Section 2: Aquaculture

Mobile hatchery: a new tool for fisheries extension

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ABSTRACT

In 2002, staff from the Aquaculture of Indigenous Mekong Fish Species sub-component, Thailand (AIMS-Thailand) developed a mobile hatchery for use in remote rural areas. The performance of the hatchery in the field exceeded expectations. It proved more flexible than anticipated and the percentages of eggs produced, fertilized, and hatched, were comparable with results achieved in a standard hatchery. The hatchery allows artificial wild fish breeding in locations where transportation of these fish from the main hatchery is impossible. Demonstrations of the hatchery have taken place in Nakhonphanom, Udonthani, Mukdahan and Nam Houm (Lao PDR).

A hatching hapa measuring 2x2x0.5 m with flow-through water supply can be used to hatch 3.4×10^6 eggs of *Barbodes gonionotus* (93% fertilization rate and 86% hatching rate), 1.5×10^6 eggs of *Labeo rohita* (74% fertilization rate and 95% hatching rate) or 1×10^6 eggs of *Cirrhinus microlepis* (60% fertilization rate and 30% hatching rate). Funnel-type incubators with 15 L volume can be used to hatch 1.0×10^5 eggs of *Probarbus jullieni* (60% fertilization rate and 40% hatching rate). Demonstrations of the mobile hatchery attracted a lot of interest from local people and helped to raise awareness of issues concerning fish conservation.

KEY WORDS: Thailand, fisheries, mobile hatchery

INTRODUCTION

In many remote rural areas, long distances and poor quality roads hinder access to the fish hatcheries that provide stocks of threatened wild species. In 2002, staff from the Aquaculture of Indigenous Mekong Fish Species sub-component, in Thailand (AIMS-Thailand), designed and built a mobile fish hatchery to help overcome this problem. The mobile hatchery allows aquaculture in the those rural areas where transportation to the main hatchery is difficult if not impossible.

METHODS

The mobile hatchery is assembled from the following materials (see Figures 1 to 7):

Water pump (Figure 1)	Brood stock fish
Electric or engine motor (Figures 2 and 3)	Hormone and distilled water
Material for set machines	Hatching hapas (Figure 4 and 4b)
Machines	Blower (Figure 5)
Pipe and valve	Funnel-type incubator (Figure 6)
Air stone	Water supply in hatchery

Demonstrations of the mobile hatchery took place in Nakhonphanom, Udonthani, Mukdahan and Nam Houm (Lao PDR). When dissembled the hatchery fits on to a pickup truck and it is easy to transport and

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Figure 1. Water pump

Figure 2. Electric motor

Figure 3. Diesel motor

Figure 4a. Hatching hapa

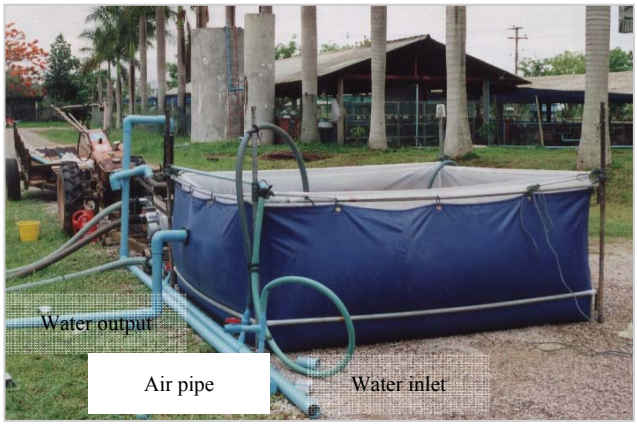

Figure 4b. Hatching hapa

Figure 5. Air Blower

Figure 6. Funnel-type incubator

simple to fabricate. It comes in three parts:

- The first part is a 2x2x0.8 metre hapa used as either a spawning tank or an incubator (Figure 4b). This hapa can hold $4.0x10^6$ semi-buoyant eggs. Another type of incubator, a funnel-type incubator can also be connected to the system (Figure 6). The 15 litre funnel type incubator can hold $1.0x10^5$ adhesive-demersal eggs.

- The second part, a pump (Figure 1), supplies water to the system.

- The third part is an air blower (Figure 5).

The water pump and air blower run by the 7.5 HP diesel engine (Figure 3) or the 5 HP electric motor (Figure 2). The mobile hatchery was prepared and assembled at a number of rural locations. The performance of the hatchery in terms of egg production, fertilisation, and hatching rates was recorded to compare its performance with that of a standard hatchery. The level of interest and participation by local inhabitants was also monitored.

RESULTS

The results of breeding in the mobile hatchery (Table 1) compare favourably with those of standard hatcheries and the hatchery has proved to be more flexible than was originally expected.

Table 1. *Parameters and performance of the mobile hatchery*

Species	No. of females	Body weight (kg)	No.of males	Body weight (g)	Eggs produced ($x10^6$)	Fertilization rate (%)	Hatching rate (%)	remark
	Hatching hapas size 2x2x0.8 meter (1 unit)							
Barbodes gonionotus	14	0.7	21	0.7	3.4	93	86	After injected hormone rearing broodstock for natural spawning.
Labeo rohita	10	1.0	15	1.0	1.5	74	95	After injected hormone rearing broodstock for natural spawning.
Cirrhinus microlepis	4	3.0 - 4.0	10	2.0 – 3.0	1.0	60	30	Artificial breeding and used dry method.
	Funnel- type incubator size 15 liter (8 unit)							
Probarbus jullieni	4	20.0 – 50.0	4	20.0 – 50.0	0.8	60	40	Artificial breeding and used dry method.

Levels of local interest and participation were high. Breeding demonstrations and fish-release activities were held in conjunction with MRRF, Mukdahan Inland Fisheries Station, and Yasothon Inland Fisheries Research and Development Centre. Approximately 100 people participated in Udonthani and about 30 at Mukdahan.

DISCUSSION

The results show that the fertilization rate and hatching rate of fish using the mobile hatchery is similar to those obtained in a standard hatchery (Sutanurak and Plodauon, 1992). The mobile hatchery is

particularly suitable for work in the field where there is no access to a regular hatchery, or to breed wild fish in the field when transportation of the fish to the main hatchery is impossible. It is a new and useful tool for fisheries extension and fisheries development in Thailand.

