Experiments on seed production and commercial culture of the freshwater prawn (*Macrobrachium nipponense*)

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ABSTRACT

Aquaculture of the freshwater prawn *Macrobrachium nipponense* has potential to develop into a high value enterprise. However, this commercial development faces the constraints of insufficient stocking material and a lack of suitable culture technology. This paper presents preliminary results of experiments designed to address these two problems.

The experiments on prawn seed production used eight small (each 2 m^2 in area) and two large hapas (each 20 m^2 in area) placed in ponds. The experiments in the small hapas gave uneven overall survival rates ranging from 8.36 to 43.82%. The yields obtained are also low and uneven, ranging from 167 to 1525 PL10/hapa. Experiment on large hapas gave reasonable overall survival rates (32.95% and 31.85%) and significantly higher yields (20,973 PL10 and 20,319 PL10). Therefore, the use large hapas is recommended for producing large number of prawn seed for aquaculture purposes.

Experiments on commercial monoculture in ponds were also conducted. Stocking material consisted of fingerlings caught from nearby reservoirs. Fingerling size varied from 0.18 to 0.28 g/ind or 5555 to 3571 ind/kg. Stocking density was 60-70 ind/m^2. All environmental parameters (DO, pH, water temperature etc) were maintained at optimum levels. After 135 – 140 days of cultivation, the highest yield was 444kg/ha with 82.6% of the harvested prawns having a body weight of more than 2g (marketable size). However, prawns in the 2g weight range dominated (50.6%) the stock resulting in a low market price. This experiment shows the potential to improve culture management, achieve high production, and increase the number of crops in a year.

KEY WORDS: Freshwater prawn, *Macrobrachium nipponense,* seed production, hapa, commercial culture.

INTRODUCTION

The freshwater prawn, *Macrobrachium nipponense*, is distributed in brackish and fresh waters and can be found in various parts of China (Yu 1931, Cai and Dai 1999, Wang and Qianhong 1999, Miao and Ge 2002), Japan (Kamita 1970 and Uno, 1971), Taiwan (Shy *et al*. 1987), Korea (Holthuis 1980), Indo – West Pacific, Iran (Holthuis 1980 and Wrong and McAndrew 1994) and Vietnam (Dang 1980, Nguyen *et al.* 2002).

The species is commercially the most important freshwater prawn in China, Korea and Japan (Kwon and Uno 1969 and Wrong and McAndrew 1994). Estimates for the production of this species in 2000 were about 100,000 tonnes and accounted for about 50% of total prawn culture production in China (Miao and Ge 2002). In Vietnam, the species has an important role in capture fisheries (Nguyen 2002) but not in aquaculture. *M. nipponense* has potential for aquaculture because it is able to reproduce easily and grows very well in natural conditions, its market price is acceptable, and the prawn can be cultured in ponds, cages, and paddy fields under intensive, semi-intensive, or poly-cultural regimes (Wang and

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Qianhong 1999, Kutty *et al*. 2000, Miao and Ge 2002).

In the Central Highland Region, the living standards of communities are usually lower than in other regions of Viet Nam and protein is in shorter supply. Small-scale aquaculture could provide a source of protein and increase the income of the region's poor people. However, the income from aquaculture in the region is still low. The sale price of the main cultured species, including grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypophthalamichthys molitrix*), bighead carp (*Aristichthys nobilis*), rohu (*Labeo rohita*), and tilapia (*Oreochromis niloticus*) is not high (under 1USD/kg for local consumption). Thus, finding species with good economic potential for freshwater aquaculture in the Central Highlands of Vietnam is very important. Research conducted to evaluate the potential *M. nipponense* as a candidate for aquaculture in this region began in 2001. Nguyen *et al*. (2002) have already presented the results of research into the biology of the species and this current paper presents the results of experiments on seed production and commercial culture.

MATERIALS AND METHODS

Seed production

The experiments presented in this paper follow on from a series of successful breeding experiments on *M. nipponense* conducted in the laboratory during 2001 and 2002. Based on the results of the laboratory experiments, the current experiments were field trials aimed to produce larger numbers of seed in hapas located in ponds. The advantages of producing prawn seed in hapas are that the technology is simple for farmers to use and that the price of seed is low.

Hapas for breeding

In order to find out optimum hapa size, experiments were conducted small hapas and bigger hapas as follows:

Eight small hapas size: 1m x 2m x 1m (area of 2 m^2)

Two large hapas size: 6.7m x 3m x 1m (area of 20.1m^2)

The mesh size of hapas: 625 meshes/cm^2

Brood stock

Berried females, collected from commercial catches in lakes and reservoirs, were conditioned in hapas placed in ponds for convenient checking. Only females that were healthy, active, well pigmented, with no missing appendages, were taken. Gravid females carrying uniformly developed eggs (dark brown or grey eggs with visible eyes), were chosen and transferred from conditioning to breeding hapas. The females were removed once the larvae were released completely.

