of good quality and provide high survival rates after hatching. However, the females cultured as broodstock begin carrying eggs very early, even at 7-10 g. This leads to poor quality eggs and larvae, and over successive generations, females mature even more precociously.

Thus, in hatchery operations, it is necessary to use broodstock collected from nature (20-50 g). As a result, resources for spawners have declined due to over-exploitation, and the dependence of wild broodstock in hatchery operations had limited hatchery production of seeds needed for the prawn culture industry.

Given this background, in order to select suitable female spawners for purposes of seed production, JIRCAS and Cantho University have developed jointly a technology "A process for determining maturity by using anti-serum against shrimp egg yolk protein", which is currently submitted to the Japan Patent Office (JPO).

This technology has been developed based on studies elucidating yolk protein structure in *M. rosenbergii* and other economically significant species of shrimp. At JIRCAS, and also in collaboration with the University of Tokyo, the full amino acid sequence of yolk protein in *M. rosenbergii* and *P. japonicus* have been determined and found that a high degree of identity exists between the two species (Tsutsui et al., 2000; Okuno et al., 2002).

Other studies at JIRCAS on the coonstriped shrimp (Tsutsui et al., 2002) and those by other authors have further demonstrated that common features exist among yolk proteins in various shrimp and prawn species; and on this basis, it has been possible to develop a means of detecting yolk protein in the hemolymph of all useful species targeted for aquaculture. The project in Vietnam is now testing this technology in order to improve the current methods of seed production that have been developed.

M. rosenbergii is a freshwater prawn, but since its larvae require brackishwater for survival, hatchery operations are usually conducted using 12 parts per thousand (12 ppt) salinity. A number of studies have been conducted by JIRCAS on osmoregulation in adults, and found that this species regulates its hemolymph osmolarity to be equivalent to that of brackishwater (12 ppt or 450 mOsm). In both freshwater and brackishwater, *M. rosenbergii* is able to maintain hemolymph osmolarity (based on ionic and free amino acid concentrations on the hemolymph), but at higher salinities, the prawn loses this ability (Wilder et al., 1998; Huong et al., 2001).

Current studies are focusing on osmoregulatory mechanisms during the larval stages. It has also been recently found that Na/K-ATPase concentrations increase rapidly at the beginning of larval development, but decrease to low levels thereafter, suggesting that the enzyme is most necessary when the larvae makes the transition from being in the closed environment of the egg to a free-swimming larvae. During its early development, 12 ppt salinity is required for 100% survival of larvae, but mid-way through the developmental period which is about 25 days, the larvae acquire the ability to survive under 6 ppt salinity, concurring with decreases in Na/K-ATPase activity (Huong, et al., 2002). This result is now being tested for possible application to improve seed production techniques, because the decrease in salinity would mean reduced labor input and costs.

Studies on larval rearing utilizing the improved static green water model ("green water" model)

Studies on larval rearing in this project were initially based on the concept of the "green water" model, which was developed by Ang and Cheah (1987) in Malaysia. An initial study was conducted to confirm if the "green water" model is applicable to the local conditions of the Mekong Delta, and whether it is easily transferable to the users. This was conducted as a comparative experiment between the "re-circulating water" and "green water" models.

The results of the study showed that the "green water" system provided more satisfactory results than did the "re-circulating water" system. Stocking densities of 60 to 120 larvae/l were recommended for both models, but the "green water" model yielded more post-larvae (PL) per liter, varying from 32.3-46.4 PL/l compared to 28.8-31.7 PL/l for the "re-circulating water" model. Moreover, the "green water" model requires less labor and is easier to implement in the "back-yard" hatchery facilities that are likely to be adopted by farmers engaging in prawn-rice culture (Table 1).

An experiment on diets for prawn larvae showed that larvae fed a custard diet formulated from chicken egg yolk (14 g); milk powder (10 g) and 2% fish oil provided the most satisfactory results in terms of survival rate and number of post-larvae produced per liter (Table 2). This diet has been proposed for use in the commercial prawn hatchery.