REFERENCE

Sutanurak, S and Plodauon, Y (1992) *A comparison of synthetic hormone (LHRHa) with pituitary gland in artificial fish breeding.* Roiet Inland Fisheries Station, Department of Fisheries, Thailand. 36 pp

A survey of aquatic animal health problems affecting small-scale aquaculture production and fisheries in Lao PDR

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ABSTRACT

This study presents the results of a survey of aquatic animal health conducted in three provinces of Lao PDR. The objectives of the study were to (1) identify problems with fish disease in Lao PDR, (2) investigate the source and cause of disease and, (3) determine its effect on aquaculture systems.

In total, 163 families were interviewed using a questionnaire; 30-40% reported the occurrence of fish disease. The spread of disease depends on many factors associated with culture in hatcheries and nursing and is more of a problem in integrated than in poly-culture systems. In Oudomxay and Vientiane, fish mortality due to disease was high and often associated with imported seed. Disease occurred mainly in the cool months from around December to April and early rainy season from about May to June. Eight major diseases are prevalent: epizootic ulcerative syndrome (EUS) and diseases caused by Lernaea, Epistylis, Trichodinia, Oodinium, Gyrodactylus, Columnaris, and *Edwardsiella tarda*.

KEY WORDS: Aquatic animal health, fish disease, aquaculture

INTRODUCTION

The number of farmers involved in aquaculture in Lao PDR has increased in recent years. Their methods generally employ extensive culture systems though an ever-increasing number of intensive commercial fish farms now operate near large towns and suburban areas and supply local markets and families with fish.

Farmers report that they often find dead fish in their ponds and this study found mortality rates in some nursing ponds were more than 90% in a number of instances.

Many factors cause the spread of disease including, the illegal importation of aquatic animals, poor knowledge of disease prevention and treatment, poor pond management, high stocking densities, and over-fertilisation.

In October 2002, the Living Aquatic Resources Research Centre (LARReC) and the Department of Livestock and Fisheries Veterinary Laboratory (DLF Vet-Lab), both government organisations, designed a questionnaire to aid in the study of fish disease in three provinces in Lao PDR:

- Vientiane municipality (three districts - Sikhottabong, Naxaythong and Xaythany)
- Oudomxay province (three districts - Houn, Beng, and Xay)
- Champassack province (three districts - Pakse, Paksong, and Pathoumphone)

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We believe that these provinces are representative of the whole country.

The objectives of the study were to:

- Identify problems with fish disease in Lao PDR
- Investigate the source and cause of disease
- Determine its effect on aquaculture systems

METHODS

Between January and July 2003, a team of five LARReC staff and two local researchers interviewed small-scale fish farmers from the regions selected for study. These fish farmers were practising fishpond, rice-fishpond, public and private hatchery, community fishpond, nursery and cage, cultures. The survey team interviewed 163 fish farmers and/or their families (between 40 and 60 from each site) and asked them to complete a questionnaire about their farming practices. The questionnaire, which followed the format of an earlier survey conducted in Savannakhet province (NACA 1999), contained questions about culture techniques, water quality and the prevention and treatment fish diseases.

Figure 1. Small silver carp infected with Lernaea

RESULTS

Presence of disease in different culture systems

In Vientiane, parasites, bacteria and fungi that cause disease in tilapia (*Oreochromis niloticus*), silver barb (*Barbonymus gonionotus*), catfish (*Clarias* sp.), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), big head (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*)

and snakehead (*Channa* sp.) were present in samples from hatcheries, nursing and grow-out ponds (Table 1). The samples also contained fish with epizootic ulcerative syndrome (EUS) along with disease caused by the following organisms: *Lernaea* sp., *Epistylis* sp., *Trichodinia* sp., *Gyrodactylus* sp., *Columnaris* sp., and *Edwardsiella tarda*.

Table 1. *Number of infected samples in Vientiane municipality and Oudomxay and Champassack provinces*

Culture	Province							
	Vientiane		Oudomxay		Champassack		All provinces	
	N° samples	% infected	N° samples	% infected	N° samples	% infected	N° samples	% infected
Fishpond	32	38	48	46	40	35	120	40
Local hatcheries	11	64	6	33	5	80	22	59
Nursing	2	50	1	100	2	0	5	40
Cage culture	5	80	0	0	2	0	7	57
Rice-fishpond	1	0	2	100	3	33	6	50
Community fishpond	0	0	0	0	3	0	3	0
Total	**51**	**45**	**57**	**47**	**55**	**35**	**163**	**42**

Notes: 1. In this, and the tables that follow, 'samples' refer to the number of fish farmers interviewed, and '% infected', to the percentage of fish farmers that reported diseased fish. 2. Fish farmers in Vientiane use imported seed for cage culture; this might explain the very high (80%) levels of infection

In Oudomxay, *Lernaea* sp., *Epistylis* sp., *Columnaris* sp., and *E. tarda* were present in samples from hatcheries and nursing ponds; *Columnaris* sp also infected cage cultures in reservoirs and rivers.

In Champassack, samples from hatcheries and grow-out ponds were found to be infected with *Oodinium* sp., *Epistylis* sp., and *Edwardsiella tarda* which cause disease in common carp, silver barb, tilapia, Indian carp (*Cirrhinus cirrhosus*), rohu (*Labeo rohita*) and silver carp.

Some of the causative factors are briefly discussed below.

Farming systems

Disease rates are significantly higher where integrated fish farming and livestock systems were in operation.

Table 2. *Incidence of disease in integrated and non-integrated farming systems*

	Culture			
	Integrated		Non- integrated	
	N° samples	% infected	N° samples	% infected
Vientiane	16	63	35	37
Oudomxay	11	73	46	41
Champassack	2	50	53	34
Total	**29**	**66**	**134**	**37**

Water source

Levels of infection in culture systems using water from irrigation canals were higher in Oudomxay than in any other province. In Vientiane and Champassack, levels were high in those systems that depended on water from the river.

Table 3. *Incidence of disease related to water source*

	Water source					
	Irrigation		**Rain**		**River**	
	N° samples	**% infected**	**N° samples**	**% infected**	**N° samples**	**% infected**
Vientiane	30	40	16	50	5	60
Oudomxay	13	69	17	41	27	41
Champassack	12	33	18	17	25	48
Total	**55**	**45**	**51**	**35**	**57**	**42**

Seed source

Farmers in each province noted some differences. In Oudomxay, fish fed on seed imported from China and Viet Nam were twice as prone to infection as those fed seed from the local hatchery.