Nursing

Feed for larvae consisted of both natural foods (plankton) and soybean milk. Soybean milk was fed to the prawns twice daily, at 07:00 and 17:00. Bundles of aquatic and nylon fibre provided substrate and shelter for the larvae. Every three days samples of larvae were collected to determine the growth-stage of the prawns. The number of larvae was determined by random sampling conducted every two weeks. Dissolved oxygen (DO), temperature, and pH were measured every 15 days at 06:00, 13:00 and 16:00. The vertical sides of hapas were cleaned daily to ensure water circulation.

Grow-out culture

Pond preparation

The experiment on prawn grow-out culture was carried out in three earthen ponds. The ponds were drained and left to dry in the sun for seven days. Prior to stocking with juveniles, lime (7 kg/100m^2) and cow manure (7.5 kg/100m^2) were broadcast over the floor of the ponds that were then filled with water to a depth of 30 cm. After one week, the level of water in ponds was raised to 1 m and stocked with juvenile prawns.

Stocking

The ponds were stocked with juveniles from breeding hapas and wild-caught from reservoirs and lakes. The density of prawns stocked ranged from 2500 to 4000 ind./kg.

Rearing

Prawns reared in ponds 1 and 2 were given unprocessed feed comprised of rice bran, fish, fishmeal, and oil cake. For the first ten days, prawns reared in pond 3 were fed 1kg/day of uncooked soybean milk. From the eleventh day until harvesting, they were fed processed feed containing rice bran (40%), soybean meal (20%), fishmeal (30%), oyster meal (2%), alga (8%) and a mixture of vitamins.

The daily amount of feed required for prawn in each pond was approximately 7-10% of estimated biomass of prawn in the pond. Feeding took place twice daily, in the morning and afternoon. In addition, feeding trays were placed at the ponds' four corners to check food consumption.

Every 15 days, lime (7 kg/100 m^2), cow manure (7.5 kg/100 m^2), super-phosphate (0.6 kg/100m^2) and urea (0.2kg/100m^2) were added to each pond.

DO, temperature, and pH were measured every 15 days at 06:00, 13:00 and 16:00.

Each month, samples of at least 40 prawns were collected to determine the growth rate.

Harvesting

Harvesting began from the third month using hand lift-nets and traps. Finally, after draining the ponds to 50 cm the remaining prawns were harvested with seines.

Treatment of data

Daily weight gain (DWG) was calculated using the following formula

$$\text{DWG (g/day)} = \frac{\text{Mean final weight (g) - Mean initial final weight (g)}}{\text{Time (days)}}$$

RESULTS

Seed production in small hapas

Table 1 gives the results of the experiment on seed production in small hapas. The results show that the environmental regimes employed through the duration of the experiment (from September to December 2002) were suitable for raising prawn larvae.

Table 1. *Results of experiment on producing* M. nipponense *seed in small hapas*

Parameter	**Hapa Number**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rearing duration (days)	29	30	31	31	30	30	33	30
Water temperature (^{o}C)	29.7	29.0	29.8	29.5	30.1	30.2	27.3	23.2
pH	8.45	8.44	8.48	8.45	8.45	8.51	8.41	8.40
Dissolved oxygen (mg/l)	4.86	4.81	5.09	4.48	4.73	4.72	4.33	4.60
N^o of gravid females	45	50	50	24	46	40	27	28
N^o of L1 produced	1992	3600	3750	2760	6072	2280	3480	1820
No L1 produced by 1 female	44	72	75	115	132	57	129	65
N^o PL 10 harvested	167	1006	433	272	947	211	1525	658
Survival rate L1 – PL10 (%)	8.36	27.94	11.55	9.86	15.60	9.25	43.82	36.15
Length of PL10 (cm)	1.2 – 1.4							
Total number of PL10 harvested	5219							

Notes: Average water depth in these hapas was 0.4 – 0.5m. Number L1 was a combination of larvae stage I, II and III

The number of stage I larvae (L1) produced depends not only on the number of gravid females in the stock but also their fertility and other, environmental, factors. Normally the more females the stock contains the more L1 produced. This is indeed the case in hapas 2 and 3; these contained 50 gravid females each and produced 3,600 and 3,650 L1 respectively. By comparison, hapas 4 and 8, stocked with 24 and 28 individuals, produced only 2,760 and 1,820 L1.