Table 1. Survival rates of larvae and final number of post-larvae (PL) produced under the "re-circulating water" and "green water" systems

Treatment	PL Density	Survival rate (%)
"Re-circulating water" system		
30 larvae/l	19.5	52.5
60 larvae/l	18.6	28.8
90 larvae/l	28.4	31.7
120 larvae/l	32.9	27.4
"Green water" system		
30 larvae/l	27.7	92.3
60 larvae/l	27.8	46.3
90 larvae/l	41.7	46.4
120 larvae/l	38.8	32.3

Table 2. Effects of different diets on larval survival rate and final number of post-larvae produced

Diets	Survival rate (%)	Post-larvae/liter
1	19.5 ± 1.6^{a}	11.7
2	64.4 ± 5.6^{b}	38.7
3	77.4 ± 19.6^{b}	46.4
4	0^{c}	0

Diet 1: *Artemia* nauplius; diet 2: chicken egg yolk (14 g), milk powder (10 g), shrimp meat (10 g), squid (10 g), pig liver (10 g) and 2% fish oil; diet 3: chicken egg yolk (14 g), milk powder (10 g), and 2% fish oil; and diet 4: commercial pellets. Values on the same column having differing superscripts significantly differ at $p<0.05$.

Moreover, the selected diet was further improved by the supplementation with vitamin C and lecithin. The results of these studies showed that both vitamin C and lecithin could enhance the survival rate, number of post-larvae produced and the quality of the post-larvae.

Based on the results and the experience of Cantho University counterparts in the field, a modified static "green water system" suitable for the conditions of seed production in the Mekong Delta was developed. In this system, super-saturated seawater from salt fields in the southernmost coastal parts of the Mekong Delta and freshwater are mixed in appropriate quantities to obtain the desired salinity concentration, and the water is treated for several days with chlorine.

In order to create "green water", tilapia is stocked for a week in a separate tank, creating an environment where planktonic algae bloom and the water turns green. *Chlorella* is obtained selectively by filtration, and the water is then transferred to tanks for prawn seed production. After the prawn larvae hatched, they are reared for about 30 days without water exchange until the larvae metamorphose into post-larvae. *Artemia* and handmade custard are provided to the prawn larvae, but the algal blooms serve as a bio-agent that stabilizes the environment in the culture tanks.

Transfer of seed production technology

Until the beginning of 2000, the supply of hatchery reared *M. rosenbergii* was not sufficient to meet the growing needs of commercial prawn culture industry. Although several national large-scale hatcheries had previously been established, such as the Long My Hatchery of the Cantho Province, the Vung Tau Hatchery of the Research Institute of Aquaculture No. 2, and the Nha Be Hatchery of the Ho Chi Minh City, these had been operating unsuccessfully (Hien et al., 1998; Phuong, 2001).

With the results of the studies between Cantho University and JIRCAS, a great deal of valuable information is now available for the establishment of effective *M. rosenbergii* seed production technology utilizing the "green water" model. Since the beginning of 2000, the "green water" model has been introduced to various users (including the provincial authorities and the private sector), and the number of hatcheries and quantity of post-larvae produced, have increased rapidly. According to Phuong and Hai (2002), the production of post-larvae reached over fifty million by the end of 2001 or about 50-fold compared to the 1990s. The transfer of the "green water" model has been accomplished in two different ways. The first was the "transfer of the whole package" (training, establishment and operation of the hatchery) and practical training. This option was made available only for provincial hatcheries.

The second option is available for private users. As of mid-2002, the "green water" model has been transferred to eleven state-run hatcheries in different provinces of the Mekong Delta, and Cantho University staff trained 108 persons in the Mekong Delta and in a few provinces of central Vietnam (Table 3). Of these 108 persons, 83 individuals have set-up small-scale hatcheries throughout the Mekong Delta and Vietnam (utilizing 10-20 cm of rearing water) based on the "green water" model. These hatcheries are now contributing to meeting the demands of prawn seeds for use in aquaculture in Vietnam.