Table 4. *Incidence of disease related to seed source*

	Seed source					
	Imported		**Home-produced**		**Local hatchery**	
	N° samples	**% infected**	**N° samples**	**% infected**	**N° samples**	**% infected**
Vientiane	7	71	7	43	37	41
Oudomxay	8	88	11	36	38	42
Champassack	11	27	9	67	35	29
All provinces	**26**	**58**	**27**	**48**	**110**	**37**

Pond preparation

Disease appears to occur most commonly in areas where pond preparation is poor.

Table 5. *Incidence of disease related to pond preparation*

	Pond preparation techniques employed			
	Yes		**No**	
	Infection rate			
	N° samples	**% infected**	**N° samples**	**% infected**
Vientiane	48	44	3	67
Oudomxay	30	40	27	56
Champassack	39	28	16	50
All provinces	**117**	**38**	**46**	**54**

Use of disease prevention techniques

Farmers who employed disease prevention techniques had a lower incidence of disease

Table 6. *ncidence of disease related to prevention techniques*

	Prevention techniques employed			
	Yes		**No**	
	Infection rate			
	N° samples	**% infected**	**N° samples**	**% infected**
Vientiane	41	37	10	80
Oudomxay	26	39	31	55
Champassack	36	31	19	42
Total	**103**	**35**	**60**	**55**

Water exchange

The level of disease levels in fish in Vientiane and Oudomxay reared in systems that do not employ water exchange mechanisms were significantly higher than in systems in areas that do. .

Table 7. *Incidence of disease related to water exchange practices*

	Water exchanged			
	Yes		**No**	
	Infection rate			
	N° samples	**% infected**	**N° samples**	**% infected**
Vientiane	37	38	14	64
Oudomxay	27	33	30	60
Champassack	11	27	44	36
Total	**75**	**34**	**88**	**49**

Seasonality

Respondents from all three localities reported that disease occurred most commonly during the cool months from about December to April and in the early rainy season from about May to June

CONCLUSIONS

Although farmers are developing intensive methods and aquaculture is on the increase in the larger cities and suburbs of Lao PDR, extensive methods are still most common. This study found that disease occurred in all systems. Aquaculture is expensive particularly as the price of feed constantly fluctuates. Some farmers attempt to reduce costs by raising fish with livestock using an integrated method of production. However, fish raised in this way are particularly prone to disease and poor pond preparation techniques, importation of seed, and high stocking densities further compound the problems. Prevention of disease is essential but this fact is not widely appreciated by farmers and consequently the

incidence of disease is high. As the industry expands, so too will the problems and costs unless action is taken to reverse the trend.

RECOMMENDATIONS

A number of recommendations follow from the results of this study:

- there is an urgent need for an education and prevention campaign (including quarantine techniques) to teach farmers how to improve their management methods
- seed needs to be of the highest quality and must be disease-free
- educational materials that promote the prevention of disease should be produced and broadcast through extension services and on national television
- capacity-building and development of human resources is required in this field
- riparian countries should continue to share information through seminars, workshops and training courses

REFERENCE

NACA (1999) *Aquatic animal health assessment in southern Lao PDR.* Network for Aquaculture Centres in Asia, Bangkok.

Artificial propagation of Hoeven's slender carp (*Leptobarbus hoevenii*)

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ABSTRACT

The artificial propagation of Hoeven's slender carp (*Leptobarbus hoevenii*) was studied under trial conditions at Research Centre for Aquaculture in the Mekong Delta, Research Institute for Aquaculture No. 2, within the framework of Aquaculture of Indigenous Fish Species (AIMS) component. Trials showed that females required two injections of hormone, preparatory and resolving, to induce spawning; males however required just a single resolving dose. Following injection females and males were kept in spawning tanks with flow-through water. Females were stripped or spawned naturally 5.5 – 8.0 hrs after the resolving injection. Relative fecundity of female ranged between 84,043 and 92,907 eggs/kg. Fertilised eggs were incubated in Zuger jars or aerated fibreglass tanks with flow-through water. Fertilisation and hatching rates ranged from 47.0 to 72.5% and 64.7 to 87.8%, respectively. Hatching period took approximately 13 hrs at water temperature of 28 – 29°C.Two-stage nursing technique in concrete tanks and thereafter in earthen ponds was tested. Survival rate of *L. hoevenii* fingerlings at 50 – 60 days old was found to be at 50 – 60%.

KEY WORDS: Viet Nam, Hoeven's slender carp, artificial propagation

INTRODUCTION

Hoeven's slender carp (*Leptobarbus hoevenii*) is an indigenous freshwater fish found naturally in rivers and springs in Viet Nam, Lao PDR, Thailand and Cambodia. It feeds on larva, worms, and zooplankton during its larval stage and phytoplankton and forest fruits when it reaches maturity (Rainboth 1996). The species is economically important to fisheries in the Mekong Delta where it is native. Here production is mainly through natural capture as efforts to culture it by artificial means to date have been relatively unsuccessful due to a lack of seed and ineffective culture techniques. However, the successful production of seed of sufficient quality and quantity for aquaculture needs further research. As well as being commercially beneficial, this seed would help to reduce the demands on the already limited numbers of this species in the wild.

METHODS

Brood-stock conditioning

Study of the artificial propagation of *L. hoevinii* was carried out from June 2001 to October 2003 at the Research Centre for Aquaculture in the Mekong Delta (Cai Be Centre), Research Institute for Aquaculture No. 2 (Cai Be district, Tien Giang province, Vietnam), under AIMS Vietnam Sub-component.

Fish were collected from the wild in June-July 2001. A further 240 individuals were collected in 2003

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and stocked at a density of 24 kg/100m^2 in two separate earthen ponds (700 m^2 each) at the Cai Be Centre.

In order to monitor water quality in the brood-stock ponds, temperature and levels of dissolved oxygen (DO) were measured daily at 07:00 and 14:00 and pH and levels of dissolved carbon dioxide (COD) were measured weekly at these same times of day.

Daily aeration of the brood-stock ponds (23:00 to 06:00) maintained DO at minimum 2.5 mg/l. Water level was kept constant at between 1 to 1.2 m and approximately 30-30% of the pond water was exchanged once or twice every month. In order to create a current, water was pumped every morning for two hours during the period from April to October.