Occasionally, however, smaller stocks can produce relatively high numbers of L1. In hapa 7, for example, only 27 females produced 3,480 L1. In this instance, the hapa had half the number of females as hapas 2 and 3 but produced similar numbers of L1.

There is no obvious relationship between initial L1 density and their survival rate to post-larval stage 10 (PL10). The overall survival rate from L1 to PL10 reached a maximum of 43.82% in hapa 7, followed by 36.15% in hapa 8. The high survival rate of prawns in these hapas may relate to the special care to given them during the experiment. The poorest survival rates were in hapas 1 (8.36%) 6 (9.25%) and 4 (9.86%). These hapa were found subsequently to contain some predators (adult prawns, fish).

The results from these experiments show that rearing prawns in small hapa produces only small number of juveniles. Accordingly, these hapa are unsuitable for farmers, who require large numbers of prawn fingerlings to stock their 'grow-out' ponds.

Seed production in large hapas

Table 2 gives the results of experiments on seed production in large hapas. The results show that the environmental regimes of both large hapas were better-suited (higher DO levels, greater water depth) for seed production than the small hapas, resulting in better productivity.

Table 2. *Results of experiment producing M. nipponense seed in large hapas*

Parameter	**Hapa 1**	**Hapa 2**
Rearing duration (day)	31	35
Metamorphosis days from L1 – PL1 (day)	13.5 – 24.5	12.5 – 25.0
Water temperature (^{0}C)	29.3	30.7
pH	8.4	8.0
Dissolved oxygen (mg/l)	5.8	5.9
Average water level (cm)	60	50
Transparency (cm)	44	38
Number of larvae at stage I,II,III (L1)	63,648	63,800
Amount of PL10 harvested (PL10)	20,973	20,319
Yield per m^2 (PL10/m^2)	1043	1011
Overall survival rate L1 – PL10 (%)	32.95	31.85
Length of PL 10 (cm)	1.37 (1.2-1.6)	

The number of larvae stage I-III (L1) produced in large hapas 1 and 2 were almost the same (63,648 and 63,800 respectively). The initial density of L1 in large hapas was similar to the highest density of L1 in the experiments on small hapas (hapa 5) but the overall survival rates of larvae were much higher (32.95% in large hapa 1 and 31.85% in large hapa 2, compared with 15.60% in small hapa 5).

Interestingly, the amount of PL10 harvested per square metre of large hapa (1043 PL10/m^2 in hapa 1 and 1011 PL10/m^2 in hapa 2) was much greater than the best results achieved in the experiments on small hapas (763 PL10/m^2 in hapa 7).

When comparing the results of the two sets of experiments the advantages of using large hapas for producing prawn seed becomes clear; these are a stable high yield and high survival rate, maintenance requiring less manpower and the greater production of prawn juveniles etc. Unfortunately, due to shortages of finance and labour we were unable to conduct the experiments using greater numbers of large hapas. Repeating the experiments using more large hapas may provide more confidence in the benefits gained by using hapas of this size.

Grow-out culture in ponds

Table 3 gives the results of experiments on growing-out *M. nipponense* in earthen ponds. The table shows that the environmental factors in all three ponds were appropriate for the growth of this species of prawn.

The initial weight of prawns stocked in pond 1 was 0.25g/ind., 0.28g/ind. in pond 2 and only 0.18g/ind. in pond 3. After 135 – 140 culture days, the final weight of prawn in the experimental ponds was 2.8 g/ ind., 3.5 g/ind. and 2.5 g/ind., respectively. The results show that the final weight of prawns correlates closely with the initial weight. The same relationship also found between initial weight and daily weight gain. Quality of feed seems to make little difference. Accordingly, prawns in pond 3 fed with higher quality feed recorded the lowest daily weight gain (0.017 g/day) because their initial weight was also the lowest (0.18 g/ind.). Likewise, prawns in pond 2, which had the heaviest initial weight (0.28 g/ind.), recorded both the largest daily weight gain (0.023 g/day) and the greatest final weight (3.5 g/ind.). As daily weight gain correlates only with initial weight and apparently is unaffected by type of feed proved (the environmental regimes in all three ponds were also suitable for culturing prawns), increasing stocking density may well be the best way to achieve higher yields.