Table 3: Numbers of prawn hatcheries established in different locations in Vietnam

Province	State-run hatcheries	Private hatcheries
Mekong Delta region		
Ben Tre	1	5
Dong Thap	1	7
Vinh Long	1	1
Ca Mau	1	3
Tra Vinh	1	3
Kien Giang	-	6
Long An	1	2
An Giang 1	11	
Tien Giang	1	4
Cantho	1	25
Soc Trang 1		
Other regions		
Ho Chi Minh City	1	2
Binh Thuan	-	3
Total	**11**	**72**

The transfer of the technology has been funded by various Vietnamese institutions including the National Aquaculture and Fisheries Extension Center of the Ministry of Fisheries, the Provincial Department of Fisheries, the Provincial Department of Science, Technology and Environment, and by the farmers themselves. The JIRCAS project is also facilitating the rapid transfer of the technology and is preparing for the publication of a manual on prawn hatchery operation and management practices based on the "green water" model.

In addition, a CD is also being produced to accompany the manual. Interested persons will be able to access these materials through the Cantho University or at bookstores. In only two years, the transfer of prawn larval rearing techniques based on results of the collaborative research between JIRCAS and Cantho University, and Cantho University's cooperation with other Vietnamese institutions would be intensified, contributing greatly to the development of the freshwater prawn culture industry in Vietnam, especially in the Mekong Delta.

FRESHWATER PRAWN CULTURE STUDIES AND PRODUCTION TRIALS

Following the successful establishment of the seed production techniques, freshwater prawn culture trials were initiated under the JIRCAS-Cantho University cooperative project. Prawn-rice farming is of two types: integrated farming of prawn with the summer-autumn rice crop, and alternative farming of prawn. In the alternative type, no summer-autumn rice crop is cultivated. Both types have been put into practice in the Mekong Delta during the last few years. The first type is more suitable for non-flooding areas, while the second type is suited for flooded areas or where summer-autumn rice cultivation is subjected to high risks due to flooding. Studies under this project have focused on the integration of rice-prawn farming with the summer-autumn rice using hatchery-reared post-larvae.

Under the JIRCAS-Cantho University project, two prawn-rice farming trials have been conducted in Tam Binh District (Vinh Long Province) and at the JIRCAS project site, Tan Phu Thanh Village (Chau Thanh District, Cantho Province). The Tam Binh trial revealed that a stocking density of 5 PL/m^2 could yield a production of 222-566 kg of marketable prawns after six months of culture (Table 4). However, the harvested prawns showed a certain degree of size variation, ranging from 10 to 40 g. This resulted in lower prices, as larger prawns command higher market value. Maturation of female prawns was observed as early as the third month from stocking, and this also affected the prawn growth. The results indicated the need to improve the harvest size and delay maturation. Nevertheless, particularly in the case of Farms 1 and 2, income from prawn culture ranged from 150 to 400 U.S. dollars. Given that income from rice is about $200 per farm depending on size. This study has shown that farmers are potentially able to increase their income levels 2-3 fold by engaging in prawn-rice farming.

Table 4. Survival rate, production levels, and income obtained from prawn-rice farming in Tam Binh

Harvest	Farm 1	Farm 2	Farm 3	Farm 4
Survival rate (%)	34.1	40.1	24.2	22.1
Productivity (kg/ha)	500	566	222	287.5
Total investment (VND/farm)	3,162,000	1,197,750	1,365,000	1,844,000
Total income (VND/farm)	8,775,000	3,315,000	1,560,000	2,852,000
Net income (VND/farm)	5,613,000	2,117,250	194,950	1,008,000

US$ 1 = VND 15.000
Farm size = 9,000-2,700 m^2

It was also noted that the first trial in Tam Binh District has promoted the further development of prawn culture in this area. Within one year following the trial, 40 households became involved in prawn farming and have plans to build a small-scale hatchery in order to provide seeds for their farming needs.

The prawn-rice farming in the Mekong Delta has prospered much beyond the initial efforts of JIRCAS and the Cantho University. Especially in Cantho, An Giang, and Vinh Long Provinces, prawn-rice farming has been actively promoted by the country's extension services at the provincial and village level, and by many farmers. Using higher stocking densities of 12-15 juveniles/m^2, yields have been as high as 1 mt/ha increasing income levels 5-6 fold. Although the statistics have not yet been officially tabulated, Vietnam's freshwater prawn culture production in the 1990s was about 3000 mt/year and has now reached approximately 16,000 mt/year.