Conditioning of the brood stock took place in two stages. During the first, from December to April, fish were fed an equivalent of 4% of their body weight. This was reduced to 2% body weight during the second stage (May to October). Local-made feed consisted of fishmeal, blood powder, rice bran, fish oil and premix (containing approx. 35% of crude protein). In addition, fruits such as guava and plum were given at a rate of 2% of body weight.

Egg samples were periodically collected from the brood stock to determine stage of maturity based on histology. Samples of eggs were also collected before and after the primary hormone injection; these were kept in Davidson solution. The diameter of each egg was measured under microscope to determine egg transformation after injection. Based on this information, technicians decided when would be the best time to apply the resolving injection.

Records of spawning seasons, maturation ratio, maturation coefficient, absolute fecundity, relative fecundity, real relative fecundity, ratio of brooders releasing eggs, fertilization and hatching rates were made.

Induced spawning

Spawning was induced by injecting Luteinising Hormone-Releasing Hormone analogue (LH-RHa) plus

Table 1. *Hormone doses used to stimulate artificial propagation in Hoeven's slender carp.*

Year	Treatment	Hormone	Preparatory dose/kg		Resolving dose/kg	
			Female	Male	Female	Male
2002	1	Pituitary (mg)	2.0		4.0	3.0
		LHRHa (µg)	80.0		200.0	80.0
		DOM (mg)	10.0		20.0	10.0
	2	Pituitary (mg)	2.0	1.0	4.0	2.0
		LHRHa (µg)	50.0	25.0	140.0	50.0
		DOM (mg)	5.0	2.5	15.0	5.0
2003	1	Pituitary(mg)	1.0		1.2	0.6
		LHRHa (µg)			130.0	65.0
		DOM (mg)			13.0	6.5

domperidone (DOM) and carp pituitary gland extract (PG). The doses used were different in 2002 and 2003 (Table 1). In the 2002 spawning season, two treatments were carried out to find the most suitable dosage. This was achieved by gradually reducing the amount of each hormone used.

Dissemination was accomplished using the 'dry' method, i.e. eggs and milt were mixed before adding water. Fertilized eggs were incubated in Zuger jars or in aerated fibre tanks with flow-through water.

Nursing

Once the yolk sac was absorbed, fry were nursed by two separately treatments:

Treatment 1 (two-stage nursing):

Stage 1: fry were nursed in 12.5 m^2 concrete tanks at a density of about 1,000-1,200 indiv/m^2 (in 2002) and 2,000 indiv/m^2 (in 2003) until they were 20 days old.

Stage 2: thereafter fish were moved to 200 m^2 earthen pond. Density reduced to 50-100 indiv/m^2. This stage last to 40 days.

Treatment 2: fry were moved into 700 m^2 earthen ponds after the yolk sac was exhausted. Density was 200-300 indiv/m^2. Nursing period lasted for 60 days.

Table 2. *Type of feed used to nurse fry*

Age (day)	Type of feed
1-10	Milk powder + moina
11-40	Fish meal + rice bran
41-60	Fish meal + rice bran + pellet feed

RESULTS AND DISCUSSION

Environmental parameters of the brood stock ponds

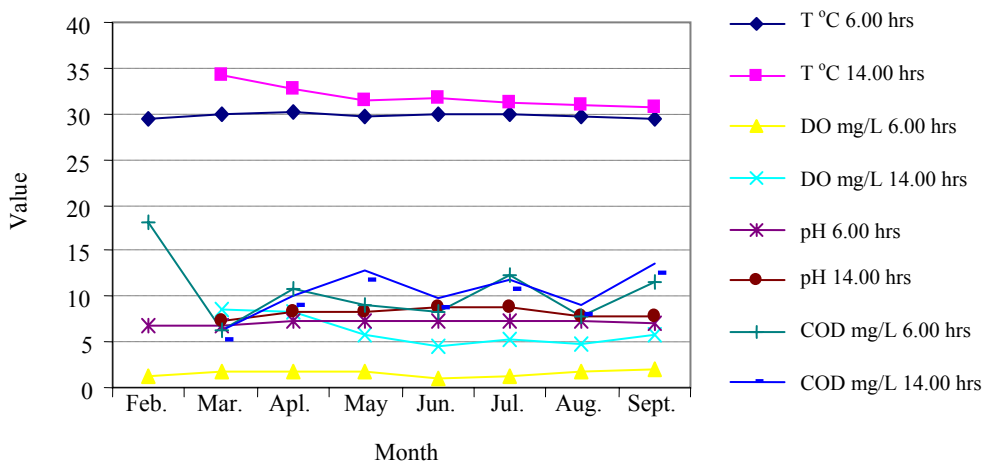

Figure 1. Water quality parameters in brood-stock ponds

Brood-stock maturation

In the wild Hoeven's carp normally take two years to teach maturity. In pond culture, the 34% of brood-stock collected in June and July 2001 reached maturity in 2002. This low percentage may be because the fish had not yet fully adapted to pond environments.

In 2003, the ratio of mature fish increased to 88% (females) and 73% (males), showing that *L. hoevinii*, can thrive well in captivity once they have adapted to artificial feed and the environmental conditions in the brood ponds.

Figure 2 illustrates the maturation ratio of females to males during the spawning season. Males matured earlier than females; while 13% of males were mature by mid-March most females did not reach phases III and IV until April. Some females in phase V could reproduce in May. By June, the maturation ratio had reached 30% in females and 20% in males.

The maturation ratio of both females and males reached a peak in June; thereafter the ratio dropped dramatically in males but remained relatively high in females. Successful spawning requires a large numbers of males to females as males produce only a small amount of sperm. As result, the reproductive season was short. Females are able to reach maturity again 90-120 days after spawning and some of the females in this study were able to reproduce twice in one spawning season.