Table 3. *Results of experiments on grow-out of* M. nipponense *in earthen ponds*

Parameter	**Pond 1**	**Pond 2**	**Pond 3**
Area (m^2)	450	350	640
Stocking density (prawns/m^2)	60	70	60
Initial day	25/1/03	16/03/2003	21/02/03
Terminal day	11/6/03	02/08/2003	10/07/03
Duration (days)	135	140	140
Average water level (cm)	85	80	85.78
Transparency (cm)	45	50	51.11
Water temperature (^{0}C)	28.9	29	29.4
pH	8.9	8.7	8.4
Dissolved oxygen (mg/l)	5.5	5.8	6.1
Types of feed	Rice bran, fish meal, fish, oil-cake.	Rice bran, fish meal, oil-cake	Soybean milk, processed feed
Initial weight (g)	0.25 ± 0.14	0.28 ± 0.28	0.18 ± 0.18
Final weight (g)	2.8 ± 1.2	3.5 ± 1.3	2.5 ± 1.2
Daily weight gain (g/day)	0.019	0.023	0.017
Total yield (kg)	17.0	8.4	28.4

Figure 1 illustrates an analysis of the weight distribution of prawns in pond 3. The modal body weight of harvested prawns is 2g (50.6% of the total population). The heaviest prawns (6.0g) account for only 3.4% of the population. The dominance of small prawns, and the resultant low market price, is the main constraint on using this species for aquaculture purposes.

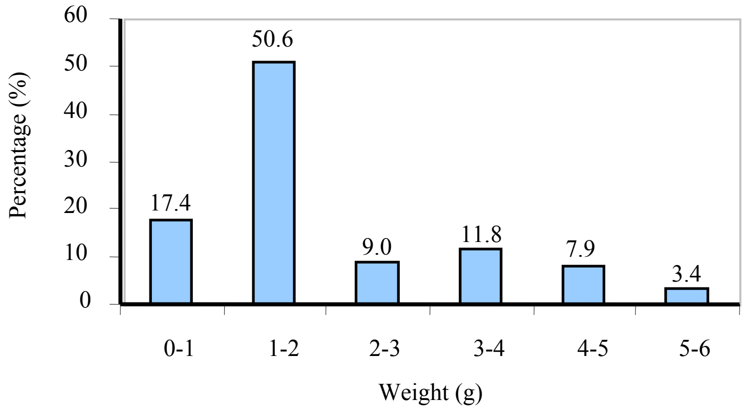

Figure 1. Weight distribution of harvested prawns in pond 3

Table 4 provides some information on the economics of culturing in ponds. The yields obtained after 135 – 140 days cultivation ranged from 240 kg/ha/crop (pond 2) to 444 kg/ha/crop (pond 1). Wang and Qianhong (1999) reported that annual production of *M. nipponense* ranged from 390 to 1,875 kg/ha in China. While the production in ponds 1 and 3 were comparable to these figures, the profit for farmers was poor.

Table 4. *Yield and economic effectiveness of three grow-out culture ponds*

	Pond 1	**Pond 2**	**Pond 3**
		Investment (US$)	
Seed	5.20	4.50	6.50
Feed	29.00	23.20	33.10
Fertilization	4.00	2.10	5.50
Total cost	**38.20**	**29.80**	**45.1**
		Yield	
Total yield (kg)	17.0	8.4	28.4
Yield (kg/ha)	378.0	240.0	443.8
		Profit and Loss (US$)	
Total income	32.98	13.30	551.0
Profit/Loss	5.30	13.50	9.90

However, increasing yields (by increasing stocking density, using suitable feed combination, etc), improving the harvested size of prawns (rotation harvesting) and applying poly-culture (with fish or other aquatic animals) may improve these slim economic benefits.

The recent low market prices fetched by this prawn in Central Highlands (US$1.94/kg) hits the economics of its cultivation. However, prices are much higher in Ho Chi Minh City and other large Vietnamese cities (upwards of US$3/kg) and therefore extending the cultivation this species more widely through the country is, potentially, an excellent commercial prospect.

CONCLUSIONS

- Using small hapas (2m^2) for producing fresh water prawn seed results in uneven overall survival rates (ranging from 8.36% to 43.82%) and low producing capacity (maximum 1,525 PL10/hapa or 763 PL10/m^2). Therefore using small hapas for producing mass numbers of prawn seed cannot be recommended.

- Large hapas (20.1 m^2) give good production results. The overall survival rate is stable (ranging between 31.85% and 32.95%). The yield of PL10 obtained from large hapas ranged between 20,973 PL10/hapa and 20,319 PL10/hapa, or 1,049 PL10/m^2 and 1,016 PL10/m^2. This size of hapa is suitable for producing the large amounts of prawn seed required for aquaculture.

- Grow-out culture in ponds generates acceptable productivities (444 kg/ha/crop). However, farmer's profits are low. Enhancing yield in ponds and improving the modal weight of the prawn population will help to increase the farmer's profit. Developing the cultivation of this species throughout Viet Nam may be a commercially viable proposition.

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