As the joint project comes to a close, JIRCAS and Cantho University initiated a socio-economic survey to assess the impact of hatchery technology development and its transfer on the prawn-rice farming industry in the Mekong Delta. This would help clarify the status of freshwater prawn culture in Vietnam and demonstrate how the JIRCAS-Cantho University joint efforts have contributed to the development of the industry.

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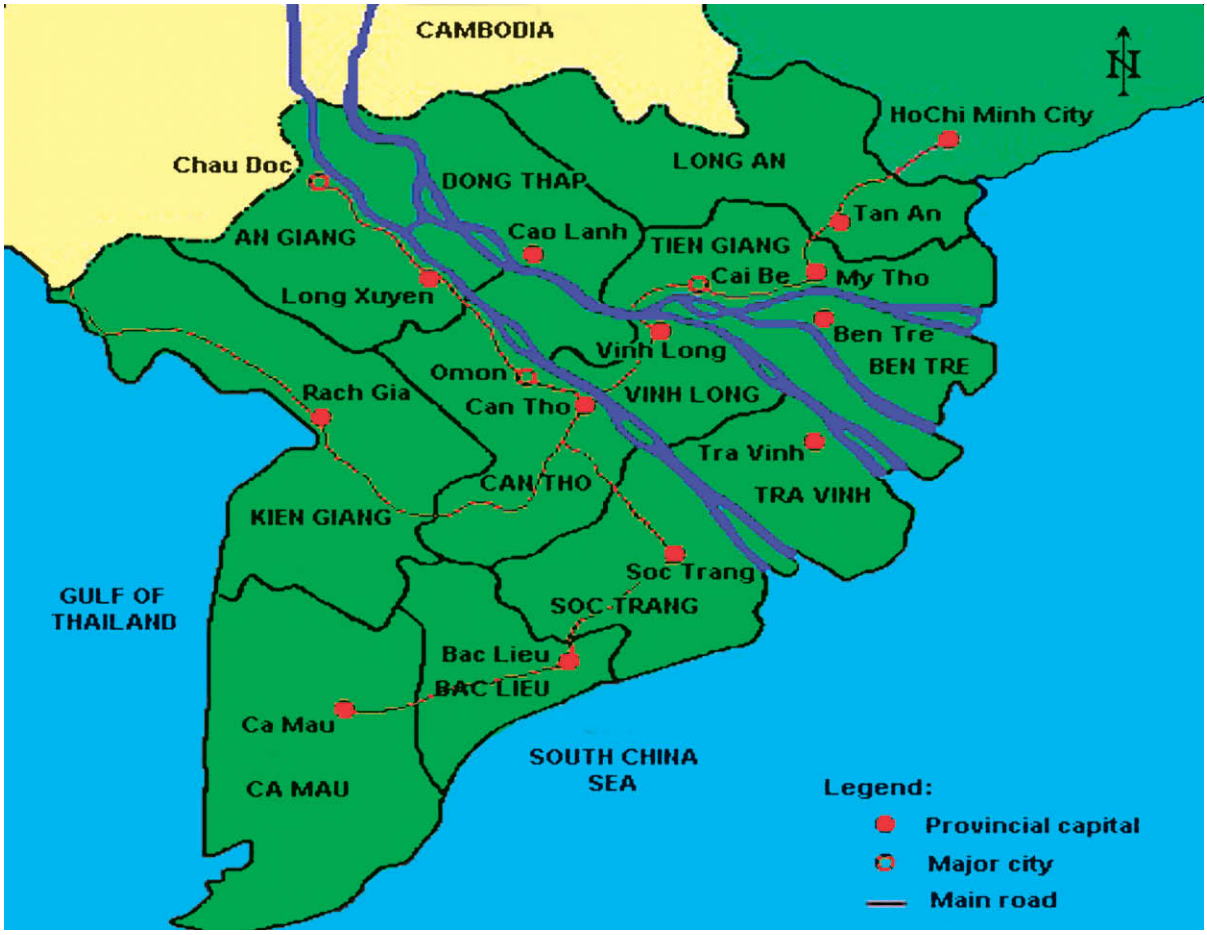

Map of the Mekong River (above), and typical prawn-rice farm in Cantho Province (right)

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