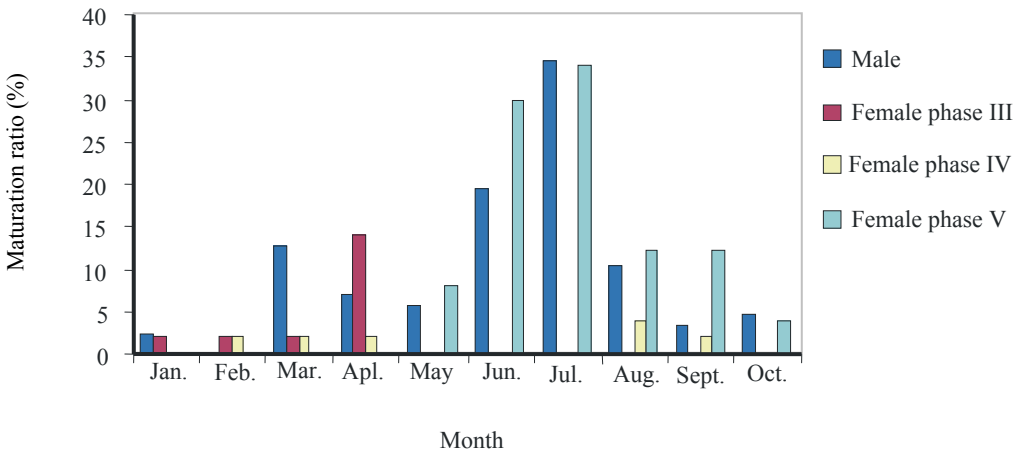

Figure 2. Maturation of brood stock in confined culture conditions

Some reproductive characteristics of L. hoevinii vs. other cyprinids

The reproductive biology of *L. hoevinii* was studied in 2002, along with other three target species (also cyprinids) of AIMS: *O. melanopleura, L. chrysophekadion* and *C. microlepis*. The GSI (Gonadal Somatic Index) of female *L. hoevinii* was 5.3 - 6.7%. Absolute fecundity ranged from 139,360 - 158,000 eggs and relative fecundity from 84,043 - 92,907 eggs/kg. The mean diameter of eggs was 0.98 mm.

L. hoevinii and *O. melanopleura* have similar GSI, which is much higher than that of *L. chrysophekadion* and *C. microlepis*, but much lower than other well-adapted cyprinids like silver barb *Barbodes gonionotus* or red-tail tinfoil barb *Barbodes altus*.

Absolute and relative fecundity of *L. hoevinii* and *O. melanopleura* were similar but were two to three times higher than that of *L. chrysophekadion* or *C. microlepis*. Relative fecundity of *L. hoevinii* was higher than the 50,000 - 70,000 eggs/kg reported by Meanakarn (1985, cited by Leelapatra *et al.*, 2000).

However, the study took place in 2002 after just one year of adaptation and conditioning; at that time, the brood-stock may not have been well matured. Feasibly, GSI, absolute and relative fecundity may be higher in fish fully adapted to artificial conditions.

Table 3. *A comparison of the reproductive characteristics of some indigenous species*

Species	GSI (%)	Fecundity		Diameter of egg (mm)
		Absolute (egg)	Relative (eggs/kg)	
Barbodes gonionotus	15-18	282,377-800,620	250,000-400,000	0.5-0.6
Barbodes altus	15-21	18,250-207,100	228,000-721,000	0.40-0.55
L. hoevinii	5.3-6.7	139,360-158,000	84,043-92,907	0.98 ± 0.03
L. chrysophekadion	1.4-1.7	42,306-51,408	28,204-27,057	1.01 ± 0.12
O. melanopleura	4.3-6.8	106,700-177,975	73,586-114,823	1.07 ± 0.01
C. microlepis	3.1-3.5	30,036-37,592	19,378-22,113	1.30 ± 0.04

Induced spawning

Table 4 gives the results of artificially propagating *L. hoevinii* in the 2002 and 2003 spawning seasons. The results in 2003 show a marked improvement over 2002. The ratio of fully ovulated females increased from 50-75% to 83-100% and fertilization and spawning rates were 47.0-72.5% and 64.1-

Table 4. *Reproductive characteristics Hoeven's slender carp propagated artificially during 2002 and 2003*

Year	Date	No. of females	Ratio of females ovulated completely (%)	Total weight of females[1] (kg)	Real relative fecundity[2] (eggs/kg)	Fertilization rates (%)	Spawning ratio (%)
2002	02/04/02	4	50	5.2	84,663	5.0	63.8
	06/05/02	4	75	4.1	30,366	16.5	64.1
	17/06/02	7	57	7.7	41,208	67.3	61.8
2003	12/05/03	4	100	6.75	41,760	10.0	23.0
	04/06/03	5	80	4.8	104,244	59.0	80.0
	05/06/03	2	100	2.5	151,740	60.0	78.5
	23/06/03	7	57	4.3	96,573	10.8	86.5
	07/07/03	7	86	7.0	88,458	72.5	87.8
	21/07/03	6	83	4.35	133,218	69.6	64.1
	11/08/03	5	100	6.7	107,185	47.0	75.2

Notes: [1]Total weight of females ovulated completely (A) (excluding the weight of females ovulated partially)
[2]Real relative fecundity = total number of eggs of females ovulated completely/A (excluding the number of eggs of females ovulated partially)

87.8% respectively. This improvement is a consequence of more *L. hoevinii* reaching maturity following induced spawning.

In 2003, the brood stock matured well considerably reducing the need for hormone injection. A consequential reduction the amount of hormone used (PG alone for the primary dose, PG and LH-RHa+DOM for the resolving dose) improved the economics of induced spawning.

Average size of eggs before and after resolving injection was 0.94-1.02 mm and 1.01-1.04 mm, respectively. The eggs did not show significant increase in size (only 0.04-0.08 mm) after the primary dose, though this varied in each spawning. The results show that the resolving injection can be given once eggs reach 1 mm in diameter. Latency time is 5-7 hrs after the resolving injection. Eggs began to hatch after 13 hours at water temperature of 29°C -30°C. The rate of hatching rate depends largely on water quality in incubation medium.

L. hoevinii spawn from April to August but mainly in June and July. According to Meanakarn (1985) and Watanadirokul and Kongship (1987) (cited by Leelapatra *et al.*, 2000) the natural spawning season of *L. hoevinii* is from May to November and for the most part from May to September. Although females in phase V were still fertile in September and October, gonad development in most of the males had declined by this time, as had the quantity and quality of sperm. Males usually mature earlier than females but deteriorate quickly making the spawning season short.

In this study, while the quality of ovulation was good, in some cycles fertilization rates were low because of a shortage of milt to fertilize the available eggs. Males matured in ponds produced little sperm and therefore successful spawning required more males than females. According to Leelapatra *et al.* (2000), the ideal spawning ratio of females to males is 1:3 although a ratio 1:2 may be adequate.

Fingerlings

Fingerlings reared under a two-stage regime reached an average weight of 2.54 g and an average length of 6.26 cm by day 60 (Table 5). This growth rate was lower than that seen in the greater bony lipped barb (weight 2.82 g and length of 6.86 cm) and the greater black shark (weight 3.91 g and length of 6.86 cm) at 60 days (Khanh *et al.* 2000).

Table 5. *Results of fingerling nursing in cement tanks and earthen ponds*

Growth rate			Survival rate (%)	
Age (day)	**Weight (g)**	**Length (cm)**	**2002**	**2003**
10	0.02 ± 0.01	1.33 ± 0.04		
20	0.15 ± 0.09	2.02 ± 0.21	70.2-91.4	72.0-76.8
30	0.74 ± 0.20	4.06 ± 0.35		
40	1.39 ± 0.47	5.10 ± 0.49		
50	1.56 ± 0.42	5.41 ± 0.83		
60	2.54 ± 0.56	6.26 ± 0.41	64.1-86.6	53.8-66.7

Two-stage nursing technology produced a high and stable survival rate in Hoeven's slender carp. Survival rates for juveniles at 20 and 60 days were 70.2-91.4% and 64.1-86.6% respectively in 2002 and 72.0-76.8% and 53.8-66.7% in 2003. The results in both these years compared favourably with rates achieved employing one-stage nursing technology. Rearing under this later regime achieved survival rates of only 58.7%.

Maintenance of water quality in the confines of the cement tank more efficient and moreover fry are able to find prey in addition to their regular feed. A clean, predator-free environment and a plentiful supply of feed at this earlier stage in the fish's life cycle promoted survival through to the next stage and beyond.

CONCLUSIONS

1. Nursing *L. hoevinii* in captivity realised maturation rates of 88% in females and 73% in males. Brood stock took two years to mature and three years to spawn efficiently. Females re-matured 90-120 days after the first reproduction of the spawning season.

2. The spawning season of *L. hoevinii* is from April to August and mainly between June and July. The spawning season is short because males and females do not mature synchronously. Males usually mature earlier and decline faster than females.

3. The maturation rate of females ranged from 5.3 to 6.7%. Absolute fecundity ranged from 139,360 to 158,000 eggs and relative fecundity 84,043 to 92,907 eggs/kg. The mean diameter of eggs was 0.98 mm.

4. Induced spawning of *L. hoevinii* using PG, LH-RHa+DOM gave good results. The ratio of females that fully ovulated was 83 to 100%. Real relative fecundity ranged from 88,458 to 51,740 eggs/kg. Fertilization and spawning rates for the 2003 spawning season were 47.0 to 72.5% and 64.1 to 87.8%, respectively. Results of induced spawning depend largely on quality of sperm.

5. *L. hoevinii* fingerlings reached 2.54 g in weight and 6.26 cm in length after nursing for 60 days. Two-stage nursing achieved a high and stable survival rate, between 53.8 and 86.6% fingerlings survived to 60 days.

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Comparison of the effects of buserelin in combination with various forms of domperidone and pituitary gland on the induction of spawning and gonadal development in the Thai carp, *Barbonymus gonionotus*

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ABSTRACT

This study set compares the effects of buserelin (BUS) in combination with various forms of domperidone (DOM) to the effects of extract of pituitary gland (PG) on the induction of spawning and gonadal development in the Thai carp, *Barbonymus gonionotus.* The results indicated that injection of 10 mg/kg BUS in combination with 10 mg/kg DOM (in the form of the human preparation, Motilium) dissolved in distilled water, dimethylsulfoxide (DMSO) or N,N-dimethylformamide (DMFM) had similar effects on the number of fish spawned, fertilization, hatching and survival rates of seven-day-old fry ($p>0.05$) to those seen after the injection of one dose of pituitary gland. Repeated treatments with BUS in combination with all forms of DOM used in this study had no negative effect on gonad development in females, which was completed within three weeks of each spawning. Fish were induced to spawn at least three times during the season and the same was true of fish that were induced to spawn by repeated use of pituitary gland.

KEY WORDS: *Barbonymus gonionotus*, *Puntius gonionotus*, induced spawning, buserelin, domperidone

INTRODUCTION

In most teleost fish, including the Thai carp (*Barbonymus gonionotus*), a surge of gonadotropin (GtH II) secreted by the pituitary initiates the final maturation of gonads and ovulation, and triggers the onset of spawning. The hypothalamus regulates this surge through the interaction of two other hormones, gonadotropin-releasing hormone (GnRH) and dopamine (an agent that inhibits the release of GtH).

Fish reared artificially, will spawn if dosed with GnRH, or its one of its analogues (GnRHa), in combination with a dopamine antagonist (DA) (Peter *et al*. 1988). In Thailand, this proved a very effective, and reliable, way of inducing several freshwater fish species to spawn (Sukumasavin and Leelapatra 1988). Sukumasavin and Leelapatra (1993) also found that buserelin (BUS), a mammalian luteinising hormone, is the most effective of the several forms of GnRHa.

To date, domperidone (DOM) is the only DA used in spawning experiments. DOM is insoluble in water but dissolves in organic solvents such as DMSO (Gissis *et al*. 1991) and DMFM (Gissis *et al*. 1991). It is also partly soluble in propylene glycol (PROP). However, the most common practice is to use Motilium suspension (MOT), a DOM preparation designed for use in humans. However, the effect of repeated use of a BUS-DOM combination on the development the Thai carp's gonads is unknown. In this study, therefore, we set out to investigate the consequences of using BUS-DOM (in various

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preparations), and extract of pituitary gland (PG), over several spawning cycles.

MATERIALS AND METHODS

The study was carried out at Surin Inland Fisheries Station from February to September 2001.

Experimental fish

Thai carp were reared in earthen ponds at a stocking density of 1 kg/4 m^2 and fed once daily with pellets containing 30% protein at 1.5% body weight. The fish used in this experiment were ripe to spawn, i.e. females with 80% of their oocytes at the germinal vesicle migration stage and males that produced milt when gentle pressure is applied to the abdomen.

Hormone and drug preparation

BUS: Buserelin (Hoechst) was diluted in distilled water at a concentration of 100µg/ml.

DOM: Two types of DOM were used i.e. the pure chemical (Sigma) and the human drug, MOT (Jenssen Pharmaceutica). Pure DOM was dissolved in:

- DMSO (Sigma) at a concentration of 25 mg/ml (DMSO-DOM)
- DMFM (Sigma) at a concentration of 25 mg/ml (DMFM-DOM)
- PROP (Sigma) at a concentration of 25 mg/ml (PROP-DOM)

MOT: MOT was ground and dissolved in distilled water at a concentration of 25 mg/ml (MOT-DOM).

PG: PG, collected from mature common carp (average body weight 500 g) about one hour prior to injection was homogenised and mixed with distilled water. The injection volume was adjusted to 0.5 ml/ kg of fish. The dosage was determined using the following formula:

- 1 dose = weight of donor/weight of recipient

Experiments

Experiment 1: Effects of various forms of DOM in combination with BUS on inducing Thai carp to spawn.

Sexually mature female Thai carp weighing an average of 300 g were divided into five groups of 80 fish each. Fish in each group were identified using spaghetti tags. Each group received an intra-peritoneal injection of BUS and DOM as follows:

Group 1: 1 dose of PG

Group 2: 10µg/kg BUS in combination with 10 mg/kg MOT-DOM

Group 3: 10µg/kg BUS in combination with 10 mg/kg DMSO-DOM

Group 4: 10µg/kg BUS in combination with 10 mg/kg DMFM-DOM

Group 5: 10µg/kg BUS in combination with 10 mg/kg PROP-DOM

Following this treatment, the groups of female fish were transferred to 10 m^3 cement tanks containing the same number of untreated males. The fish then spawned naturally. The resultant eggs incubated in hatching jars and the rates of fertilisation and hatching were counted. Newly hatched larvae were moved to cement tanks. The following data were collected:

- spawning time
- number of fish that spawning during the 8 hr induction period
- fertilization rate
- hatching rate
- survival rate of larvae at seven days old

Experiment 2: Effects of various forms of DOM in combination with BUS on gonadal development in the Thai carp.

The fish resulting from the spawning during Experiment 1 were reared together in a 400 m^2 earthen pond. Every day each fish was fed with 30% protein pellets equivalent to 1.5% its body weight. On the first day, five fish were taken from each group; these were weighed, killed and their gonads removed. This procedure was repeated every seven days. The gonadosomatic index (GSI = gonad weight*100/ body weight) was calculated for each fish. After four weeks, the surviving fish were used to repeat Experiment 1. After the fish had spawned, Experiment 2 was repeated for another cycle.

RESULTS

Experiment 1: Effects of various forms of DOM in combination with BUS on the induction of spawning of the Thai carp (Appendix I, Tables 1, 2 and 3).

The form of DOM is not a critical factor in determining the number of fish that spawn (Table 1). The difference in the number of fish that spawned following injections of PG, of DOM in the form of MOT, or various preparations of DOM, is not statistically significant. This is true for all three induction-cycles. In each cycle, latency periods were all between 4.15 - 6.15 hours and there is no significant difference

($p>0.05$) in the rates of fertilisation and hatching, and the proportion of larvae that survived to seven days old.

Experiment 2: Effects of various forms of DOM in combination with BUS on gonad development in the Thai carp (Appendix I, Table 4)

Within spawning cycles, the GCI varied little between groups of fish that had been injected with PG, different preparations of DOM and DOM in the form of MOT. At the time of injection, the index varied within the range 17.02±0.42% (MOT-DOM) and 21.13±3.99% (PG). In all instances the index fell sharply after spawning (to within the range 5.56±0.68% (PG) to 7.8±1.8% (DMSO-DOM)); thereafter it increased until, by week three, the index returned to the levels recorded at the time of the first injection. This pattern repeated during the second and third spawning cycles. Overall, there was no statistically significant variation in the levels of the GSI within, or between, induction-cycles.

DISCUSSION

The results of this study show that BUS in combination with DOM is as efficient in inducing spawning in the Thai carp as PG (c.f. Sukumasavin and Leelapatra, 1988). Furthermore, BUS in combination with DOM dissolved in DMSO, DMFM or PROP did not affect the number of fish that spawned, fertilisation rate, hatching rate or survival rate of seven-day-old larvae when compared with PG or DOM in the form of the human preparation, MOT (Sukumasavin 1994).

Sirikul (1987) demonstrated that Thai carp induced to spawn with PG would, if induced again, spawn for a second time one month later and three or more times in a spawning season. In this study, Thai carp induced to spawn with BUS in combination with DOM, if induced again, also spawned at least three times in the spawning season at intervals of one month.

This study uses GSI as an indicator of gonadal development because in the Thai carp GSI is highly correlated with mature oocytes ($r=0.9$, $p<0.01$) (Sukumasavin and Leelapatra 1994). GSI has been used as an indicator for gonadal development in several cyprinids, including goldfish (Clemens and Reed 1967; Munkittrick and Leatherland 1984). The peak GSI at the beginning of the study was between 17% and 21%, similar to that of fish reared in earthen ponds reported by Sukumasavin (1992). Furthermore, three weeks after spawning the GSI of fish treated with all forms of DOM in combination with BUS were not significantly different. This indicates that the gonadal development in the Thai carp can complete within three weeks under culture conditions. In addition, there were no significant differences in GSI between the two reproductive cycles ($p>0.05$). The two sets experiments demonstrate repeated use of DOM in combination with BUS has no negative effect on the induction of spawning or gonadal development in the Thai carp.

Table 5 (Appendix I) gives the costs of using PG and BUS in all forms of DOM to induce spawning of 1 kg Thai carp. PG is the most expensive at 10 baht/kg. BUS and MOT-DOM cost 4.65 baht/kg while the costs for DMSO-DOM, DMFM-DOM or PROP-DOM are lower. PROP-DOM is the cheapest overall at

2.27 baht/kg. These results show that PROP-DOM is the most cost effective method of inducing the Thai carp to spawn.

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APPENDIX 1

Table 1. *Effects of using 1 dose of PG and 10 µg/kg BUS in combination with 10 mg/kg DOM as MOT-DOM, DMSO-DOM, PROP-DOM, and DMFM-DOM on spawning induction in Thai carp at first spawning induction*

Hormone	N° of fish	Mean body weight (g±SD)	Latency period (hr)	N° of fish spawned	Fertilization rate (%)	Hatching rate (%)	Survival rate of 7-day-old fry (%)
PG	80	*294.63±23.38*	4.15	75	98.57±0.91	97.58±2.26	39.27±14.66
BUS+MOT-DOM	80	*315.11±07.15*	4.45	80	99.17±0.85	97.85±1.71	34.97±09.64
BUS+DMSO-DOM	80	*343.23±00.64*	4.45	80	98.42±1.39	97.83±1.14	52.33±12.79
BUS+PROP-DOM	80	*336.36±37.67*	4.45	80	98.65±0.35	96.65±2.05	35.50±09.99
BUS+DMFM-DOM	80	*341.47±02.08*	4.45	80	99.26±0.72	98.80±3.03	33.67±08.75

Table 2. *Effects of using 1 dose of PG and 10 µg/kg BUS in combination with 10 mg/kg DOM as MOT-DOM, DMSO-DOM, PROP-DOM and DMFM-DOM on spawning induction in Thai carp at second spawning induction*

Hormone	N° of fish	Mean body weight (g±SD)	Latency period (hr)	N° of fish spawned	Fertilization rate (%)	Hatching rate (%)	Survival rate of 7-day-old fry (%)
PG	40	367.47±53.41	4.15	35	95.01±1.06	91.88±2.75	37.60±05.34
BUS+MOT-DOM	40	382.03±59.78	4.50	40	96.59±2.48	92.59±2.38	37.30±10.08
BUS+DMSO-DOM	40	326.80±33.33	4.55	40	96.98±0.30	91.28±1.90	35.07±16.10
BUS+PROP-DOM	40	402.18±15.57	5.30	39	98.30±0.66	95.84±2.64	28.77±03.46
BUS+DMFM-DOM	40	359.84±37.37	4.50	39	95.01±3.79	94.89±3.03	33.77±04.31

Table 3. *Effects of using 1 dose of PG and 10 µg/kg BUS in combination with 10 mg/kg DOM as MOT-DOM, DMSO-DOM, PROP-DOM and DMFM-DOM on spawning induction in Thai carp at third spawning induction*

Hormone	N° of fish h	Mean body weight (g±SD)	Latency period (hr)	N° of fish spawned	Fertilization rate (%)	Hatching rate (%)	Survival rate of 7-day-old fry (%)
PG	5	373.49±73.45	5.50	4	95.67±1.15	99.67±0.58	42.03±16.10
BUS+MOT-DOM	5	371.03±40.79	5.55	5	96.59±2.48	99.17±1.04	35.40±05.01
BUS+DMSO-DOM	5	399.91±45.57	5.40	5	96.98±0.30	99.50±0.50	35.30±06.55
BUS+PROP-DOM	5	366.17±20.73	6.15	5	97.50±0.87	100.00±0.00	37.00±03.63
BUS+DMFM-DOM	5	410.91±50.62	6.15	5	98.80±0.34	100.00±0.00	30.83±01.26

Table 4. *Effects of using 1 dose of PG and 10 µg/kg BUS in combination with 10 mg/kg DOM as MOT-DOM, DMSO-DOM, PROP-DOM and DMFM-DOM on weekly changes in GSI during the three spawning cycles*

Time	PG	MOT-DOM	DMSO-DOM	PROP-DOM	DMFM-DOM
At 1st spawning induction	21.13±3.99[d]	17.21± 0.42[def]	20.01±0.18[e]	19.99±3.32[ef]	18.10±0.82b
After 1st spawning	5.56±0.68[a]	5.84±0.72[a]	7.48±1.76[a]	6.43±1.51[ab]	7.33±1.17a
1 week after 1st spawning	8.29±1.09[a]	7.00±1.47[ab]	9.46±1.07[ab]	9.17±1.85[bc]	8.34±2.02a
2 weeks after 1st spawning	13.78±1.27[b]	12.06±1.94[c]	13.17±1.68[bc]	13.60±1.96[d]	14.50±2.10b
3 weeks after 1st spawning	19.77±5.46[cd]	17.67±2.75[def]	18.52±2.22[de]	16.68±2.00[de]	14.79±4.19b
4 weeks after 1st spawning	20.84±3.25[d]	20.71±2.44[f]	20.60±4.80[e]	18.93±2.09[ef]	19.60±3.09b
At 2nd spawning induction					
After 2nd spawning	5.64±0.38[a]	5.65±0.59[a]	7.29±1.89[a]	4.94±0.03[a]	4.86±0.04a
1 week after 2nd spawning	8.80±2.19[a]	8.47±1.38[b]	10.06±1.47[ab]	9.80±2.40[c]	7.14±0.42a
2 weeks after 2nd spawning	17.13±2.30[bcd]	15.83±1.35[de]	14.47±2.72[cd]	14.06±2.64[d]	14.42±6.53b
3 weeks after 2nd spawning	14.58±4.36[bc]	15.54±1.21[d]	15.25±3.63[cd]	19.08±4.19[ef]	14.83±1.71b
4 weeks after 2nd spawning	21.55±2.78[d]	19.28±4.02[ef]	20.78±1.29[e]	22.15±2.64[f]	19.56±5.45b
At 3rd spawning induction					
After 3rd spawning	7.22±3.60[a]	5.60± 0.59[a]	7.02±2.53[a]	7.64±1.99[abc]	8.51±2.58a

Table 5. *Cost of induced spawning 1 kg of female Thai carp*

Hormone	Cost (baht/kg)
PG	10.00
BUS+MOT-DOM	4.65
BUS+DMSO-DOM	2.41
BUS+PROP-DOM	2.27
BUS+DMFM-DOM	2.30

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 (°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° of gravid females	45	50	50	24	46	40	27	28
N° 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° 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.

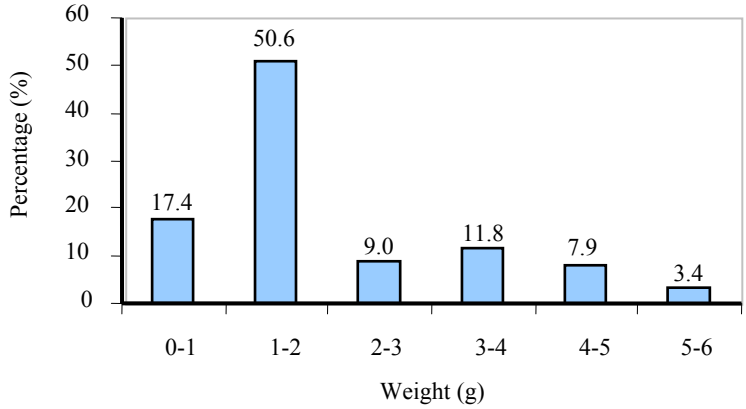

Figure 1. Weight distribution of harvested prawns in pond 3

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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